1-1-2005

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July 25, 2005

Forthcoming in MOVING TO MARKETS IN ENVIRONMENTAL PROTECTION: LESSONS AFTER 20 YEARS OF EXPERIENCE (Jody Freeman and Charles Kolstad eds. Oxford University Press)

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DESIGN, TRADING, AND INNOVATION

David M. Driesen

Proponents of "economic incentives" frequently state that emissions trading promotes technological innovation.[1] This chapter examines the claim that this trading of compliance obligations fosters innovation. While I use the term "emissions trading" throughout for the sake of concreteness, the claims made here apply fully to other kinds of environmental benefit trading.

This chapter makes two theoretical claims and two empirical claims. The first theoretical claim is that emissions trading does a poorer job, in theory, of encouraging expensive innovation than traditional regulation. I will also argue that expensive innovation has special value that justifies the expense in some important cases. The second theoretical claim is that emissions trading may perform worse than traditional regulation in encouraging inexpensive innovation as well, at least in theory.[2]

My first empirical claim is that both emissions trading and traditional regulation have sometimes encouraged innovation and sometimes failed to do so. My second claim is that we do not have convincing empirical evidence that trading fosters innovation better than a comparably designed traditional regulation.

A casual review of the literature might lead one to assume that emissions trading's advantages in encouraging innovation are well established both in theory and empirically.[3] The

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[1] *See, e.g.*, Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law: The Democratic Case for Market Incentives*, 13 COLUM. J. ENVTL. L. 171, 183 (1988); Daniel J. Dudek & John Palmisano, *Emissions Trading: Why is this Thoroughbred Hobbled?*, 13 COLUM. J. ENVTL. L. 217, 234-235 (1988); Robert W. Hahn & Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era from an Old Idea*, 18 ECOLOGY L.Q. 1, 13 (1991); Richard B. Stewart, *Controlling Environmental Risks Through Economic Incentives*, 13 COLUM. J. ENVTL. L. 153, 160 (1988); Robert N. Stavins, *Policy Instruments for Global Climate Change: How Can Governments Address a Global Problem?*, 1997 U. CHI. LEGAL F. 293, 302-03. *See also* Adam B. Jaffe et al., *Environmental Policy and Technological Change*, 22 ENVTL & RESOURCE ECON. 41, 51 (2002) (economic incentives stimulate innovation by paying firms to clean up "a bit more").

[2] I have advanced both of the claims previously. *See* David M. Driesen, *Is Emissions Trading an Economic Incentive Program?: Replacing the Command and Control/Economic Incentive Dichotomy*, 55 WASH. & LEE L. REV. 289, 313-322, 325-338 (1998) [hereinafter Driesen, *Dichotomy*]; David M. Driesen, *Free Lunch or Cheap Fix?: The Emissions Trading Idea and the Climate Change Convention*, 26 B.C. ENVTL. AFF. L. REV. 1 (1998) [hereinafter Driesen, *Cheap Fix*].

[3] *See, e.g.*, Byron Swift, *The Acid Rain Test*, 14 ENVTL. F., May/June 1997, at 17 (describing fuel switching and use of scrubbers as innovations from the acid rain program).

theory many academics mention most often, I will argue, focuses too much attention on the incentives trading creates for sellers of credits and pays too little attention to the incentives created for buyers. It also relies upon a skewed picture of traditional regulation created by academic lawyers. In light of these problems with the basis for the trading encouraging innovation argument, it is not surprising that some economists have recently questioned the premise that emissions trading always provides superior incentives for innovation.[4]

The empirical case, I will argue, is much more difficult than generally assumed. The choice between authorizing and not authorizing trading is not the only variable in a regulation that influences innovation. Decisions about the form and stringency of limits are also important.[5] It is difficult to tell whether innovation observed in conjunction with a trading program would have occurred with a performance standard providing identical emission limits, but not authorizing trading. The empirical literature has not always rigorously considered counterfactuals in assessing trading program's capacity to encourage innovation.

I limit these claims to "grandfathered" trading programs in which allowances are given away rather than sold. Whether or not polluters can trade allowances, a requirement that all polluters purchase allowances for each ton of pollution can create incentives to innovate and reduce pollution. This chapter, however, focuses on emissions trading programs that give away limited allowances for free, and then authorize trades to redistribute them. I choose this approach because all existing United States pollution trading programs give away, rather than sell, the overwhelming majority of allowances, and because this focus sharpens analysis of trading's effect on innovation.

The first part of this chapter will establish some background concepts. It will define innovation, explain its value, and establish an analytical framework that will inform the rest of the chapter This analytical framework posits that to compare a trading program to a traditional regulation, we need to compare programs with identical underlying emission limits. More widespread use of this framework will improve the rigor of both theoretical and empirical analysis.

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[4] *See, e.g.,* Joel F. Bruneau, *A Note on Permits, Standards, and Technological Innovation*, 48 J. ENVTL. ECON. & MAN. 1192 (2004); Juan-Pablo Montero, *Permits, Standards, and Technology Innovation,* 44 J. ENVTL. ECON. & MAN. 23 (2002); Juan- Pablo Montero, *Market Structure and Environmental Innovation,* 5 J. APPLIED ECON. 293 (2002) (trading, taxes, or traditional regulation can best encourage research and development when firms' products are strategic substitutes). *See also* David A. Malueg, *Emissions Credit Trading and the Incentive to Adopt New Pollution Abatement Technology*, 16 J. ENVTL. ECON. & MAN. 52 (1987) (pointing out the error and offering a correction); W. A. Magat, *Pollution Control and Technological Advance: A Dynamic Model of the Firm,* 5 J. ENV'T. ECON. & MGMT. 95 (1978).

[5] *See, e.g.,* Suzi Kerr & Richard Newell, *Policy-Induced Technology Adoption: Evidence from the U.S. Lead Phasedown,* 51 J. INDUS. ECON. 317, 320 (2003) ("We find that increased stringency . . . encouraged greater adoption of lead reducing technology").

The next two parts defend the theoretical and then the empirical claims. The fourth part explains the analysis' implications. I argue that we need to consider more imaginative use of economic incentives with an explicit goal of encouraging innovation, rather than short-term efficiency. I also spell out a research agenda suggested by the analytical framework and subsequent analysis.

I. Innovation and Trading: A Framework

A. Defining Innovation

Most of the literature claiming that emissions trading fosters innovation does not define innovation. Economists frequently define innovation as the commercialization of an invention.[6] They distinguish this from diffusion - the adoption of a successful innovation by firms or individuals.

This definition of innovation as commercialization separate from invention jibes less well with common understandings of what innovation connotes in the environmental area than it does in the production of goods. For most people, innovation involves some non-obvious change. But a definition of innovation as commercialization might accept uses of very well understood, but not yet widely deployed, pollution reducing technique as "innovation." If this were the case, then a lot of command-and-control regulation would be seen as innovation inducing, because it has frequently spurred use of well understood, but little used, technological options. But the policy literature usually treats adoption of techniques well understood by regulators or polluting firms as diffusion, not innovation.

For this reason, I define innovation as involving both the invention and use of something new. Newness, however, means something more than "it has not been done" before by a particular company or even industry. A company with no environmental controls may adopt standard, well-established techniques used in the past by their competitors or by another industry. This normally involves technological diffusion, not technological innovation.

Innovation implies a non-obvious departure from prior practice, to borrow a concept found in patent law. Innovation in this sense advances the state of the art. As we shall see, innovation defined in this manner has special value. I will refer to this as the "Newness" definition. This definition implies that a regulatory program induces innovation when a polluter or vendor develops a new technique in response to that program and then a polluter uses the technique to reduce pollution, but does not generally accept diffusion of techniques invented before the program's onset as innovations.

A second concept will also prove useful here, that of Radical Innovation. Radical Innovation in the environmental area addresses multiple pollution problems simultaneously and changes fundamental technologies at the base of the economy, not just end-of-the-pipe controls.

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[6] *See, e.g.*, Adam B. Jaffe et al., *Technological Change and the Environment, in* THE HANDBOOK OF ENVIRONMENTAL ECONOMICS 464-65 (Jeffrey Vincent ed., 2003).

Examples might include switches from fossil fuels to renewable energy and from pesticide-based agriculture to organic agriculture or genetically modified crops.

The need to distinguish innovation from diffusion to analyze instrument choice's influence upon innovation makes empirical research difficult no matter what definition is employed.[7] The Newness Definition implies a need to assess the novelty of a technological changes. This chapter's references to innovation will apply the "Newness" definition unless otherwise stated. It will assume that "Radical Innovation" is a subset of innovations found under the "Newness" rubric.

B. The Importance of Innovation

Innovation can perform one of two basic functions. It can lower the cost of a product or increase its quality.[8] Computers with word processing programs, for example, cost much more than pen and paper or a typewriter, but offer a much higher quality writing aid, making revision relatively easy.

So too with environmental innovation.[9] Innovation can reduce the cost of pollution control or make it possible to perform basic economic functions with less pollution than existing approaches. In other words, environmental innovation can either offer qualitatively better environmental results or reduce the cost of achieving a particular result.

In *The Economic Dynamics of Environmental Law* (MIT Press 2003), I argue that this former "qualitative" function has immense importance. We suffer from continued air pollution problems and worsening climate change largely because we remain addicted to very old basic technologies such as coal-fired power plants and gasoline-burning car engines.[10] Pollution from cars and power plants bears a major portion of the responsibility for tens of thousands of annual deaths from air pollution, millions of cases of asthma, cancer risks, reproductive toxicity risk,

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[7] *See* id. at 467 (finding it difficult to distinguish innovation from diffusion using a "commercialization" definition).

[8] DAVID M. DRIESEN, THE ECONOMIC DYNAMICS OF ENVIRONMENTAL LAW 78-80 (MIT Press 2003).

[9] For a definition of environmental innovation, see *id.* at 77-78. *Cf.* Richard B. , *Regulation, Innovation, and Administrative Law: A Conceptual Framework*, 69 CAL. L. REV. 1256, 1279 (1981) (distinguishing between market and social innovation).

[10] David M. Driesen, *Sustainable Development and Air Quality: The Need to Replace Basic Technologies with Cleaner Alternatives,* 32 ELR 10277, 10280, 10284 (Mar. 2002) (detailing contributions to air pollution from vehicles and power plants and the persistence of outmoded technologies); ENVIRONMENTAL LAW INSTITUTE (ELI), CLEANER POWER: THE BENEFITS AND COSTS OF MOVING FROM COAL GENERATION TO MODERN POWER TECHNOLOGIES (2001).

widespread destruction of ecosystems, and global climate change (which may produce rising seas, a spread of infectious diseases, eco-system harms, and, in places, drought and starvation).

Because of this we may need "Radical Innovation" to address these problems comprehensively in the economically dynamic world we live in--a dynamic world of growing population, increased consumption, and fierce lobbying fueled by the proceeds of increased consumption. This economic dynamic tends to make environmental problems grow over time. This dynamic almost always undermines some of the progress environmental regulation would otherwise bring about, and, at times, leads to absolute declines in environmental quality.

Technological innovation generally (not just radical innovation) also performs an important political function--making progress possible where it otherwise could not occur.[11] The climate change regime, for example, assumes that the richer countries will develop and share the technologies that will make it possible for relatively poor countries to enjoy a good quality of life and contribute to efforts to address climate change. Absent this sort of developed country leadership, developed countries may have great difficulty persuading tomorrow's greatest greenhouse gas emitters, such as China and India, to reduce emissions to tolerable levels.

We need to reframe the environmental policy debate around the question of addressing the economic dynamics of environmental law. This involves, among other things, asking how we can design environmental law that stimulates environmental innovation as effectively as we currently stimulate material innovation (some of which is environmentally destructive). In any case, environmental policy analysts generally agree upon the desirability of stimulating technological innovation to improve the environment.[12] But the emphasis upon "dynamic efficiency" in the trading literature tends to emphasize the cost saving advantages of innovation, while drawing attention away from the "qualitative" advantages.

Emissions trading has been widely implemented.[13] Hence, the question of whether it encourages innovation matters a great deal.

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[11] Timothy F. Malloy, *Regulation by Incentives: Myths, Models, and Micromarkets*, 80 TEX. L. REV. 531, 541 (2002) (innovation can ease "the way for broader environmental improvements."). *Cf.* Jaffe et al., *supra* note 1, at 54-55 (noting that cost-saving innovation may make optimal environmental policy more stringent).

[12] *See, e.g.*, Jaffe et al., *supra* note 1, at 49.

[13] *See* Driesen, *Dichotomy, supra* note 2, at 291-92. *See, e.g.* Royal C. Gardner, *Banking on Entrepreneurs: Wetlands, Mitigation Banking, and Takings*, 81 IOWA L. REV. 527 (1996) (reviewing an intertemporal trading program for wetlands conservation); David M. Driesen, *Choosing Environmental Instruments in a Transnational Context*, 27 ECOLOGY L.Q. 263 (2000) (discussing international application of emissions trading); Ann Powers, *Reducing Nitrogen Pollution on Long Island Sound: Is There a Place for Pollutant Trading?*, 23 COLUM. J. ENVTL. L. 137 (1998) (discussing proposal to use nitrogen trading regionally to control water pollution).

C. **An Analytical Framework for Comparing Trading and Non-Trading Programs**

When not analyzing emissions trading, economists commonly employ the "induced innovation hypothesis" - an assumption that high cost will tend to encourage innovation. This hypothesis would suggest that more stringent regulation would induce more innovation than less stringent regulation. Stringent regulation (with or without trading) raises the cost of routine compliance and creates an incentive to innovate in order to escape the high cost.

This observation has implications for the analysis of emissions trading programs, because all trading programs involve government decisions about stringency. While policy-makers sometimes act as if trading programs offer an alternative to regulation, experts in the area understand that trading is a variant upon an ordinary performance standard. To establish a trading program, government officials must establish a set of performance standards for regulated pollution sources, just as they would if they were establishing a traditional regulation. When a regulator permits a regulated polluter to forego local compliance with the performance standard if she purchases equivalent reductions from elsewhere, she has created a trading program. The trading program still contains pollution limits reflecting a policy choice about the amount of reductions to demand, but it introduces flexibility about the location of the reductions.

Since stringency decisions can influence the amount of innovation, isolating the effect of permission to trade on innovation requires comparison of programs with equivalent stringency. Let's assume that one state demands a 70% reduction from power plants through an emissions trading program and another demands a 50% reduction from power plants through a set of source specific performance standards. Assume that the power plants were identical in all respects prior to regulation and that the emissions trading program induced more innovation than the performance standard program. One could not assume that the trading produced the innovation. One would have to at least consider the possibility that the difference in stringency accounted for the difference in innovation rates.

Another important variable involves the form of standards. The acid rain program trading program, the phase out of ozone depleting chemicals (which I treat as a traditional regulation, because nobody seems to have used the trading provisions), and the most recent new source performance standard for power plants (which do not allow trading) feature mass-based limits. Most emissions trading programs (e.g. the open market trading programs in the states, the bubbles, and mobile source emissions trading programs) and traditional regulations, however, use rate-based limits. Mass-based limits will tend to induce more innovation than rate-based limits, because they do not allow pollution levels to rise when production increases. Hence, the form of standards provides another potentially significant variable.[14]

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[14] The economics literature sometimes uses the term "emissions standard" to refer to a rate-based standard and the term "performance standard" to refer to a mass-based standard. *See* Bruneau, *supra* note 4 at 1193 n. 1. The Clean Air Act, however, defines both these terms much more broadly. *See* 42 U.S.C. § 7602(k) (defining an "emission standard" as any standard that limits air pollution, including both numerical standards and instructions about what techniques to use); 42 U.S.C. §§ 7411(h), 7602(l) (defining a performance standard as either a rate-based or

A valid comparison between a trading program and a non-trading program should compare programs having emission limits of identical stringency and form. To isolate trading's effect on innovation, one has to ask whether an emissions trading program induces more innovation than a comparably designed traditional performance standard.

II. The Theoretical Claims

The induced innovation hypothesis suggests that emissions trading discourages innovation. Since it lowers the cost of routine compliance, it would seem to reduce the impetus to innovate. High costs encourage innovation, low costs discourage it. So, a trading program should produce less innovation than a comparably designed traditional regulation.

Oddly though, the economics literature on trading generally does not analyze the implications of the induced innovation hypothesis. I will first discuss the theory supporting the claim in the literature that emissions trading encourages innovation. I will then support my claim that trading discourages high cost innovation. Finally, I will discuss the more difficult claim, that traditional regulation might induce more low cost innovation than a comparably designed trading program.

A. **The Existing Theory**

It is common for the selection of the unit of analysis to influence results in economic theory and in other realms. This is certainly true of emissions trading.

Imagine an argument against emissions trading's capacity to stimulate innovation that went like this: In an emissions trading program, some polluters emit more than their allowable emissions; therefore, these polluters have less of an incentive to innovate than they would have under a traditional program and emissions trading decreases incentives to innovate. Let's assess this argument.

Well, emissions trading does provide an incentive for some polluters to emit more than they would under a traditional regulation.[15] But those polluters must pay other polluters to make extra emission reductions to make up the gap. Resting a model of emissions trading upon the experience of only half of the polluters (the buyers of credits) in the market skews the results. This model leaves the sellers of emission credits, who make extra reductions to sell to the buyers, out of the picture. It is obviously incomplete.

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mass-based numerical limit on air pollution, as opposed to a "work practice" standard that dictates technological choice).

[15] *See* Driesen, *Dichotomy,* supra *note* 2, at 334; Kerr & Newell, *supra* note 5, at 319 (relatively high-cost plants will have decreased incentives to adopt technology under a trading system).

If we change the unit of analysis, we can flip this result. The argument would go like this: Polluters have an incentive to make extra emission reductions under emissions trading so that they can sell credits;[16] therefore, emissions trading stimulates innovation.

This model accurately explains the situation of sellers of credits. But it is also obviously incomplete. It leaves the buyers of credits out of the picture. While emissions trading encourages sellers to decrease emissions below the levels a comparable traditional regulation, trading encourages buyers to increase their emissions above what a traditional regulation allows.

The seller-based model, incomplete as it is, actually forms the theoretical predicate for the standard argument that emissions trading encourages innovation.[17] Basing an economic model only upon the seller's decrease of emissions amounts to treating emissions trading as a program that generates extra net emission reductions. If emissions trading did that, obviously it would create a greater net incentive for innovation. For stricter regulation demands more than laxer regulation and, therefore, heightens incentives for innovation. But an emissions trading program does not generate more net emissions reductions than a comparable traditional regulation.

If the market functions perfectly, then an emissions trading program produces precisely the same amount of reductions that a traditional regulation with the same emission limits would produce, no more and no less.[18] Emissions trading shifts emission reductions, concentrating the same number of reductions among the facilities with the lowest pollution reduction costs.[19] The right question is whether this shift of reductions from high-cost to low-cost facilities encourages innovation.

I am not the first scholar to point out the incompleteness of a seller-based analysis. In 1987, David Malueg, now of Tulane University's economics department, wrote an article in the *Journal of Environmental Economics and Management* discussing the incompleteness of the seller-based model.[20] He argued that an economic model of emissions trading must recognize that some polluters make more reductions under a trading regime than they would under a traditional regulation, and some polluters make less.[21] This argument seems irrefutable. Indeed,

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[16] *See* Malueg, *supra* note 4, at 8-9 & n.33.

[17] *See id.*; Jaffe et al., *supra* note 1, at 51 ("market-based instruments can provide powerful incentives for companies to adopt cheaper and better pollution-control technologies . . . because . . . with market-based instruments, it pays firms to clean up a bit more . . .).

[18] *See* Hahn & Stavins, *supra* note 1, at 8-9 & n.33 (describing trading's tendency to seek equilibrium). *See generally* J.H. DALES, POLLUTION, PROPERTY, AND PRICES 92-100 (1968).

[19] *See* Driesen, *Dichotomy, supra* note 2, at 334; Driesen, *Cheap Fix*, *supra* note 2, at 43.

[20] *See* Malueg, *supra* note 4.

[21] *Id.* at 54-56.

the desire of some polluters to avoid otherwise required reductions generates the demand for "extra" emission decreases that drives emissions trading. In a real sense, emission increases (above otherwise required levels) finance emission decreases in an emissions trading program.[22] For the savings realized by not making expensive reductions at buyers' own facilities finance the purchase of credits that drives the market.[23]

It is not clear why a measure that reduces innovation incentives for some facilities and increases them for others will lead to an increase in overall levels of innovation among facilities subject to a regulation. And the relevant question for public policy, of course, must address overall levels of innovation, not just of a chosen subset of facilities.

Economists have recently have begun to use Malueg's model to analyze emissions trading's influence upon technological change; and they acknowledge that Malueg's model casts doubt on the thesis that emissions trading without auctioned allowances encourages innovation.[24] The selection of a seller-based model would be systematically biased toward the position that emissions trading encourages innovation, just as the selection of a buyer-based model would be systematically biased toward the conclusion that emissions trading discourages innovation. Hence, economists are right to be giving increased attention to the Malueg

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[22] *See* Driesen, *Dichotomy, supra* note 2, at 337.

[23] *Id.*

[24] Id. at 334 (employing the Malueg model); DAVID WALLACE, ENVIRONMENTAL POLICY AND INDUSTRIAL INNOVATION: STRATEGIES IN EUROPE, THE U.S.A., AND JAPAN 20 (1995) (explaining that Malueg's "more sophisticated model" casts doubt on the claim that emissions trading necessarily spurs innovation); Malloy, *supra* note 11, at 543 n.33 (discussing Malueg as suggesting that emissions trading may cause a decrease in research and development in pollution reducing technology); Kerr & Newell, *supra* note 5, at 319 (employing the Malueg model as part of a very sophisticated analysis of the lead trading program); Hahn & Stavins, *supra* note 1, at 8-9 n.33 (pointing out, consistent with Malueg, that trading encourages abatement by some sources, while encouraging high cost sources to increase emissions); Robert P. Anex, *Stimulating Innovation in Green Technology: Policy Alternatives and Opportunities*, 44 AM. BEHAV. SCIENTIST 188, 201 (2002) (market incentives do not necessarily improve incentives for innovation); Chuhlo Jung et al., *Incentives for Advanced Pollution Abatement Technology at the Industry Level: An Evaluation of Policy Alternatives*, 30 J. ENVTL. ECON. & MGMT. 95, 95 (1996) ("marketable permits may not provide greater incentives than standards, because the incentive effects of marketable permits depend on whether firms are buyers and sellers."); V. Kerry Smith & Randy Walsh, *Do Painless Environmental Policies Exist?,* 21 J. RISK & UNCERTAINTY 73, 75-76 (2000) (addressing the Malueg model); Michael Grubb & David Ulph, *Energy, the Environment, and Innovation*, 18 OXFORD REV. ECON. POL'Y 92, 104 (2002) (expressing lack of confidence in environmental policy's ability to encourage innovation without a technology policy). *See also* Jean-Jacques Laffont & Jean Tirole, *Pollution Permits and Environmental Innovation*, 62 J. PUB. ECON. 127, 128 (1996) (permits can create "inefficiencies with regard to innovation").

framework.

B. Why Trading Discourages Costly Innovation

Emissions trading disfavors costly innovation. Emissions trading creates an incentive for a polluter facing high control cost to purchase credits that cost less than the cost of control at the buyer's facility.[25] Furthermore, the buyer has an incentive to purchase the cheapest credits possible. Knowing this, rational sellers will only generate credits that cost less to produce than: 1) the control cost of prospective buyers; and 2) credits with which the seller must compete. Emissions trading by lowering the cost of compliance, restricts the price range of innovations that are economically rational.

Thus trading rules out the purchase of credits generated by relatively expensive innovation (i.e. higher than the equilibrium price created in a trading regime). But that raises the question of whether expensive innovation is desirable. In answering that question, we should bear in mind that useful innovations often follow a path where they cost a lot at the outset, but the costs of using innovations fall as producers learn better production techniques and realize savings through economies of scale.[26] Thus, an expensive innovation might function as an investment in future cheap reductions. The emissions trading market does not encourage such investments because the buyer of credits chooses the cheapest current reductions, not considering societal cost savings in the future. Because today's luxury goods often become tomorrow's important technological advance (e.g. computers), this failure to stimulate advanced technologies may be detrimental in the long run.

Furthermore, radical innovations, which might be expensive, offer a qualitative improvement that makes them quite worthwhile, even if they do cost more. Thus, for example, a technology that produces a whole raft of environmental benefits may prove valuable even if it does not offer the cheapest current method of obtaining the benefit sought by a targeted emissions trading program.

Innovations that decrease reliance upon fossil fuels offer both this qualitative superiority and the possibility of future cost savings. Renewable energy technologies have experienced rapid declines in prices as production has increased, even though they have never achieved the scale

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[25] *See* Malloy, *supra* note 11, at 542-543; Driesen, *Cheap Fix, supra* note 2, at 42 (buyers will purchase cheap credits).

[26] *See, e.g.*, Julie Edelson Halpert, *Harnessing the Sun and Selling it Abroad: U.S. Solar Industry in Export Boom,* N.Y. TIMES, June 5, 1996, at D1; Jaffe et al., *supra* note 6, at 490 (discussing economic models predicated upon falling abatement costs from "learning by doing"); *Commission on Sustainable Development (CSD), Acting as the Preparatory Committee for the World Summit on Sustainable Development, Energy, and Transport: Report of the Secretary General*, at 4, U.N. Doc. E/CN.17/2001/PC/20 (2000) (price of solar photovoltaic modules has come down about 25%).

that might facilitate really enormous reductions in price.[27] And renewable technologies promise relief not just from a particular air pollutant, but from a host of pollutants, associated destruction of land from drilling and mining, water pollution, and much else besides.[28] Yet, emissions trading tends to favor low-cost solutions, like better scrubbers and catalysts, to environmentally and economically superior solutions for the long haul.

C. **Trading and Low-Cost Innovation**

While the case against emissions trading as a method to stimulate expensive but potentially invaluable environmental innovation seems simple, irrefutable, and very strong, the question of whether it provides superior incentives for cost reducing innovation is more complex.[29] I now turn to that question.

1. *The Theory of Trading*

In theory, emissions trading may weaken net incentives for innovation. If a regulation allows facilities to use trading to meet standards, then the low-cost facilities will tend to provide more of the total reductions than they would provide under a comparable traditional regulation. Conversely, the high-cost facilities will tend to provide less of the total required reductions than they would under a comparable traditional regulation. One would expect the low-cost facilities to have a greater ability to provide reductions without substantial innovation than the high-cost facility. A high-cost facility may need to innovate to escape the high costs of routine compliance; the low-cost facility may have less of a need for this. The induced innovation hypothesis, widely employed by economists, suggests that high costs will spur, not deter, innovation.[30] So lowering the cost of routine compliance, through trading or otherwise, does not encourage innovation. Trading, by shifting reductions from high-cost to low-cost facilities, may lessen the net incentives for innovation.

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[27] *See, e.g., CSD*, *supra* note 26, at 4 (discussing declines in prices of solar photovoltaic modules); JAMES MCVEIGH ET AL., WINNER, LOSER, OR INNOCENT VICTIM?: HAS RENEWABLE ENERGY PERFORMED AS EXPECTED (Resources for the Future Discussion Paper 99-28, 1999).

[28] *See* DRIESEN, *supra* note 5, at 34-35.

[29] In fact, the case is not completely iron clad. The lead trading case may demonstrate that notwithstanding the drag trading may place on innovation, sufficiently stringent limits will force innovation if they cannot be met without it. If one reduces pollution to zero, innovation often must take place. While trading can retard the pace of innovation, as it did in the lead case, it will not prevent it. *See* Driesen, *Dichotomy*, *supra* note 2, at 317 n.131.

[30] *See* Richard G. Newell et al., *The Induced Innovation Hypothesis and Energy-Saving Technological Change*, 114 Q. J. ECON. 941 (1999). *Cf.* Malloy, *supra* note 11, at 546 (linking the induced innovation idea to the idea that traditional regulation may induce innovation)

High local control costs often serve as the catalyst for innovation. Companies do not routinely pursue all innovations.[31] Investigation of innovation often involves substantial investment without certainty about pay-off.[32] Many companies' management structures further discourage environmental innovation because environmental projects must compete with other more favored projects for company resources needed to investigate and implement the innovation. When companies face either the impossibility of compliance without innovation or very high control costs, however, the environmental compliance division acquires some bargaining power to secure resources to investigate innovation. Absent such incentives, companies will tend to comply or over-comply through application of routine technology.

Some analysis of the low emissions vehicle (LEV) program, a regulatory program that several states have enacted to stimulate innovation and secure emission reductions from automobiles, illustrates the way emissions trading may decrease incentives for innovation. The program requires introduction of a fairly large number of vehicles that must meet emission standards that car manufacturers can realize with fairly modest technological improvements, such as introduction of very efficient catalysts. But the program also requires introduction of a small number of zero emission vehicles (ZEVs), most likely electric cars.[33] The automobile industry claims that the ZEVs will prove expensive to produce. One could, in theory, design a program that provides the same net emission reductions as the LEV program by requiring more widespread implementation of the emission reduction requirements other than the zero emissions mandate as the basis for a trading program. In the short run at least, this would produce, in theory, the same emission reductions for less cost. But the zero emissions mandate provides the incentive to develop new technologies that may revolutionize the environmental performance of automobiles over time and even lower long-term costs.[34] Hence, there is a tradeoff between the short term efficiency that emissions trading promotes and the desire to promote environmentally superior technological innovation.

Another example comes the use of international emissions trading programs to meet climate change goals. The European Union is adopting trading programs that may make it possible for electric utilities, significant sources of greenhouse gases, to claim credits undertaken abroad as a substitute for making reductions below current levels at home. If European states

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[31] *See* Malloy, *supra* note 11, at 537-38, 556.

[32] *See id.* at 557; Jaffe et al., *supra* note 1, at 44 (discussing how uncertainties can lead to insufficient investment in innovation).

[33] *See* Motor Vehicle Mfrs. Ass'n of the United States v. New York State Dep't of Envtl. Conservation, 17 F.3d 521, 528 (2d Cir. 1994). For a discussion of some of the technological issues, see JAMES J. MACKENZIE, THE KEYS TO THE CAR: ELECTRIC AND HYDROGEN VEHICLES FOR THE 21ST CENTURY (1994).

[34] *See generally* MICHEAL SHNAYERSON, THE CAR THAT COULD: THE INSIDE STORY OF GM'S REVOLUTIONARY ELECTRIC VEHICLE (1996) (detailing innovations and the role of the ZEV mandate in stimulating them).

imposed strict reduction requirements upon electric utilities, they might have to switch fuels in order to meet the requirements. They might need to switch from coal to natural gas to meet fairly stringent reduction targets and very strict standards might drive them toward innovative technologies, such as almost-zero polluting fuel cells and solar energy.[35] But trading may allow them to avoid significant changes. Utility operators may eschew expensive innovation to meet a strict reduction target at home in favor of upgrading a very dirty plant abroad with off-the-shelf technology at very modest cost, or better yet, claim credits for tree planting projects of uncertain benefit.

Some writers have suggested that emissions trading provides a continuing incentive to reduce "because the number of permits remain limited."[36] Hence, economic growth will increase the demand for permits, raise the price, and provide a greater incentive for polluters to reduce their emissions.

Limiting the number of permits does not create an incentive for continuous net emission reductions below the equilibrium level required by the program. Limiting the number of total permits without decreasing the amount of emissions the permits allow would involve tolerating increases in emissions attributable to economic growth to the extent that existing polluters generate compensating pollution reductions (credits). Net emissions would remain consistent with those authorized by the promulgated emission limits, but would not decrease below that level.[37]

A legal rule limiting the number of permits creates incentives to avoid increases above the mandated level, whether or not the permits can be traded. The premise that a trading program limits the number of permits tacitly assumes that a legal rule prohibits the sources of additional pollution caused by economic growth from operating without purchased emission allowances. An argument that a trading program restrains growth in emissions from economic growth also requires an assumption that the trading regime imposes a cap on the mass of emissions of the sources within a trading program (as in the acid rain program). A program authorizing trading to meet rate-based emission limitations or allowing any pollution source to operate without purchased allowances would tolerate increases in emissions associated with economic growth

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[35] *See generally*, *At Last, The Fuel Cell*, ECONOMIST, Oct. 25, 1997, at 89; Andrew C. Revkin, *Under Solar Bill, Homeowners Could Cut Electricity Cost to Zero*, N.Y. TIMES, July 25, 1996, at B1.

[36] *See, e.g.*, James T. B. Tripp & Daniel J. Dudek, *Institutional Guidelines for Developing a Successful Transferable Rights Program*, 6 YALE J. ON REG. 369, 374 (1989).

[37] *See* Richard B. Stewart, *Economics, Environment, and the Limits of Legal Control,* 9 HARV. ENVTL. L. REV. 1, 13 (1985) ("Given a fixed supply of permits . . . [t]he system will ensure that we . . . keep in place.").

without demanding compensating credits.[38] So even the modest argument that trading can restrain growth in emissions applies only to a particular idealized trading program, not emissions trading in general.

A traditional regulatory program that prohibits economic growth from creating additional emissions would, in theory, also provide a continuing incentive to avoid net emission increases in response to economic growth.[39] Of course, traditional regulations can limit pollution by mass rather than by rate, and sometimes has.[40] Hence, traditional regulation and emissions trading based on rates fail to constrain emissions in the face of growth in production, but limits on mass, whether expressed in performance standards or tradable allowances, may constrain emissions in the face of growth. A legal rule prohibiting all non-permitted emissions would improve the environmental performance of either an emissions trading scheme or traditional regulation. But even an idealized emissions trading program does not provide a more continuous incentive for pollution reduction than a comparable traditional regulation.

One might support the idea that trading provides superior incentives for innovation by pointing out that once a planned reduction goal is met, the government can always set another more ambitious reduction goal. If the government could be counted on to continuously revise standards, then a continuous incentive to reduce would exist. But notice that this would be true whether or not the government authorized trading as the means of meeting the continuously revised goal. Even without trading, a government program that could be reliably counted upon to makes its requirements more stringent would provide an incentive for continuous reductions.

But a major critique of traditional regulation holds that it fails to provide an incentive for continuous environmental improvement, precisely because the government cannot be depended upon to strengthen standards in a predictable manner. Problems of complexity, uncertainty, and delay prevent regulators from predictably tightening limits. These problems limit traditional regulation's ability to stimulate innovation. Does emissions trading overcome this problem?

The answer seems to be no. If an administrative body sets the limits underlying a trading

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[38] *See* Swift, *supra* note 3, at 18 (explaining that emission rates do not necessarily prevent increases in the mass of emissions).

[39] The traditional program would simply duplicate the assumptions implicit in the trading model Tripp and Dudek tacitly advance. The government would set mass based emission limitations for pollution sources, something that must occur in the trading program as well. The same background legal rule would apply prohibiting the government from granting permits to new sources of emissions.

[40] *See, e.g.* Reynolds Metal Co. v. E.P.A, 760 F.2d 549, 559 n.14 (4th Cir. 1985) (discussing EPA's promulgation of mass-based standards for total toxic organics (TTO) for the can-making industry); Citizens for a Better Environment-California v. Union Oil Co. of California, 861 F.Supp. 889, 895 (N.D.Cal.1994) (discussing mass-based limits on the amount of selenium that refineries could discharge).

program, then the problems of the complexity of administrative environmental decisionmaking and the attendant delay may infect these decisions, just as they infect decisionmaking in traditional programs. A good example comes from Environmental Protection Agency (EPA) efforts to foster a regional market for nitrogen oxides across a broad region of ozone transport, which has been plagued by delays and uncertainty.[41] The resulting uncertainty can lessen incentives to innovate, just as uncertainty about future emission limitations reduces such incentives in traditional regulation.[42] Also, private parties have significant incentives to litigate disliked stringency determinations and allocation decisions.[43]

Congressional mandates of specific emission reductions may circumvent some of the problems with administrative decisionmaking, including hard look judicial review.[44] Congress has, in fact, circumvented administrative problems by mandating specific cuts of named

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[41] *See* Appalachian Power Co. v. EPA, 249 F.3d 1032, 1036-1040 (D.C. Cir. 2001) (reciting some of litigious history of this emissions trading program, prior to remanding EPA's rule calling on states to adopt an emissions trading program). In fact, EPA's rulemaking in this case does not create the emissions trading program directly, but relies upon subsequent state implementing rules. In addition, a long effort to negotiate this program precedes the event recited in the opinion.

[42] Jeanne M. Dennis, *Smoke for Sale: Paradoxes and Problems of the Emissions Trading Program of the Clean Air Act Amendments of 1990*, 40 UCLA L. REV. 1101, 1105 (1993) (if the need for reduction in acid rain becomes more urgent, allowances might be confiscated, thus upsetting the market); Suzi Clare Kerr, Contracts and Tradeable Permit Markets in International and Domestic Environmental Protection 6 (unpublished Ph.D. dissertation, Harvard University) (because of high levels of scientific uncertainty and changing preferences regulatory systems must periodically readjust targets). Professor Stewart envisions "depreciating permits" over time according to a predetermined schedule. *See* Stewart, *supra* note 9, at 1333. He suggests that this proposal would obviate the need for "constant administrative or legislative tightening." *Id.* at 1332-33.

Emissions trading schemes that do not have a fixed long-term depreciation schedule still may require periodic tightening. A long-term depreciation schedule can be applied to either marketable or unmarketable permits. Hence, whatever certainty this idea might create would exist with or without emissions trading. Professor Stewart's proposal may make sense. But it's not really an argument about emissions trading.

[43] *See* Texas Mun. Power Agency v. EPA, 89 F.3d 858, 861 (D.C. Cir. 1996) (involving claim seeking additional emission allowances); Indianapolis Power & Light Co. v. EPA, 58 F.3d 643, 647 (D.C. Cir. 1995) (same); Madison Gas & Elec. Co. v. EPA, 25 F.3d 526, 526 (7th Cir. 1994) (same); Monongahela Power Co. v. Reilly, 980 F.2d 272, 272-74 (4th Cir. 1992) (same).

[44] *See* David Schoenbrod, *Goals Statutes or Rules Statutes: The Case of the Clean Air Act*, 30 UCLA L. REV. 740, 808, 815 (1983). Professors Stewart and Ackerman seem to have assumed that Congress would always set the limits associated with emissions trading. *See* Ackerman & Stewart, *supra* note 1, at 190.

pollutants both through emissions trading[45] and through standard setting.[46] The scarcity of congressional time may limit the frequency of congressional mandates.[47] However, congressionally set limits have often fared relatively well and should be pursued.[48] Yet the advantages of specific quantitative congressional decisionmaking occur whether or not pollution sources may use trading as a means to comply with the limits.

Hence, the intuition that trading programs are easier to establish and change than traditional programs rests upon confusion of institutional choice with instrumental choice. Administrators establishing trading programs face many of the same problems that have interfered with efforts to make non-trading programs predictable stimulants of continuous innovation. And Congress, to the extent it avoids political paralysis, can overcome these problems with either trading or non-trading programs.

Some analysts believe that trading programs may prove easier to establish, because lowered cost will translate into lowered polluter resistance. But polluters with high local pollution control costs may not have information about lower cost options at other facilities, and may therefore fight just as hard as ever. Much will depend, however, upon political circumstances. Polluters will lobby if the potential gains from doing so make it worthwhile, regardless of whether the potential maximum loss has diminished. Often, even if polluters anticipate fully the reduced cost from trading, potential gains from avoiding limits or weakening them may often provide sufficient incentives for vigorous advocacy sufficient to stall progress.[49] Certainly, no rule exists that trading automatically leads to tightened limits.

In any case, most claims that trading encourages innovation have not relied upon political economy arguments hypothesizing tighter limits. Rather, they have rested upon inherent characteristics of trading that apply even when they aim at identical limits to those used in a traditional regulation. Hence, this identical limits framework, putting political economy questions aside for the time being, is the framework employed here.

2. *The Theory of Traditional Regulation: The Command and Control/Economic Incentive Dichotomy and the Law*

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[45] *See* 42 U.S.C. §7651(b)(setting goal of acid rain trading program at a cut of ten million tons of sulfur dioxide).

[46] *See* 42 U.S.C. §§7521(g)(setting numerical standards for vehicle emissions) 7511a(b)(1)(generally requiring states to cut volatile organic compounds by 15% from 1990 levels).

[47] *See* David M. Driesen, *Loose Canons: Statutory Construction and the "New" Nondelegation Doctrine*, 66 PITT. L. REV. 1, 65-67 (2002) (describing constraints on congressional time as a barrier to specific legislation).

[48] *See* David M. Driesen, *Five Lessons From Clean Air Act Implementation*, 14 PACE ENVTL. L. REV. 51, 53-55 (1997).

[49] *See, e.g.,* Brian Doherty, *Selling Air Pollution*, 28 REASON 32 (1996) (discussing vigorous industry efforts to influences baselines for California's Reclaim program, a leading emissions trading effort).

Most analysts employ a simplistic command and control/economic incentive dichotomy as a substitute for cogent analysis. They claim that traditional regulation discourages innovation.[50] Indeed, some of the less careful writing states that standard regulation prohibits innovation.[51] If this were true, emissions trading obviously would encourage innovation better than traditional regulation.

While the claim that traditional regulation often does not stimulate innovation has great merit, the view that it prohibits or blocks innovation altogether involves gross exaggeration and some significant misunderstandings.[52] These misunderstandings interfere with sound comparison of traditional regulation with emissions trading.

Environmental statutes usually encourage performance standards--a form of a standard that specifies a level of environmental performance[53] rather than the use of a particular technique.[54] Performance standards may encourage innovation by allowing polluters to choose how to comply.[55]

Many statutory provisions severely restrict EPA's authority to specify mandatory compliance methods, often by requiring a performance standard unless EPA finds that one cannot measure emissions directly to determine compliance.[56] Even when the statutes permit work practice standards or other types of standards that *do* command specific control techniques, the statutes often require EPA to approve adequately demonstrated alternatives.[57]

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[50] *See* Dudek & Palmisano, *supra* note 1, at 220; Robert W. Hahn & Gordon L. Hester, *Where Did All the Markets Go? An Analysis of EPA's Emissions Trading Program*, 6 YALE J. ON REG. 109, 109 (1989).

[51] *See, e.g.*, Hahn & Hester, *supra* note 50, at 109 ("command and control regulations . . . specify the methods and technologies that firms must use to control pollution"). *See also* Dudek & Palmisano, *supra* note 1, at 220.

[52] *See* DRIESEN, *supra* note 8, at 183-87 (discussing error of treating regulations not encouraging innovation well as "barriers to innovation").

[53] *See* United States v. Ethyl Corp., 761 F.2d 1153, 1157 (5th Cir. 1985);42 U.S.C. §§ 7521(g); 7502(c)(1); Michigan v. Thomas, 805 F.2d 176, 184-85 (6th Cir. 1986).

[54] *See* Hahn & Stavins, *supra* note 1, at 5-6 ("A performance standard typically identifies a specific goal . . . and gives firms some latitude in meeting this target. These standards do not specify the means, and therefore, provide greater flexibility. . . ."); Stewart, *supra* note 9, at 1268 ("Performance standards allow regulated firms flexibility to select the least costly or least burdensome means of achieving compliance.") *Cf*. Stewart, *supra* note 1, at 158 ("Regulatory commands dictate specific behavior by each plant, facility, or product manufacturer . . . .").

[55] LOUIS TORNATZKY & MITCHELL FLEISCHER, THE PROCESSES OF TECHNOLOGICAL INNOVATION 101 (1990); Malloy, *supra* note 11, at 546-547 & n.52 (performance standards have the express purpose of "encouraging innovation").

[56] *See* 42 U.S.C. §§ 7411(h)(1); 7412(d)(2)(D), (h)(1)-(2), (h)(4).

[57] *See* 42 U.S.C. §§7412(h)(3); 7411(h)(3).

This predominance of performance-based standards over command-and-control regulation exists regardless of the criteria used to determine the standards' stringency. Statutory provisions requiring technology-based standards, for example, instruct implementing agencies to set standards that are achievable with either existing or, in some cases, future technology.[58] Hence, agency views concerning technological capability help determine the standards' stringency.[59] Owners of pollution sources may generally use any adequate technology they choose to comply with the performance standards that an agency has developed through the evaluation of a reference technology.[60]

Professor Ackerman's detailed study of a particularly controversial new source performance standard (NSPS) under the 1977 Clean Air Act (CAA) Amendments may have indirectly contributed to frequent characterization of technology-based standards as "command and control" regulation.[61] Economists accustomed to a static framework of analysis read Professor Ackerman's statements that this NSPS involved "forced scrubbing" as indicating that "technology-based standards identify particular equipment that must be used to comply with the regulation."[62] This NSPS, however, allowed utilities to meet their emission limitations through innovative means, although it precluded complete reliance upon techniques that could not meet the emission limitations.

This NSPS limited sulfur dioxide emissions to 1.2 pounds (lbs.) per million British thermal units (MBtu).[63] It also required a 90% reduction from uncontrolled levels except for plants emitting less than 0.6 lbs./MBtu. These cleaner plants needed only to meet a 70% reduction requirement. Nothing in the regulation specifically required any particular technology, such as wet scrubbing. Indeed, EPA specifically designed the regulation to leave open opportunities for plants to meet the standards through dry scrubbing and other alternatives that EPA regarded as somewhat experimental.[64] Hence, if a plant operator developed some

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[58] *See, e.g.,* 42 U.S.C. §7412(d)(2); Michigan v. Thomas, 805 F.2d 176, 180 (6th Cir. 1986); International Harvester Co. v. Ruckelshaus, 478 F.2d 615, 628-29 (D.C. Cir. 1973).

[59] *See, e.g.,* Sierra Club v. Costle, 657 F.2d 298, 360-69 (D.C. Cir. 1981). Usually statutory provisions do allow EPA to take cost and some other factors into consideration. *See, e.g., id.* at 319-336.

[60] *See, e.g.,* 33 U.S.C. §1314(b)(1)(A), (b)(2)(A); E.I. du Pont de Nemours v. Train, 430 U.S. 112, 122 & n.9 (1977); American Petroleum Inst. v. EPA, 787 F.2d 965, 972 (5th Cir. 1986); Association of Pac. Fisheries v. EPA, 615 F.2d 794, 802 (9th Cir. 1980); American Paper Inst. v. Train, 543 F.2d 328, 340-42 (D.C. Cir. 1976); American Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1045 (3d. Cir. 1975), *modified*, 560 F.2d 589 (3d. Cir. 1977).

[61] *See* BRUCE A. ACKERMAN & WILLIAM T. HASSLER, CLEAN COAL/DIRTY AIR 15-21 (1981).

[62] *Compare* Hahn & Stavins, *supra* note 1, at 5 *with* Bruce A. Ackerman & William T. Hassler, *Beyond the New Deal: Coal and the Clean Air Act*, 89 YALE L. J. 1466, 1481-88 (1980) (discussing NSPS that allegedly mandated flue gas scrubbing); ACKERMAN & HASSLER, *supra* note 61, at 15-21 (same).

[63] Sierra Club v. Costle, 657 F.2d 298, 312 (D.C. Cir. 1981).

[64] *Id.* at 324, 327-28, 340-43, 346-47.

completely new approach that met these standards, the utility could use it.

Operators probably could not meet this standard solely through the use of coal washing, because coal washing, which was not a new innovation at the time, probably could not produce a 70% reduction by itself.[65] Reading Professor Ackerman's reference to the NSPS as a standard based on "full scrubbing" to indicate that the NSPS precluded subsequent innovations meeting the numerical standards would involve technical misunderstanding of the regulation. The U.S. Court of Appeals for the District of Columbia Circuit explained in reviewing this NSPS that "*given the present state of pollution control technology*, utilities will have to employ some form of . . . scrubbing."[66] This necessarily implies that if utilities can develop a new technology that meets the required emission limit, nothing in the regulation precludes its use, a conclusion that necessarily flows from the numerical limits stated in the standard in any case.

This error reflects a habit of thinking in static terms. Thinking in more dynamic terms about the possibility of new technology makes it impossible to equate the NSPS Ackerman studies with specification of a technology.

A static frame of reference has frequently led to characterization of technology-based regulation as "command-and-control" regulation. This term is misleading, except as applied to the relatively rare standards that actually specify techniques rather than just performance levels.

Moreover, emissions trading cannot substitute for true command-and-control regulation, regulation that requires specific techniques.[67] The law only authorizes command-and-control regulation when measurement of emissions is impossible. Trading, however, relies upon good monitoring.[68] When good measurement proves impossible, trading will not succeed.

The incorrect suggestion that traditional regulation generally requires government-chosen technology would lead to a conclusion that traditional regulation legally forbids innovation. But some have made more subtle incentive-based arguments for characterizing traditional regulation as discouraging innovation.

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[65] *See id.* at 368-73; Ackerman & Hassler, *supra* note 62, at 1481; Bruce A. Ackerman & William T. Hassler, *Beyond the New Deal: Reply*, 90 YALE L. J. 1412, 1421-22 n.43 (1981). *Cf.* Howard Latin, *Ideal Versus Real Regulatory Efficiency: Implementation of Uniform Standards and "Fine-Tuning" Regulatory Reforms*, 37 STAN. L. REV. 1267, 1277 n.41 (1985) (noting that standard allows using coal washing as offset, decreasing the percentage reduction needed from scrubbing); ACKERMAN & HASSLER, note 51, at 15, 66-68 (noting that coal washing reduces any given emissions base by only 20-40%, but replacing new source standards with less stringent reduction requirement that also applies to existing sources would produce better results)

[66] *Sierra Club*, 657 F.2d at 316 (emphasis added)**.**

[67] *See* Kerr, *supra* note 42, at 66.

[68] Hahn & Hester, *supra* note 50, at 111 (monitoring and enforcement issues play critical role in efficient design of emissions trading); Sidney A. Shapiro & Thomas O. McGarity, *Not so Paradoxical: The Rationale for Technology-Based Regulation*, 1991 DUKE L.J. 729, 748-49 (1991) ("[E]missions trading and pollution taxes require inspectors to monitor constantly the amount of pollution that a plant emits."); Stewart, *supra* note 1, at 161, 166.

The fundamental notion that economic incentives are powerful would suggest that polluters have substantial economic incentives to use the flexibility that performance standards offer to employ innovative means of meeting emission limitations that are less costly than traditional compliance methods. Such use of innovations saves polluters money. This incentive exists even for technology-based performance standards that did not contemplate the innovative compliance mechanism a polluter discovers.

Professor Richard Stewart of New York University, however, has stated that polluters have "strong incentives to adopt the particular technology underlying" a technology-based performance standard because "its use will readily persuade regulators of compliance."[69] He does not explain why this countervailing persuasion incentive would overcome the economic incentive to realize savings through an effective and cheaper innovation, even if the persuasiveness incentive were powerful. Polluters, after all, have a number of means of persuading regulators that their innovations perform adequately if they in fact do so. First, polluters may monitor their pollution directly to demonstrate compliance. Second, in some cases polluters may eliminate regulated chemicals, which certainly demonstrates compliance. Traditional regulation offers ample incentives for pollution prevention eliminating chemicals or reducing them below regulatory thresholds, because of the substantial savings involved. While the uncertainty of innovation's outcome may discourage innovation under traditional regulation, in spite of opportunities for cost savings, it may do the same thing with respect to emissions trading, in spite of the opportunity for some profits from "extra" reductions.

In any case, neither Professor Stewart nor anybody else has come forward with empirical evidence that polluters with compliant and cheap innovations have failed to employ them because of fears of permitting difficulties under a performance standard.[70] Indeed, as we shall see, the empirical record shows that at least on some occasions, this negative incentive, if it exists, has been overcome.

III. **Empirical Evidence**

The literature, however, gives the impression that solid empirical proof supports emissions trading's superiority in stimulating innovation. The literature discusses two types of evidence, both surprisingly thin:[71] Evidence that traditional regulation does not simulate innovation and evidence that emissions trading does. In fact, what the literature shows is something much less dramatic, that both trading and traditional regulation sometimes stimulate

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[69] Stewart, *supra* note 9, at 1269.

[70] Driesen, *Dichotomy, supra* note 2, at 302 n.65; Nicholas A. Ashford & George R. Heaton Jr., *Regulation and Technological Innovation in the Chemical Industry*, 46 LAW & CONTEMP. PROBS., 109, 139-40 (1983).

[71] *See* Jaffe et al., *supra* note 1, at 55 (because of a "paucity of available data," there has been "exceptionally little empirical analysis" of instrument choice's effect upon innovation.); Malloy, *supra* note 11, at 547 (empirical evidence provides "inconclusive evidence of significant environmental innovation under existing trading programs.")

innovation and sometimes do not.

A. **Traditional Regulation**

The empirical literature on traditional regulation shows that industry sometimes chooses techniques different from those an agency relies upon in standard setting.[72] Because so many studies claim that traditional regulation, usually described as command-and-control regulation, thwarts innovation, a brief review of some of the cases where this simply has not proven true seems worthwhile. Most industry responded to the Occupational Safety and Health Administration's (OSHA's) and EPA's regulation of vinyl chloride in ways that the agencies anticipated. But a proprietary "stripping process," commercialized within a year of promulgation, significantly improved polyvinyl chloride resin production while lowering vinyl chloride exposure, and industry adopted a number of other innovations as well.[73] Textile manufacturers met OSHA's cotton dust standard, to a significant extent, through modernization of equipment unanticipated by the government, which was needed anyway to compete with foreign companies.[74] While a few metal foundries responded to standards for formaldehyde in the workplace through ventilation and enclosure (as expected by OSHA), most developed low-formaldehyde resins.[75] Similarly, while most established smelters responded to sulfur dioxide limits by using available technologies, copper mining firms developed a new, cleaner, process to assist their entry into the smelting business.[76] These examples show that traditional regulation can encourage pollution prevention.

Industry responded to a ban upon ozone depleting chemicals with a variety of innovations.[77] The makers of ozone depleting substances developed new chemicals that damaged the ozone layer less severely.[78] And many former users of ozone depleters simply substituted soap and water for chemical solvents.[79] Operators of chloralkali plants responded to

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[72] *See* Kurt Strasser, *Cleaner Technology, Pollution Prevention, and Environmental Regulation*, 9 FORDHAM ENVTL. L.J. 1, 32 (1997) (innovation sometimes results from emission and discharge limits). *See*, *e.g.*, U.S. CONGRESS, OFFICE OF TECHNOLOGY ASSESSMENT, GAUGING CONTROL TECHNOLOGY AND REGULATORY IMPACTS IN OCCUPATIONAL SAFETY AND HEALTH--AN APPRAISAL OF OSHA'S ANALYTICAL APPROACH, OTA-ENV-635, at 64 (U.S. Government Printing Office 1995) [hereinafter OTA STUDY]; Ashford & Heaton Jr., *supra* note 70, at 109, 139-40.

[73] OTA STUDY, *supra* note 72, at 89. Nicholas A. Ashford et al., *Using Regulation to Change the Market for Innovation*, 9 HARV. ENVTL L. REV. 419, 440-41 (1985).

[74] OTA STUDY, *supra* note 72, at 90.

[75] *Id.* at 95. OSHA anticipated this possibility, but not the extent to which it dominated compliance strategies.

[76] *See* Strasser, *supra* note 72, at 28-29.

[77] *See* OZONE DEPLETION IN THE UNITED STATES: ELEMENTS OF SUCCESS (Elizabeth Cook, ed. 1996).

[78] *See id.* at 14-15, 23-26, 58-60, 90-94, 98-104, 109.

[79] *See* U.S. EPA, *Benefits of the CFC Phaseout*, *at* http://www.epa.gov/ozone/geninfo/benefits.html (last visited Jan. 24, 2001)(citing "aqueous

EPA regulation of mercury with some process innovations.[80] When EPA began phasing out mirex (a pesticide that controlled fire ants), EPA had registered no acceptable substitutes. But during a two-year phase-out period four companies sought registration of substitutes.[81] Clearly the claim that traditional regulation always discourages innovation is simply wrong.

These examples do not, however, show that traditional regulation regularly stimulates innovation. While evidence on this subject is actually thin because of the scarcity of post-compliance studies, most traditional regulation probably does little to stimulate innovation. Most of this regulation allows polluters to meet the standard through relatively cheap existing technology.[82] This "mediocre regulation" does not require stringent pollution reductions that would make conventional techniques either insufficient or very expensive.[83] By contrast, when government imposes very stringent regulation, companies tend to innovate because the conventional approaches become either inadequate or expensive.[84]

B. **Emissions Trading**

The evidence regarding emissions trading establishes that it, like traditional regulation, sometimes encourages innovation, but sometimes does not. A brief review of some of the principal programs follow.

1. *Bubbles: Inadequate Environmental Performance*

Bubble programs allow plant operators to trade emission reductions among polluting units within a plant. The empirical literature raises especially serious questions about whether

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cleaning" as an example of a cleaning process that reduced cost in phasing out CFCs); ICOLP TECHNICAL COMMITTEE, ELIMINATING CFC-113 AND METHYL CHLOROFORM IN PRECISION CLEANING OPERATIONS 114 (1994) (defining "aqueous cleaning" as cleaning parts with water to which suitable detergents, sapnifers or other additives may be added).

[80] *See* Ashford et al., *supra* note 73, at 437 (describing separation of process from cooling water to reduce contact with mercury as a "significant process innovation.").

[81] Thomas O. McGarity, *Radical Technology-Forcing in Environmental Regulation*, 27 LOY. L.A. L. REV. 943, 947 (1994) (discussing experience with lead and pesticide bans).

[82] *See generally* ADAM B. JAFFE ET AL., ENVIRONMENTAL REGULATION AND INTERNATIONAL COMPETITIVENESS: WHAT DOES THE EVIDENCE TELL US? (1993) (regulation's economic impact to minor to have great impact upon competitiveness). *See also* STEPHEN M. MEYER, ENVIRONMENTALISM AND ECONOMIC PROSPERITY: TESTING THE ENVIRONMENTAL IMPACT HYPOTHESIS (Oct. 5, 1992) (unpublished manuscript on file with author).

[83] *See, e.g.,* ENVIRONMENTAL LAW INSTITUTE, BARRIERS TO ENVIRONMENTAL TECHNOLOGY INNOVATION AND USE (1998).

[84] *See* Malloy, *supra* note 11, at 549-550; Ashford et al., *supra* note 73, at 432-444 (discussing examples); McGarity, *supra* note 81, at 945-52 (discussing experience with lead and pesticide bans).

bubbles have spurred adequate environmental performance.[85] The few studies of bubble implementation reveal that polluters often could not document claims that they had made required emission reductions.[86] Where polluters could verify claimed reductions, they often involved using credits from activities that would have occurred anyway to justify escape from pollution reduction obligations that would have otherwise generated additional pollution reductions.[87] Hence, gaming has been a problem.

EPA introduced bubbles primarily as deregulatory mechanisms[88] and they have often stimulated neither innovation nor adequate environmental performance at a cheaper price.[89] Rather, they have generated cost savings for industry, often by allowing unverifiable claims of compliance and paper credits to substitute for actual emission reductions and by reducing pollution reduction demands.[90]

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[85] *See* RICHARD A. LIROFF, AIR POLLUTION OFFSETS: TRADING SELLING AND BANKING 28-29 (1980) (noting the need to avoid "paper offsets," reductions in emissions that exist only on paper). *See generally* Dudek & Palmisano, *supra* note 1, at 236-237 (noting that emissions trading has been the "harbinger of bad news").

[86] For example, when EPA and its California counterpart inspected plants to verify compliance with bubble regulations for the aerospace industry in the late 1980s, they found that "almost all large sources operating under . . . bubbles . . . are not achieving the emission reductions or levels of control that are required." *See* California Air Resources Board and U.S. EPA, Phase III Rule Effectiveness Study of the Aerospace Coating Industry 4 (1990) (unpublished report on file with author); *See also* David Doniger, *The Dark Side of the Bubble,* 4 ENVTL. F. 33, 34-35 (1985); RICHARD A. LIROFF, REFORMING AIR POLLUTION REGULATION: THE TOIL AND TROUBLE OF EPA'S BUBBLE 80-89 (1986) (examples of bubbles that avoided requirements to reduce actual emission levels). Hahn and Hester have concluded that emissions trading (defined to include bubbling and netting) has had "a negligible effect on environmental quality." Hahn & Hester, *supra* note 50, at 137. They do not, however, base this assertion on empirical data. Rather, they rely "on the fact that the rules governing the various trading programs contain prohibitions against trades that would result in significant increases in emissions." *Id.* at 137 n.146. They do not explain the basis for their belief that these rules are adequate and the implicit assumption that they have been regularly and correctly enforced. In any case, subsequent experience suggests they have not prevented abuse.

[87] Dr. Liroff provides many examples of these bubbles. *See* LIROFF, *supra* note 86, at 62-67, 89-91.

[88] *See* ID. at 37-38 (describing genesis of the bubble idea in the steel industry).

[89] ID. at 100 (most "innovations"under bubbles are merely rearrangements of conventional technologies).

[90] *See* ID. at 99 ("cost saving approaches are not necessarily more cost-effective ways of meeting a goal, instead, they may be ways to avoid costs that may be necessary to meet the goal"); Richard A. Liroff, *Point and Counterpoint*: *The Bubble: Will it Float Free or Deflate,* 4 ENVTL. F. 28, 30 (Mar. 1986) (stating that a compliance method that relaxes regulatory requirements at some points without compensating reductions may be more prevalent than

2. *Lead Phase-Down: A Stringent Limitation Driving Substantial Change*

EPA allowed gasoline producers to trade lead allowances during a phase-down of lead from gasoline.[91] The lead phase-down did create a substantial change, the reformulation and then virtual elimination of leaded gasoline. But the driver for this achievement seems to be the underlying requirement of a phase-down of lead. Faithful implementation of a traditional phase-down without trading would probably have produced the same change more quickly.[92]

Indeed, in a very sophisticated empirical analysis of the lead trading program employing the Malueg model, economists Suzi Kerr and Richard Newell conclude that "*increased*

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bubbles that reduce actual emissions); David D. Doniger, *Point . . . And Counterpoint*, 4 ENVTL. F. 29, 34 ("In practice . . . there has been far more innovation in shell games and sharp accounting practices than in pollution control technology."); Proposed Open Market Trading Rule for Ozone Smog Precursors, 60 Fed. Reg. 39668, 39670 (Aug. 3, 1995) ("Bubbles, netting and offsets have reduced source's overall compliance costs. However, there have been significant problems of quality control, reducing the environmental effectiveness of the programs.").

[91] For accounts of the program, *see* Suzi Kerr & David Mare, *Market Efficiency in Tradeable Permit Markets with Transaction Costs: Empirical Evidence from the United States Lead Phasedown* in Kerr, *supra* note 42; Robert W. Hahn & Gordon L. Hester, *Marketable Permits: Lessons for Theory and Practice*, 16 ECOLOGY L.Q. 361, 380-391 (1989);Kerr & Newell, *supra* note 5.

[92] The introduction of inter-refinery trading into the lead phasedown program probably slowed the pace of environmental improvement. EPA's 1985 trading rule actually led to increased production of leaded gasoline in 1985 (rather than purely unleaded) because the rule allowed increased production of low lead gasoline to generate credits. *See* Regulation of Fuels and Fuel Additives; Banking of Lead Rights, 50 Fed. Reg. 13116, 13119 (Apr. 2, 1985); Hahn & Hester, *supra* note 91, at 382 n.125; U.S. GENERAL ACCOUNTING OFFICE, VEHICLE EMISSIONS: EPA PROGRAM TO ASSIST LEADED-GASOLINE PRODUCERS 20 (1986) [hereinafter GAO, VEHICLE EMISSIONS]. EPA's 1985 lead trading rule supplanted a rule that required refiners to meet a standard of 1.1 grams of lead per leaded gallon, effective January 1, 1986. 50 Fed. Reg. at 13116. The 1985 trading rule allowed refiners that banked purchased credits to continue exceeding these limits through the end of 1987. 50 Fed. Reg. at 13177, 13127 (codified at 40 C.F.R. §80.20(e)(2)). Furthermore, in actual implementation inadequate reporting, compliance verification, and enforcement may have marred environmental performance. *See* GAO, VEHICLE EMISSIONS at 3-4, 18-19, 23-24 (citing failure to enforce against 25 potential violators, 49 cases of claimed credits not matching claimed sales of credits, error rates in reporting between 14% and 49.2% and no verification of compliance). *Cf*. Hahn & Hester, *supra* note 91, at 388, n.146.

stringency . . . encouraged adoption of lead-reducing technology."[93] They credit the trading with providing flexibility in the timing and distribution of reductions, which lowered the cost of the technological transition the stringency of a phase-out brought about.[94]

3. *Acid Rain: Little Initial Trading or Innovation*

Phase one of the acid rain trading program has produced some changes in scrubber technology, operational methods, and the use of cleaner coal, which some analysts described as innovations.[95] But at the time that scholars began citing the acid rain programs stimulation of these methods as evidence that trading stimulates innovation, only 3 of 51 firms used interfacility trading to meet their reduction obligations (although 30 of the 51 did use some intrafacility averaging).[96] So, analysts should have hesitate to ascribe those results to trading. Byron Swift of the Environmental Law Institute has claimed that EPA's old rate-based standards would not have permitted some of the innovations he identified, but he admits that a mass-based program without trading would have allowed most of the technologies he identifies as innovations.[97]

As a general matter, it's hard to consider coal scrubbing, use of low sulfur coal, or dispatch orders favoring cleaner units as innovations, since all of these techniques have been well understood options for many years.[98] Nevertheless, some of the improvements in scrubbing have received patents, which suggests that they might qualify as genuine innovations.[99]

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[93] *See* Kerr & Newell, *supra* note 5, at 320 (emphasis added).

[94] *Id.* at 320.

[95] *See, e.g.,* Byron Swift, *Command without Control: Why Cap-and-Trade Should Replace Rate Standards for Regional Pollutants*, 31 ELR 10330 (Mar. 2001).

[96] *Id.* at 10331.

[97] Swift does claim that trading was essential to two technologies. *Id.* at 10338. One of those "technologies," trading, is a transaction, not a technology. He does not claim that the other technology, power shifting, is an innovation. Indeed, the shifting of dispatch orders to use cleaner units more intensively than dirty units is a well-understood operational option.

[98] *See generally* Malloy, *supra* note 11, at 548-49 (discussing debate about innovation under the acid rain program).

[99] Other papers also employ very broad definitions of innovation and stop short of attributing the observed "innovations" to trading alone. For example, Dallas Burtraw describes various kinds of non-patentable practices as innovations. DALLAS BURTRAW, INNOVATION UNDER THE TRADABLE SULFUR DIOXIDE EMISSION PERMITS PROGRAM IN THE U.S. ELECTRICITY SECTOR, 17 (Resources for the Future Discussion Paper 00-38, 2000). These include rather routine adaptations to the opportunity to sell abatement technologies, which one would expect with a comparably designed performance standard. For example, he describes

But the most detailed study available comparing innovation in sulfur dioxide control technology before and after the acid rain program has concluded that "the history of innovation in SO_2 control technology does not support" trading's superiority in inducing innovation.[100] Similarly, David Popp of the Maxwell School of Citizenship finds that both the acid rain program and prior traditional regulation encouraged the patenting of new technology.[101] Indeed, he shows that there was more patenting of new environmental technologies prior to the introduction of the acid rain program. He states, however, that the programs created different types of technological incentives: the traditional program led to innovations reducing the cost of scrubbing, while the trading program produced patents improving pollution control characteristics. Yet this very useful research stops short of proving even the limited proposition that trading changes the type of innovation. For the non-trading programs that limited sulfur dioxide emissions prior to 1990 have much laxer limits and a different form of limits than the trading program enacted in the 1990 Amendments to the CAA. These differences, rather than the trading, may account for the observed difference.

In any case, so far the acid rain program has not produced significant diffusion or creation of much cleaner technologies, such as natural gas power plants or renewable energy, nor has it resulted in really path breaking radical innovation (such as new designs for fuel cells).[102] This suggests that something other than the mere existence of a trading program may be important to stimulating meaningful innovation.

4. *State Programs After 1990*

Since 1990, states have implemented a variety of emissions trading programs. These programs have performed unevenly in a number of respects. For example, New Jersey suspended a trading program for poor performance and California's Reclaim program came

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laying track and changing the size of trains (to deliver low sulfur coal) as innovations. *See id.* at 19. He makes no effort to determine whether the minority of firms engaged in trading employed these "innovations" more vigorously than firms that simply complied as if this were a standard technology-based performance standard expressed as a mass-based limit. The paper's conclusion, consistent with the limitations of this mode of study, does not claim that emissions trading induced innovation. Instead, he claims that the acid rain program contributes to the employment of innovation. *See id.* at 18. But this simply begs the question of whether a mass-based program with the same limits and no trading would induce as much or more innovation.

[100] *See* Margaret R. Taylor, Edward S. Rubin, and David A. Hounshell, *Regulation as the Mother of Innovation: The Case of SO_2 Control*, 27 LAW & POL'Y 348, 370 (2005).

[101] *See* David Popp, *Pollution Control Innovations and the Clean Air Act of 1990*, 22 J. POL'Y ANALYSIS & MGMT 641 (2003).

[102] *See* A. DENNY ELLERMAN ET AL., MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM 130 (2000).

under heavy fire for reasons of environmental justice and for poor environmental performance.[103]

Facilities have primarily relied upon tried and true control technologies in many of these programs. For example, the regional trading program for nitrogen oxide emission reductions EPA organized to aid state attainment of the old ozone standard produced a large number of orders for selective catalytic reduction technologies.[104] But some sources have relied on less conventional techniques, such as Thermalo$NO_{x,}$ rotating overfired air, and reburn technology. And many RECLAIM sources have relied upon junking of old cars, which seems imaginative, but hardly constitutes an advanced innovative technology and creates fraud problems.[105] EPA's evaluation of RECLAIM states that most sources relied upon conventional off-the-shelf technology, but a few used innovative compliance methods.[106] Since very few sources generated credits through over-compliance to sell into the market, we do not know whether it is correct to ascribe the innovation that did occur under the RECLAIM program to the program's authorization of emissions trading.[107]

C. **A Summary of the Empirical Record**

I provide all of this evidence to support a very modest assertion: Both traditional regulation and trading often failed to produce innovation, but sometimes succeeded. I do not claim that traditional regulation is free from design flaws or gaming. Nor do I claim that all trading programs are bad. I have offered extensive treatment of a variety of trading programs only to cure a tendency to compare the best trading program we have ever had, the acid rain program, to negative stereotypes about traditional regulation. The proper analysis compares a

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[103] *See* CURTIS MOORE, RECLAIM: SOUTHERN CALIFORNIA'S FAILED EXPERIMENT WITH AIR POLLUTION TRADING 2 (2003) (describing RECLAIM as a failure in reducing emissions); Richard Toshiyuki Drury et al., *Pollution Trading and Environmental Injustice: Los Angeles' Failed Experiment in Air Quality Policy,* 9 DUKE ENVTL L. & POL'Y F. 231 (1999); Approval and Promulgation of Air Quality Implementation Plans; New Jersey; Open Market Emissions Trading Program, 67 Fed. Reg. 64347 (October 18, 2002) (announcing EPA decision not to proceed with processing New Jersey SIP revisions, because New Jersey had found such serious problems in its emissions trading program that it was planning to abandon it).

[104] *See* NESCAUM, POWER COMPANIES' EFFORTS TO COMPLY WITH THE NO_x SIP CA;; AND SECTION 126, 4 (2003) (61 of 100 units with announced commitments have chose selective catalytic reduction).

[105] *See* Drury et. al., *supra* note 103, at 258-263 (discussing fraud in the estimation of credits and debits that systematically undermines environmental performance).

[106] *See* EPA, AN EVALUATION OF SOUTH COST AIR QUALITY MANAGEMENT DISTRICT'S REGIONAL CLEAN AIR INCENTIVES MARKET-LESSONS IN ENVIRONMENTAL MARKETS AND INNOVATION 26-27 (2002).

[107] *See id.* at 21, 27 (relying upon design variables other than the trading possibility to explain the innovation).

trading program to a traditional regulation with equivalent emission limits.

IV. **Implications**

Emissions trading obviously does nothing to encourage expensive innovation--even innovation that would produce long-term efficiency and enormous environmental improvement. Nor does either the empirical record or sound economic theory strongly support a milder conclusion, that emissions trading does a better job of encouraging relatively cheap innovation. Under traditional regulation, the high cost sources have an incentive to adopt any innovation promising compliance for less cost than its relatively high cost of control. Under emissions trading, only innovations costing less than the marginal cost of additional reductions at facilities with relatively low control costs can find a market. Thus, trading discourages innovation by lowering the price at which innovation will become economically viable.

A. **A Research Agenda**

I would argue that we need more research on the topic. Malueg's model and David Popp's empirical work suggest a milder hypothesis than a generic assertion of trading's superiority in encouraging innovation: The hypothesis that trading may change the type of innovation rather than the amount. The low cost sources under trading have an incentive to generate extra emission reductions. High cost sources under comparable traditional regulation face incentives to adopt innovations that save them money, but not necessarily innovations that increase control efficiency. So, polluters may have better incentives to innovate to increase control efficiency under a trading regime than under traditional regulation, even if overall incentives for maximizing the number of innovations have declined.

A recent empirical analysis, however, concludes that more innovation in improving environmental performance occurred prior to the acid rain program.[108] Several reasons exist to doubt even Popp's milder thesis. First, emissions trading creates enormous opportunities to use a very wide variety of traditional technologies to generate credits while avoiding the uncertainty involved in innovation. These opportunities may weaken incentives for innovations with greater control efficiencies. Traditional technologies typically provide excess reductions under traditional regulation because sources need to make sure that they remain in continuous compliance. Under trading, polluters using conventional techniques will sell some of this surplus, thus lessening any demand for innovation. Furthermore, trading provides opportunities to engage in minor non-innovative tweaking of operating conditions to generate excess emission reductions. An example involves using dispatch orders from electric utilities to use cleaner units more extensively. This is hardly innovative, but it does realize some extra emission reductions. Trading might well provide good incentives to seize non-innovative (i.e. obvious) pollution prevention opportunities that provide a small quantity of emission reductions. Finally, the flexibility for trading may invite use of traditional technologies with relatively weak environmental performance because every increment has some value. An example involves the

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[108] *See* Taylor, Rubin, and Hounshell, *supra* note 100, at 369 (most improvement in sulfur dioxide control efficiency occurred before the 1990 Amendments).

use of low sulfur coal in the acid rain program. Second, by weakening incentives for cost reducing innovation at high cost facilities, trading may indirectly limit innovations that will produce higher control efficiencies. Facilities whose high costs come from exceptionally dirty processes may adopt new technologies just to meet (not exceed) emission limits at their own facilities, but these same technologies may provide superior environmental performance at cleaner facilities. And new ideas pursued to lower costs may lead to ideas for greater pollution control. For a variety of reasons, the hypothesis that emissions trading may systematically change the type of innovation induced in a desirable manner might not stand.

This much milder claim about the nature of innovation, however, stands on firmer ground than the traditional claim that emissions trading spurs more innovation than traditional regulation. It certainly merits further research and exploration. Even if trading turns out to have some innovation stimulating advantages, trading's clear inferiority in spurring initially expensive, but environmentally excellent innovation stands as a significant problem.

The framework for analysis that I have offered points the way toward a research agenda to explore both Popp's claims about the nature of innovation under trading and more general claims about low cost trading. I have pointed out that when innovation occurs in conjunction with the trading program, it is very hard to figure out whether the trading or some other feature of the program explains the observed increase in innovation. Since empirical analysis shows that stringent traditional regulation has encouraged innovation, it is possible that when we see innovation in a trading program, stringent underlying emission limits, not the trading itself, explain the observed results. The proper way to test this involves comparing trading programs based on a set of limits to a non-trading performance standard based on the same limits. Some of the analysis of the acid rain program above applies this approach to the acid rain program, relying primarily on Byron Swift's analysis. It may appear, however, that this poses an impossible challenge for empirical research, since two identical programs may not exist in the real world.

It is possible, however, to find this situation in the real world. Existing analysis reaches conclusions about innovation by examining compliance choices of pollution sources subject to trading programs, *whether or not they actually trade*. But a pollution source that does not buy or sell credits has innovated or failed to innovate because of the underlying requirement for reductions, not because of the incentives provided by trading. Researchers might compare the compliance strategies of facilities earning extra credits or buying credits that they eventually sell in a trading program to the strategies of firms subject to the same program rules that opt for local compliance without trading. The trading sources (both buyers and sellers of credits) should reflect the incentives trading provides, whereas the non-traders choices should provide some information about how a performance standard without trading would influence compliance choices. In this way, we might be able to reach more convincing conclusions about innovation and trading than we have to date.

B. **The Importance of Design**

Framing the question of whether trading improves innovation as requiring a comparison with an identical performance standard without trading yields important insights. Since both trading and traditional regulation sometimes stimulates innovation and sometimes does not, some factors besides instrument choice must influence the degree of innovation. This Article has already suggested that the stringency of limits has a large influence.[109] In the *Economic Dynamics of Environmental Law*, I explain that the form of emission limits matters as well (building on work by Byron Swift on mass-based limits).[110] One would expect that a program with mass-based limits and relatively stringent targets would produce more innovation than a rate-based program with lax limits, whether or not trading was used. In spite of widespread recognition that good monitoring is essential to trading, EPA has allowed states to continue programs that do not feature continuous monitoring. Such programs tend to produce no innovation and usually fail to produce contemplated environmental improvements. The literature's preoccupation with a simplistic and misleading command and control/economic incentive dichotomy has led to a failure to adequately address crucial design issues. Design considerations such as stringency and the existence of adequate monitoring may matter even more than the choice between trading and non-trading programs.

C. Broader Theoretical Implications

The significance of emissions trading's inferiority in stimulating innovation (especially expensive innovation) depends upon the value of innovation relative to other factors. Emissions trading retains significant cost saving advantages over traditional regulation, something that regulators will take into account. My *Economic Dynamics* book explains why innovation deserves more emphasis than it has received, especially with respect to environmental problems difficult to reverse.[111] Leading economists agree that the development and spread of new technologies "may, in the long run" play a major role in determining the "success or failure of environmental protection efforts."[112]

While this article has focused primarily upon a comparison between traditional regulation and emissions trading, a more interesting point may be that both have significant shortcomings in stimulating innovations, especially radical innovation. Neither mediocre regulation nor most emissions trading programs do very well in stimulating radical innovation. They both depend upon government standard setting, which tends toward demands unlikely to disrupt the status quo. Pollution taxes would suffer from the same problem.[113] Recognizing the weaknesses of

[109] *Cf.* Kerr & Newell, *supra* note 5, at 320 (explaining that stringency induced innovation in the lead program).

[110] *See* Swift, *supra* note 145; DRIESEN, *supra* note 8, at 193-197.

[111] *See* DRIESEN, *supra* note 8.

[112] *See, e.g.*, Jaffe et al., *supra* note 1, at 49.

[113] *Cf.* Nathaniel O. Keohane et al., *The Choice of Regulatory Instruments in Environmental Policy*, 22 HARV. ENVTL. L. REV., 313, 348 (1998) (explaining that polluters' preferences have generally prevented enactment of pollution taxes); James M. Buchanan &

trading and other oft-discussed approaches in stimulating innovation should make us eager to explore more imaginatively the possibilities for more creative use of economic incentives.

We can design more dynamic economic incentives that encourage competition to reduce pollution, much as the free market creates competition to provide better amenities. This requires creation of mechanisms that circumvent the need for repeated government decisions and allow private actions, rather than government decisions, to stimulate reductions in pollution.

The law can apply either positive economic incentives (revenue increases or cost decreases) or negative economic incentives (revenue decreases or cost increases) to polluters. This reveals a possibility that has received too little attention.[114] Negative economic incentives can fund positive economic incentives.

Governments have designed programs that use negative economic incentives to fund positive economic incentives. New Zealand addressed the depletion of its fishery by imposing fees on fishing (a negative economic incentive) and using revenue from these fees to pay some fishermen to retire (a positive economic incentive). This may reduce pressure on the fish if fees are high enough.[115] The California legislature has considered a program (called Drive ++) that involves imposing a fee upon consumers purchasing an energy inefficient or high pollution vehicle and using the proceeds to fund a rebate on the purchase of an energy efficient vehicle or low polluting vehicle.[116] Similarly, New Hampshire officials have proposed an "Industry Average Performance System" that redistributes pollution taxes to the polluting industry in ways that favor lower emissions.[117]

Gordon M. Tullock, *Polluters' Profits and Political Response: Direct Control Versus Taxes*, 65 AM. ECON. REV. 139, 141-142 (1975) (explaining why polluters oppose pollution taxes); Driesen, *Dichotomy, supra* note 2, at 340-343 (describing various impediments to setting tax rates for pollution).

[114] It has received some attention. *See, e.g.,* Stewart, *supra* note 37, at 12 n.31 (fees from a pollution tax could be used to subsidize pollution reduction); Robert W. Hahn, *Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders,* 3 J. ECON. PERSP. 95, 104-107 (describing effluent taxes dedicated to funding environmental improvement); MIKAEL SKOU ANDERSEN, GOVERNANCE BY GREEN TAXES: MAKING POLLUTION PREVENTION PAY (1994) (advocating earmarking of green taxes to fund pollution reduction).

[115] T. H. Tietenburg, *Using Economic Incentives to Maintain our Environment,* CHALLENGE, Mar./Apr. 1990, at 42, 43.

[116] *See* Nathanael Greene & Vanessa Ward, *Getting the Sticker Price Right: Incentives for Cleaner, More Efficient Vehicles*, 12 PACE ENVTL. L. REV. 91, 94-97 (1994).

[117] *See* New Hampshire Representative Jeffrey C. MacGillivray and Kenneth Colburn, Director, New Hampshire Department of Environmental Services, A New Approach to Air Pollution Regulation, Industry-Average Performance Systems (IAPS) (1997) (on file with

One can build on this principle to craft laws that mimic the free market's dynamic competitive character far better than taxes or subsidies. In a competitive free market, a firm that innovates to reduce its cost or increase its revenues not only increases its profits, it often reduces its competitors' profits. Hence, firms in a very competitive market face strong incentives to innovate and improve.[118] Failing to do so can threaten their survival. Doing so can make them prosper.

One could craft an "environmental competition statute" that requires polluters to pay any costs that competitors incur in reducing pollution plus a substantial premium, thereby creating a significant incentive to be among the first to reduce pollution.[119] An environmental competition statute directly attacks a fundamental problem with existing free market incentives: The polluting firm must bear any cleanup costs itself. Since the firm does not experience all of the costs of pollution itself (most are externalized and felt by the general public), it rarely pays to clean up.[120] If firms could systematically externalize the costs of cleanup without substantial administrative intervention, just as they externalize the cost of pollution, then even a fairly modest premium might create adequate incentives to control pollution.

An environmental competition statute would create a private environmental law with a few public decisions setting up the law, but with substantial enforcement by low polluting businesses against competitors. The statute would create a private right of action that allowed a business that realized environmental improvements through investment in pollution reducing (or low pollution) processes, control devices, products, or services to secure reimbursement for expenses, plus some premium, from more polluting competitors. Hence, the scheme would create economic incentives for some companies to become enforcers of the law, rather than creating incentives for all companies to resist enforcement.

Such a proposal overcomes the fundamental problem with traditional regulation, emissions trading, and taxes. These mechanisms rely on government decisions as the driver for pollution reductions. An environmental competition statute makes private initiative, motivated

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author).

[118] *See* TORNATZKY & FLEISCHER, *supra* note 55, at 168 (intense competition tends to stimulate spread of innovation).

[119] I have sketched this idea previously in Driesen, *Dichotomy*, *supra* note 2, at 344-347 and Driesen, *supra* note 10, at 10288-10230. The idea receives a fuller defense in DRIESEN, *supra* note 8, at 151-161, 163, 213. An EPA economist has recently offered a "feebate" proposal for electric utility that bears some resemblance to my proposal. *See* Andrew M. Ballard, *Fee/Rebate System May Offer Flexibility in Reducing Emissions, EPA Economist Tells Conference,* 33 ENV'T REP. (BNA) 1437 (June 28, 2002).

[120] *See* ANDERSON ET. AL., ENVIRONMENTAL IMPROVEMENT THROUGH ECONOMIC INCENTIVES 3-4 (1977).

by the prospect of gain and the fear of loss, the driver of environmental improvement, thus replicating free market dynamics.[121] The magnitude of the incentive may depend upon the extent of industry fears about competitors' achievements rather than the fixed cost directly imposed by government.

Moreover, such a scheme provides a continuous incentive to reduce pollution. Any company can profit by making an environmental improvement or lose money by failing to make one.[122] The government does need to establish the premium to be paid to first movers. But once it established this, repeated government decisions are not necessary. Securing maximum incentives for innovation may require legal structures that induce competition to produce environmental improvement and lessen the need for repeated government decisions.

I do not mean to suggest that the environmental competition statute offers the only possible approach to inducing innovation. For example, government research and subsidies may have a legitimate and important role to play, or may be ineffective because of special interest capture. But I do wish to suggest that a recognition of trading's limits in stimulating innovation should encourage a more imaginative exploration of potential alternatives.

Conclusion

Emissions trading certainly does a poor job in stimulating radical innovation and other relatively expensive (but potentially valuable) innovation. It may stimulate less innovation than a comparably designed traditional regulation. As a result, we should think more critically about the automatic preference for emissions trading. While policymakers will continue to rely upon emissions trading in the near future,[123] we need more attention to design issues and, in the long run, creative alternatives to emissions trading.

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[121] An environmental competition statute might seem to only create incentives to reduce first and do nothing to motivate reductions from slow movers. But the dynamic such a program creates, like the dynamic of a free market, works more broadly than that. Nobody would know *a priori* who the first movers would be. This means that anybody who didn't actively seek emission reductions would risk financial loss of uncertain dimension, precisely the risk companies face when they fail to innovate in making new products (or improving old ones) in a competitive market.

[122] Companies might conclude that they would rather collude to avoid such a scheme than compete to earn money from it. All of the companies subject to the statute could defeat it by deciding to do nothing. To prevent this collusion, lawmakers might restrict communication between companies regarding their plans under the law.

[123] *See, e.g., 'Clear Skies' Legislation to Cut Emissions from Power Plants Introduced in Congress*, 33 ENV'T REP. (BNA) 1693, 1694 (Aug. 2, 2002) (both Jefford's bill and Bush Administration's Clear Skies proposal rely upon a cap and trade approach, says Holmstead).