The Effects of Vintage-Differentiated Environmental Regulation

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VINTAGE-DIFFERENTIATED ENVIRONMENTAL REGULATION

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1. Introduction

Vintage-differentiated regulation (VDR) is a common feature of many environmental and other regulatory policies in the United States. Under VDR, standards for regulated units are fixed in terms of the units' respective dates of entry, or "vintage," with later entrants facing more stringent regulation. In the most common application, often referred to as "grandfathering," units produced prior to a specific date are exempted from new regulation or face less stringent requirements.

The vintage-differentiated approach has long appealed to many participants in the policy community, for reasons associated with efficiency, equity, and simple politics. First, it is frequently more cost-effective—in the short-term—to introduce new pollution-abatement technologies at the time that new plants are constructed than to retrofit older facilities with such technologies. Second, it seems more fair to avoid changing the rules of the game in mid-stream, and hence to apply new standards only to new plants. Third, political pressures tend to favor easily-identified existing facilities rather than undefined potential facilities.

On the other hand, VDRs can be expected—on the basis of standard investment theory—to retard turnover in the capital stock (of durable plants and equipment), and thereby to reduce the cost-effectiveness of regulation in the long-term, compared with equivalent undifferentiated regulations.[1] A further irony is that, when this slower turnover results in delayed adoption of new, cleaner technology, VDR can result in higher levels of pollutant emissions than would occur in the absence of regulation.

In this Article, I survey previous applications and synthesize current thinking regarding VDRs in the environmental realm, and develop lessons for public policy and for future research. In Part 2, I describe the ubiquitous nature of VDRs in U.S. regulatory policy, and examine the reasons why VDRs are so common. In Part 3, I establish a

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[1] *See generally* RICHARD A. BREALEY & STEWART C. MYERS PRINCIPLES OF CORPORATE FINANCE (6th ed. 2001), chapter 2, 15-29 (providing background on investment theory).

theoretical framework for analysis of the cost-effectiveness of alternative types of environmental policy instruments to provide a context for the analysis of VDRs. In Part 4, I focus on the effects of VDRs, and describe a general theory of the impacts of these instruments in terms of their effects on technology adoption, capital turnover, pollution abatement costs, and environmental performance. In Parts 5 and 6, I examine empirical analyses of the impacts of VDRs in two significant sectors: Part 5 focuses on the effects of VDRs in the U.S. auto industry, and Part 6 on the effects of new source review, which is a form of VDR, in power generation and other sectors. In Part 7, I examine implications for policy and research, and recommend avenues for improvements in both.

2. The Prevalence of Vintage-Differentiated Regulation

VDRs are found throughout U.S. regulatory policy. They are prominent features of a diverse set of federal environmental statutes and regulations, state and local environmental laws, as well as of a host of non-environmental regulations (Table 1). In this section of the Article, I summarize the use of VDRs in the environmental realm, and then examine explanations for the prevalence of these approaches.

A number of important federal environmental laws make use of VDR. For example, VDRs appear within the Clean Air Act in its standards for emissions from new versus existing stationary sources, motor vehicle and motor vehicle engines, non-road engines and vehicles, and commercial vehicles; within the Clean Water Act in a wide variety of aspects, including in effluent limits for public treatment plants; within the Safe Drinking Water Act; and within laws affecting the generation and disposal of hazardous and solid waste.[2] State and local environmental laws also make frequent use of VDRs, for stationary and mobile source emissions limits, and energy-efficiency standards in new construction, among other instances.[3] In the non-environmental realm, VDRs appear in a variety of occupational health and safety laws, automotive safety regulations, consumer product safety laws, and building codes.[4]

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[2] *See infra* Table 1.

[3] For example, California has established differentiated emissions standards for new motor vehicles. *See infra* Table 1.

[4] For example, the Occupational Safety and Health Act of 1970 seeks to assure men and women of safe working conditions, but some regulations under the statute exempt facilities built before specific dates. *See* Occupational Safety and Health Act of 1970, 29 U.S.C. §§ 651-678 (2005). Likewise, many cities have adopted regulations from fire codes written by national technical organizations, such as the National Fire Protection Association (NFPA); some older facilities—such as dry cleaning shops—are not required to comply with codes that were passed after the shops began operation. Consumer product safety laws, such as regulations promulgated under the Consumer Product Safety Act of 1972, 15 U.S.C. §§ 2051-2084 (2005), typically control (either by design standard or outright banning) new products manufactured for sale, offered for sale, distributed in commerce, or imported into the United States, but do not control products already purchased and in use. Similarly, automotive safety regulations—such as passive passenger restraint requirements—affect new cars, not the entire existing stock of automobiles. And, obviously, most building codes—including those regulating lot size and setback requirements—affect new construction, not previously built structures. See: REDWOOD KARDON, MICHAEL CASEY, AND DOUGLAS HANSEN. CODE CHECK BUILDING: A FIELD GUIDE TO BUILDING CODES. (2005) (providing a review of national building codes).

Why have VDRs been such a common feature of U.S. regulatory policy? As suggested above, proponents frequently claim that VDRs are efficient and equitable. Indeed, it is typically cheaper to build a new plant with required technology in the first place than to retrofit an older, existing plant. In terms of equity, it seems fair to avoid changing the rules for facilities that have already been built or for products that have already been manufactured. On the other hand, the claim of efficiency is based on a static view that ignores the perverse dynamic incentives that such a time-differentiated standard can put in place.[5] Such standards give firms an incentive to continue using (exempt) older polluting plants, rather than investing in new, more environmentally friendly plants that would fall under more stringent regulations. And, in terms of equity, VDRs by definition lack a "level playing field," which hardly appears fair from the perspective of those entering the market and facing the more stringent component of an age-differentiated regulation.

A broader explanation for the prevalence of VDRs is fundamentally political. Both regulated constituents and legislators have very strong incentives to favor these policies.[6] First, on the regulatory demand side, some types of regulations can augment firms' profits through the generation of rents[7] and erection of entry barriers. Consider a simple model of an industry made up of identical firms in long-run competitive equilibrium. If the government imposes a command-and-control standard that sets an allowable level of pollution for each firm, and firms can meet the standard only by reducing their output, the standard will lead to reduced total production and therefore an increase in price along the aggregate demand curve.[8] If the environmental restriction is not exceptionally severe, the new price will be above average cost for all firms, and firms will earn rents. Firms, however, are not limited to the single response of cutting output. They can also reduce emissions by adopting a new technology or changing their input mix. Yet, in this more realistic scenario, command-and-control standards can still have the effect of conveying rents to regulated firms, depending on the stringency of the standards and other factors.[9]

These rents, however, are only sustainable to the extent that other participants cannot freely enter the market—enhanced industry profitability resulting from rents is sustainable *only* in the presence of entry restrictions.[10] In theory, such a mechanism might

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[5]It is by no means impossible, however, to design a VDR that accelerates investment. The nitrous oxide (NO_x) requirements in Titles I and IV of the Clean Air Act Amendments of 1990, for example, provided an inducement in the form of a less ambitious standard for early adopters. *See* Clean Air Act Amendments, Pub. L. No. 101-549, 104 Stat. 2399 (1990).

[6] *See generally,* Nathaniel Keohane, Richard Revesz & Robert Stavins, *The Choice of Regulatory Instruments in Environmental Policy*, 22 HARV. ENVTL. L. REV. 313 (1998) (developing a political economy model of the supply and demand for alternative environmental policy instruments).

[7] Economic rents are payments made to a factor of production—labor, land, or capital—that are in excess of what is required to elicit the supply of that factor.

[8] James M. Buchanan & Gordon Tullock, *Polluters' Profits and Political Response: Direct Controls Versus Taxes*, 65 AM. ECON. REV. 139, 139-141 (1975) (setting out the basic theoretical model of how conventional regulations can convey rents to firms).

[9] Michael T. Maloney & Robert E. McCormick, *A Positive Theory of Environmental Quality Regulation*, 25 J.L. & ECON. 99,105, 122 (1982).

[10] Higher than normal profits in an industry, due to rents, will encourage other firms to enter the market

prohibit new entry outright, but a more politically feasible approach simply imposes higher costs on new entrants.[11] This is precisely what VDRs do. Accordingly, private firms and their trade associations demand command-and-control standards that are more stringent for new sources. This is one important explanation for the prevalence of VDRs in U.S. environmental laws.

Another demand-side explanation for the prevalence of VDRs arises from the differential costs of environmental compliance across firms resulting from varying pollution abatement costs from one firm to another. Because of this heterogeneity, a firm may support policy instruments that impose costs on it, as long as those costs affect it less than the industry average and thus give it a competitive advantage.[12] One form of cost differential arises as a result of the erection of barriers to entry. It is important to distinguish here between the entry of new firms and the expansion of existing firms, but the entry barriers of environmental regulation generally apply to both situations. Thus, within an industry, firms with no plans to expand would derive a greater benefit from entry barriers, which could discourage further growth by their competitors.

Turning to the supply side of regulation, legislators are typically more concerned with the distribution of costs and benefits—in particular their geographic distribution—than with a comparison of total benefits and costs.[13] Politicians are likely to oppose instruments that may induce firms to close business in their districts and relocate elsewhere, leading to localized unemployment.[14] Although there will be winners as well as losers from such relocation, potential losers are likely to be more certain of their status, and thus exert greater political pressure, than potential gainers.[15] This asymmetry creates a bias in favor of the status quo.

For the same reason, grandfathering is likely to be a politically expedient option for legislators, since it allows leeway in rewarding firms and in distributing the costs and benefits of regulation among jurisdictions. By limiting the scope of regulation to new capital assets, the burden of regulatory compliance is concentrated on a small subset of the electorate and the cost is transferred to unspecified, future "new sources." In addition,

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until competition drives down prices, eliminating the rents. Only at this point will other firms cease to enter the market. Hence, barriers to entry are necessary for the sustainability of such rents.

[11] George J. Stigler, *The Theory of Economic Regulation*, 2 BELL J. ECON. 3,5 (1971) (examining how the powers of the state can be used to assist firms through the control over entry of potential rivals); *see generally* Eric Rasmusen & Mark Zupan, *Extending the Economic Theory of Regulation to the Form of Policy*, 72 PUB. CHOICE 167 (1991). (examining how firms choose desired policies from the set including entry barriers, price floors, subsidies, and demand stimulation).

[12] Robert A. Leone & John E. Jackson, *The Political Economy of Federal Regulatory Activity: The Case of Water-Pollution Controls, in* STUDIES IN PUBLIC REGULATION 231, 247, 254, 260 (Gary Fromm ed., 1981) ; Sharon Oster, *The Strategic Use of Regulatory Investment by Industry Sub-Groups*, 20 ECON. INQUIRY 604, 610-611 (1982).

[13] Robert W. Hahn & Robert N. Stavins, *Incentive-based Environmental Regulation: A New Era from an Old Idea?*, 18 ECOLOGY L.Q. 1, 40-41 (1991).

[14] Robert W. Hahn & Roger G. Noll, *Environmental Markets in the Year 2000*, 3 J. RISK & UNCERTAINTY 351, 358 (1990).

[15] When a firm leaves an area, the "losers"—such as those losing their jobs—are easily identified, whereas there is considerable uncertainty regarding the "gainers," i.e. the identification of those individuals who will actually succeed in getting the new jobs.

the costs of such regulation are less obvious when combined with major investments in new capital.[16] In contrast, if regulations were to require retrofits to existing capital assets, the costs would be vastly more transparent.[17]

In summary, the prevalence of VDRs can be understood not simply through claims made about the efficiency and fairness of these approaches, but also through fundamental political forces. Demand for VDRs comes from existing firms, which seek to erect entry barriers to restrict competition and to protect the rents created by command-and-control standards. Environmentalists often support strict standards for new sources because they represent environmental progress, at least symbolically.[18] On the supply side, more stringent standards for new sources allow legislators to protect existing constituents and interests by placing the bulk of the pollution control burden on future facilities.

Recognizing the ubiquity of VDRs in environmental regulation in the United States, I next develop an analytic framework within which these mechanisms can be normatively assessed.

3. The Cost-Effectiveness of Alternative Environmental Policy Instruments

In order to assess the role of VDRs in environmental policy, it is necessary to identify normative criteria by which alternative policy instruments can be judged. A variety of normative criteria have been posited as relevant for choosing environmental policy instruments, including: (1) whether the policy instrument will achieve the stated goal or standard; (2) whether it will do so at the lowest possible cost, including both private-sector compliance and public-sector monitoring and enforcement; (3) whether it provides government with the information it needs to implement the policy; (4) whether the instrument will be flexible in the face of changes in tastes and technology; (5) whether the instrument provides dynamic incentives for research, development, and adoption of better pollution-abatement technologies; (6) whether the implementation of the policy instrument will result in an equitable distribution of the benefits and costs of environmental protection; and (7) whether the policy will be politically feasible in terms of enactment and implementation.[19] Items (1) through (5) together refer to a comprehensive description of the criterion of *cost-effectiveness*, while item (6) refers to

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[16] *See* Keohane, Revesz, & Stavins, *supra* note 6 at 359, 364.

[17] In the context of automobile emissions regulation, Robert W. Crandall and his co-authors noted that "owners of existing equipment can organize to fight regulation that adversely affects their interests. For instance, California automobile owners successfully fought retrofit requirements in the 1960s. In contrast, future purchasers of new equipment do not constitute as cohesive an interest group; therefore regulation tends to be focused upon new vehicles." ROBERT W. CRANDALL ET AL., REGULATING THE AUTOMOBILE 89 (1986).

[18] *See* Keohane, Revesz, & Stavins, *supra* note 6 at 354-56.

[19] *See* Peter Bohm & Clifford F. Russell, *Comparative Analysis of Alternative Policy Instruments*, *in* 1 HANDBOOK OF NATURAL RESOURCES AND ENERGY ECONOMICS 395, 399-402 (Allen V. Kneese & James L. Sweeney eds., 1985) (proposing a list of criteria for environmental regulations). For further details, *see* Richard L. Revesz & Robert N. Stavins, *Environmental Law and Policy*, *in* HANDBOOK OF LAW AND ECONOMICS (A. Mitchell Polinsky & Steven Shavell eds.) (forthcoming 2005).

distributional equity, and item (7) refers to *political feasibility*.[20] This section focuses on the cost-effectiveness criterion.

Cost-effectiveness refers to the allocation of pollution control requirements among sources which results in an aggregate pollution target being achieved at the lowest possible cost. It is well known that the necessary condition for cost-effectiveness is that all sources (that exercise some degree of control) experience the same marginal abatement costs.[21] Recall that the marginal costs of pollution control are the additional or incremental costs of achieving an additional unit of pollution reduction. If these marginal costs of control are not equal across sources, then the same aggregate level of pollution control could be achieved at lower overall cost simply by reallocating the pollution control burden among sources so that the low-cost sources controlled proportionately more pollution and the high-cost sources controlled proportionately less. Additional savings could theoretically be achieved through such reallocations until marginal costs were identical at all sources. Thus, when examining alternative types of environmental policy instruments, a key question is whether particular instruments are likely to result in marginal abatement costs being equated across sources—the point at which they are cost-effective.

The most frequently employed division of environmental policy instruments is between command-and-control versus market-based approaches. Conventional approaches to regulating the environment—frequently characterized as command-and-control[22]—allow relatively little flexibility in the means of achieving goals. Such policy instruments tend to force firms to take on similar shares of the pollution-control burden, regardless of the cost, sometimes by setting uniform standards for firms, the most prevalent of which are technology- and performance-based standards.[23]

Market-based instruments, including pollution charges, tradeable permits, market-friction reductions, and government subsidy reductions, encourage behavior through market signals, rather than through explicit directives regarding pollution control levels or methods.[24] These policy instruments can be described as "harnessing market forces,"[25]

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[20] *See* Bohm & Russell, *supra* note 19.
[21] WILLIAM J. BAUMOL & WALLACE E. OATES, THE THEORY OF ENVIRONMENTAL POLICY 165-67 (Cambridge University Press 1988) (1975).
[22] The phrase "command-and-control" is by far the most commonly employed characterization for conventional environmental policy instruments, including uniform performance and technology standards. Admittedly, the phrase has an inescapable negative stigma associated with it, and so a better, more neutral description of this category of policy approaches might be "prescriptive instruments." Nonetheless, "command-and-control" is the generally accepted name for this category.
[23] Note that uniform standards can specify the amount of pollution that can be released into the environment (an emission standard) or the permissible concentration of pollution in the air, water, or soil (an ambient standard). The cost-effective allocation consistent with ambient standards requires equalization of the marginal costs to reduce a unit of ambient concentration, rather than emission.
[24] *See* Hahn & Stavins, *supra* note 13, at 7-15. *See also* Robert N. Stavins, *Experience with Market-Based Environmental Policy Instruments*, *in* 1 THE HANDBOOK OF ENVIRONMENTAL ECONOMICS 355, 360-61 (K.G. Mäler & J. Vincent, eds., Elsevier 2003). Liability rules can also be thought of as a market-based instrument, because they provide incentives for firms to take into account the potential environmental damages of their decisions, allowing full flexibility in technology and control practices. *See generally,* RICHARD L. REVESZ, FOUNDATIONS IN ENVIRONMENTAL LAW AND POLICY (1997) (considering liability

because, when well designed and properly implemented, they encourage firms or individuals to undertake pollution control efforts through generation of an economic interest in compliance.

Where there is significant heterogeneity of costs, holding all firms to the same target will be unduly expensive, and command-and-control methods will not be cost-effective. Real world control costs can vary enormously due to production design, physical configuration, age of assets, and other factors. Indeed, abatement cost heterogeneity is a ubiquitous and important characteristic of many environmental problems.[26] The cost of controlling a unit of a given pollutant may vary by a factor of 100 or more among sources.[27] This heterogeneity argues for the use of market-based instruments in many cases.

If properly designed and implemented, market-based instruments can allow any desired level of pollution cleanup to be realized at the lowest overall cost to society, by providing the incentives for the greatest reductions in pollution to those firms that can achieve the reductions most cheaply. Rather than equalizing pollution levels among firms, market-based instruments have the effect of encouraging firms to equalize their marginal abatement costs.[28] Command-and-control approaches could, in theory, achieve this cost-effective solution, but this would require that different standards be set for each pollution source, and, consequently, that policy makers obtain detailed information about the compliance costs each firm faces. Such information, which is privately generated by firms when it is known at all, is simply not available to government. Thus, potentially cost-effective, non-uniform performance standards are generally considered to be

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rules among other market-based instruments). Other taxonomies of regulatory instruments are possible, and some take a more inclusive view, including, for example, contractual approaches. On this, *see generally* ENVIRONMENTAL LAW (Peter S. Menell, ed., 2002) (including contractual approaches as a category of environmental policy instruments).

[25] *See generally* J.B. OPSCHOOR & HANS B. VOS, ECONOMIC INSTRUMENTS FOR ENVIRONMENTAL PROTECTION (Org. for Econ. Coop. and Dev. 1989) (surveying economics-based environmental policy instruments); ECON. INCENTIVES TASK FORCE, U.S. ENVTL. PROT. AGENCY, PUB. NO. 21P-2001, ECONOMIC INCENTIVES: OPTIONS FOR ENVIRONMENTAL PROTECTION (1991) (discussing economic incentives in solid waste, climate change, and water resources contexts),; ALAN CARLIN, U.S. ENVTL. PROT. AGENCY, PUB. NO. EPA-230-R-92-001, THE UNITED STATES EXPERIENCE WITH ECONOMIC INCENTIVES TO CONTROL ENVIRONMENTAL POLLUTION (1992) (for early assessments of the use of market-based instruments in environmental policy).

[26] TOM H. TIETENBERG, EMISSIONS TRADING: AN EXERCISE IN REFORMING POLLUTION POLICY 16, 42-43 (1985) (describing heterogeneity in abatement costs).

[27] For numerical examples of the heterogeneity of incremental costs of pollution control, see Robert W. Crandall, *The Political Economy of Clean Air: Practical Constraints on White House Review*, *in* ENVIRONMENTAL POLICY UNDER REAGAN'S EXECUTIVE ORDER: THE ROLE OF BENEFIT-COST ANALYSIS 205, 210-15 (V. Smith ed. 1984). But where costs are similar among sources, command-and-control instruments may perform equivalently to (or better than) market-based instruments, depending on transactions costs, administrative costs, possibilities for strategic behavior, political costs, and the nature of the pollutants. *See generally* Richard G. Newell & Robert N. Stavins, *Cost Heterogeneity and the Potential Savings from Market-Based Policies*, 23 J. REG. ECON. 43 (2003) (analyzing the effects of abatement cost heterogeneity on the magnitude of aggregate abatement costs).

[28] David W. Montgomery, *Markets in Licenses and Efficient Pollution Control Programs*, 5 J. ECON. THEORY 395, 400-01 (1972); Baumol & Oates, *supra* note 21, at 168, 182.

infeasible, both because of the asymmetric information problem identified above and because unequal standards would raise questions of fairness among policy makers.

If the government has reason to believe that abatement costs are highly correlated with the (more easily observed) vintage of sources, despite the fact that it cannot observe source-specific abatement costs, then an appropriately-designed vintage differentiated regulation could theoretically serve as an approximation of a cost-effective, non-uniform standard. The quality of that approximation would depend, of course, on the degree of correlation of abatement costs with the VDR's quantitative pollution standards. Given that abatement cost heterogeneity is typically distributed continuously and as a function of many factors, it is unlikely that a simple, unidimensional and dichotomous VDR would serve as a good approximation.[29] Nevertheless, this is an empirical question.[30]

Even if a VDR were perfectly correlated with underlying abatement cost heterogeneity, and therefore cost-effective in the short term, such an instrument, like any non-uniform performance standard, would still fail to provide dynamic incentives for sources to adopt cheaper and better pollution-control technologies over time. With market-based instruments, most clearly with emission taxes, firms benefit by cleaning up a bit more than is required if a sufficiently low-cost method (technology or process) of doing so can be identified and adopted.[31]

Furthermore, VDRs, unlike market-based instruments, and indeed unlike ordinary non-uniform standards, present another problem: an environmentally negative dynamic incentive for regulated firms to extend the useful lives of their plant and equipment, thereby reducing cost-effectiveness and possibly retarding environmental progress. This issue—the effect of VDRs on investment and maintenance decisions, and the implications for abatement costs and environmental performance—is the focus of the remainder of this article.

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[29]This assessment of the potential static cost-effectiveness of VDRs is specific to the realm of pollution abatement, for the reasons given above. For an analysis of the economic implications of a much broader class of policies, of which VDRs are only one category, and environmental VDRs a still smaller subset, *see generally* Steven Shavell, *Optimal Legal Change When Adjustment to Legal Change is Costly* (Harvard Law School, Working Paper, 2005) (on file with author). The key previous work along those lines is by Louis Kaplow. *See* Louis Kaplow, *An Economic Analysis of Legal Transitions*, 99 HARV. L. REV. 509, 582-92 (1986); Louis Kaplow, *Government Relief for Risk Associated with Government Action*, 94 SCANDINAVIAN J. ECON. 525, 534-35 (1992).

[30]The existing theoretical and empirical literature on environmental VDRs (surveyed in subsequent sections of this paper) gives very little attention to the potential static cost-effectiveness of VDRs as dichotomous approximations to unobservable continuous distributions of abatement-cost heterogeneity. Rather, this possibility seems to be taken for granted, a reality that was brought home to me by Shavell, *supra* note 29.

[31] Paul B. Downing & Lawrence J. White, *Innovation in Pollution Control*, 13 J. ENVTL. ECON. & MGMT. 18, 21-22 (1986); Scott R. Milliman & Ronald Prince, *Firm Incentives to Promote Technological Change in Pollution Control*, 17 J. ENVTL. ECON. & MGMT. 247, 257-58 (1989); Adam B. Jaffe & Robert N. Stavins, *Dynamic Incentives of Environmental Regulations: The Effects of Alternative Policy Instruments on Technology Diffusion*, 29 J. ENVTL. ECON. & MGMT. S43, S45-46 (1995).

4. Impacts Theory of Vintage-Differentiated Regulation

The core theory of the effects of vintage-differentiated regulation on the lives of durable plant and equipment comes from the general theory of the determinants of the age of capital.[32] Consider a simple model in which a firm's production decision can be characterized by the choice of two variables: the number of pieces of durable equipment to be operated and the lives of each of these devices. Inevitably, these pieces of durable equipment (for example, machines) degrade over time. In other words, maintenance costs rise as the machines age. If competitive firms seek to maximize their profits, they will place new machines in service if and only if the present discounted value of the expected future net revenue per machine (revenue from its use minus maintenance costs) exceeds a new machine's initial cost. This theory leads to the intuitive profit-maximizing rule that machines should be run until maintenance costs equal net revenues.

The impacts of vintage-differentiated environmental regulation can be understood with this simple model of capital replacement. VDR endows old machines with a value that cannot be transferred, since new machines are rendered systematically more costly due to more stringent regulation. The effective price of new capital is increased, and old capital is accordingly retired at a later date. Hence, the average age of capital increases and the rate of investment decreases.[33]

A more specialized model, with explicit representations of product and pollutant output[34] reinforces the finding that the systematic bias against new sources in VDR has the effect of retarding the rate of turnover of the capital stock. Pollution abatement costs are therefore higher under a VDR scheme than under an equivalent undifferentiated regulation scheme. Strikingly, the relationship between aggregate pollutant emissions and regulatory stringency can be perverse, with more stringent regulation leading to increased aggregate emissions. This can occur when VDR is applied to technologies in which newer vintages have lower pollutant emissions (even in the absence of the vintage differentiated regulation).[35] Requiring pollution control technologies only for new

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[32] Robert N. Stavins, *The Effects of Vintage-Differentiated Environmental Regulation*, 2005 AEI-BROOKINGS JOINT CTR. FOR REGULATORY STUDIES, Related Pub. 05-03, 4 (explicating a mathematical model of differentiated regulation); *see also* Michael T. Maloney & Gordon L. Brady, *Capital Turnover and Marketable Pollution Rights*, 31 J.L. & ECON 203, 207-09 (1988) (describing a simpler model that this article employs); *see generally* Howard K. Gruenspecht, Differentiated Social Regulation in Theory and Practice (1981) (unpublished Ph.D. dissertation, Yale University) (providing a detailed theoretical model of differentiated regulation).

[33] A more complex model would also allow for endogenous maintenance. As is discussed in sections 5 and 6 below, VDRs create incentives to extend the useful lives of equipment in two ways: first, by keeping it longer (as in the model above), and second by investing more in maintenance throughout the life of the equipment than would otherwise be the case. The latter incentive reinforces the capital investment effect examined above. For a general discussion of endogenous maintenance, *see* Nathaniel Keohane et al., *Controlling Stocks and Flows to Promote Quality: The Environment, with Applications to Physical and Human Capital* (NAT'L BUREAU OF ECON. RESEARCH 31-36, Working Paper No. 7727, 2000) (discussing optimal maintenance of physical capital).

[34] *See generally* Gruenspecht, *supra* note 32. (describing and using such a model).

[35] These effects are heightened, of course, if the older technology in question exhibits increasing emissions (degraded abatement) as it ages.

sources forces a choice between continuing to operate older, uncontrolled equipment and adopting new, cleaner equipment with the additional expense of a pollution control technology. Such conditions are typical in the environmental regulatory sphere.[36] Thus, increasing the stringency of a VDR can drive up costs *and* simultaneously drive down benefits (by increasing emissions due to the continued use of old equipment without emission control).

In summary, VDRs can have significant impacts on decisions regarding capital investment. A regulatory bias against new sources will reduce investment in new facilities and lengthen the economic lives of existing facilities. Most remarkable, more stringent VDRs can, at least in the short-term, be environmentally counter-productive, increasing the aggregate emissions level, rather than reducing it, if they discourage the use of cleaner new technology strongly enough.[37] Granted, in theory, a more stringent VDR would lead ultimately to lower aggregate emissions as the older, retained vintage of equipment is retired. Nevertheless, the perverse effects on investment can lead to short-term emissions increases.

A key question is, therefore, how long the "short-term" will be. If the short-term is truly short, perverse effects of VDRs will be minimized. However, the trade-off between short-term and long-term effects becomes problematic when the sources subject to regulation have especially low rates of deterioration and technical obsolescence–conditions which are met by power plants, for example. In this case, the "short-term" is very long, on the scale of decades, and vintage-differentiated regulations are likely to be particularly problematic. It is an empirical question, however, as to whether the extreme, counter-productive outcome actually occurs in any given case. I examine empirical evidence of the effects of VDRs in the auto industry (where turnover might be expected to be relatively high) and in the power generation industry (where turnover is very low) in parts 5 and 6, below.

5. Vintage-Differentiated Regulation in the U.S. Auto Industry

Vintage differentiation has been a prominent feature of U.S. motor vehicle regulation, including automobile emissions standards under the Clean Air Act, automotive safety standards under the National Traffic and Motor Vehicle Safety Act (1966), and the Corporate Average Fuel Economy (CAFE) standards under the Energy Policy and Conservation Act amendments (1975).[38] In all three cases, more stringent standards apply to vehicles of later vintages. Research in this area suggests the following.

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[36] As market forces push technological developments to reduce economic waste, the result can be more efficient use of energy, fewer discharges, and so on. Hence, in the environmental realm, it is frequently the case that new generations of technologies exhibit lower pollutant emissions (even in the absence of vintage differentiated regulations intended to bring down emissions over time).

[37] Howard K. Gruenspecht, *Differentiated Regulation: The Case of Auto Emissions Standards,* 72 AM. ECON. REV. 328, 328 (1982).

[38] Clean Air Act, Pub. L. No. 95-95, 91 Stat. 865, (codified as amended at 43 U.S.C. §§ 7401-7661) (1977) ; National Traffic and Motor Vehicle Safety Act, Pub. L. No. 89-563, 80 Stat. 718 (codified as amended at 15 U.S.C. §§ 1381-1431); Energy Policy and Conservation Act Amendments, Pub. L. No. 94-163, 89 Stat. 871 (codified as amended at42 U.S.C. §§ 6231-6247) (1975).

First, VDRs have extended the useful lives of cars on the road, and therefore theoretically may have increased aggregate emissions.[39] But empirical analyses addressing whether motor vehicles—with their relatively rapid rate of turnover—have actually exhibited counter-productive emissions increases due to VDRs has been less clear cut. Whereas cost-effectiveness was certainly compromised, impacts on aggregate emissions appear to have been small (although statistically significant) and temporary.[40] Furthermore, the costs of retrofitting motor vehicles for pollution control or fuel efficiency are typically prohibitive (less so for some safety standards),[41] and so in this realm the simple replacement of VDRs with undifferentiated regulation (that is, elimination of grandfathering) is not an attractive or even feasible alternative. Rather, a number of alternative regulatory strategies may hold some promise.[42]

5.1 Theoretical Analysis of the Effects of Automobile VDR

In general terms, the anticipated effects of automobile VDR are linked with a retirement decision regarding a durable good. With well-functioning markets for both new and used cars, it is reasonable to anticipate that (on average) cars will be scrapped if and only if the net market value of a car in operable condition is less than that car's repair cost.[43]

Since new and used cars are substitutes for each other, any increase in the price or operating costs of new cars causes substitution of used cars, increasing demand in that relatively inelastic[44] market and thereby driving up the price of used cars. The result is that the economic lives of used cars are extended, scrapping rates fall, and there are more cars of the older vintage on the road.[45] Since the emissions of older vintages of cars are generally greater than those of newer vintages of cars, the delay in retiring vehicles could result in counter-productive increases in aggregate emissions. Again, whether such emission increases actually occur is an empirical question; two of the key variables required to answer it are the price elasticities of scrappage and of new vehicle sales.[46]

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[39] See notes 52-55 *infra*, and accompanying text.
[40] See notes 52-54 *infra*, and accompanying text.
[41] *See* Crandall et al., *supra* note 17, at 89.
[42] See section 7, *infra*.
[43] *See* Gruenspecht, *supra* note 37 at 328. For further details on the underlying mathematical model, see Stavins, *supra* note 32.

[44] Elasticity of demand refers to the responsiveness of demand to changes in price. An inelastic market is one in which a one percent change in price leads to less than a one percent change in quantity demanded.
[45] *See* Gruenspecht, *supra* note 37 at 328.
[46] Researchers have conducted theoretical and empirical investigations of "accelerated vehicle retirement programs" as a means of reducing aggregate pollutant emissions by increasing the rate of turnover of the automobile fleet . *See, e.g.,* Robert W. Hahn, *An Economic Analysis of Scrappage,* 26 RAND J. ECON. 222, 238-40 (1995) (examining the impact of policies aimed at encouraging the retirement of older, high-polluting vehicles) ; *see generally* Anna Alberini et al., *Determinants of Participation in Accelerated Vehicle-Retirement Programs,* 26 RAND J. ECON. 93 (1995) (presenting an empirical analysis of the factors affecting participation in accelerated vehicle-retirement programs).

In a comprehensive assessment of automotive regulation, Crandall et al. raised three primary concerns.[47] First, because VDR increases the price of new cars, it affects the used car market (as outlined above) and provides incentives to extend the useful lives of automobiles. Such extensions can "partially or fully offset the direct emissions-reducing impact of tighter standards for a considerable period."[48] Second, since VDR establishes a direct link between the rate of fleet turnover and environmental performance, when new car sales fall below expectations environmental progress can be compromised.[49] Third, VDRs for automobiles provide no incentives for individual car owners to maintain their emissions control systems (in the absence of inspection programs).[50]

5.2 Empirical Analysis of the Effects of Automobile VDR

Analyzing the effects of motor vehicle VDRs provides an opportunity to test a centrally important empirical question: do VDRs have counter-productive effects on aggregate emissions even when applied to a durable good with a relatively rapid rate of capital turnover? To investigate this, Gruenspecht estimated the key demand elasticities of scrappage and new vehicle sales from empirical data and combined these with an independent estimate of the cost penalty associated with the 1981 new car emissions standards for carbon monoxide (CO) and nitrogen oxides (NO_x).[51] This enabled him to calculate the effect of the adoption of the more stringent new car standards on auto scrappage rates and then estimate the net effects of the VDR on aggregate emissions.

Gruenspecht found that the VDR had depressed new car sales by between 2% and 4% over the first five years after the regulation came into force.[52] As a result, CO emissions were actually increased by the regulation by approximately 1% per year over the first four years before declining in year five. Hydrocarbon emissions were increased up to 2% per year over the first five years before declining in year six, while NO_x emissions were uniformly decreased by regulation. Of course, the CO and hydrocarbon effects were short term. Six years after the regulation had come into effect, emissions of all three pollutants had declined.[53] By the end of 1990, the level of emissions had fallen 5.3% below baseline for CO and 16% below baseline for HCs.[54] Thus, counter-productive environmental performance was a temporary phenomenon.[55] Nevertheless, by

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[47] *See* CRANDALL ET AL., *supra* note 17 at 89-90. In an earlier theoretical study, Kwoka demonstrated that CAFE alters the mix and total number of vehicles in the fleet in ways that could "partially or even fully offset the fuel savings envisioned by a rising CAFE." John E. Kwoka Jr., *The Limits of Market-Oriented Regulatory Techniques: The Case of Automotive Fuel Economy.* 98 Q. J. ECON 695, 696 (1983

[48] CRANDALL ET AL., *supra* note 17, at 89.

[49] CRANDALL ET AL., *supra* note 17, at 89-90.

[50] CRANDALL ET AL., *supra* note 17 at 90.

[51] *See generally* Gruenspecht, *supra* note 37 (for details of his analysis).

[52] Gruenspecht, *supra* note 37, at 330.

[53] *Id.*

[54] *Id.*

[55] *Id* at 330-31. The long-term favorable effects on emissions of the retirement of older vehicles when new car emissions standards become more stringent are documented by Matthew E. Kahn, *New Evidence on Trends in Vehicle Emissions*, 27 RAND J. OR ECON. 183, 194-95 (1996).

delaying turnover in the vehicle fleet, the VDR did not reduce emissions as quickly as the legislative standards would suggest[56] and the cost-effectiveness of the policy was reduced.

A few authors have contrasted the vintage-differentiated regulations in motor vehicle emissions laws and the VDR-based Corporate Average Fuel Economy (CAFE) standards[57] with alternative approaches. For example, Gruenspecht considered a $250 "bounty" for scrapping 15-year old cars,[58] for which he predicted an environmental performance better than either the actual VDR or the absence of it. Similarly, Crandall contrasted the CAFE program with commensurate gasoline taxes; Crandall found CAFE to be the more costly regulatory option for improving fuel economy.[59] This comparison goes well beyond VDRs, of course: there are other reasons why CAFE standards are a relatively costly means of achieving fuel conservation in addition to the component of CAFE that features vintage differentiation.[60] Nevertheless, it should be noted that CAFE adds to the cost of new vehicles, thereby reducing new car sales and extending the life of old vehicles while having no fuel-use reducing effects on old vehicles. This contrasts with a gasoline tax, which increases the marginal cost of driving for all vehicles while simultaneously inducing car owners to trade in old fuel-inefficient cars for newer, more fuel-efficient ones by increasing the cost of operation of older cars.[61]

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[56] CRANDALL ET AL., *supra* note 17, at 91-97.

[57] The Energy Policy and Conservation Act of 1975 established fuel efficiency standards for automobiles and light trucks, requiring manufacturers to meet minimum sales-weighted average fuel efficiency for their fleets sold in the United States. A penalty is charged per car sold per unit of average fuel efficiency below the standard. The program operates like an intra-firm tradeable permit system, since manufacturers can undertake efficiency improvements wherever they are cheapest within their fleets. Light trucks, which are defined by the Federal government to include "sport utility vehicles," face weaker CAFE standards.

[58] Gruenspecht, *supra* note 37, at 329-330.

[59] Robert W. Crandall, *Policy Watch: Corporate Average Fuel Economy Standards,* 6 J. ECON. PERSPECTIVES 171, 175-79 (1992).

[60]For varying assessments of the CAFE program's costs relative to equivalent gasoline taxes, see generally CRANDALL ET AL. (1986), *supra* note 17; Pinelopi K. Goldberg, *The Effects of the Corporate Average Fuel Efficiency Standards* (Nat'l Bureau of Econ. Research, Working Paper No. 5673, 1997) (finding a 780% increase in gas tax would be required to make the emissions reductions gains reached through CAFE) National Research Council, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (The National Academies Press 2002) (finding fuel tax to be a superior alternative to CAFE); Ian W. Parry et al., *Should Corporate Average Fuel Economy (CAFE) Standards be Tightened?* (Resources for the Future, Discussion Paper 04-53, 2004) (discussing factors affecting efficacy of higher CAFE standards).

[61] How strong have these effects, which result both from CAFE's VDR component and its other aspects, been? Estimates of the welfare costs of CAFE range from $0.41 to $0.63 per gallon of gasoline conserved, compared with welfare costs of $0.08 per gallon conserved for a 2.4 cents per gallon tax, indicating a five to eight-fold cost differential *See* Robert W. Crandall & John D. Graham, *The Effect of Fuel Economy Standards on Automobile Safety,*32 J. L. & ECON. 97, 115-18 (1989); David L. Greene, *CAFE or Price?: An Analysis of the Effects of Federal Fuel Economy Regulations and Gasoline Price on New Car MPG, 1978-89*, 11 ENERGY J. 37 (1990) Andrew N. Kleit, *The Effect of Annual Changes in Automobile Fuel Efficiency Standards*, 2 J. REG. ECON. 151, 164 (1990). Not too much should be made of this comparison, however, since the CAFE program is much more stringent than a 2.4 cent per gallon gasoline tax. If the marginal costs of fuel efficiency increase over the relevant domain, which is the case, then on this basis alone, one would anticipate some cost differential.

The perverse incentives of VDRs also arose in the context of the California Air Resources Board's 1990 requirement that automobile manufacturers include zero-emissions vehicles[62] (ZEVs) in their 1998 California sales mix.[63] Although the requirement would have slightly reduced emissions from the average new car sold in the state, the program would also have had the effect of increasing prices of both electric (ZEV) and non-electric vehicles, as manufacturers spread the costs of developing the ZEVs and the subsidies needed to induce consumers to buy them. Gruenspecht found that new car purchases would consequently fall by 2% to 3%, commensurate with an increase in the retention of less efficient older cars in the fleet.[64] Gruenspecht's analysis indicates that the extra emissions thereby generated would more than offset the emissions reductions from the ZEVs.

Have VDRs had counter-productive effects on aggregate emissions in the automotive sector, despite the relatively rapid rate of capital turnover that characterizes this realm? It appears clear from the existing body of research—both theoretical and empirical—that VDRs have extended the useful lives of cars on the road, and therefore *can* increase aggregate emissions. Empirical analysis addressing whether motor vehicles have exhibited counter-productive emissions increases due to VDRs indicates that, as would be expected, these impacts have been temporary and relatively short term. Nevertheless, cost-effectiveness was compromised. But because the costs of retrofitting motor vehicles for pollution control or fuel efficiency would be prohibitive, the simple replacement of VDRs with undifferentiated regulation is not an attractive or even feasible alternative in the automotive realm. Rather, alternative regulatory approaches merit ongoing exploration, a topic to which I return in section 7 of this article.

6. New Source Review

The Clean Air Act's New Source Review (NSR) program is a widely studied example of vintage-differentiated regulation, particularly as it relates to the coal-fired electricity generation sector.[65] This is an important and controversial application of VDRs

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[62] Zero Emissions Vehicles (ZEVs) are those certified to meet the most stringent emission standards established by the California Air Resources Board, which require zero regulated emissions of nonmethane organic gases, carbon monoxide, and nitrogen oxides. For a summary of California's ZEV regulations, including links to regulations for each model year, *SEE* California Air Resources Board, Zero Emissions Vehicle Legal and Regulatory Activities (2005), http://www.arb.ca.gov/msprog/zevprog/zevregs/zevregs.htm (last visited Nov. 3, 2005) (on file with author). A ZEV is most likely powered by electricity, fuel cells, or hydrogen.

[63] For historical and current requirements and methods of compliance, see: California Air Resources Board. Memorandum from Alan Lloyd, Chairman, regarding "Zero-Emission Vehicle (ZEV) Credit Reporting and Tracking System." Manufacturers Advisory Correspondence (MAC) 2004-01, www.arb.ca.gov/msprog/macs/mac0401/mac0401.pdf, March 24, 2004 (last visited Nov. 3, 2005) (on file with author).

[64] Howard K. Gruenspecht, *Zero Emission Vehicles: A Dirty Little Secret*, 142 RESOURCES 7, 8 (2001).

[65] In 2003, the Bush administration initiated changes in the New Source Review program. The research considered in this paper deals with the program prior to those changes. The basic requirements of the NSR program were established in Parts C and D of Title I of the Clean Air Act. A series of regulatory changes in NSR, not analyzed in this article, are detailed at: EPA New Source Review Regulatory Actions, http://www.epa.gov/nsr/actions.html (last visited Oct. 30, 2005) (on file with author).

in U.S. environmental policy, and it contrasts with the automotive sector because of the longer life of the relevant capital. NSR sets technology-based emissions control requirements for new sources and for sources that are being expanded or modified significantly. The regulations thereby exclude existing facilities from emissions control requirements, essentially requiring new or upgraded power plants and some other types of facilities to be cleaner than old ones.[66] Because of the incentives this creates to extend the life of older plants rather than build new, more stringently-regulated, facilities, concern exists that NSR wastes resources and can retard environmental progress.[67]

The NSR program applies to any new source whose potential emissions at full utilization are high enough to qualify it as a major source.[68] The program also applies to any modification at an existing major source resulting in an emissions increase. In addition to securing a permit prior to commencing construction or modification, sources subject to NSR must achieve emission rates that reflect the performance of the best-available emissions-control technology.[69]

The NSR requirements under the Clean Air Act date back to the 1970s. Those who wrote the Act presumably thought they could secure greater environmental progress by imposing tougher emissions standards on new power plants (and certain other emission sources) than on old ones. The frequently-voiced theory was that emissions would fall as old plants were retired and replaced by new, cleaner plants.[70] Critics claim that experience over the past 25 years has shown this approach to be both excessively costly and environmentally counterproductive, because firms have been motivated to keep old (and dirty) plants operating and to hold back on investments in new (and cleaner) power generation technologies.

[66] 42 U.S.C. § 7411 (B)(1)(b) (2005); *see also* 42 U.S.C. § 7411 (D)(1) (2005) (establishing standards for existing sources); *see generally* U.S. ENVTL. PROT. AGENCY, Document No. II-A-01, NSR 90-DAY REVIEW BACKGROUND PAPER (2001) *available at* http://www.epa.gov/nsr/documents/nsr-review.pdf (last visited Nov. 3, 2005) (on file with author).

[67] *See, e.g.*, Howard K. Gruenspecht & Robert N. Stavins, Op-Ed., *A Level Field on Pollution at Power Plants*, BOSTON GLOBE, Jan. 26, 2002 at A15; Howard K. Gruenspecht & Robert N. Stavins, *New Source Review Under the Clean Air Act: Ripe for Reform,* 147 RESOURCES 19, 19 (2002) [hereinafter Gruenspecht and Stavins, *New Source Review*].

[68] The cut-off value used to determine whether a source is major generally varies between 10 and 100 tons of emissions per year, depending on the source category and the severity of any air quality problem where the source is located. *See* U.S. ENVTL. PROT. AGENCY, note 66 *supra*, at 3.

[69] NSR sources located in areas that do not meet national ambient air quality standards are also required to secure offsets for their emissions. *See* U.S. Envtl. Prot. Agency, note 66 *supra*, at 5.

[70] For a historical perspective on the development of the 1971 and 1979 new source standards, *see generally* BRUCE A. ACKERMAN & WILLIAM T. HASSLER, CLEAN COAL/DIRTY AIR (1981). For an early assessment of the effects of the regulations, *see generally* Frank M. Gollop & Mark J. Roberts, *Environmental Regulations and Productivity Growth: The Case of Fossil-fueled Electric Power Generation,* 91 J. POL. ECON. 654 (1983).

6.1 NSR and New Power Plants

In theory, NSR can create perverse environmental incentives, especially when major technology advances make new plants much cleaner than old ones. Several studies have empirically examined the hypothesis that NSR in the electricity generation sector has extended the useful lives of existing plants and delayed the construction of replacement capacity, thereby having a perverse effect on emissions abatement.

One study examined the relationships between regulation and capital turnover, and capital age and emissions.[71] In research carried out across time and across firms, the researchers found a statistically significant inverse relationship between the rate of new plant investment and the presence of air quality regulation, controlling for other relevant variables. In other words, increased air quality regulation was correlated with decreased new plant investment even when allowing for the effects of other factors. The authors conclude that "these results convince us that regulation has induced delay in the retirement of capital and that this delay has been detrimental to the improvement of the environment."[72]

A second study, working with different data, provided partial validation of the presence of a regulatory-induced lengthening of the life of capital, finding that "increases in regulatory intensity lead firms to delay the construction of new steam-generating plants."[73] In this case, the researchers found that over the period from 1969 to 1983 environmental regulations increased plant age by more than twenty-two percent.[74] However, for the most part, the study did not find a significant effect of plant age on emissions.[75] The reason for this may be found in an earlier study by Joskow and Schmalensee, which noted that fuel efficiency in coal-fired plants improved throughout the 1960s, but stabilized in the 1970s (and may even have declined for some new units).[76] If fuel efficiency was related to emissions, then older plants may not have been more polluting than newer ones during that period.

A much more recent analysis by Swift illustrates how NSR requirements can impede the adoption of cleaner and more efficient energy technologies, such as combined

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[71]*See generally* Maloney & Brady, *supra* note 32.

[72]*Id.* at 222. In particular, Maloney & Brady found that in the ten states with the greatest regulatory expenditures, the regulation-induced component of capital longevity was approximately 8 years (of an average longevity of 33 years), and emissions rates were elevated 27 percent because of the impacts of regulation on the age of capital. *See also* Randy A. Nelson, *Regulation, Capital Vintage and Technical Change in the Electric Utility Industry*, 66 REV. ECON. & STAT. 59, 66 (1984).

[73]Randy A. Nelson, Tom Tietenberg, & Michael R. Donihue, *Differential Environmental Regulation: Effects on Electric Utility Capital Turnover and Emissions*, 75 REV. ECON. & STAT. 368, 371 (1993).

[74] *Id.* at 373.

[75] *Id.*

[76] Paul L. Joskow & Richard Schmalensee, *The Performance of Coal-Burning Electric Generating Units in the United States: 1960-1980*, 2 J. APPLIED ECONOMETRICS 85, 107 (1987)

heat and power (CHP) systems.[77] Swift found that NSR rules pose a deterrent to the spread of CHP technology, although it is difficult to disentangle the effects of the regulation's technology-standard approach from the effects of the regulation's NSR component *per se*.[78] In any event, the rules require the application of end-of-pipe control technology to an already clean turbine with very low emissions.[79] This requirement can significantly increase the cost of a CHP project and removes only a small amount of pollution, resulting in a very high cost-per-ton of removal, more than $25,000 by Swift's estimate for the most modern plants, or twenty-five to seventy-five times the cost of emissions reductions available from existing sources.[80]

In addition to delaying capital stock turnover, NSR can promote environmentally perverse decisions regarding the use of new capacity. NSR can change the operating costs of plants of various vintages in ways that theoretically provide incentives for companies to favor the utilization of older plants over newer ones fitted with more effective emissions control technologies. For example, new coal-fired power plants built following passage of the 1977 Clean Air Act Amendments were essentially required to install scrubbers to remove sulfur dioxide (SO_2) emissions. But the "costs of running scrubbers were high enough that new coal-fired plants were more expensive to operate than many existing ones, which were not regulated under a new source standard." [81] "Under these conditions, utilities might be expected to reduce output from their new, scrubbed units while operating older plants at full capacity during off-peak seasons and time periods."[82]

These effects were validated empirically in an econometric analysis by Stanton, which found that plants with laxer environmental requirements were utilized more intensely.[83] Thus, by reversing the usual preference for maximizing use of modern plants, vintage-differentiated regulation of SO_2 emissions under the Clean Air Act reduced the environmental benefits resulting from the mandated investment in expensive scrubbing equipment.[84]

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[77]In a modern CHP system, fuel is burned in a turbine to generate electricity, and the waste heat from combustion, which in conventional stand-alone generation systems is vented to the atmosphere, is used in commercial or industrial processes at the site. A new CHP installation using a gas-fired turbine with low-nitrogen oxide burners and no end–of–pipe emissions controls substantially reduces nitrogen oxide emissions from levels that would result from the continued operation of an existing onsite boiler to provide process heat and an offsite power plant to provide power. CHP also allows for a substantial reduction in the total primary energy input required to meet heat and power needs, yielding economic benefits and lower carbon dioxide emissions. *See generally*, Byron Swift, *Grandfathering, New Source Review and NOx - Making Sense of a Flawed System*, 31 BUREAU NAT'L AFF. ENV'T REP. 1538 (2000). (describing CHP systems and assessing the impacts of NSR)

[78] *See* Swift, *supra* note 77, at 1539-42.]
[79] *Id.* at 1541.
[80] *Id.* at 1539, 1542.
[81] *Id.*.
[82] *Id.* at 21.
[83] Timothy J. Stanton, *Capacity Utilization and New Source Bias: Evidence from the U.S. Electric Power Industry*, 15 ENERGY ECON. 57, 58-60 (1993). (examining statistically the relationship between operating costs at U.S. electric power plants and utilization rates).

[84] The SO_2 allowance trading program, implemented in 1995 under the Clean Air Act Amendments of 1990, overcame these inefficiencies in SO_2 regulation associated with NSR-type programs. *See* Byron

6.2 NSR and Existing Power Plants

NSR applies to existing plants only if they carry out a major modification which results in a net increase in emissions.[85] This approach—which at first may sound perfectly reasonable—has several problems.[86] First, old plants typically emit the vast majority of total pollution in any sector,[87] but NSR does not provide a continuous and effective incentive for emissions reductions at these plants. As a result, many of the most cost-effective emissions reduction opportunities are simply left untouched.[88] Second, because the lengthy and costly NSR process is triggered by "modifications," the NSR program provides a powerful disincentive for improvements and efficiency upgrades at old plants.[89] Since adjusting existing equipment to perform more efficiently can be a source of pollution reductions as well as cost savings, this effect of NSR can be both economically and environmentally harmful.

Finally, NSR creates an uncertain regulatory environment with potentially high transaction costs.[90] NSR may discourage companies from maintaining their existing facilities. Plant owners contemplating maintenance activities must weigh the possible loss of considerable regulatory advantage if the work crosses the murky line between upkeep and improvement.[91] Protracted, costly, and time-consuming legal wrangling is inevitable

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Swift, *How Environmental Laws Work: An Analysis of the Utility Sector's Response to Regulation of Nitrogen Oxides and Sulfur Dioxide Under the Clean Air Act*, 14 TUL. ENVTL. L.J. 309, 390-91 (2001).

[85] *See* U.S. ENVTL. PROT. AGENCY, note 66 *supra*, at 3-5.
[86] *See* Gruenspecht & Stavins, *New Source Review*, *supra* note 67, at 21-22.

[87] *See id.*, *supra* note 67, at 21.
[88] *Id.*
[89] The finding of a major modification inevitably raises tricky issues in situations where changes are made to an existing plant. The combination of delay costs, control technology costs, and the costs of emissions offsets create a powerful incentive for existing sources to avoid triggering NSR. Existing plants can avoid triggering NSR requirements by demonstrating that a modification, even if major, does not increase emissions. *See* U.S. ENVTL. PROT. AGENCY, note 66 *supra*, at 3-5. For steam-electric generating units, actual emissions before the change are compared with projected emissions after the change to determine whether a modification increases emissions. *See* 57 Fed. Reg. 32314 (July 21, 1992). Modifications that allow a plant to produce more electricity per unit of fuel burned can lead to an increase in its projected future emissions, since better efficiency will often result in higher projected utilization. Such projects can trigger NSR, even if they reduce emissions in the region, because they induced changes in the utilization of other facilities.

[90] Routine maintenance, repair, and replacement activities are recognized as falling outside the scope of the NSR program, but the line separating these activities from a change that would be covered by the NSR process is subject to uncertain and changing interpretation. *See* Gruenspecht & Stavins, *New Source Review*, *supra* note 67, at 21. Several enforcement actions against electric generators were initiated in 1999, alleging that the utilities had evaded NSR requirements by improperly classifying major upgrade and life-extension projects as activities that do not count as major modifications under EPA's regulations. *See, e.g.,* Patrick D. Traylor, *New Source Review Inoculation: Environmental Risk Management in the Face of Regulatory Uncertainty*, HOGAN & HARTSON LLP FOCUS ON ENVIRONMENT, Mar. 2005.
[91] In 2003, the Bush administration initiated changes in the NSR program, and some of those changes were intended to sharpen the threshold between routine maintenance and upgrades that would trigger NSR. As indicated previously, the research surveyed in this paper predates those changes, and hence this paper takes no position with regard to the impacts of the 2003 proposed changes. For a description of these changes and

over whether maintenance activities have crossed a threshold sufficient to justify forcing an old plant to meet new plant standards.[92] In the electricity sector, the deferral of maintenance compromises plant reliability, and thereby increases the risk of outages.[93]

6.3 NSR in Other Sectors

Although most empirical analyses regarding NSR have focused on the electricity generation sector, a number of studies have been carried out in other areas as well. As early as 1979, Hartman, Bozdogan, and Nadkarni analyzed the economic impacts of the Clean Air Act, including NSR, on the U.S. copper industry and detected what may have been the first evidence of negative effects on capacity growth.[94] Similarly, in the early 1980s, an analysis by Crandall of eight industrial sectors offered quantitative estimates of what was then characterized as "new source bias."[95]

A more recent study examined whether the timing of plant investments was affected by the nature of regulation.[96] In a study of several industries over the period between 1963 and 1992, the researchers found that NSR significantly depressed the "birth" of new plants, keeping old plants in use.[97] For example, in an empirical analysis of the organic industrial chemicals industry, Becker and Henderson found that grandfathering of plants contributed to environmental degradation by raising survival rates, reducing plant turnover rates, and keeping otherwise unprofitable operations in business.[98] This also slowed improvements in air quality by prolonging the lives of older, dirtier plants.[99] They concluded that "a more uniform policy with respect to age would

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preliminary analyses of their affects, *see generally* NATIONAL RESEARCH COUNCIL, INTERIM REPORT OF THE COMMITTEE ON CHANGES IN THE NEW SOURCE REVIEW PROGRAMS FOR STATIONARY SOURCES OF AIR POLLUTANTS (2005) (describing initial results of congressionally mandated investigation), *available at* http://www.nap.edu/books/0309095786/html/ (last visited Nov. 3, 2005) (on file with author).

[92] *See* Gruenspecht & Stavins, *New Source Review* , *supra* note 67, at 21-22.

[93] For further discussion of the ways in which NSR may impede reinvestment in existing capital stock due to the uncertainty implicit in the NSR process, *see* UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, NEW SOURCE REVIEW: REPORT TO THE PRESIDENT 1 (2002), *available at* http://www.epa.gov/nsr/documents/nsr_report_to_president.pdf (last visited Nov. 3, 2005) (on file with author).

[94] Raymond Hartman, Kirkor Bozdogan, & Ravindra M. Nadkarni, *The Economic Impact of Environmental Regulations on the U.S. Copper Industry*, 10 BELL J. ECON. 589, 593 (1979) (using an econometric model to simulate the impacts of environmental regulations on the U.S. copper industry).

[95] ROBERT W. CRANDALL, CONTROLLING INDUSTRIAL POLLUTION: THE ECONOMICS AND POLITICS OF CLEAN AIR 39-44 (The Brookings Institution 1983) (examining the effects of "new source bias" in regulations on compliance costs per unit of economic activity).

[96] *See generally*, Randy Becker & Vernon Henderson, *Effects of Air Quality Regulation on Polluting Industries*, 108 J. POL. ECON. 379 (2000) (examining unintended impacts of air quality regulation).

[97] *Id.*

[98] *Id.*

[99] *Id.*

have encouraged retrofitting and other antipollution activities of existing VOC[100] and NO_x emitters much earlier in the regulatory process."[101]

What can be concluded from the empirical analyses that have been carried out on the effects of New Source Review, both in the electricity generating sector and in other sectors? First, there is considerable evidence that this form of VDR has retarded turnover of the capital stock, increased the age of plants, driven up the costs of environmental improvement, and had counter-productive effects on emissions in the electricity generating sector. Second, there is also evidence that NSR has promoted environmentally perverse decisions regarding the use of new (high-cost) capacity. Third, because NSR does not provide a continuous and effective incentive for emissions reductions at the old plants that typically are the most polluting in any sector, it has reduced cost-effectiveness of pollution control among existing plants. Fourth, although there has been no statistical analysis to date of the impacts of NSR on maintenance and improvements at old plants, theoretical arguments—if not common sense—provide support for these concerns. Fifth and finally, in a series of studies going back forty years or more, researchers have found statistical evidence in a number of other sectors of similar negative impacts of NSR regulations.

7. Implications for Policy and Research

The theoretical and empirical findings regarding VDRs reported above have implications for public policy in the environmental realm. The results from previous studies also point the way to promising areas for future research.

Previous research has shown that VDRs drive up costs and can result in worse environmental quality than would have occurred if firms faced cost-effective regulation without a disincentive to invest in new, cleaner technologies. In some cases, where capital turnover rates are low and rates of technologically-driven environmental improvements are high, VDRs may actually lead to worse environmental quality than would result from an absence of regulation. Environmental regulation is often necessary to achieve emissions reductions, however. If in some cases it would make sense to abandon VDRs, what should be put in their place?

In the context of point sources, such as in the electricity generation sector, one approach would be to move toward a level playing field through even-handed regulation that motivates both old and new plants to cut emissions in order to achieve environmental objectives. This might be accomplished through a cap on total pollutant emissions together with the use of an allowance trading system to ensure that any emissions increases at one plant are balanced by offsetting reductions at another. The SO_2 allowance trading program in the 1990 Clean Air Act is one among many possible models.[102] No matter how emissions are initially allocated across plants, the owners of

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[100]"VOC" refers to volatile organic compound.

[101]Becker and Henderson, *supra* note 96 at 415.

[102]*See generally,* Robert N. Stavins, *What Can We Learn from the Grand Policy Experiment? Lessons from SO_2 Allowance Trading,* 12 J. ECON. PERSP. 69 (1998) (reviewing performance and implications of the SO_2

existing facilities and those who wish to build new ones would face appropriate incentives with respect to retirement decisions, investment decisions, and decisions regarding the use of alternative fuels and technologies to reduce pollution.[103]Thus, in principle, it should be possible to strengthen environmental laws by selectively and gradually phasing out reliance on VDRs, replacing some of these age-discriminatory mechanisms with binding environmental constraints, sometimes implemented through cost-effective, market-based policy instruments.

How might such selective and gradual phasing out proceed? Research has identified important trade-offs in VDR use, including short-term emissions increases versus long-term emissions reductions, and increases in unit abatement costs versus reductions in pollution levels.[104] Hence, it is necessary to ask *which* VDRs should actually be targeted for phase out. Much remains to be learned if such priorities are to be established. Research should focus on investigating the circumstances in which VDRs are most likely to be welfare-reducing compared with viable alternatives. Some of the relevant factors affecting the conditions under which VDRs are particularly troublesome can be identified, but future research will need to establish the relationships with greater rigor and quantify the magnitude of their respective effects. The list of candidates for further analysis includes the following.

First, as the natural economic life of the relevant durable good increases, so too does the potential for VDRs to reduce the rate of turnover of the capital stock. This is one of the reasons why the investment-retarding effects of the NSR program have been so pronounced in the electricity generation sector, particularly for large-scale, coal-fired plants. It is also the reason why the impacts of VDRs in the automotive sector may be becoming more severe over time. As the quality of motor vehicles has greatly improved, the average life of vehicles on the road has nearly doubled over the past twenty-five years. What, empirically, is the relationship between the durability of a capital good and the effectiveness of VDRs?

Second, and conversely, a combination of circumstances may argue in favor of the retention of VDRs in spite of the impact they have on the lives of durable goods and thereby on abatement costs. If abatement cost heterogeneity is great, cost heterogeneity is highly correlated with vintage, and a cost-effective instrument is not feasible, then the static cost-effectiveness associated with an appropriate VDR may overwhelm the perverse dynamic effects on costs (and environmental performance). In these circumstances, VDRs may be the better choice. For example, the cost of retrofitting new pollution-abatement devices to existing fleets of cars is typically prohibitive (a situation that contrasts with the situation of retrofitting power plants). What degree of vintage-

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allowance trading program).

[103]Presumably requirements for localities to meet ambient air quality standards would remain in effect, preventing a concentration of emissions in any geographic region that would conflict with needs to protect public health.

[104] See sections 3 and 4, *supra*.

correlated abatement cost heterogeneity would make VDRs the most cost-effective policy instrument?

Third, if the rate of positive relevant technological change is great, that is, if newer vintages of given machines are also much cleaner, then VDRs can lead to an unintended inverse relationship between the stringency of regulation and aggregate emissions. For example, if the overall energy efficiency of some type of fuel-burning equipment is increasing with newer vintages, then newer vintages of the machine in question will likely have lower levels of air pollutant emissions per unit of services provided. By providing an incentive to keep the older equipment in place, a VDR can theoretically lead to an inverse relationship between the stringency of regulation and aggregate emissions. What rate of environmentally positive technological change in a given capital good renders VDR application problematic?

Fourth, the negative impacts of VDRs on pollution levels may be heightened if the older technology in question exhibits increasing emissions (degraded abatement) as it ages. For example, if the energy efficiency of the equipment degrades as it ages (and hence the emissions increase as the equipment ages), then the negative consequences of VDRs when they extend the lives of such durable goods will be heightened. What is the empirical relationship between the rate of age-correlated emissions increases and the potential perverse effects of VDRs?

Fifth, market structure matters. For example, selective deregulation of electricity markets has presumably rendered affected generators more sensitive to environmental compliance costs than they were in a world of rate-of-return regulation (when such compliance costs could typically be passed on to rate payers). This suggests that the negative consequences of VDRs may have increased, all else being equal, in this sector during the period of deregulation—a correlation that could be tested empirically. Which market structures are likely to amplify the negative affects of VDRs?

Sixth and finally, the underlying regulatory structure itself seems significant. In theory, VDRs can be employed within the context of command-and-control instruments, such as technology-based standards, or within market-based systems, such as tradable permits. For example, a command-and-control instrument such as a uniform performance standard can involve VDRs, whereby old facilities are permitted one emissions rate and new facilities are limited to a more stringent rate. Likewise, in a tradable permit system, older units can be allocated larger numbers of permits, while newer units are allocated smaller numbers (or even none at all). How does the underlying regulatory structure in which a VDR is placed affect its effectiveness?

In sum, while theoretical analysis regarding the use of VDRs suggests clear hypotheses, there is need for more empirical analysis examining the actual effects of these age-discriminatory mechanisms in practice. Of the research possibilities discussed above, three areas stand out: the role of market structure in determining the effects of VDRs, the impact of VDRs on motor vehicle turnover rates, and the performance of VDRs in combination with alternative policy instruments.

7.1 The Role of Market Structure

One area of research that has not been explored despite strong theoretical evidence to suggest its relevance is the role of market structure in determining the effects of VDRs. Theoretically, more competitive markets should exhibit more severe perverse consequences from VDRs: the competitive nature of these industries forces firms to seek cost savings wherever possible, including through prolonging the life of capital equipment in order to avoid incurring higher pollution abatement costs. Less competitive industries should be less vulnerable to such cost-saving pressures. A natural experiment on the effects of market structure on VDR outcomes occurred in the United States when several regions deregulated electricity markets while other regions maintained rate-of-return regulations.[105] It would be illuminating to compare the rates of capital turnover in states with deregulated systems to states with regulated systems.

A variety of challenging methodological issues will need to be addressed in such research. First, there is the possibility that the policy variable—deregulation—is itself a function of various economic variables. The concern would be that unobservable factors (such as general economic conditions in a jurisdiction) that affect whether or not a plant is subject to deregulation also affect the frequency of pollution control equipment installation. For example, states that had the greatest costs from rate-of-return regulation[106] may have been those that opted to deregulate. If this were true, it would be essential to test whether the degree of inefficiency in the regulated system is correlated with the rate of turnover. If relevant deregulation decisions were largely political, in contrast, then they were exogenous to the rate of capital turnover. In either case, a careful consideration of the endogeneity issue is required.[107] The gradual and partial deregulation of the electricity generation industry is a promising natural experiment for analyzing the effect of market structure on capital turnover rates under VDRs.

7.2 Impacts on Turnover of Mobile Capital

A critical issue with VDRs is their effect on the rate of retirement of durable goods. Research is needed in general on the rate of turnover of mobile capital, automobiles in particular. The longevity of American cars has increased, in part due to decreasing replacement part prices but new car sales continue to be significant.[108] One

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[105]Dallas Burtraw, Karen Palmer, & Martin Heintzelman, *Electricity Restructuring: Consequences and Opportunities for the Environment, in* 5 INTERNATIONAL YEARBOOK OF ENVIRONMENTAL AND RESOURCE ECONOMICS, pp. 40-89 (Henry Folmer &Tom Tietenberg, eds. 2001).

[106] Under conventional rate-of-return regulation, electricity generators were granted a local monopoly and thus protected from competition. Hence, regulators had to make determinations about what price could be charged for electricity; in general, they allowed firms to charge a price that would give them a reasonable rate of return on their capital.

[107]In addition, there might be a concern about the validity of the natural experiment if states that were not deregulated anticipated being deregulated in the near future. If there was uncertainty over future deregulation, then regulated states might not be a good control for what would have happened to the rate of capital turnover in the absence of deregulation.

[108] *See generally* Bruce W. Hamilton & Molly K Macauley, *Competition and Car Longevity* (Resources for

can define the gross turnover rate for a given policy jurisdiction to be car retirements less new car sales and the net turnover rate to be the gross turnover rate plus transfers out of the area. The increased longevity of automobiles combined with an increased sales rate then implies that the gross turnover rate has been declining. But it is possible that the *net* turnover rate of automobiles has actually increased over the last decade. This would be the case if more people are buying newer cars *and* if the older cars, which have a longer life, are leaving the country (or state, in the case of California regulations).[109]

A second natural experiment that might illuminate the effect of VDRs on the rate of automobile turnover comes from selective state implementation of vintage-differentiated safety and emissions tests. In the northeastern states, for example, emissions test requirements are less stringent for older automobiles. Other states do not have emissions tests at all. This variation across states provides for the possibility of examining the effects of VDRs on automobile turnover rates. As with the possible study of the effect of deregulation on capital turnover in the electricity sector, this study would have to address the potential endogeneity of the policy variable, that is, the degree to which the policy variable is itself affected by economic forces. In particular, the density of urban areas in the northeast and the existence of reliable public transportation services may lead to lower turnover rates for automobiles in these states, even in the absence of VDRs.

7.3 Performance of VDRs Combined with Alternative Policy Instruments

A third area of promising research concerns the interaction of VDRs with alternative policy instruments. As indicated above, Swift demonstrated that NSR requirements slowed the adoption of combined heat and power (CHP) systems.[110] In that case, combining vintage-differentiation with a technology standard in NSR created perverse incentives. Despite the fact that CHP systems were already highly efficient with low emissions, the technology standard required the addition of costly abatement equipment.[111] Hence, plants reasonably decided to forgo adopting CHP systems altogether. This negative effect of vintage-differentiation might have been reduced if the underlying regulation were performance-based rather than technology-based; that is, if it had emissions constraints rather than technology requirements.

One can imagine VDRs combined with alternative policy instruments in which the negative effects of VDRs are reduced, if not eliminated. The use of the SO_2 allowance

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the Future Discussion Paper 98-20, 1998) (documenting increase in commercial longevity of American automobiles).

[109] In some policy situations, the relevant turnover rate would be the net rate. Older cars leaving the state or being sold in Mexico would not affect the ultimate policy outcome within a given jurisdiction. This would be the case for local air pollution in Los Angeles, for example. But if California is employing CO_2 standards for climate change policy then old cars going to Mexico constitute a problem. In this case, the relevant turnover rate would be the gross rate.

[110] *See* Swift, *supra* note 77 at 1539-42. Swift refers to CHP plants as “combined cycle” plants, but the term refers to the same technology.

[111] *Id. at 1539*..

trading system in conjunction with NSR under the Clean Air Act Amendments of 1990 may provide the basis for empirical analysis of the effects of VDRs under alternative policy regimes. Prior to the Clean Air Act Amendments of 1990, affected facilities were regulated under a command-and-control system combined with VDR. After the 1990 Amendments came into force, some plants were regulated under the allowance trading (cap and trade) system.[112] This combination of temporal and spatial variation may provide useful data for research on how effectively combination VDR and non-VDR regulatory schemes operate.

7.4 Conclusion

Vintage-differentiated regulations, in which later vintages face more stringent standards, play prominent roles in major Federal environmental statutes, state and local environmental laws, and a variety of non-environmental regulations. This is true despite the fact that economists and others have long argued that such age-discriminatory regulations can retard turnover of the capital stock, drive up the cost of environmental protection, and may retard pollution abatement. U.S. environmental policy frequently relies on VDRs because of powerful political incentives for key constituencies to demand VDRs and for legislators to supply them.

With roots in standard investment theory, models of the impacts of vintage-differentiated regulation have been developed over the past twenty-five years. Empirical analysis in the environmental realm has accelerated over that time. Much of that empirical analysis has focused on VDRs in the automotive sector and on New Source Review in the electric power generation sector. Overall, these empirical studies have validated theoretical findings that, all else being equal, vintage-differentiated regulations have retarded the turnover of durable goods and thereby increased aggregate pollution abatement costs. In some limited cases, empirical studies have also validated the particularly perverse potential consequence of VDRs—that environmental progress has itself been slowed. These theoretical and empirical findings point the way to what could be significant improvements in public policy in the environmental realm. At the same time, much more remains to be learned, and additional research efforts in this area are likely to produce unusually large dividends.

Given the ubiquitous political forces that have made vintage differentiated regulations in the environmental realm so attractive to interest groups and legislators, it is reasonable to question whether the phasing out of VDRs in select environmental policy applications advocated here really stands any chance of being implemented. In response, it should first be acknowledged that the battle will be difficult. But the same political forces that have brought about VDRs can also help bring about their reform. Many in the regulated community (particularly new entrants and existing firms that are growing rapidly) are disadvantaged by VDRs. As they come to recognize this, they can become a force for change. Equally important, when and where the environmental advocacy

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[112] *See* Byron Swift, *How Environmental Laws Work: An Analysis of the Utility Sector's Response to Regulation of Nitrogen Oxides and Sulfur Dioxide Under the Clean Air Act*, 14 TUL. ENVTL. L.J. 309, 319-22 (2001).

community comes to recognize that VDRs are systematically not cost-effective, they may begin to favor alternative, lower-cost regulatory approaches, knowing that lower compliance costs can translate through the political process into the achievement of more ambitious goals. And finally, when environmentalists accept that VDRs can in some circumstances be counter-productive, retarding rather than advancing environmental progress, then environmental advocates may themselves become enthusiastic agents for regulatory reform.

TABLE 1:
Examples of Vintage Differentiated Regulations in U.S. Environmental Law

Regulatory Area	Application	Statute
Air Quality	Performance Standards for New and Existing Stationary Sources	Clean Air Act, 42 U.S.C. § 7411 (2005) (establishing differentiated program for stationary sources); 42 U.S.C. §§ 7521-7554 (2005) (establishing differentiated standards for mobile sources) .
	Motor Vehicle and Motor Vehicle Engine Emissions Standards	Clean Air Act, 42 U.S.C. § 7521 (2005) (establishing emissions standards for motor vehicles based on model year).
	Non-Road Engines and Vehicles	Clean Air Act, 42 U.S.C. § 7547 (2005) (applying standards only to new sources) .
	Commercial Vehicle Standards	Clean Air Act, 42 U.S.C. § 7554 (2005) (setting standards that apply only to buses manufactured subsequent to the 1993 model year).
Water Quality	Effluent Limits for Public Treatment Plants	Clean Water Act, 33 U.S.C. § 1311(a)(1)(B)-(C) (2005) (setting differential standards for plants in operation prior to July 1, 1977).
	Drinking Water Treatment	Safe Drinking Water Act, 42 U.S.C. § 300g-9(d)(4) (2005) (requiring EPA to set standards for new plants).
Waste Management	Generation and Disposal of Hazardous and Solid Waste	42 U.S.C. § 6925 (2005) (limiting new hazardous waste management to new facilities).
State & Local Environmental Laws	Stationary and Mobile Source Emission Limits; Energy-Efficiency Standards for New Construction; etc.	*See*, *e.g.*, CAL. HEALTH & SAFETY CODE § 39665-39669 (2005) (California Air Resources Board regulations setting differentiated emissions standards for new vehicles).