

Retrospective Analysis of Environmental Regulations

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1. Introduction

Policy leaders in the regulated community, Congress, and academia, as well as some in the broader public, continue to express an interest in credible retrospective analyses that can help document the extent to which the expected benefits of regulation have been realized and at what cost. Such studies can illuminate any unintended consequences, such as adverse distributional outcomes or enhancement of market power. And they can support innovation in regulatory design and help guide the reform of poorly performing rules.

Although prospective, ex ante studies—known as regulatory impact analyses (RIAs)—are now routine for major new rules, retrospective measurements of actual outcomes, based on quasi-experimental or other modern methods, are rare. Recall Michael Greenstone’s often-quoted observation that RIAs are developed at the “point when the least is known and any analysis must rest on many unverifiable and potentially controversial assumptions.”¹ The Evidence Based Policymaking Act of 2019 is an important step forward, and the pending Smart Act could further advance ex post studies of federal regulation. Nonetheless, many barriers remain.

This paper describes the results of seven new quantitative analyses of major federal environmental regulations plus a paper that assesses a range of institutional design issues to support future retrospective studies, including operation of the Evidence-Based Policymaking Act (EBPA) of 2019 and a legislative bill, the Setting Manageable Analysis Requirements in Text (SMART) Act. The quantitative studies focus on specific outcomes of regulation rather than broad-brush results and differ from studies that simply update the ex ante assumptions used in pre-regulatory analyses.

The paper is divided into five sections. Section II provides background on retrospective analyses of federal regulations.

Section III reviews the seven new quantitative studies developed for the project, including a description of the process used to select these studies and the overall rationale for the cases. This section also presents analytic lessons from the new studies, including findings about the accuracy of any ex ante analyses, and assessments of the distributional effects of the rules, whether studied ex ante or not. Additional lessons concern new evidence on the interactions and strategic behavior of state and local officials in response to major federal initiatives. Some new categories of benefits not covered in the original ex ante analyses are revealed. Further, several studies identify new or improved methodologies and data sources that could be used in future ex ante or ex post studies. Section III also offers insights into both the

¹ Michael Greenstone, “Toward a Culture of Persistent Regulatory Experimentation and Evaluation,” in *New Perspectives on Regulation*, eds. David Moss and John Cisternino (Cambridge, MA: Tobin Project, 2009), 111–26.

analytical and the policy aspects of the individual studies. Examples of the former include impacts of the ZEV program, potential limits on emissions trading, reform of auto registration fees, and reform of the boutique fuels program. Examples of the policy-relevant implications involve potential reform of the RFG and boutique fuel programs, and consideration of damage-based vehicle registration fees in lieu of the current state and local registration fee regimes, and potential reform of the industry assistance elements of California's cap-and-trade program.

Section IV focuses on institutional issues related to both the Evidence-Based Policymaking Act and the pending SMART Act. It discusses the institutional challenges identified in a conference sponsored by RFF in March 2022. Section V presents overall conclusions and a framework for further work in this area.

2. Background

2.1. General

Although regulatory agencies have been generally reluctant to develop their own rigorous retrospective analyses of individual regulations, Congress has been nudging and sometimes mandating the agencies to act. Recall that Section 812 of the 1990 Clean Air Act Amendments required the Environmental Protection Agency (EPA) to conduct retrospective studies of the 1970 Clean Air Act. Even though these studies were aggregate in nature and not based on quasi-experimental or other modern statistical methods, they represent an important part of the retrospective literature on environmental regulation.

The EBPA requires agency data to be accessible and mandates that agencies plan to develop statistical evidence to support policymaking. It also requires agencies to submit an annual plan to the Office of Management and Budget (OMB) and Congress for identifying and addressing policy questions. Although EBPA stops short of requiring a full ex post assessment, the plan must include, among other things, the following:

- questions for developing evidence to support policymaking;
- data the agency intends to collect, use, or acquire to facilitate the use of evidence in policymaking;
- methods and analytical approaches that may be used to develop evidence to support policymaking; and
- challenges to developing evidence to support policymaking, including any statutory or other restrictions to accessing relevant data.

The EBPA requires agencies to establish a “learning agenda” to identify evidence-based priorities for research questions, data needs, and planned activities. It focuses on the need for ex post evaluation using rigorous approaches to inform decision-making in both individual regulations and entire programs.

The bipartisan SMART Act (reported out of committee in February 2022) would go further in its approach to retrospective evaluation. When publishing a proposed or final major rule, an agency would have to include a framework for assessing whether the rule achieved its regulatory objectives and for measuring its effectiveness, with plans for gathering the necessary information. The retrospective analysis would have to be completed within 10 years of rule issuance and compare the rule’s anticipated and actual benefits and costs.

These legislative initiatives build on a long history that includes the regulatory lookback activities of every president since Jimmy Carter, the leadership of former regulators and others in the regulatory community, and the work of academic researchers—all attempting to assess whether and how government regulations deliver on the societal objectives established by Congress. Many agencies’ rulemakings are covered by these initiatives, but given the broad influence of EPA’s legislative authorities and rulemakings, environmental regulations represent an important element of this push for greater accountability.

2.2. Academic Literature

The academic literature on retrospective analysis of regulation is continuing to expand, aided in no small part by the development of quasi-experimental methods that share many similarities with traditional experimental design or randomized control studies, albeit without the element of strictly random assignment to treatment or control groups.² Although some academic studies focus on novel aspects of regulation rather than broader-based assessments, interest in more comprehensive analyses is growing. We expand here on two papers of this genre produced by the current authors as part of our previous work in this area.

A review paper recently published in the *Journal of Economic Literature* (Aldy et al. 2022) examined more than three dozen quasi-experimental or structural model-based analyses of the US Clean Air Act (CAA), the statute with the highest costs and benefits of any US environmental legislation. The review considers the effectiveness of CAA regulation in achieving the stated benefits, measured in total dollar terms or as changes in emissions, concentrations, or health outcomes. It also considers the unintended consequences (both adverse and beneficial) of major CAA rules on employment, plant location, and expansion of market power, as well as the

² True randomized control studies are extremely rare in the environmental policy field because of legal and other restrictions on intentionally withholding environmental and health protections from some groups or areas.

distributional effects of the rules on specific locations, industries, occupations, and subpopulations. Unsurprisingly, the studies reviewed by Aldy et al. focus on those parts of the CAA that most readily lend themselves to quasi-experimental analyses. Among this review's findings:

- **Spatially varying regulations can harm local economies** by causing adverse effects on manufacturing output and employment.
- **Current applications of market-based mechanisms fall short of expectations** for cost relief.
- **Varying fuel content regulations across the states may impose unnecessary costs on consumers** by requiring separate distribution and handling networks for multiple types of gasoline, and by facilitating the exercise of market power and creating the potential for price volatility in balkanized markets.
- **Regulatory flexibility doesn't always yield cost-effective results** because such flexibility may have adverse environmental consequences.
- **Unanticipated costs are an important issue**, especially in the design of renewable fuel requirements, resulting in unnecessary volatility in the tradable permit market and creating costly uncertainty for refiners and small innovative firms developing advanced biofuels.

The Aldy et al. review notes that beyond the CAA rules evaluated in the published economics literature, hundreds of other CAA regulations, arguably representing more than half the total costs of the act, have not been subject to any type of rigorous economic evaluation. Examples include State Implementation Plans (SIPs), New Source Review (NSR), New Source Performance Standards (NSPS), most air toxics regulations, auto tailpipe emissions standards, and heavy-duty truck standards. Where quasi-experimental methods are not feasible, other approaches might be suitable.

A second recent review paper, by Fraas et al. (2023), examines 13 significant EPA rules and identifies the main factors that drive differences between ex ante and ex post cost estimates.³ One common source of differences between ex ante and ex post estimates, the authors report, is firms' adoption of compliance strategies not anticipated in ex ante analysis; that was the case for nine of the 13 regulations. Other differences are attributed to reliance on engineering models, misspecification of the baseline, and failure to anticipate the role of new technologies.

To improve future ex ante cost analyses, Fraas et al. (2021) call for better characterization of baseline conditions, more sensitivity analysis of highly uncertain parameters, greater use of economic models of the regulated sector to better reflect

³ Art Fraas, Elizabeth Kopits, and Ann Wolverton, "A Review of Retrospective Cost Analyses," *Review of Environmental Economics and Policy* 17, no. 1 (2023), 22–42, <https://doi.org/10.1086/723595>

firms' decisionmaking, and analysis of phase-in periods. For ex post analyses, they recommend developing plans for future study at the time the regulation is adopted—now an element of the pending SMART Act. Aside from opportunistic cases, they note the difficulty of conducting thorough retrospective evaluations without an ex ante plan that identifies endpoints of interest, methods of analysis, and data needs.

2.3. Retrospective Analysis

Notwithstanding previous efforts to support retrospective analysis within the federal government, the continuing congressional interest in the subject indicates some desire to go further. Leading voices both inside and outside the government have also called for more emphasis on retrospective analysis of federal regulation.^{4,5} Clearly, few of the lookbacks conducted within government agencies over the past four decades meet the rigorous tests that would demonstrate causality. In practice, many are basically reengineered RIAs, with a limited consideration of actual ex post experience.

An ex post analysis comparable in scope to an ex ante RIA would involve a comprehensive benefit-cost analysis plus comparisons with both a counterfactual baseline and reasonable alternatives, including alternative regulatory designs. It would consider a wide range of possible economic effects, including employment effects and plant closures under alternative regulations. Where appropriate, it would also analyze distributional effects. Further, it would identify any unintended consequences and unrecognized benefits and costs (compared with the ex ante RIA), such as additional

⁴ Administrative Conference of the United States, "Retrospective Review of Agency Rules," Recommendation number 2014-5 (2014), <https://www.acus.gov/research-projects/retrospective-review-agency-rules>; Cass Sunstein, "Memorandum for the Heads of Executive Departments and Agencies: Retrospective Analysis of Existing Significant Regulations," M-11-19 (April 25, 2011), <https://www.whitehouse.gov/sites/default/files/omb/memoranda/2011/m11-19.pdf>; Institute for Policy Integrity 2016. "Strengthening Regulatory Review: Recommendations for the Next Administration from Former OIRA Leaders," NYU Law School (2016), <http://policyintegrity.org/publications/detail/strengthening-regulatory-review>; Maureen L. Cropper, Richard Morgenstern, and Arthur Fraas, "Looking Backward to Move Regulations Forward," *Science* 31, vol. 355 (no. 6332) (2017): 1375–76, DOI: 10.1126/science.aaj1469; Maureen L. Cropper, Richard Morgenstern, and Nicholas River, "Facilitating Retrospective Analysis of Environmental Regulations," *Review of Environmental Economics and Policy* 12, no. 2 (2018): 359–70, <https://doi.org/10.1093/reep/rev011>; S. E. Dudley and S. Katzen, "Crossing the Aisle to Streamline Regulation," *Wall Street Journal*, May 13, 2019, <https://www.wsj.com/articles/crossing-the-aisle-to-streamline-regulation-11557788679>.

⁵ The issue of cumulative regulatory burden, a major thrust of the 2019 *Economic Report of the President*, is also a topic of interest in regulatory circles. Concerns about cumulative regulatory burdens helped buttress the Trump administration's deregulatory efforts as well as the recent regulatory lookback activities implemented in Canada and other countries of the Organization for Economic Cooperation and Development. Quasi-experimental assessments of recent regulatory actions and other retrospective analyses can generate critically important information to augment the limited scholarly evidence.

health or environmental risks and the exercise of market power. In short, it would describe the actual responses of regulated entities and the resulting outcomes.

Most retrospective analyses are focused reports rather than comprehensive studies and reflect the constraints associated with data limitations and demands of effective quasi-experimental designs. Although they are not ideal, their results can inform regulators and the public about specific effects of individual rules, such as changes in emissions, ambient air quality, or employment numbers. Such retrospective studies can be combined with other information—including results from other retrospective studies—to provide a more comprehensive evaluation of the effects of major regulations.

3. Seven New Quantitative Case Studies

Seven new quantitative case studies were prepared for this project:⁶

- Joseph Aldy and Max Auffhammer, “Localizing Environmental Regulation: The Case of Boutique Fuels”: the effectiveness of EPA fuel content standards in reducing ambient ozone, emissions of nitrogen oxides (NO_x), and volatile organic compounds (VOCs) and the effect on gasoline prices.
- Maureen Cropper, Nick Muller, Yongjoon Park, and Victoria Perez-Zetune, “The Effect of Clean Air Act Nonattainment Regulation on Emissions and Air Quality in the 1970s”: the number of attainment and nonattainment counties in EPA’s 1972 designation versus the conventional identification of these counties in the literature, using available monitoring data.
- Art Fraas, Randall Lutter, and Joshua Murphy, “Effects of Early Childhood Exposure to Ambient Lead and Particulate Matter on Adult Personality”: how the reduction in childhood exposure to emissions of lead and particulate matter in the 1970s affects personality traits in adulthood.
- Mark Jacobsen, James Sallee, Joseph Shapiro, and Arthur Van Benthem, “Regulating Untaxable Externalities: Are Vehicle Air Pollution Standards Effective and Efficient?”: an analytical and a quantitative model of the vehicle

⁶ The results of two additional studies that were initiated but not finalized at the time of this writing are not reported here. The two studies are:

- Meredith Fowlie, Edward Rubin and Catherine Wright, “Indirect Air Quality Benefits from Power Sector Emissions Reductions”: the interactions between overlapping air quality regulations at the federal and state levels;
- Richard Morgenstern and Qinrui Xiahou, “Employment Effects of California’s CO₂ Cap-and-Trade Program”: the relative burdens of California’s carbon-pricing regime on energy-intensive, trade-exposed industries.

fleet for examining reforms, including tighter exhaust standards and increased registration fees that have complex distributional effects.

- Jonathan Ketcham, Nicolai Kuminoff and Nirman Saha, “Valuing Statistical Life Using Seniors’ Medical Spending”: the estimated value of reducing mortality risks for seniors, based on Medicare records on seniors’ consumption of medical care relative to other private goods and services and how their choices effect survival probabilities.
- Joshua Linn, “Interaction between the EPA/NHTSA CAFE Standards and California’s ZEV Requirements”: the interaction between two major regulatory programs—California’s Zero Emission Vehicle (ZEV) requirements and EPA/NHTSA’s fuel economy (and greenhouse gas) regulations.
- Jim Sweeney, “The Response of the U.S. Oil Refinery Industry to EPA’s 1990s-Era Fuel Content Regulations”: the cost of two EPA regulatory programs establishing specific requirements on the constituents in motor vehicle fuels—that is, the regulations requiring reformulated gasoline (RFG) in areas with high pollution levels and the low sulfur diesel (LSD) requirement capping the sulfur content in diesel fuel used in on-highway motor vehicles.

Summaries of the completed papers are presented later in this paper. Table 1 lists the studies according to their contributions in five knowledge areas:

- Ex post benefit and/or cost estimates versus the preregulatory analyses: were they within reasonable bounds (typically defined as ± 25 percent) of the ex post estimates?
- Distributional effects of the regulations: did the rules have measurable consequences for particular geographic, consumer, or industrial categories, or for low-income or other demographic groups?
- Interactions between the federal rule and other federal, state, and local government rules: are the outcomes of federal rules affected by state rules, and vice versa?
- New benefit categories addressed ex post but not considered in the preregulatory analyses: if one were doing the preregulatory analysis anew, would it include the new benefit categories?

Innovative methodological or data contributions: has the ex post study relied on new or unusual data sources or methods to develop the analysis?

Table 1. Key Elements of Ex Post Studies

Study	Accuracy of ex ante study	Distributional impacts	Interaction between federal and other rules	New benefit categories	New methods or data
Aldy and Aufhammer	✓		✓		
Cropper et al.					✓
Fraas et al.					
Jacobsen et al.				✓	✓
Ketcham et al.		✓			✓
Linn	✓				✓
Sweeney		✓	✓		✓

Here we categorize the studies according to the types of environmental regulations they considered.

3.1. Fuels and Mobile Sources

3.1.1. Aldy and Aufhammer

Aldy and Auffhammer estimate the ex post costs and benefits of several EPA fuel rules and find mixed results for the accuracy of EPA's ex ante analyses. EPA's estimate for VOC emissions reductions for gasoline Reid vapor pressure (RVP) was reasonably accurate before 2004, but those for VOC and NO_x emissions for RFG were too high—about double. EPA's ex ante estimate for RFG costs (8 cents per gallon) was similar to the observed cost (9 cents), and the ex ante estimate for RVP (2 cents per gallon) was too high compared with the actual cost (no statistically significant change).

Aldy and Auffhammer also evaluate the effectiveness of EPA's boutique fuel programs: low RVP fuel, cleaner-burning gasoline, winter gasoline, and sulfur limitations. These programs have been adopted in different air basins at different dates and operate only during certain parts of the year. The researchers find no statistically significant effect of boutique fuels on ozone concentrations or price, although there is some evidence of lower emissions of ozone precursors.

Finally, they report that the successive tightening of tailpipe emissions standards since 1990 (especially the adoption of Tier 2 standards) may have diminished the effectiveness of RFG and boutique fuel standards over this period, since a small reduction in emissions via the fuel standards operating on the very low-level emissions from post-2004 vehicles yields little change in ambient ozone.

3.1.2. Sweeney

Sweeney uses a unique, detailed structural model to evaluate the cost of two EPA regulatory programs establishing specific requirements on the constituents in motor vehicle fuels: the regulations requiring RFG in high-pollution areas and the LSD requirement capping the sulfur content of diesel fuel for on-highway motor vehicles. Sweeney exploits the difference between regulated and unregulated markets. For RFG, the regulated market comprised the highly polluted areas of the nation—primarily in the Northeast corridor and California—versus the unregulated gasoline markets in other regions. The LSD rule regulated sulfur in on-highway diesel fuel, leaving the heating oil and nonhighway diesel markets unregulated.

In terms of the accuracy of EPA's RIAs, Sweeney reports an RFG cost estimate of 7.1 cents per gallon, which is within the range of the ex ante estimates, and an LSD cost estimate of 3.3 cents per gallon, which is slightly below the ex ante estimate of 4.3 cents per gallon. For both rules, costs varied significantly across refineries. In addition, Sweeney finds that refiners responded to these content restrictions by shifting product mix and by increasing product sales in unregulated markets, with a corresponding reduction in consumer prices in the unregulated markets. As a result, the increased cost associated with both programs in the regulated markets was partially offset by a reduction in the price of gasoline and diesel fuel in the unregulated markets.

In terms of the RFG program's distributional effects, the shift in product mix to unregulated markets had the effect of reducing the cost of gasoline in unregulated regions of the country—much of the South, Midwest, and West (apart from California). In the case of LSD, the shift in product mix reduced fuel costs in the unregulated markets, especially the cost of home heating oil.

3.1.3. Fraas et al.

Fraas et al. examine how the reduction in childhood exposure to emissions of lead in the 1970s has affected personality traits in adulthood. They focus on the effects of lead on noncognitive adult personality traits (e.g., agreeableness and conscientiousness)—endpoints left largely unexamined in environmental economics research. They address the following questions: Can available data on lead in gasoline be used to develop a novel county-level measure of childhood lead exposure during the 1970s that successfully predicts adult outcomes? Does cumulative exposure over the first five years capture the critical period of childhood exposure? Given the effect of the reduction in childhood lead exposure in this period on adult outcomes, do exogenous changes in childhood exposure to total suspended particulates (TSP) also affect adult personality traits?

The principal contributions of the paper include developing a new measure (data set) of the density of lead (Pb) emissions from motor vehicles by county and calendar year and show that this measure performs better than available Pb air monitoring data. The

authors also improve the modeling of the effects of Pb on personality traits (going beyond a recent PNAS study) and conduct the first modeling of the effects of both pollutants on adult personality.

3.1.4. Linn

Linn develops a highly detailed structural model of the new-vehicle market that incorporates endogenous modeling of both ZEV and fuel economy credit prices, regional markets (rather than a single national market), and the distortions associated with the market power of auto manufacturers and the undervaluation of fuel economy by consumers, then uses this model to examine the distributional effects of two regulatory programs.

Linn's analysis suggests a potential synergistic relationship in reducing US gasoline consumption between California's ZEV program—a technology-focused program leading a push for the production of electric vehicles—and subsequent EPA/NHTSA fuel economy decisions. Specifically, Linn reports that a tighter ZEV standard of 22 percent (in place of a 17 percent standard), combined with more stringent CAFE standards, would yield an additional \$0.6 billion in net benefits per year but also increase CO₂ emissions by 3 million tons per year. The CO₂ increase arises from the additional CAFE credits awarded for the production of fuel-efficient ZEVs.

In terms of distributional effects, Linn finds that the ZEV program, considered alone, is regressive because high-income households benefit more than low-income households. In effect, the purchasers of gasoline-powered vehicles (who tend to have lower income) “subsidize” the purchasers of ZEVs (who tend to have higher income). Overall, however, Linn concludes that the combined ZEV and CAFE programs are progressive: in his view, the substantial cost savings realized by low-income households with the CAFE program outweigh the modest regressive effects of the ZEV program.

3.1.5. Jacobsen et al.

Jacobsen et al. assemble a unique data set of new light-duty vehicle emissions over the past 60 years, along with millions of emission tests of used vehicles. They also assemble the first national data set for vehicle property taxes and registration fees. In addition, they develop the first analytical and quantitative model of the vehicle and scrap markets that accounts for vehicle emissions. Model results suggest that tighter exhaust standards increase social welfare and that higher registration fees on dirty vehicles yield even larger gains by accelerating the scrappage of older vehicles.

To address the inefficiency associated with the absence of regulations addressing the emissions from older vehicles, the authors propose damages-based registration fees. They acknowledge that this approach creates a trade-off between efficiency and equity and offer a qualitative discussion of the compromise.

3.2. Stationary Sources

3.2.1. Cropper et al.

Despite limited causal evidence, the CAA is often credited with observed reductions in monitored levels of ambient air pollution during the 1970s. Cropper et al. examine whether counties designated as out of attainment with the NAAQS under the 1970 CAA experienced larger reductions in TSP during the 1970s than attainment counties. The authors use the official designation of nonattainment status, which in 1972–1978 was by Air Quality Control Region. Newly digitized data from balanced panels of TSP monitors in operation from 1969 to 1978 and in operation from 1971 to 1978 are used to examine the effect of nonattainment status on TSP. The authors also examine the effect of nonattainment status on TSP using the definition common in the literature—a county is out of attainment if any of its monitors violated the NAAQS.

Using these newly organized data, the authors' initial findings suggest that the CAA's effect on levels of TSP appear slightly larger than previously estimated. The findings for health and property values remain to be explored.

3.3. Other Analytic Issues

3.3.1. Ketcham et al.

Ketcham et al. estimate the value of statistical life (VSL) for US seniors aged 67–97 based on the rates at which they choose to consume medical care, relative to other private goods, and then examine the effects of their choices on their survival probabilities. These revealed preference effects are estimated from individuals' survey responses linked with their Medicare records. The authors find that the mean VSL is below \$1 million and that it decreases with age; by age, it increases with income, education, and health. They also find the VSL is higher for women and people who never smoked. The estimated VSL is far less than the value commonly used by federal agencies, which typically assume a constant VSL between \$6 million and \$10 million (year 2010 dollars) for every avoided death, regardless of age and health.

Beyond offering new evidence on the VSL, the methodological contributions of this paper are important for future regulatory analyses. The authors link panel data from the Medicare Current Beneficiary Survey (MCBS), which includes information on socioeconomic characteristics, household composition, labor market participation and self-assessed health, to administrative records, including financial records, on the same individuals from the US Centers for Medicare and Medicaid Services. The linked data provide a nationally representative sample of the 65-plus population because all Americans become eligible for Medicare benefits at age 65. Importantly, the MCBS provides comprehensive measures of each respondent's total and out-of-pocket medical spending, which can be used to develop estimates of health benefits for a group particularly affected by air pollution.

4. Lessons for Future Analyses and for Policy

Several lessons for both future analyses and for policy emerge from these studies.

4.1. Lessons for Analysis

Turning to the national requirements for RFG and LSD and focusing on lessons for analysis rather than directly considering policy, Sweeney notes the importance of considering shifts in product mix (across product and geographic markets) in estimating overall costs. In effect, he suggests that the often-ignored fuel price reductions in unregulated markets may offset the higher prices seen in regulated markets. Although analysis of these distributional spillovers can be challenging, considering them in national-level RIAs would reduce the estimated overall burden of rules like the RFG and LSD fuel policies and give impetus to further consideration of the winners and losers.

Ketcham et al.'s estimate of a VSL for seniors is substantially below the levels currently used in RIAs, and the finding appears robust. The politics of this issue are obviously difficult.

Fraas et al. support a new category of potential adult benefits from reducing childhood exposure to lead and total suspended particulates in the environment. They were not able, however, to disentangle effects of early childhood exposure to lead and TSP on adult personality traits.

The work by Cropper et al. is largely of methodological interest. It suggests that CAA regulation in the 1970s was a bigger factor in observed air pollution improvements than previously thought.

4.2. Policy Suggestions

Aldy and Auffhammer report that the RPG and boutique fuel programs now operating across the states and localities do not have a significant effect on ambient ozone. Based on their analysis, there may be few downsides to eliminating these programs. EPA should do further work to evaluate the merits of phasing out these programs.

Jacobsen et al. find that current state and local registration fees are not cost-effective in decarbonizing the US vehicle fleet, since registration fees for new, low-emitting vehicles are substantially higher than for older, higher-emitting vehicles. The authors suggest that damages-based registration fees would address the inefficiency associated with the absence of regulations on the emissions from older vehicles. They

project that this approach could yield enormous welfare gains—on the order of \$30 billion annually. They also acknowledge, though, that further attention needs to be given to the distributional effects of the very large damage-based registration fees implied by this approach. There may also be alternative approaches—approaches not explored by the authors—that would encourage retirement of older, high-emitting vehicles without imposing the costs and adverse distributional effects of damages-based registration fees.

In terms of the interaction between different regulations, Linn reports that a ZEV standard of 22 percent (in place of the current 17 percent standard) coupled with more stringent CAFE limits would yield an additional \$0.6 billion in net benefits per year, but it would also increase CO₂ emissions by 3 million tons per year relative to the alternative standard. Linn finds the ZEV program alone to be regressive, since high-income households benefit more from the program than low-income households. At the same time, he suggests that a tighter ZEV standard would support a tighter CAFE standard. Overall, Linn concludes that the combined ZEV and CAFE programs are generally progressive.

4.3. Institutional Issues

As noted in Section II, the recently enacted Evidence-Based Policymaking Act of 2019 and the now pending SMART Act represent new efforts by Congress to strengthen the use of systematic and analytic approaches to the evaluation of federal regulation via retrospective analysis.

4.3.1. Evidence-Based Policymaking Act

The EBPA, enacted in January 2019, seeks to enhance agencies' strategic planning and the use of evidence-based evaluation in the policy process across all agencies. The law incorporates many of the recommendations of the US Commission on Evidence-Based Policymaking to improve the use of evidence and data to generate policies and inform programs in the federal government.

The EBPA requires that each agency develop an evidence-building plan—"a systematic plan for identifying and addressing policy questions relevant to the programs, policies, and regulations of the agency" (Section 312(a)). Consistent with updating the strategic plan every four years (Section 306), the head of each agency is required under Section 312(b) to develop annual "evaluation plans" that include (1) questions for each significant evaluation study that the agency plans to begin in the next fiscal year; (2) information collections or acquisitions the agency plans to begin in the next fiscal year; and (3) any other information included in guidance issued by the OMB director under Subsection (a)(6). In addition, the EBPA requires each agency to designate evaluation and statistical officers and calls for the establishment of an advisory committee with broad membership among experts within the agency and outside.

Although the EBPA does not directly require periodic ex post review of regulations, it does set a framework for periodic strategic plans (Section 306) and annual evaluation plans (Section 312) so that agencies can conduct periodic evaluations of their policies or programs and share expertise across agencies through the advisory committee.

To implement the EBPA, OMB has issued memoranda to federal agencies, outlining the specifics of the newly required learning agendas. In addition, the Office of Evaluation Science at the General Services Administration has published “Evidence Act Toolkits” to assist agencies in their learning agendas.

A review of the early progress in implementing the EBPA (Bennear et al. 2022) revealed both accomplishments and shortcomings of the agencies’ responses so far. For example, for EPA, Bennear et al. found that 16 evaluations (both quantitative and nonquantitative) had been conducted: seven regulatory evaluations, seven nonregulatory, and two mixed, including several enforcement and IT issues. The Department of Energy, the Nuclear Regulatory Commission, and other agencies reported additional evaluations, for 198 in total. At the same time, the authors note that some agencies failed to report any specific evaluations by the due date.

Bennear et al. 2022 categorized the evaluations according to focus—costs, benefits, cobenefits, countervailing risks, and distributive effects, among others. Overall, the great majority of the evaluations considered distributive effects.

Beyond the individual evaluations, Bennear et al. examined the agencies’ annual evaluation plans and learning agendas. Here the story was also mixed, with several agencies submitting fairly complete reports and others not. EPA appears to be one of the more responsive agencies, submitting a total of 15 questions in its learning agenda, concerning both strategic and operational issues, per the OMB guidance. For example, in the area of air quality benefit assessment methodologies, EPA identified specific areas that need more investment to allow comprehensive cost-benefit analysis.⁷ For drinking water systems out of compliance, EPA reports development of a method for assessing the effect of Safe Drinking Water Information System data quality on compliance rate calculation, reviewing data accuracy, and gathering and synthesizing past and ongoing analyses.

⁷ For further follow-up, see “Notice of Request for Nominations for a Science Advisory Board Panel on BenMAP and Benefits Methods,” June 13, 2022, <https://www.federalregister.gov/documents/2022/06/13/2022-12703/request-for-nominations-for-a-science-advisory-board-panel-on-benmap-and-benefits-methods>.

Although Benneer et al. 2022 make no summary judgments about EBPA implementation, it is clear that more work needs to be done. They identify the following challenges for the agencies:

- data access;
- low response rate to surveys;
- cross-agency coordination;
- resources (time, staff, funds);
- inference (interpreting the evaluation results and attributing outcomes to the effects of a particular policy or program); and
- potential effect of COVID-19 on conducting evaluation activities and collecting data.

4.3.2. SMART Act

In February 2022, the Senate Committee on Homeland Security and Governmental Affairs reported out to the Senate a bipartisan bill titled Setting Manageable Analysis Requirements in Text (S. 2801, referred to as the SMART Act), sponsored by Senators Kyrsten Sinema (then D-Arizona) and James Lankford (R-Oklahoma). The SMART Act would require agencies to include, as part of each major final rule, a framework for a retrospective analysis that compares the projected and actual benefits and costs and assesses whether the rule, as implemented, is achieving its regulatory objectives. The required framework must include the design of the retrospective analysis and a plan for gathering the data necessary to support the analysis. This analysis must be completed within 10 years. The bill includes a limited court review provision focused on ensuring that agencies provide the required plan for retrospective analysis.

At the [RFF March 2022 conference on retrospective analysis](#), Senator Sinema, cosponsor of the SMART Act, said it would provide a holistic approach to retrospective analysis, as opposed to the reactive approach mandated by existing executive orders. Key to this distinction is the requirement for agencies to develop specific plans for retrospective analysis, including data collection, at the time of rule issuance. Overall, she argues, the bill would support a culture of review and learning in the regulatory agencies that could be used in designing new regulations and, where needed, adjusting existing regulatory programs.

Following the senator's remarks, we convened a group of individuals with broad expertise on regulatory and institutional issues: Joseph Aldy, Kennedy School, Harvard University, formerly with the White House staff on energy and environmental issues; Katherine Dawes, EPA's Evidence Act officer and long-time leader of evaluation activities in the agency; Michael Livermore, University of Virginia expert on regulatory issues, formerly at NYU law school; and Albert McGartland, head of EPA's policy office and the agency's national center for environmental economics.

The panel fully embraced the need to focus more on the role of retrospective analysis as contributing to a learning agenda for the agency instead of politicizing the process by critiquing existing rules. Several commentators expressed concern that a broad program of retrospective analysis could result in additional legal or political challenges for regulatory agencies. Finally, a general consensus emerged among the panelists on the importance of providing adequate funding and staff support for retrospective analysis.

Other observations made by panel members include the following:

- Both the problems facing regulators and the plausible policy options are more complex today than in the earlier days of environmental management. Unsurprisingly, control costs are also higher. These factors strengthen the case for retrospective analysis as a means of improving the design and implementation of federal regulation.
- Planning ahead for retrospective analysis should be done at the time of rule proposal or promulgation. It should include specifics of the proposed data collection and the methods to be used in the evaluation studies. Analysts should be creative about the data sources and look broadly across both the public and private sectors for relevant information. To promote transparency, several panelists called for an up-front articulation of how the newly collected data would be used down the road.
- Traditional program evaluation approaches, focusing on intermediate steps rather than a strict outcomes orientation, should continue to have a role, one panelist said, because such studies may reveal some of the reasons for over- or underachievement of the stated goals.
- The cost of conducting retrospective analyses and the potential increase in workload for regulatory agencies concerned some panelists. There was broad support for additional funds for these analyses. Some panelists proposed that academics and other outside experts could augment the capacity of agencies to perform high-quality studies.

Despite no overall consensus on next steps for advancing the role of retrospective analysis under the EBPA, panelists expressed support for a presidential executive order. Some panelists noted the substantial heterogeneity across agencies and pointed to the current approach under existing executive orders for ex ante analysis—that is, general guidance from OMB and agency-specific guidance for regulatory analysis—as a reasonable approach. Several panelists also discussed a possible forcing action from Congress, such as specific funding for retrospective analysis, legislative riders, or specific requirements along the lines of the SMART Act.

5. Conclusions

We believe this project is contributing to the growing effort to introduce greater rigor and accountability in the federal regulatory process, especially for environmental regulation. Here we highlight the major accomplishments.

5.1. Methods and Data Development

Most of the studies used quasi-experimental approaches to evaluate federal regulations; two studies (Linn and Sweeney) used structural models to explore the effects of federal rules. Examples of data development and analysis include Aldy and Auffhammer, Kuminoff et al., and Fraas et al.

5.2. Lessons Learned for Future Analyses

Examples include the importance of considering the effects of certain rules on unregulated markets (Sweeney); consideration of new quantifiable and monetizable benefit categories (Fraas et al.); and the potential for updating a critical element of most regulatory analyses, namely the value of statistical life (Kuminoff et al.)

5.3. Policy Recommendations

Linn notes the potential synergy between the ZEV and CAFE programs versus the conventional view that ZEV requirements conflict with CAFE; the Aldy and Auffhammer results suggest little or no effect of the RFG and boutique fuels programs on ambient ozone—a result that could trigger a review of these programs.

5.4. Institutional Issues

Benjamin et al. have developed the first empirical examination of the Evidence-Based Policymaking Act and identified challenges for agencies in advancing the role of retrospective analysis in the federal regulatory process. Their review also identifies some options to address these challenges.

