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Design, Trading, and Innovation

David M. Driesen*

A Retrospective on Twenty Years of Market Based Instruments for Environmental Protection:
Has the Promise Been Realized?

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David M Driesen

Proponents of “economic incentives” frequently state that emissions trading promotes technological innovation.¹ Emissions trading programs authorize polluters to meet pollution reduction obligations by purchasing extra reductions from polluters reducing their emissions below applicable limits. This Article examines the claim that this trading of compliance obligations fosters innovation. This claim relies upon an error in economic theory,² which many economists and lawyers have repeated,³ and on insufficiently analyzed, incomplete anecdotal observation.⁴ There are solid reasons to suspect that an emissions trading program does a poorer job of stimulating innovation than a comparably designed traditional regulation.⁵ But much depends upon design details.

¹ See, e.g., Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law: The Democratic Case for Market Incentives*, 13 <BI>Col. J. Env'tl. L.<D> 171, 183 (1988); Daniel J. Dudek & John Palmisano, *Emissions Trading: Why is this Thoroughbred Hobbled?*, 13 <BI>Col. J. Env'tl. L.<D> 217, 234-235 (1988); Robert W. Hahn & Robert N. Stavins, *Incentive-Based Environmental Regulation: A New Era from an Old Idea*, 18 <BI>Ecology L. Q.<D> 1, 13 (1991); Richard B. Stewart, *Controlling Environmental Risks Through Economic Incentives*, 13 <BI>Colum. J. Env'tl. L.<D> 153, 160 (1988); Robert N. Stavins, *Policy Instruments for Global Climate Change: How Can Governments Address a Global Problem?*, 1997 <BI>U. Chi. Legal F.<D> 293, 302-03.

² See David A. Malueg, *Emissions Credit Trading and the Incentive to Adopt New Pollution Abatement Technology*, 16 <BI>J. Env't Econ. & Man.<D> 52 (1987) (pointing out the error and offering a correction).

³ See Adam B. Jaffe et al., *Environmental Policy and Technological Change*, 22 <BI>Env'tl & Resource Econ.<D> 41, 51 (2002) (economic incentives stimulate innovation by paying firms to clean up “a bit more”); Stewart, *supra* note 1, at 160 (“economic incentives provide enterprises with ongoing incentives to devise new . . . technologies to further reduce pollution”). As we shall see, I do not claim that these statements are false, but that they are so radically incomplete and misleading as to constitute a theoretical error.

⁴ See, e.g., Byron Swift, *The Acid Rain Test*, 14 <BI>Env'tl. F.<D>, May-June 1997, at 17 (describing fuel switching and use of scrubbers as innovations from the acid rain program).

⁵ See David M. Driesen, *Is Emissions Trading an Economic Incentive Program?: Replacing the Command and Control/Economic Incentive Dichotomy*, 55 <BI>Wash. & Lee L. Rev.<D> 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 <BI>Bost. Coll Env'tl. Aff. L. Rev.<D> 1, (1998) [hereinafter Driesen, *Cheap Fix*].

In theory, government can require all polluters to purchase allowances from a limited supply at an auction.⁶ Whether or not polluters can trade allowances, this requirement that all polluters purchase allowances for each ton of pollution can create incentives to innovate and reduce pollution. This Article, 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,⁷ and because this focus sharpens analysis of trading's effect on innovation.

Defining Innovation

I define innovation as 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. Innovation in this sense advances the state of the art. As we shall see, innovation defined in this manner has special value.

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.⁹

So too with environmental innovation.¹⁰ Innovation can reduce the cost of pollution

⁶ See Brennan Van Dyke, *Emissions Trading to Reduce Acid Deposition*, 100 *Yale L. J.* 2707, 2715-2721 (1991) (arguing for the superiority of an auction based system). The acid rain program authorizes direct sales and auctioning of a tiny fraction of the available allowances. See 42 U.S.C. §7651o.

⁷ See 42 U.S.C. §§7651c(e), 7651d (giving away almost all allowances). Cf. 42 U.S.C. §7651o (authorizing the sale and auction of very limited numbers of allowances). I am not aware of any other U.S. trading program that requires purchase of allowances from the government.

⁸ David M. Driesen, *The Economic Dynamics of Environmental Law* 78-80 (MIT Press 2003).

⁹ *Id.* at 79.

¹⁰ For a definition of environmental innovation, see *id.* at 77-78. Cf. Richard B. Stewart, *Regulation, Innovation, and Administrative Law: A Conceptual Framework*, 69 *Cal. L.*

control or make it possible to perform basic economic functions with less pollution than existing approaches.¹¹ In other words, environmental innovation can either offer qualitatively better environmental results or reduce the cost of achieving a particular result.

In a new book, *The Economic Dynamics of Environmental Law*, I argue that this former “qualitative” function has immense importance.¹² 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.¹³ 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, 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).¹⁴

We need to change current technologies drastically if we hope 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.¹⁵ This economic dynamic tends to make environmental problems grow over time.¹⁶ This dynamic almost always undermines some of the progress environmental regulation would

Rev.<D> 1256, 1279 (1981) (distinguishing between market and social innovation).

¹¹ See <BI>Driesen, *Economic Dynamics*<D>, *supra* note 8, at 81.

¹² See *id.* at 85-89.

¹³ See 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); <BI>Environmental Law Institute (ELI), *Cleaner Power: The Benefits and Costs of Moving from Coal Generation to Modern Power Technologies*<D> (2001).

¹⁴ See Driesen, *Sustainable Development*, *supra* note 13, at 10277-10280 (discussing air pollution’s affects and fossil fuel combustion’s contribution to air pollution); <BI>Climate Change 2001: Synthesis Report<D> 9-12 (Robert T. Watson et al. eds., 2001); <BI>The Regional Impacts of Climate Change: An Assessment of Vulnerabilities<D> 5 -7 (Robert T. Watson et al. eds., 1998); <BI>Lynne T. Edgerton, *The Rising Tide: Global Warming and World Sea Levels*<D> (1991).

¹⁵ See <BI>Driesen, *Economic Dynamics*<D>, *supra* note 8, at 114, 123-125 (discussing population growth and lobbying by regulated industry); Driesen, *Sustainable Development*, *supra* note 13, at 10285-19286 (discussing benefits of changing basic power plant and vehicle technologies); <BI>ELI, *Cleaner Power*<D>, *supra* note 13 (discussing costs and benefits of moving from coal-fired power production).

¹⁶ See <BI>Driesen, *Economic Dynamics*<D>, *supra* note 8, at 123-126.

otherwise bring about, and, at times, leads to absolute declines in environmental quality.¹⁷

Technological innovation also performs an important political function--making progress possible where it otherwise could not occur.¹⁸ 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.¹⁹ 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.²⁰

We need to reframe the environmental policy debate around the question of addressing the economic dynamics of environmental law.²¹ 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).²² In any case, environmental policy analysts generally agree upon the desirability of stimulating technological innovation to improve the environment.²³

Emissions trading has been widely implemented.²⁴ Hence, the question of whether it

¹⁷ *See id.* at 123.

¹⁸ *See* 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 3, at 54-55 (noting that cost-saving innovation may make optimal environmental policy more stringent).

¹⁹ *See* Driesen, *Cheap Fix*, *supra* note 5, at 15.

²⁰ *See id.* at 50; Deborah E. Cooper, Note, *The Kyoto Protocol and China: Global Warming's Sleeping Giant*, 11 *Geo. Int'l L. Rev.* 401, 429 & n.202 (1999) (citing a Chinese official's statement that the United States is shirking its climate change responsibilities to support the statement that China has objected to additional responsibilities for developing nations); Joyeeta Gupta, *The Climate Change Convention and Developing Countries: From Conflict to Consensus* 129 n.41 (1997).

²¹ *See* Driesen, *Economic Dynamics*, *supra* note 8, at 10-11, 215.

²² *See id.* at 12, 183-201.

²³ *See e.g.* Jaffe et al., *supra* note 3, at 49.

²⁴ *See* Driesen, *Dichotomy*, *supra* note 5, 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

encourages innovation matters a great deal.

The Theoretical Error

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.

This argument is wrong. Why?

Well, emissions trading does provide an incentive for some polluters to emit more than they would under a traditional regulation.²⁵ But those polluters must pay other polluters to make extra emission reductions to make up the gap.²⁶ Resting a model of emissions trading upon the experience of only half of the polluters (the buyers of credits) in the market is obviously wrong. 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.

Now, let's make an equally wrong argument for the other position. The argument would go like this: Polluters have an incentive to make extra emission reductions under emissions trading so that they can sell credits;²⁷ 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.²⁸ Many economists, legal scholars, and practicing lawyers repeat this obviously incomplete argument over and over again as gospel.²⁹

<BI>Colum. J. Envtl. L.<D> 137 (1998) (discussing proposal to use nitrogen trading regionally to control water pollution).

²⁵ See Driesen, *Dichotomy*, *supra* note 5, at 334; Suzi Kerr & Richard Newell, *Policy-Induced Technology Adoption: Evidence from the U.S. Lead Phasedown*, 3 (Resources for the Future Discussion Paper 01-14, 2001) (relatively high-cost plants will have decreased incentives to adopt technology under a trading system).

²⁶ *See id.*

²⁷ *See* Malueg, *supra* note 2, at 8-9 & n.33.

²⁸ *See id.*

²⁹ *See e.g.* Jaffe et al., *supra* note 3, at 51 ("market-based instruments can provide powerful incentives for companies to adopt cheaper and better pollution-control technologies . . .

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 does not generate more net emissions reductions than a comparable traditional regulation. A perfectly functioning trading program will generate the same reductions as 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.³⁰ Emissions trading shifts emission reductions, concentrating the same number of reductions among the facilities with the lowest pollution reduction costs.³¹ The right question is whether this shift of reductions from high-cost to low-cost facilities encourages innovation.

Claiming that emissions trading provides individual facilities an incentive absent from traditional regulation--the incentive to produce credits for sale--does not save the argument that emissions trading is superior in stimulating innovation. For emissions trading decreases incentives present in traditional regulation--the incentive for high-cost facilities to innovate in order to save money. Economists have no real explanation 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.

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.³² 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.³³ This argument seems irrefutable. Indeed, 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

because . . . with market-based instruments, it pays firms to clean up a bit more . . .).

³⁰ See Hahn & Stavins, *supra* note 1, at 8-9 & n.33 (describing trading's tendency to seek equilibrium. See generally <BI>J.H. Dales, Pollution Property and Prices<D> 92-100 (1968).

³¹ See Driesen, *Dichotomy*, *supra* note 5, at 334; Driesen, *Cheap Fix*, *supra* note 5, at 43.

³² See Malueg, *supra* note 2.

³³ See *id.* at 54-56.

program.³⁴ For the savings realized by not making expensive reductions at buyers' own facilities finance the purchase of credits that drives the market.³⁵

Amazingly, the economics literature does not refute Malueg's model or defend the incomplete model most economists have selected. While sophisticated analysts recognize that Malueg's model casts doubt on the thesis that emissions trading without auctioned allowances encourages innovation,³⁶ many articles continue to give a reasonably complete model short shrift while basing conclusions on an obviously incomplete model.³⁷ Worse, the selection of a seller-

³⁴ See Driesen, *Dichotomy*, *supra* note 5, at 337.

³⁵ *See id.*

³⁶ Driesen, *Dichotomy*, *supra* note 5, 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 18, 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 25, at 3 (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").

³⁷ *See, e.g.*, Jaffe et al., *supra* note 3, at 51 (stating that economic incentives pay firms to "clean up a bit more", but not mentioning that emissions trading pays others not to clean up). Hahn & Stavins, writing in the *Ecology Law Quarterly*, state that emissions trading encourages innovation by paying firms for additional cleanup. *See* Hahn & Stavins, *supra* note 1, at 13. In a footnote they cite Malueg for the proposition that trading may reduce traditional incentives for abatement "under certain circumstances." *Id.* n.70. *See also* Eran Feitelson, *An Alternative Role for Economic Instruments: Sustainable Future for Environmental Management*, 16 *Envtl. Mgmt.* 299, 301 (1992) (Malueg has "shown that trading permits do not provide in all cases

based model is 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.

The Theoretical Case Against Emissions Trading as a Stimulator of Innovation

A rudimentary understanding of emissions trading shows that it will disfavor 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.³⁸ 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.

This rules out the purchase of credits generated by relatively expensive innovation. 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.³⁹ Thus, an expensive innovation might function as an investment in future cheap reductions.⁴⁰ 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.⁴¹

Furthermore, some expensive innovations offer a qualitative improvement that makes

a superior incentive for pollution control innovations"). But Malueg's claim applies to all trading programs that give away allowances (i.e., just about all of the extant programs), not just "certain circumstances." It's not an exception to some general rule, it is the rule.

³⁸ See Malloy, *supra* note 18, at 542-543; Driesen, *Cheap Fix*, *supra* note 5, at 42 (buyers will purchase cheap credits).

³⁹ 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; Adam B. Jaffe et al., *Technological Change and the Environment*, in *The Handbook of Environmental Economics* 33 (Jeffrey Vincent ed., 2003) (forthcoming) (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, U.N. Doc. E/CN.17/2001/PC/20 (2000) (price of solar photovoltaic modules has come down about 25%).

⁴⁰ See, e.g., Driesen, *Economic Dynamics*, *supra* note 8, at 83-85.

⁴¹ See, e.g., Driesen, *Cheap Fix*, *supra* note 5, at 44.

them quite worthwhile, even if they do cost more.⁴² 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 that might facilitate really enormous reductions in price.⁴³ 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.⁴⁴ Yet, emissions trading tends to favor low-cost solutions, like better scrubbers and catalysts, to environmentally and economically superior solutions for the long haul.

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.⁴⁵ I now turn to that question.

Emissions trading creates two sets of incentives. It creates weaker incentives for innovation from buyers of credits than a comparable traditional regulation, encouraging the buyer to forego reductions and innovation at her facility.⁴⁶ On the other hand, it creates stronger incentives for sellers of credits to innovate, encouraging them to make extra emission reductions at their facilities (in order to sell credits). The difficult and appropriate question is whether this spatial shift of reductions increases or decreases net innovation.

In theory, emissions trading probably weakens net incentives for innovation.⁴⁷ 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

⁴² See, e.g., <BI>Driesen, *Economic Dynamics<D>*, *supra* note 8, at 85-86

⁴³ See, e.g., CSD, *supra* note 39, 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).

⁴⁴ See <BI>Driesen, *Economic Dynamics<D>*, *supra* note 8, at 34-35.

⁴⁵ 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 5, at 317 n.131.

⁴⁶ See Kerr & Newell, *supra* note 25, at 3 (buyers have decreased incentives for technological adoption).

⁴⁷ Driesen, *Cheap Fix*, *supra* note 5, at 42.

regulation.⁴⁸ Conversely, the high-cost facilities will tend to provide less of the total required reductions than they would under a comparable traditional regulation.⁴⁹ One would expect the low-cost facilities to have a greater ability to provide reductions without substantial innovation than the high-cost facility.⁵⁰ 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.⁵¹ The induced innovation hypothesis, widely employed by economists, suggests that high costs will spur, not deter, innovation.⁵² 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.⁵³

High local control costs often serve as the catalyst for innovation. Companies do not routinely pursue all innovations.⁵⁴ Investigation of innovation often involves substantial investment without certainty about pay-off.⁵⁵ 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.⁵⁶ 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.⁵⁷ 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

⁴⁸ *Id.* at 43.

⁴⁹ Driesen, *Dichotomy*, *supra* note 5, at 334.

⁵⁰ *Id.*

⁵¹ *Id.*; Driesen, *Cheap Fix*, *supra* note 5, at 42-43.

⁵² 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 18, at 546 (linking the induced innovation idea to the idea that traditional regulation may induce innovation)

⁵³ Driesen, *Dichotomy*, *supra* note 5, at 335.

⁵⁴ See Malloy, *supra* note 18, at 537-38, 556.

⁵⁵ See *id.* at 557; Jaffe et al., *supra* note 3, at 44 (discussing how uncertainties can lead to insufficient investment in innovation).

⁵⁶ See Malloy, *supra* note 18, at 567-586 (describing various forms of competition for resources within firms),

⁵⁷ See *id.* at 550 (discussing how very stringent regulation leaves the firm with little choice but to innovate).

several states have enacted to stimulate innovation and secure emission reductions from automobiles, illustrates the way emissions trading may decrease incentives for innovation.⁵⁸ 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.⁵⁹ But the program also requires introduction of a small number of zero emission vehicles (ZEVs), most likely electric cars.⁶⁰ 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.⁶¹ 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.⁶² 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 from joint implementation, an international emissions trading

⁵⁸ See *Association of Int'l Auto. Mfrs., Inc. v. Commissioner*, 208 F.3d 1, 3-4 (1st Cir. 2000) (discussing California's rescission of prior zero emission vehicle (ZEV) mandate and negotiation of a memorandum of understanding creating an informal ZEV mandate); *American Auto. Mfrs. Ass'n v. Cahill*, 152 F.3d 196, 199 (2d Cir. 1998) (same); *Virginia v. EPA*, 108 F.3d 1397, 1412 & n.16 (D.C. Cir. 1997) (Connecticut, Massachusetts, and New York have adopted the LEV program); *American Auto. Mfrs. Ass'n v. Commissioner*, 31 F.3d 18 (1st Cir. 1994) (upholding Massachusetts LEV program); *Motor Vehicle Mfrs. Ass'n of the United States v. New York State Dep't of Env'tl. Conservation*, 79 F.3d 1298 (2d Cir. 1996) (upholding New York LEV program).

⁵⁹ See *Studies Will Examine Effects of Sulfur on Catalysts in Low Emission Vehicles*, 28 *Env't. Rep. (BNA)* 403 (June 27, 1997).

⁶⁰ See *Motor Vehicle Mfrs. Ass'n of the United States v. New York State Dep't of Env'tl. 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).

⁶¹ In practice, one could not do so with any integrity. Measurement of the mass of automobile emissions is notoriously difficult, especially "evaporative emissions." ZEVs will virtually eliminate evaporative emissions as well as tailpipe emissions.

⁶² See generally Michael 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).

program proposed as a means of meeting climate change goals.⁶³ The United States has sponsored pilot projects to demonstrate the feasibility of allowing electric utilities, significant sources of greenhouse gases, to claim credits undertaken abroad as a substitute for making reductions below current levels at home. If instead the United States 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.⁶⁴ But joint implementation may allow them to avoid this. 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, claiming 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.”⁶⁵ Hence, economic growth will increase the demand for permits, raise the price, and provide a greater incentive for polluters to reduce their emissions.⁶⁶

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.⁶⁷

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

⁶³ See *Remarks at the National Geographic Society*, 1997 <BI>Pub. Papers<D> 1408 (Oct. 22, 1997) (President Clinton’s statement on climate change policy).

⁶⁴ See generally, *At Last, The Fuel Cell*, <BI>The Economist<D>, Oct. 25, 1997, at 89; Andrew C. Revkin, *Under Solar Bill, Homeowners Could Cut Electricity Cost to Zero*, <BI>N.Y. Times<D>, July 25, 1996, at B1.

⁶⁵ See, e.g., Tripp & Dudek, *supra* note 69, at 374.

⁶⁶ *Id.*

⁶⁷ See Richard B. Stewart, *Economics, Environment, and the Limits of Legal Control*, 9 <BI>Harv. Envtl. L. Rev.<D> 1, 13 (1985) (“Given a fixed supply of permits . . . [t]he system will ensure that we . . . keep in place.”).

pollution caused by economic growth from operating without purchased emission allowances.⁶⁸ 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 without demanding compensating credits.⁶⁹ 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.⁷⁰ Of course, traditional regulations can limit pollution by mass rather than by rate, and sometimes has. Hence, traditional regulation and emissions trading based on rates fail to constrain emissions in the face of growth in production, but limits on mass,

⁶⁸ Tripp & Dudek, *supra* note 69, at 375. This may be quite a heroic assumption, since adopting and enforcing a prohibition on all pollution may prove difficult politically. The Clean Air Act (CAA) does not currently contain such a prohibition. The Clean Water Act does contain a general prohibition on non-permitted discharges. *See* Train v. Colorado Pub. Interest Research Group, Inc., 426 U.S. 1, 7 (1976) (Act prohibits discharge of pollutants without a permit); EPA v. California ex rel. State Water Resources Control Board, 426 U.S. 200, 205 (1976) (same); Natural Resources Defense Council v. Costle, 568 F.2d 1369 (D.C. Cir. 1977). *Cf.* Arkansas v. Oklahoma, 503 U.S. 91, 107-108 (1992) (EPA may permit discharges into water bodies violating existing water quality standards). But the courts and EPA have not always faithfully implemented the prohibition of non-permitted discharges. *See* Axline & McGinley, *Universal Statutes & Planetary Programs: How EPA Has Diluted the Clean Water Act*, 8 *J. Envtl. L. & Litig.* 253 (1993); Atlantic States Legal Found., Inc. v. Eastman Kodak, 12 F.3d 353 (2d Cir. 1994) (holding that discharges of pollutants not listed in permit is permissible); Joanna Bowen, *Atlantic States Legal Foundation v. Eastman Kodak Co.: The Second Circuit Affirms the NPDES Permit as a Shield and Tries to Sink the Clean Water Act*, 12 *Pace Envtl. L. Rev.* 269 (1994) (arguing that court interpreted the Act more narrowly than EPA, which believes that pollutants not listed in permit application cannot be discharged). *Cf.* Northwest Envtl. Advocates v. Portland, 56 F.3d 979, 986 (9th Cir. 1995) (citizens may sue to enforce water quality conditions in permits, not just effluent limitations).

⁶⁹ *See* Swift, *supra* note 4, at 18 (explaining that emission rates do not necessarily prevent increases in the mass of emissions).

⁷⁰ 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.

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 of 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.⁷¹ 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 make 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.⁷² 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 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.⁷³ 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.⁷⁴ The resulting uncertainty can lessen incentives to innovate, just as uncertainty about future emission limitations reduces such

⁷¹ Driesen, *Economic Dynamics*, *supra* note 8, at 61.

⁷² See Ackerman & Stewart, *supra* note 1, at 174; Stewart, *Innovation*, *supra* note 10, at 1273-77.

⁷³ See Driesen, *Dichotomy*, *supra* note 5, at 327-32; Howard Latin, *Ideal Versus Real Regulatory Efficiency: Implementation of Uniform Standards and "Fine-Tuning" Regulatory Reforms*, 37 *Stan. L. Rev.* 1267, 1290 (1985) (to the extent that trading programs can be adjusted to respond to new information, they present the same moving target problem as traditional regulation).

⁷⁴ 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.

incentives in traditional regulation.⁷⁵ Further, just as traditional regulation uses technological, cost-benefit, or health-based criteria to set limitations, the same criteria can be used to set the limitations governing trading programs.⁷⁶ Also, private parties have significant incentives to litigate disliked stringency determinations and allocation decisions.⁷⁷

Congressional mandates of specific emission reductions may circumvent some of the problems with administrative decisionmaking, including hard look judicial review.⁷⁸ Congress has, in fact, circumvented administrative problems by mandating specific cuts of named

⁷⁵ 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, *Innovation*, *supra* note 10, 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.

⁷⁶ For example, California’s Regional Clean Air Incentives Market (RECLAIM) program allows adjustment of reduction allocations based on technology reviews. These reviews assume that the facilities should reduce their emissions to levels equivalent to those under the traditional regulations RECLAIM replaced. *South Coast Air Quality Management District, Second Annual RECLAIM Program Audit Report* 19-20 (1997) (on file with author). The South Coast Air Quality Management District has allocated additional emission allowances, thereby harming air quality, when it concluded that a facility could not meet its target through locally applied technology known to the SCAQMD. *Id.* at 72-73.

⁷⁷ *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).

⁷⁸ *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 through centralized emissions trading,⁷⁹ decentralized standard setting,⁸⁰ and centralized standard setting⁸¹. The scarcity of congressional time may limit the frequency of congressional mandates.⁸² However, congressionally set limits have often fared relatively well and should be pursued.⁸³ 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.⁸⁴

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 authors 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 will provide sufficient incentives for vigorous advocacy sufficient to stall progress. Lawyers are expensive, but rarely as expensive as meaningful pollution control. 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 is the framework employed here.

⁷⁹ See 42 U.S.C. §7651(b)(setting goal of acid rain trading program at a cut of ten million tons of sulfur dioxide).

⁸⁰ See 42 U.S.C. §7511a(b)(1)(generally requiring states to cut volatile organic compounds by 15% from 1990 levels).

⁸¹ See 42 U.S.C. §7521(g)(setting numerical standards for vehicle emissions).

⁸² 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).

⁸³ See David M. Driesen, *Five Lessons From Clean Air Act Implementation*, 14 *Pace Env'tl. L. Rev.* 51, 53-55 (1997).

⁸⁴ Driesen, *Dichotomy*, *supra* note 5, at 329.

The Command and Control/Economic Incentive Dichotomy and the Law

Most analysts employ a simplistic command and control/economic incentive dichotomy as a substitute for cogent analysis.⁸⁵ They claim that traditional regulation discourages innovation.⁸⁶ Indeed, some of the less careful writing states that standard regulation prohibits innovation.⁸⁷ 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.⁸⁸ 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 performance⁸⁹ rather than the use of a particular technique.⁹⁰ Performance standards may encourage innovation by allowing polluters to choose

⁸⁵ *Id.* at 290-91.

⁸⁶ 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).

⁸⁷ See, e.g., Hahn & Hester, *Markets*, *supra* note 94, 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.

⁸⁸ See Driesen, *Economic Dynamics*, *supra* note 8, at 183-87 (discussing error of treating regulations not encouraging innovation well as "barriers to innovation").

⁸⁹ See *United States v. Ethyl Corp.*, 761 F.2d 1153, 1157 (5th Cir. 1985). The technology-based standards for air emissions from new automobiles are also performance standards. They dictate a precise limitation, not a precise method for achieving the limitation. See 42 U.S.C. §7521(g). The technology-based regulations that states with dirty air must promulgate may also be performance standards. The CAA requires state plans to "provide for the implementation of all reasonably available control measures," but not through "command and control" mandates. 42 U.S.C. § 7502(c)(1). Rather, it requires "reductions in emissions from existing sources . . . as may be obtained through the adoption, at a minimum, of reasonably available control technology." *Id.* EPA and the courts have interpreted this statutory language as authorizing promulgation of numerical emission limitations that do not dictate the precise compliance method. See *Michigan v. Thomas*, 805 F.2d 176, 184-85 (6th Cir. 1986).

⁹⁰ 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, *Innovation*, *supra*

how to comply.⁹¹

Many statutory provisions severely restrict EPA's authority to specify mandatory compliance methods.⁹² Several provisions require a performance standard unless EPA finds that one cannot measure emissions directly to determine compliance.⁹³ 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.⁹⁴

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.⁹⁵ Hence, agency views concerning technological capability help determine the standards' stringency.⁹⁶ 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

note 10, at 1268 (“Performance standards allow regulated firms flexibility to select the least costly or least burdensome means of achieving compliance.”) *Cf.* Stewart, *Risks*, *supra* note 1, at 158 (“Regulatory commands dictate specific behavior by each plant, facility, or product manufacturer . . .”).

⁹¹ <BI>Louis G. Tornatzky & Mitchell Fleischer, *The Processes of Technological Innovation* 101 (1990); Malloy, *supra* note 18, at 546-547 & n.52 (performance standards have the express purpose of “encouraging innovation”).

⁹² *See* American Petroleum Inst. v. EPA, 52 F.3d 1113, 1119 (D.C. Cir. 1995) (stating that EPA may not limit use of ethanol in reformulated gasoline because CAA mandates performance standards); PPG Indus., Inc. v. Harrison, 660 F.2d 628, 636 (5th Cir. 1981) (stating that authority to set performance standards does not include authority to specify fuels).

⁹³ *See* 42 U.S.C. §§7411(h)(1); 7412(d)(2)(D), (h)(1)-(2), (h)(4).

⁹⁴ *See* 42 U.S.C. §§7412(h)(3); 7411(h)(3).

⁹⁵ *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).

⁹⁶ *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. The courts may reverse EPA if its view about the level technology can achieve is arbitrary and capricious. *See, e.g., id.* (upholding standard as achievable and consistent with statute); National Lime Ass'n v. EPA, 627 F.2d 416 (D.C. Cir. 1980) (remanding to collect additional data because record inadequately supports achievability of the standard).

evaluation of a reference technology.⁹⁷

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.⁹⁸ 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."⁹⁹ 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).¹⁰⁰ It also required a 90% reduction from uncontrolled levels except for plants emitting less than 0.6 lbs./MBtu.¹⁰¹ These cleaner plants needed only to meet a 70% reduction requirement.¹⁰² 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.¹⁰³ Hence, if a plant operator developed some 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

⁹⁷ 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).

⁹⁸ See <BI>Bruce A. Ackerman & William T. Hassler, *Clean Coal/Dirty Air*<D> 15-21 (1981) [hereinafter <BI>Ackerman & Hassler, *Clean Coal*<D>].

⁹⁹ 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 <BI>Yale L. J.<D> 1466, 1481-88 (1980) (discussing NSPS that allegedly mandated flue gas scrubbing) [hereinafter, Ackerman & Hassler, *New Deal*]; <BI>Ackerman & Hassler, *Clean Coal*<D>, *supra* note 106, at 15-21 (same).

¹⁰⁰ *Sierra Club v. Costle*, 657 F.2d 298, 312 (D.C. Cir. 1981).

¹⁰¹ *Id.*

¹⁰² *Id.*

¹⁰³ *Id.* at 324, 327-28, 340-43, 346-47.

70% reduction by itself.¹⁰⁴ 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."¹⁰⁵ 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.¹⁰⁶

In any event, one cannot draw general conclusions about the character of an entire regulatory system from a single case. A more thorough analysis of the system as a whole shows that most technology-based regulation does not command use of a particular technique. The claim that technology-based regulation does require use of the particular technology that the agency used to justify the regulation simply reflects an oft-repeated legal error, reflecting habits of thinking in static terms.

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.¹⁰⁷ The law only authorizes command-and-control regulation when measurement of emissions is impossible.¹⁰⁸ Trading, however, relies upon good

¹⁰⁴ See *id.* at 368-73; Ackerman & Hassler, *New Deal*, *supra* note 107, 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, *Clean Coal*, *supra* note 106, 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)

¹⁰⁵ *Sierra Club*, 657 F.2d at 316 (emphasis added).

¹⁰⁶ Driesen, *Economic Dynamics*, *supra* note 8, at 51.

¹⁰⁷ See Kerr, *supra* note 83, at 66.

¹⁰⁸ See, e.g., National Emission Standards for Hazardous Air Pollutants for Source Categories; Organic Hazardous Air Pollutants from the Synthetic Organic Chemical Manufacturing Industry and Seven Other Processes, 57 Fed. Reg. 62608, 62646 (1992) (codified

monitoring.¹⁰⁹ 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.

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.”¹¹⁰ 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. 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.¹¹¹ While polluters have an equally powerful economic incentive to use cheaper innovative compliance methods for true command-and-control regulations, the polluter

as amended at 40 C.F.R. pt. 63) (proposed Dec. 31, 1992); *Adamo Wrecking Co. v. United States*, 434 U.S. 275, 294-95 (Stevens J., dissenting) (work practice standard promulgated for asbestos because asbestos emissions from demolition cannot be measured); *Sierra Club*, 657 F.2d at 317 n.38.

¹⁰⁹ Hahn & Hester, *supra* note 94, 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, *Risks*, *supra* note 1, at 161, 166.

¹¹⁰ Stewart, *Innovation*, *supra* note 10, at 1269.

¹¹¹ Driesen, *Dichotomy*, *supra* note 5, 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 (Summer 1983).

may have more difficulty persuading a regulator that an alternative is viable if she cannot measure emissions directly. Nevertheless, the polluter can deploy her substantial expertise to estimate the effectiveness of alternative techniques and may persuade regulators to accept alternatives. Indeed, she may persuade a regulator that a less effective technique is equally effective because the regulator may feel insecure in second-guessing a company's judgment. Many polluting companies do not shy away from urging alternative means of complying with performance standards upon permit writers after promulgation of technology-based regulations.

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:¹¹² Evidence that traditional regulation does not simulate innovation and evidence that emissions trading does.

Traditional Regulation

The empirical literature on traditional regulation shows that industry sometimes chooses techniques different from those an agency relies upon in standard setting.¹¹³ 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.¹¹⁴ Textile manufacturers

¹¹² See Jaffe et al., *supra* note 3, 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 18, at 547 (empirical evidence provides "inconclusive evidence of significant environmental innovation under existing trading programs.")

¹¹³ See Kurt Strasser, *Cleaner Technology, Pollution Prevention, and Environmental Regulation*, 9 *Fordham Env'tl 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 119, at 109, 139-40.

¹¹⁴ *OTA Study*, *supra* note 121, at 89. Nicholas A. Ashford et al., *Using Regulation to Change the Market for Innovation*, 9 *Harv. Env'tl L. Rev.* 419, 440-41 (1985).

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.¹¹⁵ 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.¹¹⁶ This shows that traditional regulation can encourage pollution prevention. 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.¹¹⁷

Industry responded to a ban upon ozone depleting chemicals with a variety of innovations.¹¹⁸ The makers of ozone depleting substances developed new chemicals that damaged the ozone layer less severely.¹¹⁹ And many former users of ozone depleters simply substituted soap and water for chemical solvents.¹²⁰ Operators of chloralkali plants responded to EPA regulation of mercury with some process innovations.¹²¹ When EPA began phasing out mirex (a pesticide that controlled fire ants), EPA had registered no acceptable substitutes.¹²² But during a two-year phase-out period four companies sought registration of substitutes.¹²³ Clearly the claim that traditional regulation always discourages innovation is simply wrong.

¹¹⁵ <BI>OTA Study<D>, *supra* note 121, at 90.

¹¹⁶ *Id.* at 95. OSHA anticipated this possibility, but not the extent to which it dominated compliance strategies. *Id.*

¹¹⁷ *See* Strasser, *supra* note 121, at 28-29.

¹¹⁸ *See* <BI>Ozone Depletion in the United States: Elements of Success<D> (Elizabeth Cook, ed. 1996).

¹¹⁹ *See id.* at 14-15, 23-26, 58-60, 90-94, 98-104, 109.

¹²⁰ *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 cleaning" as an example of a cleaning process that reduced cost in phasing out CFCs); <BI>ICOLP Technical Committee, *Eliminating CFC-113 and Methyl Chloroform in Precision Cleaning Operations<D>* 114 (1994) (defining "aqueous cleaning" as cleaning parts with water to which suitable detergents, saponifiers or other additives may be added).

¹²¹ *See* Ashford et al., *supra* note 122, at 437 (describing separation of process from cooling water to reduce contact with mercury as a "significant process innovation.").

¹²² *See* Thomas O. McGarity, *Radical Technology-Forcing in Environmental Regulation*, 27 <BI>Loy. L.A. L. Rev.<D> 943, 947 (1994) (discussing experience with lead and pesticide bans).

¹²³ *Id.*

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,¹²⁴ most traditional regulation probably does little to stimulate innovation. Most of this regulation allows polluters to meet the standard through relatively cheap existing technology.¹²⁵ This “mediocre regulation” does not require stringent pollution reductions that would make conventional techniques either insufficient or very expensive.¹²⁶ By contrast, when government imposes very stringent regulation, companies tend to innovate because the conventional approaches become either inadequate or expensive.¹²⁷

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.

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 bubbles have spurred adequate environmental performance.¹²⁸ The few studies of bubble implementation reveal that polluters often could not document claims that they had made

¹²⁴ See Jaffe et al., *supra* note 3, at 55.

¹²⁵ 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).

¹²⁶ See, e.g., Environmental Law Institute, *Barriers to Environmental Technology Innovation and Use* (1998).

¹²⁷ See Malloy, *supra* note 18, at 549-550; Ashford et al., *supra* note 122, at 432-444 (discussing examples); McGarity, *supra* note 130, at 945-52 (discussing experience with lead and pesticide bans).

¹²⁸ See Richard A. Liroff, *Air Pollution Offsets: Trading Selling and Banking* 28-29 (1980) [hereinafter Liroff, *Offsets*] (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”).

required emission reductions.¹²⁹ 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.¹³⁰ Hence, gaming has been a problem.

¹²⁹ 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 *Env'tl. F.* 33, 34-35 (1985); Liroff, *Toil*, *supra* note 66, at 80-89 (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, *Markets*, *supra* note 94, 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.

The claim that bubbles have had a “negligible effect” on environmental quality may be read as consistent with a conclusion that bubbles have been a failure. If this negligible effect claim suggests that bubbles have not produced increases in pollution relative to baseline levels, then negligible effect constitutes gross failure. For the rules that the bubbles apply to were supposed to produce decreases in emissions rather than just limit increases.

The actual conclusions of EPA officials relying on real data that Hahn and Hester cite seem consistent with failure. They report no reductions in actual emissions. *Id.* at 129 & n.105 (describing the data backing this up). Hahn and Hester also cite a statement from the head of the Reagan era EPA’s regulatory reform staff, the primary advocate of emissions trading within EPA, stating that bubbles led to “substantially greater emissions reductions than conventional limits, with the rest producing equivalent reductions.” *Id.* at 129 & n.104. But Dr. Liroff has stated that the statements of the regulatory reform staff have been misleading as to bubble performance. Liroff, *Toil*, *supra* note 66, at 62-67. Hahn and Hester cite no real data supporting these statements.

¹³⁰ Dr. Liroff provides many examples of these bubbles. See Liroff, *Toil*, *supra* note 66, at 62-67, 89-91. Dr. Liroff explains that states lured new plants in the 1970s by providing them with offsets that the state itself created. Liroff, *Offsets*, *supra* note 136, at 13-17. The offset consisted of a paper credit for “an asphalt substitution process that already was occurring for nonenvironmental reasons.” *Id.* at 16. *Accord* *Citizens Against the Refinery’s Effects v. EPA*, 643 F.2d 183, 187 (4th Cir. 1981). Liroff states that “the offset policy can be a meaningless paper game for abating pollution.” Liroff, *Offsets*, *supra* note 136, at 22.

But the experience varies from state to state. *Id.* Dr. Liroff cites some examples of

EPA introduced bubbles primarily as deregulatory mechanisms¹³¹ and they have often stimulated neither innovation nor adequate environmental performance at a cheaper price.¹³² Rather, they probably 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.¹³³

bubbles that he regards as models. His evaluation of these bubbles shows clearly that they reduced emissions below prior baseline levels. *See, e.g.,* Liroff, Toil, *supra* note 66, at 68 (actual emissions thousands of tons below uncontrolled levels). He concludes that “bubbles can reduce emissions below levels otherwise required.” *Id.* at 68-69. But he does not appear to have compared the reductions that traditional regulation would have achieved to the bubble regulation in all cases. *See, e.g., id.* at 70-71.

Polluters have sought to claim credits even when they have taken no action to reduce pollution below actual emissions levels, by seeking to measure emission reductions against an “allowable” emissions baseline. *See generally* Hahn & Hester, *Markets*, *supra* note 94, at 116-117 (discussing the difference between actual and allowable baselines); Liroff, Toil, *supra* note 66, at 15-16 (discussing various baseline issues). Since pollution sources usually leave a “compliance cushion” this allows them to generate a paper credit without doing anything to reduce pollution.

Polluters have sometimes claimed credits for shutting down pollution sources or production slow-downs, even when they have done this for business reasons, not in order to seek environmental improvement. *Id.* at 117-118; Comment, *Emission-Offset Banking: Accommodating Industrial Growth with Air-Quality Standards*, 128 *U. Penn. L. Rev.* 937, 937 (1980).

Federal rules authorize paper credits when they fail to prohibit claiming reductions based on activities undertaken to meet state rules. If a pollution source can claim credits for actions taken to comply with state rules, then regulations designed to bring about real reductions from previously unregulated (or inadequately regulated) pollution sources will use what states have already accomplished to justify doing nothing further.

¹³¹ *See* Liroff, Toil, *supra* note 66, at 37-38 (describing genesis of the bubble idea in the steel industry).

¹³² *Id.* at 100 (most “innovations” under bubbles are merely rearrangements of conventional technologies).

¹³³ *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) [hereinafter, Liroff, *Point*] (stating that a compliance method that relaxes regulatory requirements at some points without compensating reductions may be more prevalent than bubbles that reduce actual emissions); David D. Doniger, *Point . . . And Counterpoint*, 4 *Envtl. F.* 29, 34 (“In practice . . . there has been far more

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.¹³⁴ 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.¹³⁵

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

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.”).

¹³⁴ 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 83; Robert W. Hahn & Gordon L. Hester, *Marketable Permits: Lessons for Theory and Practice*, 16 *Ecology L.Q.* 361, 380-391 (1989) [hereinafter, Hahn & Hester, *Lessons*]; Kerr & Newell, *supra* note 25. I refer to this as an example of trading for simplicity’s sake. Because the rule authorized intertemporal trades, this rule also exemplifies “banking” of emission credits.

¹³⁵ 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, *Lessons, supra* note 142, 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)(1988)). 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, *Lessons, supra* note 142, at 388, n.146.

“greater stringency . . . encouraged adoption of lead-reducing technology.”¹³⁶ 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.¹³⁷

Acid Rain: Little Trading or Innovation

The acid rain trading program has produced some changes in scrubber technology, operational methods, and the use of cleaner coal, which some analysts describe as innovations.¹³⁸ But only 3 of 51 firms used interfacility trading to meet their reduction obligations (although 30 of the 51 did use some intrafacility averaging).¹³⁹ So, analysts should 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.¹⁴⁰

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.¹⁴¹ Nevertheless, some of the improvements in scrubbing have received patents, which suggests that they might qualify as genuine innovations.¹⁴²

¹³⁶ See Kerr & Newell, *supra* note 25, at 4 (emphasis added).

¹³⁷ See *id.* at 4, 23-24.

¹³⁸ See, e.g., Byron Swift, *Command without Control: Why Cap-and-Trade Should Replace Rate Standards for Regional Pollutants*, 31 ELR 10330 (Mar. 2001).

¹³⁹ See *id.* at 10331.

¹⁴⁰ 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.

¹⁴¹ See generally Malloy, *supra* note 18, at 548-49 (discussing debate about innovation under the acid rain program).

¹⁴² 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 laying track and changing the size of trains (to

But 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.¹⁴³ 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. A student of the RECLAIM program makes the opposite claim, that trading encourages cost-saving innovation, but not improvements in control technology.¹⁴⁴

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).¹⁴⁵ This suggests that something other than the mere existence of a trading program may be important to stimulating meaningful innovation.

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

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.

¹⁴³ See David Popp, *Pollution Control Innovations and the Clean Air Act of 1990* (NBER Working Paper #8593, 2001) (forthcoming).

¹⁴⁴ See CURTIS MOORE, RECLAIM: SOUTHERN CALIFORNIA'S FAILED EXPERIMENT WITH AIR POLLUTION TRADING 17 (2003).

¹⁴⁵ 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.¹⁴⁶

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.¹⁴⁷ But some sources have relied on less conventional techniques, such as ThermalNO_x, rotating overfired air, and reburn technology.¹⁴⁸ 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.¹⁴⁹ One RECLAIM critic argues that the program actually discouraged innovation, for reasons having to do with design flaws.¹⁵⁰ EPA's evaluation of RECLAIM states that most sources relied upon conventional off-the-shelf technology, but a few used innovative compliance methods.¹⁵¹ Since very few sources generated credits through over-compliance to sell into the market, it may be incorrect to ascribe the innovation that did occur under the RECLAIM program to the program's authorization of emissions trading.¹⁵²

¹⁴⁶ See MOORE, *supra* note 152, at 2 (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 ENV'T L. & POL'Y FORUM 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)..

¹⁴⁷ 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).

¹⁴⁸ Id.

¹⁴⁹ See Drury, *supra* note 153, at 258-263 (discussing fraud in the estimation of credits and debits that systematically undermines environmental performance).

¹⁵⁰ See MOORE, *supra* note 152, at 3-5 (charging that RECLAIM suffocated environmental innovation).

¹⁵¹ 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).

¹⁵² See id. at 21, 27 (relying upon design variables other than the trading possibility to explain the innovation).

Saving a Fragment of the Economists' Argument

It's quite clear that the theoretical predicate and empirical basis for the conclusion that emissions trading encourages innovation better than a comparably designed traditional regulation is fundamentally inadequate. 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.

Nevertheless, Malueg's model and David Popp's empirical work point the way toward a theory that might partially (but only partially) salvage something resembling (but not mirroring) the standard conclusion. 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.

This argument, however, may not stand either. 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 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 achieve standard outcomes 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 weaker 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.

Reframing the Debate

One can easily say that emissions trading does stimulate innovation, for it does, at times. But one can say the same thing about traditional regulation.

This Article has already suggested a more fruitful way of framing the question: Does an emissions trading scheme produce more innovation than a comparable traditional regulation? An emissions trading scheme begins with the establishment of limits upon the number of allowances distributed.¹⁵³ These limits would form the basis for a traditional performance standard, but for the option to trade. Convincing analysis should compare a trading program with a traditional regulation employing equally stringent limits in an equivalent form.

This leads immediately to a recognition of a weakness in existing analysis and a possibility for improvement. 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.

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 the choice between trading and traditional regulation must influence the degree of innovation. This Article has already suggested that the stringency of limits has a large influence.¹⁵⁴ In the *Economic Dynamics of Environmental Law*, I explain that the form of

¹⁵³ See Driesen, *Dichotomy*, *supra* note 5, at 324.

¹⁵⁴ Cf. Kerr & Newell, *supra* note 25, at 4 (explaining that stringency induced innovation in the lead program).

emission limits matters as well (building on work by Byron Swift on mass-based limits).¹⁵⁵ 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.

Precisely because necessity is the mother of invention, emissions trading probably produces weaker incentives for innovation than a comparable traditional regulation. And emissions trading certainly provides inadequate incentives for initially expensive innovations, even when such innovations offer long-term cost savings and significant and broad environmental advantages. Design considerations such as stringency and the existence of adequate monitoring may matter even more than the choice between trading and non-trading programs.

Implications

The significance of emissions trading's inferiority in stimulating 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.¹⁵⁶ 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."¹⁵⁷

The analysis underlying this Article's conclusion points to the importance of design factors for both trading and non-trading programs. Design may have more influence upon environmental performance than the choice between trading and traditional regulation.¹⁵⁸

In order to facilitate theoretically broad conclusions, this Article has implicitly assumed that trading programs are well designed. But often emissions trading programs have not been

¹⁵⁵ See Swift, *supra* note 146; Driesen, *Economic Dynamics*, *supra* note 8, at 193-197.

¹⁵⁶ See Driesen, *Economic Dynamics*, *supra* note 8.

¹⁵⁷ See, e.g., Jaffe et al., *supra* note 3, at 49.

¹⁵⁸ This is at least true where good monitoring is possible. Where it is not possible the choice of trading over command-and-control regulation is very likely to provide poorer environmental performance.

well designed.¹⁵⁹ The economic dynamic analysis in this Article points toward the importance of good design. This Article points out that purchasers of credits will normally prefer the cheapest possible credits. This means that if any potential exists in a trading system for credits without fresh real reductions, these credits will tend to dominate the market. For poor quality credits will cost little or nothing to produce. As in currency, poor quality credits crowd out high quality credits.¹⁶⁰ Hence, good design is essential to stimulating innovation and even to just meeting basic environmental goals for a program.¹⁶¹

Finally, 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.¹⁶² Recognizing the weaknesses of 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.¹⁶³ Negative economic incentives

¹⁵⁹ See EPA, *supra* note 159.

¹⁶⁰ See generally James Salzman & J.B. Ruhl, *Currencies and the Commodification of Environmental Law*, 53 *Stan. L. Rev.* 607 (2000) (developing a somewhat different analogy to currency).

¹⁶¹ Cf. EPA, *supra* note 159, at 25 (RECLAIM produced fewer emission reductions than traditional regulation would have).

¹⁶² Cf. Keohane et al., *supra* note 69, at 348 (explaining that polluters' preferences have generally prevented enactment of pollution taxes); James M. Buchanan & 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 5, at 340-343 (describing various impediments to setting tax rates for pollution).

¹⁶³ It has received some attention. See, e.g., Stewart, *Limits*, *supra* note 75, 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

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.¹⁶⁴ The California legislature has considered a program (called Drive ++)¹⁶⁵ 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.¹⁶⁵ 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.¹⁶⁶

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.¹⁶⁷ 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.¹⁶⁸ An environmental competition

reduction).

¹⁶⁴ T. H. Tietenberg, *Using Economic Incentives to Maintain our Environment*, <BI>Challenge<D>, Mar.-Apr. 1990, at 42, 43.

¹⁶⁵ See Nathanael Greene & Vanessa Ward, *Getting the Sticker Price Right: Incentives for Cleaner, More Efficient Vehicles*, 12 <BI>Pace Env’t. L. Rev.<D> 91, 94-97 (1994).

¹⁶⁶ See <BI>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)<D>* (1997) (on file with author).

¹⁶⁷ See <BI>Tornatzky & Fleischer<D>, *supra* note 99, at 168 (intense competition tends to stimulate spread of innovation).

¹⁶⁸ I have sketched this idea previously in Driesen, *Dichotomy*, *supra* note 5, at 344-347 and Driesen, *Sustainable Development*, *supra* note 13, at 10288-10230. The idea receives a fuller defense in <BI>Driesen, *Economic Dynamics<D>*, *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 <BI>Env’t Rep.<D> (BNA) 1437

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.¹⁶⁹ 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.¹⁷⁰

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.¹⁷¹ Hence, the scheme would

(June 28, 2002).

¹⁶⁹ See Anderson et. al., *Environmental Improvement Through Economic Incentives* 3-4 (1977). For an application of this principle to international environmental law see David M. Driesen, *The Congressional Role In International Environmental Law and Its Implications for Statutory Interpretation*, 19 *B.C. Env'tl. Aff. L. Rev.* 287, 306 (1991).

¹⁷⁰ The government might still have to decide which pollutants to target. Like other economic incentive schemes, this one would require developing sufficient data to determine the relative pollution levels of facilities. The law would work best if it included some mechanism, such as a requirement that pollution levels be posted regularly on the internet, that made it possible to see whether a company has performed better than competitors environmentally, without having to obtain information from government files. Implementing legislation would also have to determine a common metric for determining relative reductions.

¹⁷¹ The definition of a competitor from whom an environmentally exceptional company might claim a payment would play an important role in such a statute. EPA traditionally regulates by grouping industrial processes that share standard industrial classification (SIC) codes and then creating subgroupings to try and address plants with similar environmental or physical characteristics. This makes sense for regulation.

But SIC codes do not fully describe competitors in a system designed to reward environmentally friendly innovation and apply a negative economic incentive to dirtier means of meeting the same consumer goal. Ideally, somebody who develops a system of integrated pest management (IPM), for example, that makes it possible to increase beet yield with little or no pesticides, should be able to collect a payment from pesticide manufacturers that compete with her to maximize beet yield. Even if the IPM developer operates a research farm and the pesticide manufacturer operates a pesticide plant, the statute should regard them as competitors (or allow courts to develop a common law of competition based on broad principles).

Application of an environmental competition statute to a well-defined group of polluters with very clear definitions tailored to one problem would probably not generate large volumes of

create economic incentives for some companies to become enforcers of the law, rather than creating incentives for all companies to resist enforcement.¹⁷²

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 by the prospect of gain and the fear of loss, the driver of environmental improvement, thus replicating free market dynamics.¹⁷³ The magnitude of the incentive may depend upon the extent

disputes (but also would produce less widespread environmental improvement). For example, one could require all electric utilities to pay fees for each ton of nitrogen oxide emissions and divide the proceeds evenly among the five electric utilities with the lowest rate of nitrogen oxide emissions at the end of the year 2000. This would be rather simple to administer. Broader programs would pose more competitor definition issues, but would offer even broader incentives for innovation and environmental improvement while tending to discourage collusion.

¹⁷² Such a law should have a dispute resolution mechanism. Competitor enforcement may produce more need for conflict resolution. An environmental competition statute may create conflicts resembling those of other commercial disputes, disputes about what is a competitor, what costs a company incurred, and what reductions in pollution actually occurred. One may want to use some fees from polluters to finance specialized arbitration of these disputes.

An environmental competition statute should not generate complicated environmentally fruitless disputes. The Superfund law makes a variety of parties associated with toxic waste dumps strictly jointly and severally liable for cleanup. Representatives of companies facing Superfund liability often complain that this has led to protracted disputes largely because apportioning liability among potentially responsible parties (PRPs) has proven difficult. *See* Rena I Steinzor & Linda E. Greer, *In Defense of the Superfund Liability System: Matching the Diagnosis and the Cure*, 27 ELR 10286, 10290 n.19 (1997)

But the principle causes of protracted disputes under Superfund would not exist under an environmental competition statute. Allocating responsibility has proven difficult under Superfund because good information about the past history of toxic waste dumps (who dumped, who allowed dumping, etc.) is hard to come by and the program creates great uncertainty about the means and scope of eventual cleanup. It will usually not be difficult to figure out who caused a reduction under an environmental competition statute, since liability will only arise after a pollution reducing activity is completed and documented.

PRPs and EPA often seek to allocate responsibility under Superfund before completion of cleanup. This also hinders settlement because the total value of liability remains open-ended at the time of negotiation. An environmental competition statute should only allow claims based on already completed cleanup.

¹⁷³ 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

of industry fears about competitors' achievements rather than the fixed cost directly imposed by government.¹⁷⁴

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.¹⁷⁵ 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.

Conclusion

Emissions trading certainly does a poor job in stimulating radical innovation. It probably stimulates 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,¹⁷⁶ we need more attention to design issues and, in the long run, creative alternatives to emissions trading.

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.

¹⁷⁴ See, e.g., Tornatzky & Fleischer, *supra* note 99, at 86 (describing how firm research and development expenditures tend to respond to competitive pressures).

¹⁷⁵ 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. Communication about reduction plans might be considered a combination in restraint of environmental trade and banned on a kind of antitrust theory. Laws drafted to make it possible for new entrants in markets to compete should also limit opportunities for collusion.

¹⁷⁶ 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).