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The Production Function of the Regulatory State

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Article

The Production Function of the Regulatory State: How Much Do Agency Budgets Matter?

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"We're going to have little tidbits left . . . ."[1]

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1. Donald Trump, commenting during the 2016 Republican presidential primaries on his proposed cuts to the Environmental Protection Agency's budget. *See* Kyle Feldscher, *Trump Says He'd Eliminate 'Department of Environment Protection,'* WASH. EXAMINER (Mar. 3, 2016), https://www.washingtonexaminer.com/trump-says-hed-eliminate-department-of-environment-protection/article/2584908.

INTRODUCTION

Calls to cut regulatory-agency budgets have rung through the halls of the Capitol and statehouses continuously for well over three decades.[2] They have never resonated more loudly than in the 2016 presidential election.[3] The Environmental Protection Agency (EPA) has been a favorite target, with Congress trying to restrain its activities both by legislation and, less directly, by reducing the agency's resources.[4] As one would expect, interest groups fall on both sides of the fence when budget cuts are in the air. Pro-regulatory interests generally warn of dire consequences for the public. The Natural Resources Defense Council (NRDC) decried EPA's budget reductions in 2011 as "a contract on America masquerading as a spending bill. It's nothing short of a declaration of war on our most basic health protections. It would do away with fundamental safeguards that keep our air, water and lands clean."[5] The Center for Effective Government similarly assailed Congress's proposed EPA budget for 2015:

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2. *See, e.g.*, *Clinton Takes Aim at Bureaucracy*, CHI. TRIB. (Feb. 11, 1993), http://articles.chicagotribune.com/1993-02-11/news/9303177668_1_cuts-committees-and-subcommittees-congressional-leaders; Mark Landler & Annie Lowry, *Obama Bid to Cut the Government Tests Congress*, N.Y. TIMES (Jan. 13, 2012), http://www.nytimes.com/2012/01/14/us/politics/obama-to-ask-congress-for-power-to-merge-agencies.html; Sean Murphy, *Oklahoma Governor Orders Agencies To Prepare for Budget Cuts*, WASH. TIMES (Oct. 26, 2015), http://www.washingtontimes.com/news/2015/oct/26/oklahoma-governor-orders-agencies-to-prepare-for-b.

3. *See, e.g.*, Gary Fineout, *Jeb Bush Vows to Cut Spending, Lobbying*, BOS. GLOBE (July 21, 2015), http://www.bostonglobe.com/metro/2015/07/20/bush-vows-cut-spending-washington-lobbing/1Hk9xP6IPBjfH52DVImySN/story.html; Heather Haddon, *Donald Trump Vows To Slash Funding for Education, EPA*, WALL STREET J. (Jan. 11, 2016), http://www.wsj.com/articles/donald-trump-vows-to-slash-funding-for-education-epa-1452551107.

4. *See, e.g.*, Coral Davenport, *E.P.A. Faces Bigger Tasks, Smaller Budgets and Louder Critics*, N.Y. TIMES (Mar. 18, 2016), http://nytimes.com/2016/03/19/us/politics/epa-faces-bigger-tasks-smaller-budgets-and-louder-critics.html; Carl Hulse & David M. Herszenhorn, *E.P.A. and Public Broadcasting Are on House Republicans' List for Deep Cuts*, N.Y. TIMES (Feb. 11, 2011), http://www.nytimes.com/2011/02/12/us/politics/12congress.html; Janet Hook et al., *GOP Wins Deep Cuts in Environment Spending*, WALL STREET J., Apr. 13, 2011, at A4.

5. *House Panel's Spending Bill Threatens Public Health Protections*, NRDC (July 6, 2011), http://www.nrdc.org/media/2011/110706. As Joel Mintz has concluded, "any form of budget cutting in EPA's severely understaffed enforcement program is likely to have an adverse effect on the robustness and effectiveness of the Agency's critical enforcement work." Joel Mintz, *Cutting*

> In a continuing effort to dismantle the ability of the [EPA] to protect public health and the environment, Congress is poised to adopt a fiscal year 2015 budget that would reduce the agency's funding for the fifth year in a row. The $60 million cut in EPA's budget, which builds on previous reductions, will bring the agency's staffing to its lowest level since 1989. These funding cuts are not surprising, given that anti-regulatory forces in Congress have made clear their intent to use the budget process to block EPA's work.[6]

There is no question that budget-cutting initiatives, whether aimed at specific agencies or the regulatory state in general, have gone far beyond rhetoric to impose real impacts on agency resources. For example, the Obama Administration acquiesced to significant personnel cuts in 2013 and 2014 as part of the broader sequestration initiative across government agencies.[7] The long-term trends in EPA personnel and inflation-adjusted budget tracked in Chart 1 show a generally static or slightly falling level of total resources from 1990 through 2013, with diminishing resources dominating the picture since 1998.[8] The EPA's experience matches a history of similar declines in other agencies.[9]

EPA's Enforcement Budget: What It Might Mean, CTR. FOR PROGRESSIVE REFORM: CPRBLOG (Apr. 12, 2012), http://www.progressivereform.org/CPRBlog.cfm?idBlog=A6A2E941-98B3-8007-9CEEB42458BED78E.

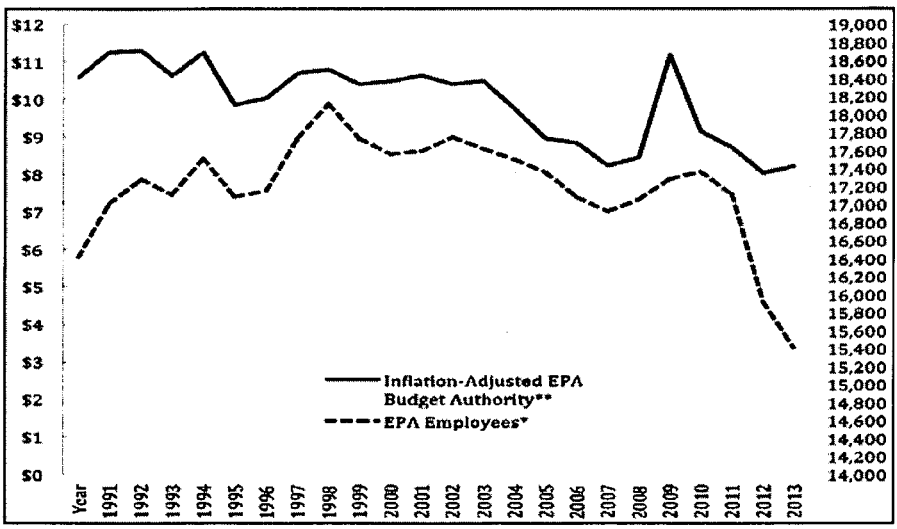
6. Ronald White, *Congress Slashes EPA Budget Again Despite Strong Public Support for Strengthening Health Protections*, CTR. FOR EFFECTIVE GOV'T (Dec. 12, 2014), http://www.foreffectivegov.org/blog/congress-slashes-epa-budget-again-despite-strong-public-support-strengthening-health-protection.

7. *See* Andy Medici, *Government Cuts 84,500 Federal Employees in Three Years*, FED. TIMES (Jan. 20, 2015), http://www.federaltimes.com/management/leadership/2015/01/20/government-cuts-84500-federal-employees-in-three-years; Matthew Yglesias, *The Idiocy of Sequestration*, SLATE (Jan. 30, 2013), http://www.slate.com/articles/business/moneybox/2013/01/what_is_sequestration_the_budget_cuts_will_slam_government_spending_yet.html.

8. CHRISTOPHER SELLERS ET AL., ENVTL. DATA & GOVERNANCE INITIATIVE, PT. 1, THE EPA UNDER SIEGE: TRUMP'S ASSAULT IN HISTORY AND TESTIMONY 23–24 (2017), https://envirodatagov.org/wp-content/uploads/2017/06/Part-1-EPA-Under-Siege.pdf; *see EPA's Budget and Spending*, EPA, https://www.epa.gov/planandbudget/budget (last visited Nov. 4, 2017) (reporting EPA's budget and spending data).

9. The U.S. Department of Housing and Urban Development (HUD) budget decreased six percent from 2002 to 2012 (when adjusted for inflation). *See* CONG. RESEARCH SERV., R42542, DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD): FUNDING TRENDS SINCE FY2002, at 1 (2016), http://www.everycrsreport.com/reports/R42542.html. The Department of Interior's workforce shrunk 8.2% from 2006 to 2015; the Department of Agriculture's workforce shrunk 8.7% from 2006 to 2015. *See* U.S. OFFICE OF PERS. MGMT., SIZING UP THE EXECUTIVE BRANCH: FISCAL YEAR 2015 tbl.3 (2016).

Chart 1: EPA Budget and Employees 1991–2013



The charge by the NRDC and Center for Effective Government is straightforward: limiting EPA's resources will make it less effective and, as a result, will worsen the pollution of our air, water, and lands.[10] The connections are easy to draw. It seems intuitive that reducing resources means fewer personnel and inspections for compliance monitoring, fewer enforcement actions, less deterrent effect, and therefore more violations that harm the environment.[11] It means fewer resources for permitting, drafting new regulations, and revising existing regulations. Indeed, according to the Center for Effective Government, EPA's strategic plan to balance its budget in 2014 called for a forty to fifty percent reduction in inspection and enforcement cases.[12] One might call this future an Age of Austerity, one of doing less with less.

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10. As former EPA Deputy Administrator, Bob Perciasepe, describes, "EPA's budget in 1990 for example was $5.5 billion and that would be $10.1 [b]illion in 2016 with inflation to just do the same work. EPA[']s 2016 budget is $8.1 [b]illion and that includes implementing the Safe Drinking Water Act and the Food Quality Protection acts in 1996 and the new TSCA [Toxic Substances Control Act] this year. EPA had 16,300 employees in 1990 and they have 15,300 in 2016." E-mail from Bob Perciasepe, President, Ctr. for Climate & Energy Sols., to authors (Oct. 16, 2016, 16:02 PDT) (on file with authors).

11. *See* Joel A. Mintz, *"Running on Fumes": The Development of New EPA Regulations in an Era of Scarcity*, 46 ENVTL. L. REP. 10510, 10511–12 (2016).

12. White, *supra* note 6.

There is, however, a competing narrative. Terry Anderson, the noted "free market environmentalist,"[13] argues that "if lawmakers are looking for an agency in which to cut spending without causing harm to the environment, the EPA is a great place to start."[14] Anderson and others championing agency budget cuts defend their actions as trimming fat from the bureaucracy.[15] This was one of the central themes behind Congress's haircut strategy of sequestration—cutting equal amounts from all agencies.[16] Increasing agency budgets is far more likely, they imply, to promote bureaucracy than improvements in regulatory outcomes, such as environmental quality in EPA's case. This strategy centers on doing more with less.

Which narrative is accurate—will budget cuts harm environmental quality or have no impact? To bolster his side of the argument, Anderson graphed EPA's inflation-adjusted budget against measures of air quality for selected pollutants, shown in Chart 2 below.[17] Despite a flat or declining budget, Anderson's chart shows air quality steadily *improving* over three decades. This is not what one would expect from the doing less with less dystopia.

13. *Terry Anderson*, PROP. & ENVTL. RES. CTR. (PERC), www.perc.org/staff/terry-anderson (last visited Nov. 4, 2017).

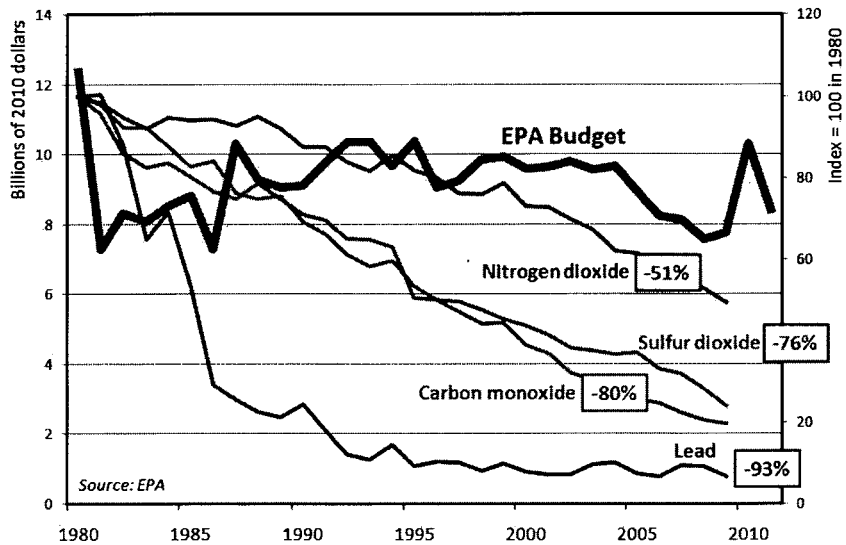
14. Terry Anderson, *EPA Budget Cuts: Reducing Bureaucracy, Not Environmental Quality*, PERC: THE PERCOLATOR, http://www.perc.org/blog/epa-budget-cuts-reducing-bureaucracy-not-environmental-quality (last visited Nov. 4, 2017) [hereinafter *EPA Budget Cuts*].

15. *See id.* ("Such data suggest that increasing the EPA's budget . . . will only increase bureaucracy, not air quality.").

16. *See* Jonathan Weisman, *Answers to Questions on Capital's Top Topic*, N.Y. TIMES (Feb. 21, 2013), http://www.nytimes.com/2013/02/22/us/politics/questions-and-answers-about-the-sequester.html.

17. *EPA Budget Cuts*, *supra* note 14.

Chart 2: Air Quality and EPA Budget



The explanation for Anderson's chart—why steady and declining agency resources appear to correlate with clear and continuous improvements in air quality—is far from obvious. To be sure, all the chart shows is a correlation, and environmental policy experts no doubt could offer alternative causal explanations. Perhaps the reductions in pollutants would have been even more rapid had EPA been provided more resources. Perhaps EPA internally allocated more resources to air quality while other environmental quality goals, such as protection of drinking water, suffered by comparison. One could even argue that the chart, rather than proving EPA is a bloated agency, actually shows EPA is quite effective, continuing to knock down air pollution levels while receiving no additional or even fewer resources. Or perhaps EPA's budget does not matter so much after all. To know which of these very different explanations is most on target turns on one fundamental question: *What is the relationship between the funding levels provided to regulatory agencies and the social-welfare outcomes they are charged with delivering?*

The crux of that question—*how does more or less funding move the needle on outcomes*—is asked and answered routinely throughout the private sector. Every budget cycle, companies must determine how most effectively to allocate their funds to grow the bottom line. Managers must decide whether to increase

budgets for research and development (R&D) and manufacturing, for example, or decrease for marketing. Similar questions about the dynamic linkage between funding and outcomes also lie at the core of research into most fields of social importance. What is the relationship between police funding and crime? How does health care spending influence medical outcomes? What is the significance of school funding on test scores? In these sectors and many others, researchers devote a great deal of time and effort to examining the relationship between resources and results.[18] Yet virtually no research has considered this relationship in the context of *regulatory* agencies.

The most basic question about agency resources and outcomes—*are we getting what we pay for?*—remains informed largely by anecdotes and political sound bites. Leading Republican candidates during the 2016 presidential primaries repeatedly denounced regulatory agencies, with Donald Trump calling for dramatic reduction of EPA's budget and Ted Cruz promising to eliminate four cabinet agencies were he to become president.[19] Democratic candidates ridiculed their proposals.[20] But neither side offered any robust evidence of what would happen to regulatory outcomes if funding were to move in either direction.

To take the example of EPA, do greater EPA resources actually lead to better environmental protection efforts? If so, to what extent do these regulatory efforts then lead to improved environmental quality in the field? Is the converse true, with reduced resources leading to poorer environmental quality? Which aspects of environmental quality are most at risk from reduced EPA resources and which are less vulnerable to backsliding?

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18. *See infra* Part I.

19. Igor Bobic, *Donald Trump Would Cut Department of Education, EPA*, HUFFINGTON POST (Oct. 18, 2015), http://www.huffingtonpost.com/entry/donald-trump-epa-education_us_56240035e4b02f6a900cc0e7; Oliver Milman, *Republican Candidates' Calls To Scrap EPA Met with Skepticism by Experts*, GUARDIAN (Feb. 26, 2016), http://www.theguardian.com/environment/2016/feb/26/republican-candidates-donald-trump-eliminate-epa-law-experts; *see* Amber Phillips, *Four Federal Agencies President Ted Cruz Could Do Without*, WASH. POST (July 24, 2015), http://www.washingtonpost.com/news/the-fix/wp/2015/07/24/four-federal-agencies-president-ted-cruz-could-do-without/z?utm_term=.4aa88982a5f5.

20. *See, e.g.*, Evan Lehmann, *Trump, Clinton Argue over Climate Change*, SCI. AM. (Sept. 27, 2016), http://www.scientificamerican.com/article/trump-clinton-argue-over-climate-change.

We focus on EPA in this Article because it has a clear overarching agency goal—environmental protection—that is measurable.[21] Our findings, however, are broadly applicable across the administrative state. The empirical questions we address have important theoretical and practical implications for all regulatory agencies. Indeed, these implications are heightened, given the antiregulatory stance of the Trump administration.[22]

Moreover, these questions will become increasingly important, no matter who occupies the White House.[23] They deserve serious study, not the current state of sweeping ideological claims from politicians and interest groups on both sides of the debate. But how would one go about addressing these questions? That is the ambitious aim of this Article.

This Article lays the groundwork for a new field of theoretical and empirical research, using what we call the "regulatory production function," to understand more clearly the effects of incremental changes (reductions or increases) in regulatory-agency budgets on the levels of benefits they produce. To ensure our theory is grounded, we present a case study using EPA as the regulatory agency and environmental quality as the targeted social welfare outcome. But our theoretical framework and empirical findings have important implications across the regulatory state on the relationship between agency funding and outcomes for public health, safety, and welfare agencies.

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21. While the data on agency performance are hardly plentiful at EPA, the data that EPA regularly compiles and makes available (at least for certain air pollutants) are superior to comparable information at other agencies.

22. For example, his nominee to head the Department of Energy, Rick Perry, had as a presidential candidate called for the elimination of the agency. *See* Coral Davenport, *Rick Perry, Ex-Governor of Texas, Is Trump's Pick as Energy Secretary*, N.Y. TIMES (Dec. 13, 2006), http://www.nytimes.com/2016/12/13/us/politics/rick-perry-energy-secretary-trump.html.

23. The simple math of discretionary spending means that money available for regulatory agencies will likely continue to be tight in the coming decades. Absent radical legislative reform, increases in future spending for Social Security and Medicare are built-in. *See* CONG. BUDGET OFFICE, MEDICARE-CONGRESSIONAL BUDGET OFFICE'S JUNE 2017 BASELINE 1 (2017), http://www.cbo.gov/sites/default/files/recurringdata/51302-2017-06-medicare.pdf. Therefore, for agency budgets to stay level, one of the following must occur: (1) an increase in federal revenues, which would likely require higher taxes; (2) an increase in deficits; (3) a fall in discretionary spending; or (4) some combination of the first three. Regardless of the exact combination, the likelihood of significant increases in EPA's and other regulatory agencies' budgets seems low for the foreseeable future.

Part I opens by describing relevant scholarship on the relationship between government resources and outcomes, showing the paucity of theoretical and empirical analysis, particularly with respect to regulatory agencies. To begin to fill the theoretical void, Part II introduces the production function concept and how it can provide a framework to think more clearly about the linkages between agency funding and regulatory outcomes. To demonstrate the usefulness of the model, Part III uses it to develop a set of hypotheses that could explain why EPA funding levels may or may not have a significant effect on environmental quality. Part IV introduces an empirical component, assessing what the available data can tell us about the relationship between agency funding and environmental benefits. Using regression analysis, we do not find statistically significant correlations between the EPA or state agency funding levels and air pollution, but major data constraints limit the strength of these analyses.

Part V then explores the important research questions that emerge from the regulatory production function model and our empirical findings. The administrative state has developed and come to rely heavily on sophisticated cost-benefit analysis for evaluating specific policy proposals. As valuable as it is for those purposes, cost-benefit analysis provides little insight into the complex budget-outcome relationship. A new mode of analysis is needed, and new forms of data, including comparative, time series, and experimental studies, must be compiled. With this in hand, a whole series of important research questions comes into focus. Consider the following, for example:

(1) How would Congress or the agency know which are its most cost-effective budget investments going forward, or where to make the next round of cuts?

(2) How should an agency manage its activities in an extended period of austerity?

(3) What role do resources play in maintaining agency resilience and how can this be assessed?

(4) Is there a difference as to how an agency might respond to budget cuts compared to budget increases?

(5) Are there other institutions, public or private, that could provide more bang for the buck were funding diverted to them from the incumbent agency?

These and related questions are of the first importance, yet cannot be answered by current methods of analysis and data compilations. Part V thus closes by setting forth the major components and approaches of a new analytic tool that will help inform agency-scale decisions regarding institutional design and instrument choice. It also delineates the broader set of decisions regarding federalism and reliance on private governance as a supplement to public authority.

Decades ago, scholars proposed greater agency reliance on cost-benefit analysis and risk assessment to guide agency actions. At the time, this must have seemed ridiculously ambitious, given the complexity of the issues and the simplicity of the tools. Over time, however, these tools have been developed into important contributors to agency management. We argue that the regulatory production function should follow the same trajectory.

The relationship between agency resources and regulatory outcomes is fundamental and complex. It goes to the very heart of regulatory policy, which explains why politicians and interest groups take strong positions about how it works. Yet it remains woefully underdeveloped theoretically and understudied empirically. This Article provides the first step in laying an intellectual foundation to address these shortcomings and set out future avenues for research.

I. SCHOLARSHIP EXAMINING THE RELATIONSHIP BETWEEN AGENCY RESOURCES AND OUTCOMES

As discussed in the Introduction, the relationship between public funding and outcomes has long been an active field of research in a wide range of social sciences. For example, many scholars have examined the relationship between public spending on education and student academic achievement.[24] The vast

24. *See, e.g.*, ULRICH BOSER, CTR. FOR AM. PROGRESS, RETURN ON EDUCATIONAL INVESTMENT: 2014, at 1–2 (2014), http://cdn.americanprogress.org/wp-content/uploads/2014/07/ROI-report.pdf (comparing academic achievement, as measured by the percentage of students scoring proficiently on state exams, with the educational spending of school districts, while controlling for factors including the cost of living and student poverty); ANDREW J. COULSON, CATO INST., STATE EDUCATION TRENDS: ACADEMIC PERFORMANCE AND SPENDING OVER THE PAST 40 YEARS 1 (2014), http://object.cato.org/sites/cato.org/files/pubs/pdf/pa746.pdf (using a time-series regression approach to adjust state SAT score averages for factors including participation rate and student demographics from 1972 to the present. The study then compares these adjusted SAT scores with the raw SAT scores and inflation-adjusted per-pupil spending

majority find that increasing educational spending does not, on its own, improve student achievement.[25] Other research has focused on the relationship between police funding and crime rates. The findings have not been uniform, with some studies showing that crime rates are positively correlated with police funding (suggesting that higher crime rates trigger greater funding) and others that increases in police levels tend to reduce crime at the local level.[26] Significant research efforts have also

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to examine the link between education funding and outcomes); Rob Greenwald, Larry V. Hedges & Richard D. Laine, *The Effect of School Resources on Student Achievement*, 66 REV. EDUC. RES. 361, 361 (1996) (analyzing a comprehensive collection of sixty school funding and achievement studies that have been performed, and using combined significance analysis and effect magnitude estimation to determine the relationship between three variables—public expenditures (i.e., per-pupil spending), teacher background characteristics (e.g., certification, educational history, and ability), and class/school sizes—and the standardized test scores considered by the surveyed articles); Emiliana Vegas & Chelsea Coffin, *When Education Expenditure Matters: An Empirical Analysis of Recent International Data*, 59 COMP. EDUC. REV. 289, 291–95 (2015) (comparing per capita GDP, per pupil educational spending, and learning outcomes, as measured by mean scores in mathematics and reading as reported by the Program for International Student Assessment).

25. Instead of simply increasing aggregate funding, the studies suggest moderate increases in funding on specific resources could greatly improve student achievement (such as reducing class sizes, school sizes, and improving the quality of teachers). For studies of school funding using a production function model, see *infra* note 62.

26. *See* Thomas B. Marvell & Carlisle E. Moody, *Specification Problems, Police Levels, and Crime Rates*, 34 CRIMINOLOGY 609, 623–24 (1996) (comparing the number of police employees around the country divided by population with crime rates for the seven crime types and finding it makes little difference whether police expenditures are considered in place of police employees because the two factors are strongly correlated and because the bulk of police expenditures are for personnel); Thomas F. Pogue, *Effect of Police Expenditures on Crime Rates: Some Evidence*, 3 PUB. FIN. Q. 14, 15–17 (1975) (exploring the relationship between public spending on law enforcement and the rate of criminal activity, as measured by the proportion of arrests to crime reported in the FBI's index of serious crime, across metropolitan areas); Ben Vollaard & Joseph Hamed, *Why the Police Have an Effect on Violent Crime After All: Evidence from the British Crime Survey*, 55 J.L. & ECON. 901, 902–05 (2012) (exploring the relationship between police funding and crime in the U.K. by, first, assuming that police funding levels are tied to the crime rate, and then considering factors including: police funding, the number of police personnel, crime rates as recorded by the police, and crime rates as deduced by police staffing and police funding levels); Ashish Yadav & Paul D. Berger, *On the Relationship Between Police Funding and Crime Rates*, 2 INT'L J. INNOVATION RES. 1, 2 (2015) (evaluating the link between police funding and crime by comparing the following factors across fifty small cities in the United States: total reported crime, reported violent crime, annual police funding per resident, and educational attainment of residents below and above age twenty-five).

addressed the relationship between health care spending and health outcomes. These studies tend to show that increasing public spending on healthcare improves quality of life by, for example, reducing infant and childhood mortality. Some studies, though, find that differences between state expenditures on healthcare have little effect on infant mortality rates between different states.[27]

Of course, there are important differences between direct funding of police, doctors, or teachers and funding a regulatory agency like EPA. Funding for EPA and other regulatory agencies has a less direct relationship to outcomes than do these other social-welfare funding programs. For example, many of the funds spent to produce improved environmental quality are spent not by EPA but by regulated parties as they invest labor and capital to comply with EPA mandates. EPA's success thus depends in large part on how regulated parties behave.[28] That said, it is reasonable to assume that agency resources matter at least to some degree in that regard. And the scale of agency resources surely is meaningful outside the environmental field. The Food and Drug Administration (FDA), Occupational Safety

27. *See* Marwa Farag et al., *Health Expenditures, Health Outcomes and the Role of Good Governance*, 13 INT'L J. HEALTH CARE FIN. & ECON. 33, 33 (2013) (examining the relationship between public health spending and health outcomes, including infant and child mortality, in 133 low- and middle-income countries for the years 1995, 2000, 2005, and 2006); Richard Heijink, Xander Koolman & Gert P. Westert, *Spending More Money, Saving More Lives? The Relationship Between Avoidable Mortality and Healthcare Spending in 14 Countries*, 14 EUR. J. HEALTH ECON. 527, 527 (2013) (comparing the growth of the proportion of healthcare spending to GDP with "avoidable mortality" in fourteen western countries, based on data from 1996 to 2006); David R. Morgan & James T. LaPlant, *The Spending-Service Connection: The Case of Health Care*, 24 POL'Y STUD. J. 215, 215 (1996) (exploring the relationship between public healthcare spending at the state and federal levels, various service measures (e.g., the quantity of hospital beds and full-time equivalent healthcare workers) and several health outcomes, including low infant birthweight, infant mortality, and childhood mortality); John Nixon & Philippe Ulmann, *The Relationship Between Health Care Expenditure and Health Outcomes: Evidence and Caveats for a Causal Link*, 7 EUR. J. HEALTH ECON. 7, 7 (2006) (analyzing the relationship between healthcare expenditures and health outcomes, including life expectancy and infant mortality, for fifteen member-states of the European Union, relying on data from 1980 to 1995).

28. *See, e.g.*, EPA, THE BENEFITS AND COSTS OF THE CLEAN AIR ACT, 1970 TO 1990, at 7 (1997) (estimating the private sector's total direct compliance costs of the Clean Air Act at nineteen billion dollars); *EPA's Budget and Spending*, EPA, https://www.epa.gov/planandbudget/budget (last visited Nov. 4, 2017) (documenting EPA's budget in 1990 at $5.46 billion).

and Health Administration (OSHA), Federal Aviation Administration (FAA), Center for Disease Control (CDC), and a host of other regulatory bodies have strong mandates to protect the public.[29] How much their funding matters to providing these protections, therefore, ought to be a question of great interest to anyone weighing in on the budgeting debate.

Nevertheless, there have been few studies examining the practical impact of resource levels for regulatory agency outcomes. Prominent exceptions include studies of funding for securities regulation[30] and for OSHA regulation of the workplace.[31] It stands to reason that those and other regulatory agencies' funding levels determine their effectiveness, but overall there has been strikingly little research examining the connection between agency resources and public health, safety, and welfare outcomes. This is most certainly true in the environmental field.

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29. *See, e.g.*, *Safety: The Foundation of Everything We Do*, FAA, http://www.faa.gov/about/safety_efficiency (last updated July 24, 2017) ("We continually strive to improve the safety and efficiency of flight in this country."); *What We Do*, FDA, http://www.fda.gov/aboutfda/whatwedo (last updated Apr. 4, 2017) (stating the "FDA is responsible for advancing the public health"); *About OSHA*, OSHA, https://www.osha.gov/about.html (last visited Nov. 4, 2017) (stating OSHA "assure[s] safe and healthful working conditions for working men and women").

30. In a comparative study across nations, Jackson and Roe found that agency resources (budget and staff) are a better predictor of regulatory outcomes than formal elements of regulation, arguing that increased public enforcement is an effective means of obtaining the market outcomes security regulators seek. Howell E. Jackson & Mark J. Roe, *Public and Private Enforcement of Securities Laws: Resource-Based Evidence*, 93 J. FIN. ECON. 207, 207 (2009); *see also* James D. Cox, Randall S. Thomas & Dana Kiku, *SEC Enforcement Heuristics: An Empirical Inquiry*, 53 DUKE L.J. 737, 742 (2003) (arguing that SEC resource limitations lead to insufficient enforcement); Jason Scott Johnston, *A Game Theoretic Analysis of Alternative Institutions for Regulatory Cost-Benefit Analysis*, 150 U. PENN. L. REV. 1343, 1362–63 (2002) (asserting that agency budget decreases will reduce regulatory capacity).

31. McGarity and Shapiro's comprehensive analysis of OSHA inspections and workplace injuries concluded that OSHA inspections have had a greater impact on the injury rates of inspected firms and therefore that greater funding will increase workplace safety. They also cite an OSHA assertion that fifteen percent budget cuts would lead to an additional 50,000 workplace injuries and 50,000 cases of occupational disease. Thomas O. McGarity & Sidney A. Shapiro, *OSHA's Critics and Regulatory Reform*, 31 WAKE FOREST L. REV. 587, 597, 638 (1996); *see also* SIDNEY SHAPIRO ET AL., REGULATORY DYSFUNCTION: HOW INSUFFICIENT RESOURCES, OUTDATED LAWS, AND POLITICAL INTERFERENCE CRIPPLE THE 'PROTECTOR AGENCIES' 6 (Ctr. for Progressive Reform White Paper No. 906 2009) (arguing that the CPSC was responsible for twenty-five percent drop in injuries caused by durable goods but following budget cuts in the Reagan years, injury rates leveled off).

To be sure, regulatory agencies generate plenty of data. Taking EPA as a representative example, the agency provides a great deal of useful data about its work and about environmental quality. Annual reports are published on environmental quality indicators for air, water, and solid waste,[32] as well as detailed data on inspections, enforcement actions, fines collected, technology mandated, and other sanctions.[33] The Government Performance and Results Act requires the EPA and other agencies to submit reports to Congress identifying goals and updates on how well it has achieved them.[34] While providing an impressive stockpile of data, however, none of these reports assesses the *relationship* between funding and outcomes.

Nor have academics filled this gap. A small number of publications address aspects of this issue, but none get at the question directly and comprehensively. At a macro level, for example, the Environmental Kuznets Curve literature has explored the relationship between GDP and common pollutants.[35]

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32. *See, e.g.*, *Our Nation's Air: Status and Trends Through 2016*, EPA, http://gispub.epa.gov/air/trendsreport/2017/#home (last visited Nov. 4, 2017) (containing annual reports); *Providing Safe Drinking Water in America: National Public Water Systems Compliance Report*, EPA, http://www.epa.gov/compliance/providing-safe-drinking-water-america-national-public-water-systems-compliance-report (last visited Nov. 4, 2017) (containing annual reports); *EPA's Report on Environment (ROE): Quantity of Municipal Solid Waste Generated and Managed*, EPA, http://cfpub.epa.gov/roe/indicator.cfm?i=53 (last updated July 28, 2017) (containing annual report).

33. *See Enforcement Annual Results for Fiscal Year 2016*, EPA, http://www.epa.gov/enforcement/enforcement-annual-results-fiscal-year-2016 (last updated May 9, 2017).

34. *See* Government Performance and Results Act of 1993, Pub. L. No. 103-62, § 1116, 107 Stat. 285, 288. "Departments and agencies must clearly describe the goals and objectives of their programs, identify resources and actions needed to accomplish these goals and objectives, develop a means of measuring their progress, and regularly report on their achievements." *Glossary of Terms: Government Performance and Results Act*, EPA, https://rcrainfo.epa.gov/rcrainfo/help/generalhelp/glossary_of_terms.htm#governmentperformance (last visited Nov. 4, 2017). EPA's goals and assessments, though, are quite general.

35. Across a wide range of countries, research has shown that as societal wealth increases, there is an inflection point where pollutants decrease. The basic explanation is that environmental quality becomes a priority once more fundamental needs such as food and shelter have been met. This is an important insight as an economy-wide matter, but does not provide insight into agency funding. *See, e.g.*, Gene M. Grossman & Alan B. Krueger, *Economic Growth and the Environment*, 110 Q.J. ECON. 353, 353 (1995); John A. List & Craig A. Gallet, *The Environmental Kuznets Curve: Does One Size Fit All?*, 31 ECOLOGICAL ECON. 409, 409 (1999).

There has also been a small number of more specific articles by economists and political scientists examining the connection between government size and air quality, the link between public expenditures for social goods and air pollution levels, and the connections between state-level environmental expenditures and public-health outcomes, among others.[36]

The most relevant contribution in legal scholarship is by Victor Flatt and Paul Collins. Focusing on the state level, they found that an increase in state environmental-agency enforcement funding led to shorter periods of noncompliance under the Clean Air Act.[37] They treated noncompliance as a proxy for environmental quality. While a useful study and the most rigorous examination of regulatory agency budget-outcome relationships to date, this does not answer our research question, for the simple reason that periods of noncompliance may have little impact on environmental quality.[38]

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36. Bernauer and Koubi examined the connection between government size and air quality (as measured by sulfur dioxide concentrations) by surveying forty-two countries from 1971 to 1996. Thomas Bernauer & Vally Koubi, *Are Bigger Governments Better Providers of Public Goods? Evidence from Air Pollution*, 156 PUB. CHOICE 593, 604 (2013) (finding a positive correlation between a government's size and air pollution). Islam and López looked at the link between public expenditures for social goods and air pollution levels. Asif M. Islam & Ramón E. López, *Government Spending and Air Pollution in the US*, 8 INT'L REV. ENVTL. & RESOURCE ECON. 139, 141 (2014) (finding that shifting public funding from private subsidies to social and public goods at the state level improves air quality, whereas the same is not true at the federal level); *see also* SUSAN HUNTER & RICHARD W. WATERMAN, ENFORCING THE LAW: THE CASE OF THE CLEAN WATER ACTS 203 (1996) (considering the relationship between state agency organizational form and water pollution levels); Alexander C. Heckman, *Desperately Seeking Management: Understanding Management Quality and Its Impact on Government Performance Outcomes Under the Clean Air Act*, 22 J. PUB. ADMIN. RES. & THEORY 473, 487 (2012) (finding a statistically significant but "modest or negligible" impact from spending on environmental outcomes); Neal D. Woods, David M. Konisky & Ann O'M. Bowman, *You Get What You Pay for: Environmental Policy and Public Health*, 39 PUBLIUS 95, 103–04 (2009) (tracking state-level environmental expenditures to public-health outcomes for three years, finding that, all else being equal, states with stronger enforcement and more funding have lower levels of pollution and better public health, as shown by a composite measure of seventy environmental conditions).

37. Victor B. Flatt & Paul Collins, Jr., *Environmental Enforcement in Dire Straits: There Is No Protection for Nothing and No Data for Free*, 85 NOTRE DAME L. REV. 55, 83 (2009).

38. It may well be the case, for example, that the noncompliance by some firms has only minimal impacts on air or water quality because other major emitters are in compliance. To assess the relationship between periods of noncompliance and environmental quality, one would need to know more about which parties were in noncompliance and the resulting environmental impacts.

In short, while helpful in understanding specific aspects of government resources and environmental outcomes, none of these studies has focused on EPA budgeting and environmental quality, and studies looking more broadly at other regulatory agencies are few and far between. More fundamentally, no scholarly contributions from law, economics, political science, or other relevant disciplines have sought to develop a theoretical framework for how one would approach studying the question for EPA or any other regulatory agency. We propose such a model in Part II.

II. BETWEEN AGENCY FUNDING AND OUTCOMES: MODELING THE REGULATORY PRODUCTION FUNCTION

Terry Anderson's macro analysis in Chart 2 found air quality improvements over an extended period of flat to declining EPA budgets.[39] But what does that prove about the relationship between EPA's budget and environmental quality? This is fundamentally a matter of understanding what happens *between* agency funding and intended outcomes. Yet, for the most part, the debate over EPA funding treats that space as a black box.

To be sure, cost-benefit analysis of discrete EPA regulations and other actions, though it has its critics,[40] informs us about the relative values of different options.[41] But this method of analysis does not speak to budget dynamics. Even aggregating all of the cost-benefit analyses conducted for a given time period of EPA actions would only tell us how much EPA expected to spend on its actions and the value of the environmental quality benefits it expected them to produce. While its explanation for the latter would necessarily need to describe some form of causal

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See generally Victor B. Flatt, *A Dirty River Runs Through It (The Failure of Enforcement in the Clean Water Act)*, 25 B.C. ENVTL. AFF. L. REV. 1, 4–6 (1997) (arguing that lack of adequate EPA funding has diminished water quality across states).

39. *EPA Budget Cuts*, *supra* note 14.

40. *See* Frank Ackerman & Lisa Heinzerling, *Pricing the Priceless: Cost-Benefit Analysis of Environmental Protection*, 150 U. PA. L. REV. 1553, 1562–63 (2002) (arguing the ineffective nature of cost-benefit analysis as seen in its creation of artificial markets and devaluation through discounting); Amy Sinden, *A "Cost-Benefit State"? Reports of Its Birth Have Been Greatly Exaggerated*, 46 ENVTL. L. REP.: NEWS & ANALYSIS 10933, 10934–39 (2016) (discussing agencies' abilities to consider costs through means other than cost-benefit analysis).

41. For a seminal outline of how cost-benefit analysis can be employed in the regulatory state, see CASS R. SUNSTEIN, THE COST-BENEFIT STATE: THE FUTURE OF REGULATORY PROTECTION (2002).

chain between its action and the change in environmental quality—for example, that factories complying with a new emissions standard will reduce emissions by some level—that would not provide a dynamic understanding of the relationship between agency resources and outcomes, much less what the consequences of more or less agency funding would be going forward. In short, understanding what happens *after* EPA issues the new standard does not improve our understanding about what happens *before* EPA issues the new standard—from the time of funding to the promulgation of the standard—nor does it improve our understanding regarding whether the funding dollars could have been more effectively deployed by EPA or *another actor*.

To frame the challenge of our research question using a different context, consider the corporate budgeting process. Assume you are the CEO of a business and must decide next year's operating budget. This involves determining allocations to each corporate division. To do this intelligently requires deciding (1) the basic amounts needed for each division to perform its core operations; (2) a marginal analysis of which *additional dollar above the previous year's budget* for each division will result in the greatest contributions to the bottom line; and (3) a marginal analysis of which *dollar reduction below the previous year's budget* for each division will minimize harm to the bottom line. Should R&D receive a greater increase than marketing? What about logistics? To flip the question, when the head of R&D requests her annual budget, she needs to justify why additional resources should go to her division rather than be dedicated to other uses, as well as why lowering her budget would harm the company. These marginal analyses all require understanding the firm's production function.

Similarly, claims about whether decreasing EPA funding will or will not affect environmental protection are at heart claims about the production function of environmental quality. The doing less with less position argues that EPA funding has a significant impact on the nation's production of environmental quality. Those advocating the doing more with less position argue that other factors—Anderson's chart does not identify *which* factors—are more important and EPA funding can be decreased without reducing (or perhaps while even improving) environmental protection. Indeed, these competing hypotheses dominate today's political rhetoric regarding regulatory agency funding, yet they have not been carefully assessed.

In this Part, we develop a more robust and complete model of the regulatory production function, using EPA and environmental quality as the case study. In short, claims that increased or decreased funding for EPA will or will not affect environmental quality account for only the beginning and the end of the production function: funding is a raw input and environmental quality is the final product. Quite obviously, what goes on between those two points also matters.

A. PRODUCTION FUNCTION THEORY

Economists have developed the production function model to examine the manner in which an output is related to the quantity and nature of inputs, also known as the factors of production, used to create it.[42] In its most common application, the production function relates the physical output of the final products from a production process, such as the proverbial widget, to the physical inputs or factors of production, such as labor and raw materials. Expressed mathematically, the production function in its most basic form appears as such: $P = f(X, Y)$, where P is total product output and X and Y represent possible inputs.[43] For a single-product firm, the production function describes the maximum output it can produce in a fixed period of time. Inputs have been traditionally categorized as labor, capital, land, and entrepreneurship.[44] Production functions are often used to determine how best to maximize output with a given input or minimize input for a given output.

Production functions in simple form are subject to a number of assumptions. For instance, production functions are generally assumed to be linearly homogenous, meaning different combinations of different quantities of X and Y inputs can produce the same output P.[45] To illustrate this, consider a production function for potato chips wherein potatoes and labor are two of the inputs. An increase in labor might result in more efficient peeling of the potatoes, which in turn could lead to less waste and

42. Thomas M. Humphrey, *Algebraic Production Functions and Their Uses Before Cobb-Douglas*, 83 ECON. Q. 51, 51 (1997).

43. *Id.*

44. Gerald Beer, *The Cobb-Douglas Production Function*, 53 MATHEMATICS MAG. 44, 44 (1980).

45. Udo Ebert & Heinz Welsch, *Environmental Emissions and Production Economics: Implications of the Materials Balance*, 89 AM. J. AGRIC. ECON. 287 (2007); Edmund H. Mantell, *Antinomies in Antitrust Law: Tying and Vertical Integration*, 7 J.L. & COM. 23, 35–36 (1987).

thus lower the necessary amount of potatoes for a given level of output. Production functions also assume the existence of an effective manager within the firm, who is able to determine how to best maximize output given a set of inputs.[46] Adopting assumptions like these, the production function can be used to analyze issues of allocative efficiency for the firm.

While the production function's real-world accuracy is limited by its simplifying assumptions, it is a key concept of neoclassical economics and the subject of rigorous research and refinement to produce more nuanced models that can apply beyond the single-product firm with linear input substitution.[47] One thrust of variation, for example, focuses on integrating variable elasticities of substitution between inputs.[48] Another well-known variation adds technological innovation, or knowledge, as a multiplier making labor and capital more productive,[49] leading some commentators to describe innovation as "the real engine of economic growth."[50]

Yet another important multiplier that can affect output is the intermediate-products effect.[51] Intermediate products are outputs of one production function that serve as inputs to another product's production function. Economists track the series of intermediate products needed to produce the final good—the good that is consumed or invested—to calculate gross national income.[52] For example, natural gas, a product of its own production function, can be an intermediate product used to produce electricity, and electricity can be an intermediate product used in multiple other production functions leading ultimately to final products, such as a finished automobile that is purchased by a

46. Beer, *supra* note 44.

47. For a lengthy discussion of some of the better-known production functions, see S K Mishra, *A Brief History of Production Functions*, 8 IUP J. MANAGERIAL ECON. 6 (2010).

48. Beer, *supra* note 44; J. Davidson Frame, *National Commitment to Intellectual Property Protection: An Empirical Investigation*, 2 J.L. & TECH. 209, 221–22 (1987).

49. Shi-Ling Hsu, *Capital Rigidities, Latent Externalities*, 51 HOUS. L. REV. 719, 721 n.2 (2014).

50. Herbert Hovenkamp, *Restraints on Innovation*, 29 CARDOZO L. REV. 247, 253 (2007).

51. Charles I. Jones, *Intermediate Goods and Weak Links in the Theory of Economic Development*, 3 AM. ECON. J.: MACROECONOMICS 1, 1–2 (2011).

52. Thomas C. Brown et al., *Defining, Valuing, and Providing Ecosystem Goods and Services*, 47 NAT. RESOURCES J. 329, 335–37 (2007).

consumer. Intermediate products link production sectors (for example, natural gas production to electricity production to automobile production), thus creating the multiplier effect—greater efficiency in producing natural gas leads to greater efficiency in generating electricity, and so on down the chain into the other sectors where electricity is an input.

As production becomes more complex and scales up, production-function theory runs into several complications. One such problem is how to aggregate highly heterogeneous capital into a single input value. Adding a robotic machine and a hammer into the same category, called capital, strikes some commentators as pure fiction.[53] Even more problematic is the challenge of aggregating firm-level production functions into the level of industry-wide or economy-wide production functions, which many commentators argue is possible, if at all, only under the most stringent of assumptions and conditions.[54] Nevertheless, production function theory remains firmly rooted in the research agenda of neoclassical economics.

Though it originated to analyze economic production, the production function concept has found application in a number of other contexts. For example, a significant amount of legal and scientific scholarship has applied the production function to the ecological-economics context with a particular focus on ecosystem goods and services.[55] Ecosystem services, such as the purification of water and pollination of plants, are essential to human well-being and can be thought of economically in that sense. Ecosystem services are created by ecosystem processes wherein physical and biological factors interact to produce what we perceive as the natural world. In other words, ecosystem services are the output of a production function that relies purely on "natural capital."[56] For instance, photosynthesis is the production function that changes soil, water, and sunlight into plants.[57]

53. Joan Robinson, *The Production Function and the Theory of Capital*, 21 REV. ECON. STUD. 81, 95 (1953).

54. Steven Pressman, *What Is Wrong with the Aggregate Production Function?*, 31 E. ECON. J. 422, 422 (2005).

55. Edward B. Barbier, *Valuing Environmental Functions: Tropical Wetlands*, 70 LAND ECON. 155, 167–71 (1994); James Boyd et al., *Compensation for Lost Ecosystem Services: The Need for Benefit-Based Transfer Ratios and Restoration Criteria*, 20 STAN. ENVTL. L.J. 393, 403–06 (2001) (cited pages directly discuss production functions); Geoffrey Heal et al., *Protecting Natural Capital Through Ecosystem Service Districts*, 20 STAN. ENVTL. L.J. 333, 357–59 (2001).

56. Brown et al., *supra* note 52.

57. Laurie A. Wayburn & Anton A. Chiono, *The Role of Federal Policy in*

Ecosystem services may serve as intermediate product inputs of the production functions of other ecosystem services, meaning that impairing or promoting one ecosystem service would affect the output of another.[58] In turn, ecosystem goods and services can become inputs for manufactured goods and services along with labor and built capital. Many goods and services that are directly beneficial to human life are therefore dependent on ecosystem goods and services in some way.[59] Once the production functions of ecosystem services and their interactions are determined, therefore, more socially efficient environmental regulation can take place.[60]

As an example of using production functions in social-investment contexts like the agency budget-output problem, production function analysis has also found applications in education funding policy. Its use there may be particularly enlightening to the agency budget-output question because it addresses the central issue of whether or not funding matters in determining educational outcomes. The earliest attempt to formulate an educational production function investigated inequalities in American schools and sought to explain them from an input-output perspective focused on increasing output by adjusting purchasable inputs like teacher salary and class size.[61] Study results in this education domain have conflicted in their findings, with scholars still heavily divided on the issue.[62]

The extension of the production function concept to contexts such as ecosystem services and education reveals both its value and its limits. On the one hand, building the production function model of systems, such as ecosystem services and educational quality moves analysis, from the proverbial black box to a more robust conceptualization of relationships between components of

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Establishing Ecosystem Service Markets, 20 DUKE ENVTL. L. & POL'Y F. 385, 392–93 (2010).

58. Boyd et al., *supra* note 55.

59. Brown et al., *supra* note 52.

60. Heal et al., *supra* note 55.

61. *Id.*

62. *See* Michael A. Rebell, *Poverty, "Meaningful" Educational Opportunity and the Necessary Role of the Courts*, 85 N.C. L. REV. 1467, 1479–82 (2007) (discussing the academic debate over educational production functions). *Compare* Eric A. Hanushek, *When School Finance "Reform" May Not Be Good Policy*, 28 HARV. J. ON LEGIS. 423, 430 (1991) (finding no relationship), *with* Richard J. Murnane, *Interpreting the Evidence on "Does Money Matter?"*, 28 HARV. J. ON LEGIS. 457, 462 (1991) (finding a relationship).

the system. In this situation, intervention, whether through regulation or funding, can most move the needle in terms of improving outcomes policy makers care about. On the other hand, building such models and putting them to the empirical test tends to reveal how complex the systems are and how much is not known about them. With those challenges in mind, in the next section, we apply the basic concepts of the production function model to the context of regulatory agency budgets.

B. REGULATORY AGENCIES AS PRODUCERS

As described above, there are important conceptual similarities between the production functions for corporations and regulatory agencies. Both seek to understand how marginal changes of inputs will impact the respective bottom lines, whether balance of sheets or air quality.[63] We want to make clear at the outset, though, that determining the production function of regulatory benefits such as environmental quality is a great deal more complex than a single firm's production function for widgets. There is a good reason scholars have avoided this topic. As Clifford Rechtschaffen has cautiously observed, "Causality between program activities and outcomes is usually impossible to prove. Outcomes cannot generally be attributed to individual functions of an agency or program. 'Prevention' or deterrence of undesired outcomes is difficult to measure."[64]

Building a comprehensive model may well be beyond our scope and grasp, but building even a simple model would represent a major improvement over the current superficial debate of *funding = benefits* versus *funding ≠ benefits*. Our efforts below represent a starting point for generating hypotheses in Part III to explain why the relationship between agency funding and social-welfare outcomes is as complicated as Rechtschaffen posits and why EPA funding may have a less influential role in the production of environmental quality than the doing less with less position asserts.

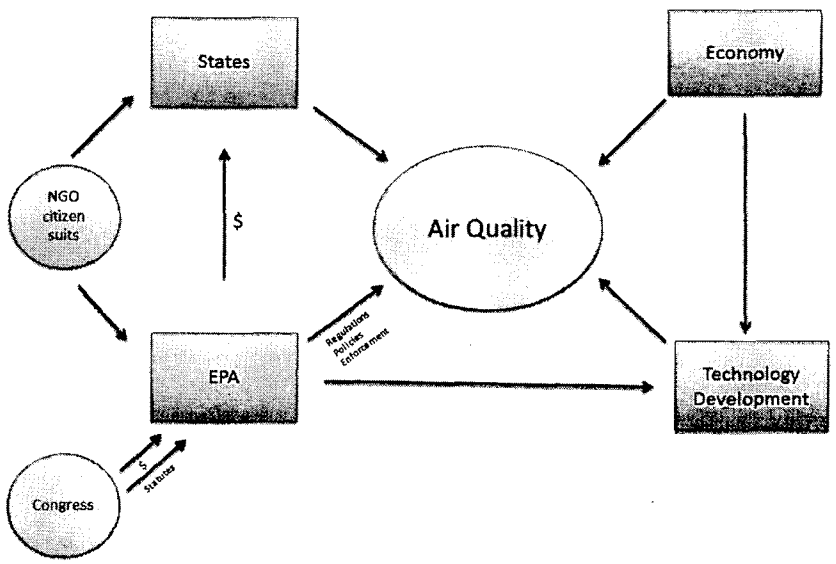
As a starting point, despite its complex appearance, the figure below sets out a simplified model of the key factors affecting

63. *See generally* Humphrey, *supra* note 42 (discussing the production function model and its examination of the relationship between outputs and inputs).

64. Clifford Rechtschaffen, *Deterrence vs. Cooperation and the Evolving Theory of Environmental Enforcement*, 71 S. CAL. L. REV. 1181, 1272 n.390 (1998) (quoting EPA, MEASURING THE PERFORMANCE OF EPA'S ENFORCEMENT AND COMPLIANCE ASSURANCE PROGRAM, DRAFT REPORT OF THE NATIONAL PERFORMANCE MEASURES STRATEGY (Sept. 1997)).

air quality and how the factors interact with one another. Beyond EPA action, these include the actions of Congress, state governments, and nongovernmental organizations; technological innovation; and economic activity. In addition, it is likely that some of these factors have an extended effect over time, and indeed may have a *greater* effect only once some time has passed. Our point here is not to claim that we have captured exactly how environmental quality is determined—to the contrary, we believe the flowchart certainly oversimplifies matters—but rather to show the broad schematics of the dynamic.

Figure 1



We are seeing this dynamic play out in the early stages of the Trump Administration. With threats of reduced EPA funding by Congress and the President, some states have proclaimed plans to increase their activities to protect the environment,[65] and donations to environmental groups that pledge to fight the

65. *See* Adam Nagourney & Henry Fountain, *California, at Forefront of Climate Fight, Won't Back Down to Trump*, N.Y. TIMES (Dec. 26, 2016), https://www.nytimes.com/2016/12/26/us/california-climate-change-jerry-brown-donald-trump.html (discussing California's climate initiative and desire to work with other nations and states to fight climate change).

new administration in the courts have increased.[66]

In addition to the range of actors involved and their influence on one another, it is also important to recognize the vectors. EPA, for example, influences air quality through its production of regulations, policies, and enforcement, among other actions. These can be thought of as intermediate products in the production of environmental quality because they are produced between raw inputs (funding) and the final product (air quality). These are critical to production of the final product, but are part of the production chain, not the final product. In most cases, therefore, EPA does not use funding to produce environmental quality directly; it first has to produce intermediate products such as regulations, monitoring tools, education programs, and so on. EPA and other institutions then use these intermediate products to continue down the production chain until some actor or action changes conditions that *directly* change environmental quality, such as reducing emissions or restoring a wetland area. For example, a new EPA regulation could be enforced by a state agency that issues a permit requiring an industrial facility to install technology to reduce air emissions. When emissions fall, *that* is when environmental quality changes, not EPA receiving funding or issuing the rule. The central role of intermediate products is equally true for other governance institutions, such as states and counties.

Acknowledging the numerous institutions and intermediate products involved in the production of environmental quality is not a new revelation. The problem is that rarely do academics or practitioners step back to ask how the system as a whole works. In fact, quite the opposite: they tend to focus on the production and performance of *intermediate products* rather than the production of *environmental quality*, the latter being what they really should care about. This is a critically important point.

Agencies, scholars, and politicians weighing in on the EPA's role in the production of environmental quality generally focus on the EPA's production of intermediate products and how they perform.[67] The EPA's strategic plans set goals for regulations

66. *See* John O'Connell, *Election Provides Fundraising Windfall for Environmental Organizations*, CAPITAL PRESS (Jan. 19, 2017), http://www.capitalpress.com/Nation_World/Nation/20170119/election-provides-fund-raising-windfall-for-environmental-organizations (discussing the inflow of financial support for environmentalist groups, along with the desire to use the courts to make public the tax awards to successful claims).

67. *See, e.g.*, William F. Pedersen, Jr., *Why the Clean Air Act Works Badly*,

promulgated, rules reviewed, companies inspected, or sanctions enforced.[68] Cost-benefit analysis and risk assessments scrutinize proposed agency regulations and policies.[69] Litigation challenges intermediate products such as regulations and permits.[70] These are all important activities, so one can understand the focus on intermediate products. Agency offices, for example, can directly control intermediate products such as regulations but cannot directly control air quality or water quality since there are too many intervening factors. The problem is that a myopic focus on intermediate products risks missing what really matters—whether pollution in the environment is increasing or decreasing. To coopt a metaphor, agencies, scholars, and politicians are focusing on intermediate product trees rather than the environmental quality forest.

From a budgeting perspective, however, it is vital to scrutinize not only how agencies produce intermediate products, but how the system works *overall*—how agencies and other institutions take the raw input of upstream funding to produce intermediate products that are used downstream to produce environmental quality (or not). Moreover, as we shall discuss in Part V, it is equally as important to consider how the various intermediate products compare, not only within the agency, but also across

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129 U. PA. L. REV. 1059, 1063 (1981) (discussing EPA efforts that it expects will result in pollution control); Press Release, Representative Lamar Smith, House Comm. on Sci., Space, & Tech., Smith Criticizes EPA Methane Rule (May 12, 2016).

68. *See, e.g.*, EPA, FY 2014–2018 EPA STRATEGIC PLAN 54 (2014) (detailing annual performance measures that aid in the achievement of EPA's goals). The Government Performance and Results Act of 1993 had a larger goal in mind, requiring agencies to develop five-year strategic plans that set long-term goals for the agency's major functions, set performance measures, and report results. Pub. L. No. 103-62 (1993), as amended by the GPRA Modernization Act of 2010, Pub. L. No. 111-352 (2011). In the case of EPA, however, the goals have been largely qualitative and focused on intermediate products. *See, e.g.*, EPA, OFFICE OF INSPECTOR GENERAL, ANNUAL PERFORMANCE REPORT: FISCAL YEAR 2013, at 5–9 (2014), http://www.epa.gov/sites/production/files/2015-09/documents/epa_oig_annual_performance_report_fy_2013.pdf (detailing the EPA's themes and goals for the year).

69. *See, e.g.*, EPA, OFFICE OF AIR & RADIATION, THE BENEFITS AND COSTS OF THE CLEAN AIR ACT FROM 1990 TO 2020, at 7-1 (2011), https://www.epa.gov/sites/production/files/2015-07/documents/fullreport_rev_a.pdf (predicting the likelihood, though uncertain, that benefits of the Clean Air Act will exceed costs).

70. *See, e.g.*, Michigan v. EPA, 135 S. Ct. 2699, 2712 (2015) (holding that EPA, when deciding to regulate power plants, unreasonably considered cost to be irrelevant).

institutions. Perhaps a corporate training program or state agency information-disclosure program could improve pollution reduction outcomes more efficiently than does an EPA inspection program. In short, one cannot reasonably understand the relationship between regulatory agency funding and the outcomes without studying the larger production function—the entire system, both upstream and downstream—from budget, to intermediate products, to environmental quality.

Understanding how environmental quality is produced, though, is easier said than done. It is a complex function, in the true sense of the term. To understand why, in Part III we open the black box and look inside.

III. UNPACKING THE REGULATORY PRODUCTION FUNCTION

In Part II, we sketched a simplified model of how environmental quality is produced and identified the importance of intermediate products at EPA and other institutions use their inputs to produce. Most research and measures of agency success tend to focus on the production and performance of discrete intermediate products rather than the larger production function linking budget inputs with social welfare outputs. In this Part, we identify the specific drivers of the larger production function, setting out four broad categories of factors that might explain Terry Anderson's graph showing no apparent relationship between overall EPA funding and improvements in air quality: (1) funding processes; (2) the diverse ecosystem of institutions and their intermediate products; (3) the internal dynamics of the production function; and (4) external forces potentially disrupting the production function.

A. ENVIRONMENTAL GOALS AND FUNDING

EPA is surely in the business of environmental protection. That said, while environmental quality is a key goal of EPA, it may not be its only goal, and sometimes not even its most important goal. Given its multiple principals and audiences, the agency has other concerns as well.[71]

To begin with, EPA's budget may not be primarily directed

71. *See generally* JAMES Q. WILSON, BUREAUCRACY 315–17 (1989) (discussing how government agencies often focus efforts on those activities that can be observed and counted).

at environmental quality. Unlike a business, an agency's spending discretion is limited and the result of an explicitly political, rather than technical, process. Every February, the President submits a budget to Congress reflecting the negotiations between the different agencies and the White House. The Office of Management and Budget (OMB) is the key player in these discussions.[72] The submitted budget is subjected to committee hearings and adjusted by Congress, with members influencing the budget to reflect their particular concerns (which may or may not focus on maximizing environmental quality).[73] Taken together, the final budget can differ considerably from what the agency first proposed. In 2016, for example, the President's budget proposal for EPA requested $8.6 billion[74] and Congress appropriated $8.1 billion.[75] Just over forty percent of this amount was for State and Tribal Assistance Grants that pass through directly to the recipients.[76] EPA has no authority to spend this money.[77] When those funds were combined with funds dedicated to cleaning up contaminated sites, about fifty-six percent of EPA's proposed budget was locked up.[78] Even the agency's remaining funds are somewhat constrained because of statutory requirements and court-ordered consent decrees.[79]

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72. Eloise Pasachoff, *The President's Budget as a Source of Agency Policy Control*, 125 YALE L.J. 2182, 2207–08 (2015).

73. *See generally* Joseph C. Stanko, Jr., *EPA's Budget: How Low Will It Go?*, HUNTON & WILLIAMS: THE NICKEL REPORT (June 20, 2017), http://www.huntonnickelreportblog.com/2017/06/epas-budget-how-low-will-it-go (discussing the proposed reduction to EPA's budget and the reduction's effect on the EPA's operations).

74. *See* EPA, FY 2016: EPA BUDGET IN BRIEF 3 (2015), http://www.epa.gov/sites/production/files/2015-02/documents/fy_2016_bib_ combined_v5.pdf.

75. *See EPA's Budget and Spending*, *supra* note 8.

76. The total allocated for State and Tribal Assistance Grants under the 2016 EPA budget was $3.5 billion, or approximately 43.8% of the total budget. EPA, FY 2017: EPA BUDGET IN BRIEF 85 (2016) [hereinafter 2017 EPA BUDGET], http://www.epa.gov/sites/production/files/2016-02/documents/fy17-budget-in-brief.pdf.

77. *See Multipurpose Grants to States and Tribes*, EPA, http://www.epa.gov/grants/multipurpose-grants-states-and-tribes (last visited Nov. 4, 2017) (discussing the use of these funds to support "state-defined high priority activities").

78. The 2016 Superfund Cleanup budget was $1.1 billion. 2017 EPA BUDGET, *supra* note 76, at 83. Thus, the total dedicated in 2016 to State and Tribal Assistance Grants and Superfund cleanup was $4.6 billion, or 56.8% of the total 2016 EPA budget.

79. *See, e.g.*, Larry Bell, *EPA's Secret and Costly 'Sue and Settle' Collusion with Environmental Organizations*, FORBES (Feb. 17, 2013), http://www.forbes

Given that the budget results from politics rather than a focus on the environmental bottom line, one would not expect a tight correlation.

Moreover, much attention—in Congress, in the media, and by researchers—is paid to EPA's compliance and enforcement efforts. Compliance and enforcement tend to be easily quantifiable: how many enforcement actions are taken, and how large are the fines? Enforcement actions against large companies, and the imposition of large fines, have tended to draw considerable media coverage.[80] It would hardly be unreasonable for EPA to choose to divert resources to measures that it feels the media carefully follows even if they are indirectly related to environmental quality. Equally, one might expect an agency with little oversight to feel free to pursue long-term, as opposed to short-term, goals—likely those that are less quantifiable and less readily subject to measurement.

Since there will always be more than one goal for the agency to pursue, it will also need to allocate resources among its goals. The emergence of a new policy concern might cause an agency to spread its resources around. For example, the issue of climate change and greenhouse gases has loomed larger and larger over the last decade, requiring more agency resources. Nor is there a single measure of air quality. EPA might choose to pursue environmental quality by seeking to meet all uniform nationwide standards (as the Clean Air Act does through its creation of national ambient air quality standards), by focusing on improving environmental quality in areas where it is especially poor, or by prioritizing some pollutants over others.[81] Moreover, the silo approach of the agency's organization—under which personnel and

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.com/sites/larrybell/2013/02/17/epas-secret-and-costly-sue-and-settle-collusion-with-environmental-organizations/#44f50b8ef4e5 ("[T]he U.S. Chamber of Commerce discovered many new rulemakings and unreasonable permitting delays which appeared to have resulted from such consent decrees in which the EPA agreed to bind itself to issue new regulations on a specific timetable . . . .").

80. *See, e.g.*, Chris Isidore, *Fiat Chrysler Cheated on Diesel Emissions, EPA Says*, CNN (Jan. 13, 2017), http://money.cnn.com/2017/01/12/news/companies/epa-emissions-cheating-fiat-chrysler/index.html?iid=ob_homepage_deskrecommended_pool (discussing how multiple carmakers have been caught cheating on emissions tests).

81. *Cf.* James T. Hamilton & W. Kip Viscusi, *The Magnitude and Policy Implications of Health Risks from Hazardous Waste Sites*, *in* ANALYZING SUPERFUND 55, 76–80 (Richard L. Revesz & Richard B. Stewart eds., 1995) (criticizing risk assessment under CERCLA statute as sometimes too stringent, in part as a response to public perceptions of risks of hazardous waste sites); Jonathan

management responsibilities are divided according to separate media (air, water, solid waste)[82]—means that there will be internal office decisions as to which goals to prioritize, and those decisions may not align with overall improvements in environmental quality.

B. INSTITUTIONS AND THEIR INTERMEDIATE PRODUCTS

As the diagram in Part II showed, a range of institutions contribute to improving environmental quality—such as the EPA, state and local government, industry, and NGOs. In some cases these institutions have interconnecting relationships with EPA—such as when EPA delegates pollution permitting authority to a state and then oversees how that state administers the program to regulate private entities.[83] But all environmental quality production need not necessarily begin with, go through, or even touch EPA. State and local agencies have budgets and authorities that may be outside the scope of EPA's domain,[84] and private institutions can engage in their own forms of environmental policy, independent of any EPA mandates.[85]

Importantly, in all of these instances (except direct industry emissions) these institutional players are producing intermediate products in the form of policy instruments. In other words, EPA uses its budget to produce regulations, monitor, sanction, educate, conduct research, and so on. The same is true for state and local regulators. Industry groups develop codes of practice, and businesses and NGOs file citizen suits, lobby agency and elected officials, and mobilize at the grassroots. None of these activities *directly* produces improvements or harms to environ-

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Remy Nash & Richard L. Revesz, *Markets and Geography: Designing Marketable Permit Schemes To Control Local and Regional Pollutants*, 28 ECOLOGY L.Q. 569, 578–79 (2001) (explaining how the shape of the damage function for a pollutant determines whether the pollutant is better uniformly distributed or concentrated a few points).

82. *See EPA Organization Chart*, EPA, https://www.epa.gov/aboutepa/epa-organization-chart (last updated Mar. 14, 2017).

83. *See, e.g.*, 40 C.F.R. § 71.10 (2017) (authorizing the EPA to delegate authority to administer air quality operating permits to state, local, or tribal agencies).

84. Clifford Rechtschaffen & David L. Markell, *Improving State Environmental Enforcement Performance Through Enhanced Government Accountability and Other Strategies*, 33 ENVTL. L. REP. 10559, 10577 (2003).

85. Michael P. Vandenbergh, *Private Environmental Governance*, 99 CORNELL L. REV. 129, 162–63 (2013).

mental quality. These are all outputs of each institution's particular production function that then, as intermediate products, go into the larger environmental quality production function.

These intermediate products, though, are much easier to measure and link directly to resource levels, which explains why most studies of how we produce environmental protection have focused on evaluating the role of intermediate products such as enforcement actions.[86] Less attention is paid to their role in the larger production of environmental quality—that is, which intermediate goods are most influential in the production function—which will likely change depending on the measure of environmental quality and over time. One could hold constant or increase funding of the agency, for example, but not contribute to environmental quality because the agency is producing the wrong intermediate products. Some of the most important of these intermediate products are briefly described below.

1. Regulations

Some of Terry Anderson's chart can be explained by regulatory history—the production of highly effective intermediate products in the form of regulatory standards. Referring back to Chart 2, one can spot large drops in pollution soon after major regulatory enactments. Lead levels dropped dramatically after EPA adopted regulations in the early 1970s[87] and NO_x fell after regulations the EPA adopted pursuant to the 1990 Clean Air Act Amendments.[88]

It should not be surprising that promulgation of strict regulations leads to pollution reductions. As a consequence, resources spent on regulatory drafting and implementation will likely have greater impacts on environmental quality than other agency expenditures, such as on public education. And these can be relatively inexpensive activities. Moreover, when money is spent developing a regulation and when it is implemented may differ considerably, confounding efforts to link agency spending on environmental quality.

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86. *See, e.g.*, Mintz, *supra* note 11, at 10511 (discussing a reduced number of facility inspections and civil actions as evidence of a less effective EPA).

87. *See* Joseph L. Annest et al., *Chronological Trend in Blood Lead Levels Between 1976 and 1980*, 308 NEW ENG. J. MED. 1373, 1373, 1375–76 (1983).

88. *See, e.g.*, *Nitrogen Oxides (NO_x) Control Regulations*, EPA, http://www.epa.gov/region1/airquality/nox.html (last updated Sept. 1, 2017) (noting a fall in NO_x emissions from utilities and large stationary sources between 1990 and 1996).

Nevertheless, focusing on agency budgets may also largely miss the point. As a regulatory agency, EPA's costs are a relatively minor factor in the overall production function of environmental quality. The main costs for reducing pollution fall on the regulated community.[89] Thus, one reaction to budget cuts might be that the agency shields its regulation-producing offices, protecting its most effective units (similar to how the body shunts blood to the brain when starved of oxygen).[90]

2. Monitoring and Enforcement

The conventional wisdom is that less agency enforcement will result in worse outcomes in the relevant policy area. As Gary Becker's classic formulation asserted, rational actors will adjust their noncompliant behavior based on the likelihood of detection and the magnitude of sanction.[91] This partly explains the results of the Flatt and Collins research: when state agencies spend less on enforcement, plants spend more time in noncompliance.

There is an equally strong body of literature, however, suggesting that much environmental noncompliance is not the result of bad faith but rather lack of capacity.[92] Most regulated parties, this literature suggests, would comply if they knew how.[93] The problem is not inadequate monitoring and sanctions

89. Interestingly, measured in terms of the number of rules published in the Federal Register, there has been little or no correlation between regulation and budget. According to the Americans for Competitive Enterprise, a deregulatory think tank, apart from the drop in 2012–2013 that the authors attribute to a decrease in regulatory activity in the run-up to the 2012 election, EPA regulations did not noticeably decline from 2002–2013. Clyde Wayne Crews, *Red Tapeworm 2014: Are Environmental Protection Agency Regulations Declining? Don't Bet on It*, COMPETITIVE ENTER. INST. (Aug. 19, 2014), https://www.cei.org/blog/red-tapeworm-2014-are-environmental-protection-agency-regulations-declining-dont-bet-it.

90. Former EPA Deputy Administrator Robert Perciasepe has described the agency's budget strategy in terms of saving jobs. Perciasepe, *supra* note 10 ("For many years, a budget priority for EPA was to preserve the work force. That came to an end in the first term of Obama as the budget kept getting squeezed both [in funding] and by inflation. A 'preserve the workforce' policy was eroding research, extramural assistance (contractors) and basic employee support like training and new computer equipment. EPA let the FTE level float down to 15,000 from about 18,000 by attrition and buyouts.").

91. Gary S. Becker, *Crime and Punishment: An Economic Approach*, 76 J. POL. ECON. 169, 207 (1968).

92. J.B. Ruhl & James Salzman, *Mozart and the Red Queen: The Problem of Regulatory Accretion in the Administrative State*, 91 GEO. L.J. 757, 794–96 (2003).

93. *Id.* ("For us the important message is that the regulatory community—

but lack of resources to navigate complex regulatory regimes.[94]

Put another way, it is possible that reducing enforcement expenditures would have little impact on environmental quality because most parties would still comply. This is an empirical question and has important implications for EPA's enforcement strategies. If true, it suggests that EPA could shift its enforcement emphasis from specific deterrence (changing the behavior of the individual charged) to general deterrence (a smaller number of enforcement actions intended to influence the larger regulated community).

3. The Importance of State and Local Protection Efforts

The intermediate products of state and local agencies also include regulations, inspections, and enforcement. If you compare the number of environmental agency personnel at the federal and state levels, state officials far outnumber those at EPA.[95] Indeed, through its cooperative federalism model, the EPA has delegated the implementation and enforcement of most of its significant environmental laws to states, writing the regulations for states to enforce while retaining an oversight and strategic role.[96] As a result, one would expect that the EPA's budget would be less important for environmental quality than are state budgets. A key question, therefore, is whether there is a correlation between state agency budgets and environmental quality. The Flatt and Collins study suggests this may be the

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both regulators and the regulated alike—strongly perceives the sheer number of rules as an impediment to compliance.").

94. *Id.*

95. EPA had 15,376 full-time equivalents in FY 2016. *See* EPA, *supra* note 76, at 11. California has over 4000; New York over 3000; Texas about 2800; Florida about 3100. *CalEPA Employment Information*, CAL. EPA, http://calepa.ca.gov/Employment (last visited Nov. 4, 2017); *Employment*, N.Y. DEP'T OF ENVTL. CONSERVATION, http://www.dec.ny.gov/about/jobs.html (last visited Nov. 4, 2017); *About the TCEQ*, TEX. COMM'N ENVTL. QUALITY, http://www.tceq.texas.gov/about (last visited Nov. 4, 2017); *Administration*, FLA. DEP'T OF ENVTL. PROT., http://www.dep.state.fl.us/secretary/stats/administration.htm (last visited Nov. 4, 2017).

96. *See, e.g.*, 42 U.S.C. § 7410 (2012) (assigning to states the responsibility to create Clean Air Act state implementation plans, subject to EPA approval); 33 U.S.C. § 1342(b) (2012) (allowing EPA to delegate some NPDES permitting to states); SARAH GRACE LONGSWORTH ET AL., ENVTL. COUNCIL OF STATES, STATE DELEGATION OF ENVIRONMENTAL ACTS (2016), https://www.ecos.org/documents/state-delegations ("Many federal environmental statutes were designed by the U.S. Congress to allow states to assume partial or full control of the resulting programs through the delegation process.").

case, but more direct research is needed (we provide an example below in Part IV). A potential problem with this explanation is that many state environmental agency budgets have also been cut over time, some dramatically so.[97]

4. Industry Codes of Conduct

Linked to the explanation of market forces described above, private standards may serve the purpose of regulation and obviate the need for EPA resources. For example, Michael Vandenbergh has provided many examples of private certification systems effectively acting as regulations through supply chains and being enforced by large retailers such as Walmart and Home Depot.[98] The key question, of course, is to what extent such private standards actually influence environmental quality.

5. Nongovernmental Actors' Use of Citizen Suits

One of the defining features of environmental law is the ability of nonstate actors under many statutes to step into the shoes of public prosecutor and litigate against agencies when they are not carrying out mandatory duties or against any entity, including the agency, alleged to be violating the statute.[99] These so-called citizen suits can be path breaking and certainly offer one likely explanation for why environmental quality might not decline, or could even increase, during times of agency austerity. Indeed, the number of citizen suits clearly increased during the Reagan Administration, when EPA enforcement efforts were reduced.[100] As a result, even when agency resources dwindle or

97. Eighteen states decreased the budget of their environmental agencies between 2011 and 2015. *See* Linda K. Breggin, *Are State Agency Budgets Rising Enough To Meet New Challenges?*, ENVTL. F., Sept.–Oct. 2016, at 11.

98. Vandenbergh, *supra* note 85, at 197 (discussing Walmart's commitment to reduce its supply-chain emissions); Michael P. Vandenbergh, Keynote Address at Pace Environmental Law Review Symposium: Reconceptualizing the Future of Environmental Law (Mar. 20, 2015) (transcript on file with Pace Law School), http://www.law.pace.edu/symposium-reconceptualizing-future-environmental-law; *Performance*, HOME DEPOT, https://corporate.homedepot.com/responsibility/performance (last visited Nov. 4, 2017) (describing Home Depot's progress in reducing emissions and using less energy).

99. *See* Jonathan H. Adler, *Stand or Deliver: Citizen Suits, Standing, and Environmental Protection*, 12 DUKE ENVTL. L. & POL'Y F. 39, 46 (2001) (describing the standard citizen-suit provisions that appear in most of the major environmental statutes).

100. *See* Michael S. Greve, *The Private Enforcement of Environmental Law*, 65 TUL. L. REV. 339, 352, 360 n.94 (1990) (discussing an increase in citizen suits during the mid-1980s).

there is little political will for strong enforcement, there exists a potent backup. Organized interest groups can take on enforcement efforts at times of agency austerity.

C. INTERNAL DYNAMICS

In addition to the range of intermediate products produced by EPA and other actors, one must also consider their relative importance. A thoughtful decision-maker needs to choose not only which intermediate products to produce but how much of each. This decision requires consideration of marginal returns, substitutability, path dependence, and innovation.

1. Marginal Returns

Following neoclassical economic theory, adding marginal increments of an input over time eventually leads to diminishing marginal returns of the final product.[101] Applying this principle to the environmental quality production function, each production input that influences environmental quality, from raw inputs like funding to intermediate product inputs like regulations, likely does so in a nonlinear relationship with diminishing marginal returns.

For example, let's say EPA initiates a new widget facility inspection program. In year one, it inspects 100 facilities and detects 200 violations, which when corrected reduces emissions by quantity *X*. Each year it adds 100 facilities into the program until, after five years, all 500 widget facilities are being inspected every year. It is highly unlikely that the program will produce *5(X)* emissions reductions year after year. Each time a facility is first inspected, the most egregious violations are detected—the program catches the low hanging fruit. Over time, most violations the program detects will be minor except for possible bad actor violations. As a result, the program cannot possibly expect to return the same annual emissions reductions over time.

A particular policy instrument may also have diminishing marginal returns because of physical properties of technology and the environment. It may simply not be possible to produce a widget without some level of particulate emissions. Once regulation or other measures have squeezed the widget industry down

101. *Law of Diminishing Returns*, A DICTIONARY OF ECONOMICS (2d ed. 2002).

to that level, only reductions in total widget production or a technological breakthrough will produce lower total emissions. This is why many pollution regulation programs take technology into account.[102]

Diminishing marginal returns can explain why EPA funding changes may have little impact on air quality measures. EPA's mix of intermediate products devoted to reducing particulate emissions, for example, could reach a phase of diminished marginal returns where the low-hanging fruit have all been picked. This works in both directions, however: if EPA has reached the point that adding another dollar to produce an intermediate product yields little or no incremental addition in aggregate benefit, then taking away a dollar will likewise yield little or no incremental reduction in aggregate benefit.

Keep in mind, however, that while decreasing budgets for intermediate products may initially, and perhaps for a good while, produce little incremental change in emissions, eventually the reductions in budget, because of the nonlinear property of the budget-outcome dynamic, would move back into a phase of increasing marginal effects. At some point, therefore, major cuts in EPA funding should result in significant reductions in environmental quality. This raises issues of resiliency, which we address in Part V.

2. Input Substitutability

Given the large universe of institutions and instruments at work in the environmental quality production function, it is highly likely that (1) not every input has the same marginal returns curve; and (2) some inputs can substitute for others and improve production efficiency. To put it bluntly, if you had $100 million to spend on environmental quality improvement, would you simply hand it all to EPA and say, here you go, run with it? Certainly not. A prudent investor in environmental quality would investigate which inputs get the most *marginal* bang for the buck. Perhaps financing industry best-practice codes is more effective on the margin in reducing emissions than adding to EPA's monitoring budget, or perhaps financing NGO citizen

102. *See* Thomas O. McGarity, *Media-Quality, Technology, and Cost-Benefit Balancing Strategies for Health and Environmental Regulation*, 46 LAW & CONTEMP. PROBS. 159, 198–99 (1983) (discussing how Congress has "acknowledged economic concerns by adopting a technology-based approach").

suits is more effective than financing industry codes. If the intermediate products EPA is using have low marginal returns and other institutions are using products with higher marginal returns, the other institutions are necessarily going to have more influence with the marginal dollar on the intended regulatory benefits.

3. Path Dependence from Capital Investments

We have already noted the relationship between strict regulation and improvements in environmental quality. This relationship raises additional questions: Why do regulated parties comply initially with the regulations, and then continue to improve performance over time? For many pollutants, capital investment locks in pollution gains. For those air pollutants that are reduced by pollution control devices, once the control technologies have been installed they should keep pollutant levels down so long as there is not a high cost of operation and maintenance. And even if there are high operating costs, companies may still choose to keep the technologies in place. The implication is that once EPA sets the reductions in motion through regulation, the reductions become locked in place irrespective of later reductions in EPA's budget. While this could explain initial drops in pollution, however, it does not explain why the concentrations of many pollutants continued to drop over time. That may be due, at least in part, to different plants reaching full compliance at different times.

4. Innovation

Production function theory includes innovation as a powerful force in improving the ability of firms to produce products more efficiently. Similarly, just as a new technology or new product can change the production function of a widget, the creation of new institutions and instruments can strongly affect the regulatory production function. For example, the creation of EPA in 1970 changed the production function of environmental quality by providing an institutional framework for the implementation of the new environmental laws.[103] The lead phasedown and Toxic Release Inventory programs were all new *kinds* of intermediate

103. *But see* Jonathan H. Adler, *The Fable of Federal Environmental Regulation: Reconsidering the Federal Role in Environmental Protection*, 55 CASE W. RES. L. REV. 93, 96 (2004) (pointing out that "by 1966, every state had adopted water pollution legislation of some sort").

products that changed the production function. And some innovative market-based instruments, such as the SO_2 cap-and-trade program and wetlands mitigation banking, have greatly reduced the costs of regulation.[104] These are all examples of regulatory innovation, not just iterations of traditional regulatory approaches, each having a profound effect on the efficiency of the regulatory production function.[105]

D. EXTERNAL FORCES

The last major driver of the production function for environmental quality is external to the system. These include most prominently market forces, global and domestic politics, and natural stochastic events. While increasing agency spending might improve environmental quality *all else equal*, all else will *not* be equal. For example, spending money to expand the size of a police force might well reduce crime "all else equal," but other extrinsic factors—such as the state of the economy, overcrowding in prisons, and the weather—may have a larger combined marginal effect on crime.[106] Depending on those other factors, it is possible that an increase in funding might be seen to accompany a *decrease* in goal quality. In other words, external forces could overwhelm actions by EPA, indeed by most of the relevant government actors, to influence environmental quality.

1. Market Effects

Market forces act on economic and regulatory production functions at both the macro and micro levels. At the macro level, economic growth has a major influence on levels of production of goods and services and therefore levels of most pollutants. The

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104. *See* Richard Schmalensee & Robert N. Stavins, *The SO2 Allowance Trading System: The Ironic History of a Grand Policy Experiment*, 27 J. ECON. PERSP. 103, 106–09 (2013) (discussing the performance of the SO_2 cap-and-trade program); Shirley Jeanne Whitsitt, *Wetlands Mitigation Banking*, 3 ENVTL. LAW. 441, 459–62 (1997) (describing the benefits of wetlands mitigation banking).

105. *See* David L. Markell & Robert L. Glicksman, *Dynamic Governance in Theory and Application, Part I*, 58 ARIZ. L. REV. 563, 629 (2016) (arguing that policy design should account for potential innovation in regulatory approaches, giving administrators management tools that are adaptive enough to enable them to take advantage of potential developments and thus promote efficiency).

106. *See* Mitchell B. Chamlin & Beth A. Sanders, *Reintroducing "Time" into the Time Series Analysis of the Police Size-Crime Relationship: An Error Correction Approach*, 31 POLICING: INT'L J. POLICE STRATS. & MGMT. 499, 509 (2008) (discussing the challenge of controlling for the effect of extrinsic factors).

recent history of China provides clear evidence of that; as is also true in the United States.[107] Recessions tend to reduce pollution while boom periods lead to greatly increased levels of potentially polluting activities.[108] We address this dynamic in our regressions reported in Part IV by controlling for sovereign gross product.

At the micro level, every pollutant tells its own story. In particular, parties may have economic incentives to reduce pollution wholly apart from regulatory compliance. It may just be good business.

Some of the reductions in particulate matter, for example, can be explained by commodity prices. In particular, fracking has dramatically changed energy markets in recent years.[109] Natural gas, a cleaner fuel than coal, has dropped in price.[110] As a result, there has been a large-scale shift as coal-fired utilities reduce their coal use and build natural-gas-fired units. The overall effect is a drop in particulate matter from electricity generating units.[111]

2. Politics

Like market forces, significant changes in political landscapes also can substantially alter the regulatory production function at macro and micro scales. As of this writing, for example, President Trump has set in motion sea changes in energy

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107. *See, e.g.*, Jason J. Czarnezki, *Climate Policy & U.S.-China Relations*, 12 VT. J. ENVTL. L. 659, 661 (2011) (linking the fact that the U.S. and China are the world's largest greenhouse gas emitters to the economies of those countries).

108. *See* Garth Heutel & Christopher J. Ruhm, *Air Pollution and Procyclical Mortality*, 3 J. ASS'N ENVTL. & RESOURCE ECONOMISTS 667, 683 (2016).

109. *See, e.g.*, Christina Nunez, *How Has Fracking Changed Our Future?*, NAT'L GEOGRAPHIC (Nov. 11, 2013), http://environment.nationalgeographic.com/environment/energy/great-energy-challenge/big-energy-question/how-has-fracking-changed-our-future.

110. *See, e.g.*, Marianne Lavelle, *Natural Gas Nation: EIA Sees U.S. Future Shaped by Fracking*, NAT'L GEOGRAPHIC (Dec. 7, 2012), https://news.nationalgeographic.com/news/energy/2012/12/121207-annual-energy-outlook-2013.

111. While market forces are clearly part of the story, this cannot be the sole explanation for three reasons. First, particulate matter concentrations were falling before the advent of fracking. Second, other conventional air pollutants also have fallen over time so, at a minimum, researchers would need to understand the role of market forces in their respective stories. And finally, another market reason for fuel switching from coal to natural gas has been the added costs of regulatory compliance from recent Clean Air Act regulations aimed at coal-burning pollution. Regulation is also part of the explanation.

policy, environmental policy, and other regulatory domains.[112] Although the basic diagram of the air quality production function depicted above in Chart 1 is likely to remain representative—despite campaign rhetoric, EPA does not appear to be a target for complete elimination—the relationships between the actors and sectors, as well as the internal cultures of each actor, are likely to be transformed to some nontrivial degree. At a macro scale, one could reasonably surmise that new federal policies promoting energy development, infrastructure, and economic interests in general will ascend in priority. This broad policy trend in turn would likely redirect EPA's agenda, increase environmental NGO activity, and leave more work to the state environmental agencies in states pursuing more active environmental policies. President Trump has made clear, for example, that EPA will not continue down the road of climate-change regulation the agency pursued under the Obama Administration.[113] Environmental NGOs are likely to step up activities to resist that policy shift, such as litigating to challenge agency repeal of regulations, and some state and local agencies will move to fill the gaps created by the new federal agenda. The upshot is that the marginal impact on environmental quality of funding the next dollar to EPA, an NGO, or a state agency is likely to be altered as a result of this massive political upheaval.

Political effects also are not limited to major events bearing so directly on the regulatory production function and may come from seemingly distant sources. For example, OPEC's decisions regarding oil production have profound impacts on the U.S. domestic economy,[114] which as discussed above can influence the effectiveness of additional investment in regulation.[115] Similarly, decisions made by India and China regarding the development and burning of fossil fuels necessarily influence the effectiveness of U.S. domestic policies regarding carbon emissions.[116]

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112. *See, e.g.*, *A Running List of How Trump Is Changing the Environment*, NAT'L GEOGRAPHIC, http://news.nationalgeographic.com/2017/03/how-trump-is-changing-science-environment (last updated Oct. 25, 2017).

113. *See* Exec. Order No. 13,783, 82 Fed. Reg. 16,093, 16,094 (Mar. 31, 2017) (rescinding Obama administration executive orders on climate change policy).

114. *See, e.g.*, Don Briggs, *How Does OPEC Affect US Oil Prices?*, USA TODAY (Oct. 4, 2015), http://www.usatoday.com/story/money/business/2015/10/04/opec-affect-us-oil-prices/73346054.

115. *See supra* notes 107–08.

116. *See, e.g.*, Massachusetts v. EPA, 549 U.S. 497, 533 (2007) (noting, though rejecting, the argument that EPA ought not regulate greenhouse gas

3. Natural Stochastic Events

Parents forever debate the relative contributions of nature and nurture, and environmental protection is no different. While anthropogenic emissions and waste clearly affect environmental quality, so, too, does natural variation. Particularly wet seasons will reduce concentrations of water pollutants, while droughts will increase them. Wind patterns can disperse concentrations of air pollutants. Periods of clear skies and still air will lead to greater production of smog than windy and overcast periods. Thus, our contributions to environmental quality will always be in combination with the changing environmental conditions themselves.

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To summarize, in Part III we have provided a more complete (and more complicated) picture of the production function sketched in Part II. A few key insights emerge:

(1) Numerous institutions are involved in the production of environmental quality, but not all of these institutions necessarily view environmental quality as their most important product;

(2) Regulatory agencies use funding to produce and use intermediate instrument products such as regulations, standards, litigation, and monitoring that impact environmental quality;

(3) The influence each input and intermediate product has on the production function depends on internal functional dynamics such as its marginal effects, substitutability, capital investments, and innovative effect; and

(4) The overall production function will be affected by external forces such as stochastic natural, market, and political events.

Importantly, these insights are equally applicable to other regulatory agencies, whether their charge be human health or market stability

IV. EMPIRICAL ANALYSIS: HOW MUCH DO REGULATORY AGENCY BUDGETS MATTER?

We have used Terry Anderson's chart overlaying EPA's budget and air quality levels to address the question politicians and interest groups have put in play—*how much do regulatory agency budgets matter?*—and to develop the production function

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emissions voluntarily, lest the United States lose leverage to negotiate with developing countries).

model as a way of framing the theoretical dimension of the question. But what about the empirical question: is there evidence that spending by environmental agencies has a positive effect on environmental quality? The preceding Parts explained why even an environmental agency that sought to improve environmental quality might face severe difficulties in being able directly to attain that goal. These same difficulties—the existence of actors other than EPA in determining environmental quality; the role of, and interplay among, intermediate products in determining final environmental quality; and the unpredictable nature of external forces as intervening factors in the causal chain—also make it challenging to measure empirically whether government spending has an effect on environmental quality. There also is the question of exactly what measure of environmental quality to use.[117]

With that caveat, we nevertheless endeavor to examine empirically Anderson's focus on the effect (if any) of environmental agency spending on ambient air pollution levels for criteria pollutants.[118] Anderson's chart suggests no such relationship. The competing theory—the notion that an agency will do less with less (and thus more with more) suggests, to the contrary, that an increase in agency spending should lead to a decrease in ambient pollution levels.

Along these lines, we consider two primary hypotheses that posit how environmental agency funding affects environmental quality. The first, Hypothesis A, corresponds to the more with more thesis.

> Hypothesis A: An increase in environmental agency funding results in an increase in environmental quality.

In contrast to Hypothesis A stands the Null Hypothesis, which

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117. *See* HUNTER & WATERMAN, *supra* note 36, at 212–15 (noting the difficulty in identifying the proper measure for water quality). *Compare* William E. Kovacic, *Rating the Competition Agencies: What Constitutes Good Performance?*, 16 GEO. MASON L. REV. 903 (2009) (proposing metrics by which to measure output of competition agencies), *with* Edward Iacobucci & Michael Trebilcock, *Evaluating the Performance of Competition Agencies: The Limits of Assessment Methodologies and Their Policy Implications* (Sept. 21, 2016) (unpublished manuscript) (on file with the author) (arguing that it is largely fruitless to try develop measures to compare performance across national competition agencies).

118. *See* 42 U.S.C. § 7408 (2012) (directing the EPA Administrator to develop national ambient air quality standards for criteria pollutants).

here corresponds to the more with less thesis.

> Null Hypothesis: An increase in environmental agency funding results in no change in environmental quality.

The possibility that there is a lag between funding and expenditures on the one hand, and changes in environmental quality on the other, poses a significant challenge. Ideally, we would have run our regressions using time-lagged variables, but the paucity of the available data made that impractical. Instead, two features of our analysis help mitigate the time-lag problem. First, as our dependent variable, we focus on annual changes in 2.5-micrometer particulate matter levels.[119] Since particulate matter is heavier than other pollutants, it remains suspended in the air for a shorter time. That, in turn, shortens the time horizon across which changes in environmental agency funding affects (if indeed it does affect) pollutant concentrations. Second, most states' fiscal years—and the fiscal years for all the states in our study—end on June 30,[120] while pollutant data are based on the calendar year. There is, in other words, a built-in six-month lag.

Our focus on annual changes in 2.5-micrometer particulate matter levels as our dependent variable offers other benefits as well. For one thing, data on criteria pollutants—including particulate matter—are readily available for a large number of air quality monitoring stations nationwide and over an extended period of years.[121] In addition, the fact that particulate matter is a heavier pollutant, and remains suspended in the air a shorter time, means that it travels a shorter distance from its source than do lighter pollutants. This should minimize the challenge of accounting for enforcement efforts in distant jurisdictions (which would be very relevant for pollutants that travel greater distances).[122]

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119. We took annual averages of the "annual,2013" measure of 2.5-micrometer particulate matter ($PM_{2.5}$) levels at all receptor points for each state in the study in EPA's database.

120. *See Quick Reference Fiscal Table*, NAT'L CONFERENCE STATE LEGISLATURES, http://www.ncsl.org/research/fiscal-policy/basic-information-about-which-states-have-major-ta.aspx#fyrs (last updated July 13, 2012) (noting that all states but Alabama, Michigan, New York and Texas end their fiscal years on June 30).

121. *See Pre-Generated Data Files*, EPA, http://aqsdr1.epa.gov/aqsweb/aqstmp/airdata/download_files.html (last updated May 26, 2017).

122. *See* Nash & Revesz, *supra* note 81, at 576–78 (distinguishing among

Our independent variable is the annual change in environmental agency funding devoted to air pollution (converted to 2013 dollars).[123] We initially sought to perform our analysis on the funding of EPA itself. However, we found insufficient data going back in time to allow us to assemble a dataset with enough data points to perform meaningful statistical analysis (we discuss later the implications of this result for data compilation policy).[124] That said, though we do not report the results, we ran statistical tests on the limited EPA data we could assemble.[125] Similar to the statistical tests on the state-level data we describe below, we found no statistically significant relationship between changes in funding levels and changes in pollution levels.[126]

Instead, we performed our analysis using state environmental agency funding levels, for which more robust data are available. Given the substantial funding levels state environmental protection agencies receive from the EPA, as well as their sharing an overall structure and mission similar to the EPA's, state agencies can act as a close substitute for the EPA in this regard. We analyze data from six states: Idaho, Indiana, Maryland, New Jersey, Ohio, and Pennsylvania. These states include areas that have been identified as suffering from the worst 2.5-micrometer particulate matter pollution in the nation.[127] Because the cost of environmental compliance can sometimes vary unpredictably and unforeseeably[128]—which may tend to mask the extent to

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global, regional, and local pollutants).

123. Our choice to rely on higher-level, broader measures of environmental agency funding is a deliberate one. While program-specific funding is more likely to address directly the environmental quality issue on which we are focusing, it is also less likely to remain a consistently reported budget item over time, therefore making time series data sets difficult to compile. Broader agency funding figures will relate less directly to the particular problem but are more amenable to comparisons across periods of time.

124. *See infra* note 132.

125. We did not report the results because the limited number of data points render the findings insufficiently reliable.

126. *See infra* note 131 (noting the nature of the results of the statistical runs on EPA data).

127. *See* AM. LUNG ASS'N, STATE OF THE AIR 15 (2015) (listing areas subject to the greatest $PM_{2.5}$ pollution). We selected a subset of states that included heavily polluted areas for which we had reliable budget data.

128. *See, e.g.*, Jonathan Remy Nash, *Too Much Market? Conflict Between Tradable Pollution Allowances and the "Polluter Pays" Principle*, 24 HARV. ENVTL. L. REV. 465, 492 (2000) (explaining that market prices for tradable sulfur dioxide emissions allowances in the 1990s may have actually decreased as a result of "shift to coal . . . which has a lower sulfur content").

which enforcement spending spurs environmental quality—we also control for annual state gross product (converted to 2013 dollars).

Our analysis examines annual changes in the relevant variables, beginning with the change from 2004 to 2005, and proceeding to the change from 2012 to 2013. Thus, the study lies sufficiently after, and allows for state agency budgets to have had time to reflect, the Clean Air Act Amendments of 1990 (the last major air pollution statute). This also avoids the concern of accounting for initial reductions in pollution emissions that were relatively inexpensive to effect, and thus (under a rational actor model of deterrence), would have required relatively little threat of enforcement to induce compliance.

We ran an ordinary least-square regression, including year and state fixed effects, with robust standard errors. The results appear in Table 1. They reveal no statistically significant relationship between changes in agency funding levels and changes in particulate matter concentrations. And, though we do not report them here, the results also revealed no significant relationship for similar regressions for (1) other criteria pollutant concentrations[129] against state environmental-agency air-pollution funding levels;[130] and also (2) 2.5-micrometer particulate matter concentrations against measures of EPA funding.[131] In the end,

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129. We did not run a regression with lead concentrations as the dependent variable since some states lacked receptor points during some of the time period under study.

130. We ran regressions (otherwise identical to the regression reported in the text) with independent variable being the change in concentration in PM_{10}, carbon monoxide, nitrogen dioxide, ozone, and sulfur dioxide. In only one regression did the coefficient for the change in pollutant concentration even approach significance at the 10% level—the regression for ozone concentrations ($p = 0.102$).

131. We ran two regressions. In both, the dependent variable was the change in national $PM_{2.5}$ concentrations. We controlled in both regressions for the change in the national gross domestic product. Also, insofar as combustion of natural gas contributes to particulate matter pollution, we included the annual change in the national average citygate price for 1000 cubic feet of natural gas. *Natural Gas Prices*, U.S. ENERGY INFO. ADMIN. (Aug. 31, 2017), http://www.eia.gov/dnav/ng/ng_pri_sum_a_epg0_pg1_dmcf_m.htm.

The first regression had the change in EPA support for air quality management over the time period 2005–2006 to 2013–2014 as the key independent variable. The federal support for air quality management program includes both EPA headquarters and regional federal support to state, tribal, and local air pollution control agencies for the implementation of evaluation of programs related to the National Ambient Air Quality Standards (NAAQS). The program also includes regular review of any associated national guidance and outreach

we find no support for Hypothesis A. And, while absence of evidence of a relationship does not mean that there is no such relationship,[132] our empirical analysis confirms the implications of Terry Anderson's chart that there is not a clear relationship between agency funding and air pollutant concentrations.

information for implementation of standards. *See Catalog of Environmental Programs*, EPA, http://archive.epa.gov/oig/catalog/web/html/44.html (last visited Nov. 4, 2017).

The second regression had as the key independent variable the change in EPA sub-budget (which represents EPA's entire budget, before rescission of prior years' funds and pension and benefits accrual) over the time period 2000–2001 to 2013–2014.

While change in GDP was a statistically significant predictor of change in pollutant concentrations in both regressions, in neither regression was the change in EPA funding (or the price of natural gas) a statistically significant variable. We decline to report the results owing to the paucity of data points ($N = 9$ for the first regression, and $N = 14$ for the second).

132. In the language of statistics, we lack sufficient observations to validate a power analysis. *See, e.g.*, Susan D. Franck, *Conflating Politics and Development? Examining Investment Treaty Arbitration Outcomes*, 55 VA. J. INT'L L. 13, 41 & n.120 (2014).

Table 1: Results of regression of change in $PM_{2.5}$ concentration (2004–05 to 2012–13)

Variable	Coefficient	Standard Error	*p*-Value
Change in state environmental agency air pollution budget	-0.066	0.099	0.509
Change in gross product	-1.884	0.849	0.032**
2005–2006	-0.294	0.040	0.000***
2006–2007	-0.011	0.052	0.835
2007–2008	-0.285	0.039	0.000***
2008–2009	-0.285	0.048	0.000***
2009–2010	-0.078	0.044	0.082*
2010–2011	-0.186	0.041	0.000***
2011–2012	-0.167	0.041	0.000***
2012–2013	-0.151	0.033	0.000***
Indiana	-0.076	0.052	0.153
Maryland	-0.092	0.050	0.071*
New Jersey	-0.093	0.053	0.090*
Ohio	-0.089	0.049	0.075*
Pennsylvania	-0.081	0.056	0.100
(Intercept)	-0.069	0.057	0.000***

$N = 54$; $R^2 = 0.725$. *** = significant at the 1% level; ** = significant at the 5% level; * = significant at the 10% level.

We wish to make clear that our finding of no correlation advances the ball very little in the quest for greater understanding of the budget-outcomes relationship. That we found no correlation does not mean there is none. And that is precisely the point of our project: we used the best data available on the topic, applied state of the art regression analysis methods to them, and produced a rudimentary result.

This suggests three important implications: (1) the focus in the regulatory state on cost-benefit analysis of intermediate products does not stimulate production of the right kind of data for assessing the regulatory production function; (2) our time period tracked marginal budget changes, but correlations between

funding and pollutant levels may only appear after more significant reductions; and (3) regression analysis may not be the exclusive tool needed to address the problem. In sum, the production function model of the regulatory agency budget-outcomes relationship calls for generating new kinds of data, anticipating a broader set of influential causal factors, and applying new kinds of analytical tools. We turn to this challenge in Part V.

V. FOUNDATIONS FOR RESEARCH

We opened this paper by contrasting the conventional wisdom that reduced EPA funding will impair environmental quality with Terry Anderson's chart purporting to refute that relationship. Neither view, however, relies on more than a superficial black-box model of how EPA's budget produces environmental quality. As Part I showed, scholars from relevant disciplines have not provided a more robust theoretical or empirical explanation of the relationship between agency budget and outcomes. In Part II, we explained why a production function model would be useful in understanding this relationship, and in Part III we set out a more detailed picture of the different drivers operating within the production function, explaining why environmental quality might show no correlation to agency resources when in fact a relationship could exist. To dig deeper, Part IV then ran a series of regressions designed to test the correlation between agency budget and measures of air quality, but found no statistically significant correlation based on available data.

So, what have we learned? Alternative hypotheses continue to be available for our findings. The fact that we find no correlation between EPA funding and air quality could be because EPA is producing the *wrong* intermediate products, or not enough of the important ones compared to the intermediate products other institutions can produce (that is, the most important drivers during this time period may have been citizen suits or the low price of natural gas). Or the opposite may be true—perhaps EPA is producing the *right* intermediate products and doing so efficiently, such that budget austerity does not hinder the agency's production of environmental quality. There are three key points to emphasize: (1)these alternatives suggest very different realities with completely different law and policy implications; (2)it is not clear which is accurate; and (3) policy makers do not have a robust methodology to figure this out.

Why should we care about developing a more sophisticated understanding of the relationship between agency funding and outcomes? The obvious answer is that the competing black-box models leave policy-makers deciding the appropriate size and allocation of agency budgets with no means to assess their decision apart from the percent increase or decrease compared to previous budgets. This is as true for EPA as for other regulatory agencies. When presidential and congressional candidates call for major budget cuts, as will likely happen in the next few years,[133] we need to better understand the likely consequences beyond reducing the deficit. It may be that the regulatory production function is simply too complicated to understand through quantitative analysis, but we will never know without serious research that carefully determines the limits and potential of this new analytical model.

Moreover, lack of understanding about the budget-outcome relationship is not a problem only in times of austerity. Consider, for example, how little basis there would be for knowing how to expend an agency budget wisely and effectively in times of *abundance*. Whether cutting or expanding agency budgets, the analytical exercise is much the same.

As a thought experiment, if you were given control of an additional one billion dollars to spend on environmental protection over the next five years and instructed to maximize the environmental quality improvement return on the dollar, where would you invest? At a minimum, you would need to determine which expenditures would provide the greatest marginal yield of environmental quality, and you would also need a means to assess the effectiveness of your expenditures. These are the very same challenges you would face if cutting the budget by one billion dollars.

In this Part, we first identify the key questions that need to be asked for both such challenges—good budget times and bad—and then set out the most important analytical tasks needed for providing the answers. Taken together, these lay the core foundation for both a research agenda and strategy directed at understanding the relationship between agency budgets and outcomes. Greater knowledge of this relationship can guide

133. *See, e.g.*, Hope Yen, *Trump's Pick for Budget Director Has Urged Big Spending Cuts*, YAHOO! FIN. (Dec. 17, 2016), http://finance.yahoo.com/news/trumps-pick-budget-director-urged-big-spending-cuts-191116373—finance.html.

questions and decisions regarding institutional design, policy instrument choice, federalism, and reliance on private governance. While we use EPA as the illustrative case, our insights are equally relevant for other regulatory agencies.

A. ASKING THE RIGHT QUESTIONS

1. How should the budget be distributed among institutions?

Since EPA is not the only player in the environmental protection game and the government has a finite amount of money dedicated to environmental protection, the threshold question is how to distribute investments between federal programs, state and local programs, environmental NGOs, private sector industry, and other actors. It may very well be the case that supporting compliance training in private-sector industrial facilities would yield a greater return than investing the same amount in EPA's facility inspection program.[134] Investing in urban land trusts to secure ecosystem services, such as water filtration and groundwater recharge, could be more efficient at producing those benefits than imposing tighter federal regulation of development in wetlands.[135] Or perhaps the low-hanging fruit lies in state programs facing even more austerity than EPA. Dollar for dollar, beefing up state resources might make more of a difference to environmental quality.

2. How should the budget be allocated within the agency so as to pursue the optimal mix of intermediate products?

Once EPA's budget is set, what should you instruct EPA to do with the newfound money to maximize environmental quality? Would restoring programs that experienced the greatest budget cuts in the past provide the best return on the dollar? Our findings suggest not, at least for air quality—those cuts do not appear to have prevented reductions in emissions. So, which intermediate products that EPA produces should receive the new

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134. *See* Sarah L. Stafford, *Private Policing of Environmental Performance: Does It Further Public Goals?*, 39 B.C. ENVTL. AFF. L. REV. 73, 75 (2012) (noting that "private organizations often have better access to certain information" and "generally make decisions more quickly and with less red tape than public agencies").

135. *See, e.g.*, James Salzman, Lecture, *What Is the Emperor Wearing? The Secret Lives of Ecosystem Services*, 28 PACE ENVTL. L. REV. 591, 593 (2011) (pointing out how investments in "natural capital" can be more effective than ones in "built capital").

money? Maybe it would be most effective for EPA to experiment with producing new intermediate products. Again, there is virtually no quantitative empirical foundation on which to base these decisions.[136]

3. How should the budget be allocated to ensure resilience?

Resilience is a special kind of intermediate product meriting its own consideration. We have little understanding of the extent to which past decades of austerity may have deteriorated the resilience of EPA and other state and local agencies. It may be that marginal budget changes initially have little effect on environmental protection because the system is resting in equilibrium. If funding is reduced below a certain level, though, the equilibrium could shift into catastrophic failure through a combination of loss of credibility, key personnel, or respect for the rule of law. Many of the narratives about the drinking-water crisis in Flint, Michigan, for example, have pointed the finger at underfunded environmental agencies.[137] This was, they charge, a tragedy waiting to happen.[138] The large-scale governmental failure in the Flint drinking-water crisis may be a one-off anomaly, or it could be evidence of cracks building in the public governance infrastructure.[139] Are we close to a tipping point with EPA and other federal and state public governance institutions? Does Terry Anderson's chart take a drastic turn for the worse or do the lines keep diverging? Again, we do not know.

4. How should budget yield be measured?

The regulatory state, and environmental policy in particular, has relied heavily on the development of tools such as cost-benefit analysis and risk assessment to evaluate the merits of regulatory initiatives, such as a rule lowering particulate emis-

136. Comparatively speaking, air quality is one of the areas of environmental quality where the available data are comparatively *good*. Yet, as the analysis in Part IV brings out, even their data are sparse and the prospects for valuable empirical investigation are quite limited.

137. *See, e.g.*, Lenny Bernstein & Brady Dennis, *Flint's Water Crisis Reveals Government Failures at Every Level*, WASH. POST (Jan. 24, 2016), http://wpo.st/4A8Q2.

138. *See, e.g., id.*

139. *See id.*

sions. Indeed, in some cases cost-benefit analysis can be the driving factor in determining the structure of a new regulation.[140]

Neither of these tools, though, can usefully guide budget allocation decisions. That requires a marginal analysis between dollars invested and environmental-quality results—calculating the impact on environmental quality from an incremental investment in a particular institution's budget. To understand the marginal impact on environmental quality of raising or cutting the EPA's (or any other institution's) budget, we need different tools. Otherwise we are left trying to drive a nail with a spoon.

B. DESIGNING THE RESEARCH AGENDA

The difficulty of providing answers to the questions we have just identified should suggest caution. The production function of regulatory agencies is truly complex, with significant confounding factors. This explains in large part why our literature search uncovered such scant scholarship on the topic. Nonetheless, the questions set out above are of the first importance for law and policy. Seeking to answer them, even at a preliminary level, will require an interdisciplinary research effort among lawyers, economists, political scientists, and the environmental science disciplines. Despite the difficulty, the research task is well worth undertaking and long overdue.

The questions we asked in the previous section form, in essence, a sequential decision tree for determining budgets: (1) decide how monies should be distributed among agencies; (2) than distributed *within* agencies; (3) how to ensure resilience; and (4) how to measure the yield of budgeting decisions to assess whether we received value for money. In most instances, we cannot currently answer these questions for any agency. To do so in the future will require a focused research agenda. We set this out in the following subsections, in the reverse order from that set out in Part V.A.[141]

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140. *See, e.g.*, Entergy Corp. v. Riverkeeper, Inc., 556 U.S. 208, 217–18 (2009) (upholding EPA's use of cost-benefit analysis in determining Clean Water Act national performance standards).

141. We note that an initial question would typically call for the determination of what goal(s) an agency should pursue. Depending on the agency and what the agency is charged to do, that question may be hard to answer. *See supra* note 117 (citing to literature noting the difficulties in identifying such goals for competition agencies). In the case of EPA and similar environmental protection agencies, we think it clear that environmental quality in some form is the ultimate goal, although we hasten to add that subsidiary issues remain,

1. Developing Methods and Models to Assess Budget Yield

a. Marginal Returns Analysis Methods

As described above, cost-benefit analysis in the modern regulatory state is focused on the net social outcome of intermediate products. Our concern, by contrast, focuses on how to allocate institutional budget investments or cuts to most efficiently produce regulatory agency bang for the buck (whether environmental quality, health outcomes, or student learning—depending on the agency's mandate). In times of austerity and budget cuts, or in times of abundance, aggregate cost-benefit analysis alone cannot inform decisions about where to cut or invest the next budget dollar.

This is not to suggest that aggregate cost-benefit analysis is useless. It provides valuable insights and information about the total social costs and benefits flowing from a specific environmental-protection measure, such as a particulate emission standard, and informs the return on investment from the measure. It may shed light on whether a proposed measure is worth undertaking, but does not inform decisions to invest among intermediate products—that is, whether marginal increases should go to regulation, enforcement, education, industry training, or a different institution altogether.[142]

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such as the precise measures of environmental quality (including how the issue is framed) and questions of how environmental degradation is distributed. *See, e.g.*, Bruce A. Ackerman & Richard B. Stewart, *Reforming Environmental Law*, 37 STAN. L. REV. 1333, 1353 (1985) (lauding tradable pollution-permit regimes over command-and-control regimes to achieve environmental goals, on the ground that the former vest the important decision of how much overall pollution should be allowed with the legislature, thus enhancing democracy); Cass R. Sunstein, *Administrative Substance*, 1991 DUKE L.J. 607, 636 (same); Cass R. Sunstein, *Democratizing America Through Law*, 25 SUFFOLK U. L. REV. 949, 967 (1991) (same); Nash & Revesz, *supra* note 81, at 579–80 (discussing the relationship between dispersion of pollutants and environmental justice concerns).

142. To analyze budget cutting, we would need to assess the impact on environmental quality from a one percent budget cut versus a five percent budget cut. Knowing that the *total* social costs of a program on the chopping block are *X* and the *total* social benefits are *Y* will not answer these questions, except in the unlikely case in which the return on budget investment is constant across the entire production function from the first budget dollar to any sized budget. For example, if an EPA enforcement program were shown to have aggregate social benefits twice those of social costs, this would be a positive sign about the program's overall effectiveness. But this would not necessarily mean that investing more in the agency's enforcement program budget is a good decision. It is entirely possible that most of the environmental quality gains could have been

Federal and state agencies collect mountains of data on environmental quality and conduct comprehensive cost-benefit analyses,[143] but almost never consider marginal return on the dollar. This type of analysis is commonplace in private organizations but is exceedingly rare in the public sector. That needs to change, and will require developing a more robust production function. It may be possible, for example, to extend the kind of empirical inquiry we have started to derive more granular data about budget returns. For example, comparing the historical budgets of multiple state water- or air-quality programs against movements in relative environmental-quality indicators could begin to provide more insight than is possible in a single-agency/single-medium study like ours.

History provides a useful guide. Sophisticated cost-benefit analysis is now a routine part of administrative decision-making. But this is a fairly recent development. The method was originally developed in the 1930s to assess water infrastructure projects by the Army Corps of Engineers.[144] Its use expanded in the 1970s with President Nixon's quality of life reviews,[145] President Ford's requirement that agencies produce inflation impact statements,[146] and President Carter's Executive Order (EO) 12044.[147] The methodology became firmly implanted in regulatory processes when President Clinton initiated the regulatory impact review (RIA) process in 1993 with his Executive Order

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secured with a smaller budget investment in the first place and adding more money yields little additional gain. Conversely, if the program were shown to have costs twice those of benefits, this would not necessarily mean the program's budget should not be reduced, as scaling back to a smaller program budget could continue to produce most of the environmental quality benefits *and* improve its cost-benefit profile.

143. *See, e.g., Air Data: Air Quality Data Collected at Outdoor Monitors Across the US*, EPA, http://www.epa.gov/outdoor-air-quality-data (last updated July 18, 2017) (containing an extensive amount of data).

144. *See, e.g.*, Philip Shabecoff, *Reagan Order on Cost-Benefit Analysis Stirs Economic and Political Debate*, N.Y. TIMES, Nov. 7, 1981, at 28 (discussing how the Army Corps of Engineers has used cost-benefit analysis for many years).

145. *See* Thomas O. McGarity, *Regulatory Analysis and Regulatory Reform*, 65 TEX. L. REV. 1243, 1248 (1987).

146. *See id.*

147. Stuart Shapiro, *The Evolution of Cost-Benefit Analysis in U.S. Regulatory Decisionmaking* 3 (Jerusalem Papers in Regulation & Governance, Working Paper No. 5, 2010), http://regulation.huji.ac.il/papers/jp5.pdf ("[The Executive Order] required an economic analysis for any regulation with a likely impact of more than $100 million. Agencies were required to choose 'the least burdensome of acceptable alternatives.'").

12,866.[148] That executive order required that, when proposing a "significant regulatory action," which includes regulations having an impact on the economy of more than $100 million,[149] "[e]ach agency shall assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs."[150] EO 12,866 also established within OMB the Office of Information and Regulatory Affairs (OIRA) as the entity responsible for overseeing the RIA process.[151] OIRA has over time issued a number of guidance documents for agencies engaging in RIAs. At present the RIA process is governed by Circular A-4, which OIRA first issued in 2003.[152]

The key point is that the methodology developed for assessing dams and levees would have proven woefully inadequate in analyzing health or safety regulations. Yet cost-benefit analysis over the years has become increasingly sophisticated, such that today it is routinely used in these settings and many others. The same, we emphasize, can be done for the regulatory production function. Where to start? One of the limitations of our empirical study was the lack of consistent historical data that we could use for regressions against environmental-quality measures. It would be useful, therefore, if agencies and other institutions began compiling more comprehensive and granular accounts of budget investments over time. As program budgets scale up, are cut, or stay flat, agencies should monitor relevant environmental-quality indicators and conduct analyses like ours. And as institutions design new intermediate products, perhaps by leveraging emerging technologies such as big data or machine learning, research should be conducted from inception

148. Exec. Order No. 12,866, 58 Fed. Reg. 51,735 (Oct. 4, 1993), https://www.archives.gov/files/federal-register/executive-orders/pdf/12866.pdf. President Clinton's order replaced several orders President Reagan had issued regarding the use of cost-benefit analysis in federal agency rulemakings. *Id.* § 11. President Reagan's orders, although influential and controversial at the time, are no longer in effect and provide none of the legal authority for the modern RIA process.

149. *Id.* § 2(f).

150. *Id.* § 1(b)(6).

151. *Id.* § 2(b).

152. OFFICE OF MGMT. & BUDGET, CIRCULAR A-4 (Sept. 17, 2003), http://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A4/a-4.pdf (refining the previous "best practices" RIA guide).

to track its costs and to detect shifts in the relevant environmental-quality metrics. Better yet, experiments could be conducted to provide a more controlled research environment. For example, inspections at water polluting facilities could be boosted in one watershed compared to another similar watershed and changes in water quality measured.

The work of James Hamilton and Kip Viscusi is instructive in this regard. Hamilton and Viscusi critiqued EPA's approach of requiring hazardous-waste sites to be cleaned to allow for all possible future uses.[153] Instead, they argued that the standard to which such sites should be clean should take into account only *likely* future uses.[154] In other words, it was error for the agency not to consider the marginal return on the funds invested in cleanups.

In short, our message is to begin tracking the data necessary to refine our understanding of the marginal returns to the agency's goal from investments in budgets of different institutions and their intermediate products. Of course, designing such research can be challenging and resource intensive: the baseline must be established, other possible factors such as pollutant transport and economic fluctuations accounted for, and conditions carefully monitored and measured. Different lag times between budget investment and changes in the measure of the agency goal will complicate assessment of any one program and comparisons across programs. And the ultimate conundrum is that, particularly in times of austerity and budget cuts, new budgets for this kind of research—indeed, even for generating and collecting new data—could be hard to come by. But even those in favor of cutting budgets ought to appreciate the benefits of funding research to inform which budgets to cut and by how much! The point, however, is that no research of this kind is being conducted at all, at least none that has been reported. Just as happened with cost-benefit analysis, these tools need to be

153. *See* James T. Hamilton & W. Kip Viscusi, *Human Health Risk Assessments for Superfund*, 21 ECOLOGY L.Q. 573, 608–10 (1994) (critiquing EPA's policy of requiring cleanup of Superfund sites based on all possible future uses of sites rather than eliminating future risks by imposing land use restrictions and containment).

154. *See* James T. Hamilton & W. Kip Viscusi, *The Benefits and Costs of Regulatory Reforms for Superfund*, 16 STAN. ENVTL. L.J. 159, 167–71 (1997) (arguing in favor of determining appropriate Superfund remediation strategies based upon cost-benefit analysis of sites that would focus on health risk continued contamination would pose to current residents).

developed from a rudimentary starting point if there is to be any meaningful traction on the higher-level questions that follow.

b. Complex Adaptive System Models

Looking to the future, we believe that an advanced regulatory production function could be further refined by complexity science. The focus of complexity science is complex adaptive systems, "in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution."[155] Complexity scientists are particularly interested in studying how robust a complex adaptive system is to external disturbances.[156] How will a forest ecosystem respond to an invasive insect species? How will a transportation network respond to adding or removing a component, such as a highway or bridge?

Complex adaptive systems tend to exhibit extensive pathways of nonlinear behavior, making prediction of perturbation impacts no easy task, but it must be a focus of study for policy-relevant systems if we hope to competently manage them. One focus of complexity science is the study of systemic risk, which can lead to local or global cascading failures.[157] Complexity science is influential across an array of social science disciplines,

155. MELANIE MITCHELL, COMPLEXITY: A GUIDED TOUR 13 (2009). "Complex adaptive system" is used to distinguish between complex systems that are highly adaptive (e.g., an ecosystem) versus nonadaptive (e.g., a hurricane).

156. *See* LANCE H. GUNDERSON & C.S. HOLLING, PANARCHY: UNDERSTANDING TRANSFORMATION IN HUMAN AND NATURAL SYSTEMS 25–63 (2002).

157. *See* J.B. Ruhl, *Managing Systemic Risk in Legal Systems*, 89 IND. L.J. 559, 562–63 (2014) (describing systemic risks and their cascading failures).

including economics,[158] political science,[159] sociology,[160] and international affairs.[161] It also has been applied in the study of a

158. *See, e.g.*, ERIC D. BEINHOCKER, THE ORIGIN OF WEALTH: EVOLUTION, COMPLEXITY, AND THE RADICAL REMAKING OF ECONOMICS 289–91 (Hollis Heimbouch ed., 2006) (describing how local dynamics and interactions between agents throughout business hierarchies will result in larger actions in the physical world relating to budgets, products, and marketing); PAUL KRUGMAN, THE SELF-ORGANIZING ECONOMY 32 (1996) ("Phase space representations of dynamic systems are extremely common modern economic analysis."); Didier Sornette & Ryan Woodard, *Financial Bubbles, Real Estate Bubbles, Derivative Bubbles, and the Financial and Economic Crisis*, *in* ECONOPHYSICS APPROACHES TO LARGE-SCALE BUSINESS DATA AND FINANCIAL CRISIS 101, 138 (Misako Takayasu et al. eds., 2010) (stating that the cause of financial crises is the interaction and mutual reinforcement of multiple economic bubbles); Neil Johnson & Thomas Lux, *Financial Systems: Ecology and Economics*, 469 NATURE 302, 303 (2011) (criticizing a model which focuses on individual optimization because it ignores complex interactions and fails to consider systemic risk factors).

159. *See, e.g.*, ROBERT AXELROD, THE COMPLEXITY OF COOPERATION: AGENT-BASED MODELS OF COMPETITION AND COLLABORATION 148–51 (Philip W. Anderson et al. eds., 1997) (utilizing complexity science to understand how nations and cultures emerge); ROBERT JERVIS, SYSTEM EFFECTS: COMPLEXITY IN POLITICAL AND SOCIAL LIFE 266–72 (1997) (describing the Domino Theory Paradox, in which small domestic defeats can generate widespread policy implications and impact the global perception of a country); SCOTT DE MARCHI, COMPUTATIONAL AND MATHEMATICAL MODELING IN THE SOCIAL SCIENCES 156–64 (2005) (framing encoding preferences as adaptive landscapes to represent aggregated voting preferences); Michael J. Ensley et al., *District Complexity as an Advantage in Congressional Elections*, 53 AM. J. POL. SCI. 990, 996–98 (2009) (determining that the unpredictable nature of complex districts benefits incumbents by deterring challengers from entering); Scott E. Page, *Path Dependence*, 1 Q.J. POL. SCI. 87, 103–05 (2006) (suggesting that voting processes today are dependent upon the processes and paths of early and recent history).

160. *See, e.g.*, R. KEITH SAWYER, SOCIAL EMERGENCE: SOCIETIES AS COMPLEX SYSTEMS 3–4 (2005) (using the process of language shift to demonstrate how simple rules and interactions at the local level can give rise to collective behavior); Elizabeth E. Bruch & Robert D. Mare, *Neighborhood Choice and Neighborhood Change*, 112 AM. J. SOC. 667, 669–70 (2006) (examining neighborhood segregation with complexity science to demonstrate that "aggregate outcomes may be quite sensitive to . . . assumptions at the micro level"); Elinor Ostrom, *Collective Action and the Evolution of Social Norms*, 14 J. ECON. PERSPECTIVES 137, 153 (2000) (stating that external threats such as migration and market changes will impact the norms of trust and reciprocity in self-organized regimes).

161. *See, e.g.*, WALTER C. CLEMENS JR., COMPLEXITY SCIENCE AND WORLD AFFAIRS 71–72 (2013) (applying insights from complexity science to understand the divergent outcomes of successor states following the collapse of communist regimes across Eurasia); Robert Axelrod, *The Dissemination of Culture: A Model with Local Convergence and Global Polarization*, 41 J. CONFLICT RESOL. 203, 207–11 (1997) (utilizing complexity science to explain the development of cultural regions); Lars-Erik Cederman, *Modeling the Size of Wars: From Billiard Balls to Sandpiles*, 97 AM. POL. SCI. REV. 135, 144–45 (2003) (identifying conflict-generating factors within complex systems that can lead to war).

wide variety of policy challenges such as terrorist networks,[162] organized crime,[163] transportation systems,[164] urban growth,[165] and national security.[166]

One of the systems most relevant to EPA's mission—the environment—is also widely recognized and studied as a complex adaptive system.[167] Understanding how subjecting an environment to more pollution or more land development—which, in es-

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162. *See, e.g.*, E. Ahmed et al., *On Complex Adaptive Systems and Terrorism*, 337 PHYSICS LETTERS A 127, 127 (2005) (applying aspects of complex adaptive systems to terrorism to determine that the complete eradication of terrorism is "highly unlikely"); Antoine Bousquet, *Complexity Theory and the War on Terror: Understanding the Self-Organising Dynamics of Leaderless Jihad*, 15 J. INT'L REL. & DEV. 345, 360–61 (2012) (explaining that a decentralized, bottom-up structure allows terrorist networks to better plan and execute complex operations such as September 11); Vito Latora & Massimo Marchiori, *How the Science of Complex Networks Can Help Developing Strategies Against Terrorism*, 20 CHAOS, SOLITONS & FRACTALS 69, 73–74 (2004) (demonstrating how complex systems science may be used to disrupt terrorism by identifying "critical components" in the terrorist network).

163. *See, e.g.*, Paul A. C. Duijn et al., *The Relative Ineffectiveness of Criminal Network Disruption*, *in* 4 SCIENTIFIC REPORTS 1, 1–2 (2014), https://www.nature.com/articles/srep04238.pdf (describing criminal networks as complex adaptive systems and identifying strategies to disrupt these networks).

164. *See, e.g.*, A. Aw & M. Rascle, *Resurrection of "Second Order" Models of Traffic Flow*, 60 SIAM J. APPLIED MATHEMATICS 916, 931–33 (2000) (examining the effects of perturbations on the stability of traffic flow); Debashish Chowdhury et al., *Statistical Physics of Vehicular Traffic and Some Related Systems*, 329 PHYSICS REP. 199, 213 (2000) (stating that the "unsystematic" behavior of traffic is a reflection of the dynamics of the vehicles in a traffic jam); Petter Holme, *Congestion and Centrality in Traffic Flow on Complex Networks*, 6 ADVANCES COMPLEX SYSTEMS 163, 174 (2003) (stating that when estimating traffic congestion in one region, one must also consider aspects of the neighboring regions); Bosiljka Tadić et al., *Traffic on Complex Networks: Towards Understanding Global Statistical Properties from Microscopic Density Fluctuations*, 69 PHYSICAL REV. E 036102-1, 036102-4 (2004) (stating that "[t]here is a robustness in the [traffic] system in the sense that minor changes to the query discipline or buffer sizes do not lead to a qualitative difference"); Bosiljka Tadić et al., *Transport on Complex Networks: Flow, Jamming and Optimization*, 17 INT'L J. BIFURCATION & CHAOS 2363, 2374–77 (2007) (identifying underlying indicators that give rise to complex inefficiencies in the system).

165. *See, e.g.*, Robert H. Samet et al., *Complexity, the Science of Cities and Long-Range Futures*, 47 FUTURES 49, 56–57 (2013).

166. *See, e.g.*, Jürgen Scheffran, *The Complexity of Security*, 14 COMPLEXITY 13, 15–17 (2008).

167. SIMON LEVIN, FRAGILE DOMINION: COMPLEXITY AND THE COMMONS 12–15 (1999) (describing the features of a complex adaptive system and how those are illustrated in ecosystems).

sence, are external perturbations—necessarily implicates complex adaptive systems analysis.[168] The regulatory production function can be usefully analyzed as a complex adaptive system, as well. The description of the regulatory production function in Part III certainly maps well onto the complex adaptive systems model: (1) a diverse network of interconnected actors is in motion; (2) no single central control mechanism dictates system behavior; (3) how any intermediate product performs depends on a multitude of factors both internal and external to the defined system; and (4) over time the system adapts and evolves. Budget cuts (or increases) are, in a very real sense, perturbations to this system.

Hence it would be incomplete to use complexity science to improve our understanding of only one of the coupled systems in the budget-outcomes analysis—the environment—while treating the regulatory production function as some form of nonlinear system subject to study exclusively through conventional statistical computation methods.[169] Indeed, legal scholars have begun to employ complexity science as one lens through which to probe descriptive and normative questions about legal system complexity.[170] Legal complexity theorists have focused on mapping the legal system's complexity by examining how each attribute of complex adaptive systems described in complexity science research finds close parallel in legal system structure and behavior. There have been numerous such accounts of how complex adaptive system attributes appear in a broad range of legal systems including administrative law,[171] mediation and alternative

168. Simon A. Levin et al., *Social-Ecological Systems as Complex Adaptive Systems: Modeling and Policy Implications*, 18 ENV'T. & DEV. ECON. 111, 113–14 (2013).

169. J.B. Ruhl, Daniel Martin Katz & Michael J. Bommarito II, *Harnessing Legal Complexity*, 355 SCIENCE 1377, 1377 (2017).

170. For an overview of complexity science and how scholars in the social sciences, including law, have integrated it, see J.B. Ruhl, *Law's Complexity: A Primer*, 24 GA. ST. U. L. REV. 885 (2008).

171. *See* Donald T. Hornstein, *Complexity Theory, Adaptation, and Administrative Law*, 54 DUKE L.J. 913 (2005).

dispute resolution,[172] bankruptcy law,[173] environmental law,[174] business law,[175] international law,[176] land-use regulation law,[177] intellectual property law,[178] international development law,[179] regulation of the internet,[180] the law of war,[181] health law,[182] and telecommunications regulation.[183]

Of course, the regulatory agency budget-outcomes production function model encompasses more than just a legal system. Its law component is embedded within a larger system involving politics, the economy, and the environment, all of which also could be described as complex adaptive systems. Researchers

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172. *See* Robert A. Creo, *Mediation 2004: The Art and the Artist*, 108 PENN. ST. L. REV. 1017 (2004); Arthur B. Pearlstein, *The Justice Bazaar: Dispute Resolution Through Emergent Private Ordering as a Superior Alternative to Authoritarian Court Bureaucracy*, 22 OHIO ST. J. ON DISP. RESOL. 739 (2007).

173. *See* Bernard Trujillo, *Patterns in a Complex System: An Empirical Study of Valuation in Business Bankruptcy Cases*, 53 UCLA L. REV. 357 (2005); Bernard Trujillo, *Self-Organizing Legal Systems: Precedent and Variation in Bankruptcy*, 2004 UTAH L. REV. 483 (2004).

174. *See* Gerald Andrews Emison, *The Potential for Unconventional Progress: Complex Adaptive Systems and Environmental Quality Policy*, 7 DUKE ENVTL. L. & POL'Y F. 167 (1996).

175. *See* Thomas Earl Geu, *Chaos, Complexity, and Coevolution: The Web of Law, Management Theory, and Law Related Services at the Millennium*, 65 TENN. L. REV. 925 (1998).

176. *See* Mark D. Belcher & James W. Newton, *International Legal Development: A Complex Problem Deserving of a "Complex" Solution and Implications for the CAFTA Region*, 12 SW. J.L. & TRADE AM. 189 (2006); Rakhyun E. Kim & Brendan Mackey, *International Environmental Law as a Complex Adaptive System*, 14 INT'L ENVTL. AGREEMENTS 5 (2013).

177. *See* John R. Nolon, *Champions of Change: Reinventing Democracy Through Land Law Reform*, 30 HARV. ENVTL. L. REV. 1 (2006).

178. *See* Andrea M. Matwyshyn, *Organizational Code: A Complexity Theory Perspective on Technology and Intellectual Property Regulation*, 11 J. TECH. L. & POL'Y xiii (2006); Deborah Tussey, *Music at the Edge of Chaos: A Complex Systems Perspective on File Sharing*, 37 LOY. U. CHI. L.J. 147 (2005).

179. *See* Belcher & Newton, *supra* note 176.

180. *See* Susan P. Crawford, *Shortness of Vision: Regulatory Ambition in the Digital Age*, 74 FORDHAM L. REV. 695 (2005); David G. Post & David R. Johnson, *"Chaos Prevailing on Every Continent": Towards a New Theory of Decentralized Decision-Making in Complex Systems*, 73 CHI.-KENT L. REV. 1055 (1998).

181. *See* Carla Crandall, *If You Can't Beat Them, Kill Them: Complex Adaptive Systems Theory and the Rise in Targeted Killing*, 43 SETON HALL L. REV. 595 (2013).

182. *See* M. Gregg Bloche, *The Emergent Logic of Health Law*, 82 S. CAL. L. REV. 389 (2009).

183. *See* Barbara A. Cherry, *The Telecommunications Economy and Regulation as Coevolving Complex Adaptive Systems: Implications for Federalism*, 59 FED. COMM. L.J. 369 (2007); Susan P. Crawford, *The Biology of the Broadcast Flag*, 25 HASTINGS COMM. & ENT. L.J. 603 (2003).

from a broad variety of fields increasingly are exploring how these systems of systems policy challenges can be better understood through complexity science models. For example, the National Academy of Sciences recently described the diverse economic, physical, social, and policy dynamics that drive the vast conglomerate food system as a complex adaptive system,[184] and financial policy researchers have proposed using complexity science models to better design policy responses to systemic risk in the financial system.[185]

Following those leads, we believe it would be useful, even in the early stages of empirical research, to view the budget-outcomes dynamic through the lens of complexity science and to think of budget cuts (or increases) as external perturbations. While we are not currently able to build out a complete system model, our point is that the goal should be to develop this kind of deeper understanding of the system and initiate a research agenda with that goal in mind. Just as with improving marginal analysis methodologies, complexity systems models will require more robust datasets regarding public and private regulatory investments and the outcomes those investments are intended to produce. Given the substantial advancements in data collection, management, and analytics that have been made in the last decade, progress seems likely to continue.

2. Assessing and Maintaining Resilience

In addition to modeling and measuring budget yield, one particular intermediate product—resilience—warrants special attention because it raises different analytic challenges.

Investment in maintaining resilience of infrastructure—whether highway bridges or a metro system or public governance—rarely provides an obvious and immediate return on the dollar, but failing to invest will eventually take its toll. Collapsé can be nonlinear—a function of systemic risk reaching the breaking point—and repair efforts might come too late to avoid a cas-

184. INST. OF MED. & NAT'L RESEARCH COUNCIL, A FRAMEWORK FOR ASSESSING EFFECTS OF THE FOOD SYSTEM 6–7 (Malden C. Nesheim et al. eds., 2015).

185. Stefano Battiston et al., *Complexity Theory and Financial Regulation*, 351 SCIENCE 818, 818 (2016).

cade of failure. The bridge may work fine until it collapses. Resilience thus is a complex adaptive system's front-line defense against system failure.[186]

From this vantage, both Terry Anderson and the environmental groups decrying budget cuts could be correct. It may be the case that reduced agency funding has little direct correlation to measures of environmental quality but a close correlation to individual pollution disasters.

Since the early 2000s, there has been an explosion of theory and research on the theme of organizational resilience in the business enterprise context.[187] There has also been a rising interest in agencies like EPA on how they can promote resilience in environmental quality.[188] Only recently, however, has the resilience goal been directed at public agencies themselves—how to make and keep them resilient.[189] Notwithstanding privatization rhetoric, the public quickly turns to agencies like EPA, and not generally to the private sector, to (1) protect against failures like the Flint drinking-water crisis; and (2) respond when they occur with return on the dollar not the primary concern. Further research is needed on what supports and sustains regulatory agency resilience. In particular, there must be greater focus on calculating the baseline investments needed to ensure resilience as well as ways to assess this measure within agencies. This is a nascent field but with important research payoffs.

3. Evaluating and Comparing Intermediate Products

A key feature of the regulatory production function will be the assessment of intermediate products—specifically, identifying which intermediate goods are most important to environmental quality. From a historical perspective, there may be much to learn from EPA's strategic response to congressional

186. *See* Ruhl, *supra* note 157, at 563.

187. *See generally* Ran Bhamra et al., *Resilience: The Concept, A Literature Review and Future Directions*, 49 INT'L J. PRODUCTION RES. 5375 (2011) (describing resilience scholarship across several fields).

188. *See, e.g.*, Melinda Harm Benson & Ahjond S. Garmestani, *Can We Manage for Resilience? The Integration of Resilience Thinking into Natural Resource Management in the United States*, 48 ENVTL. MGMT. 392, 395 (2011), https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1200&context=usepapapers.

189. *See, e.g.*, J.B. Ruhl, *General Design Principles for Resilience and Adaptive Capacity in Legal Systems – With Applications to Climate Change Adaptation*, 89 N.C. L. REV. 1373, 1401 (2011).

zero-budgeting strategies. In order to maintain agency effectiveness, which activities were protected and which felt the brunt of budget cuts? The converse of this analysis is worth considering, as well. Which aspects of environmental quality are most at risk from which types of reduced EPA activity, and which are less vulnerable to backsliding?

Part of this research would focus on those agency products that most depend on nonsubstitutable options. In other words, certain agency resources can be substituted with private or market resources in periods of austerity (such as agency enforcement by citizen suits), while others cannot as easily (such as regulation development). Likewise, for substitutable intermediate products, which option is most effective?

Once again, data will be critical. With access to more data comes the possibility of more focused and calibrated statistical analyses. Ideally, for example, one might deploy two regressions: one to measure how funding (as an input) affects generation of an intermediate product, and a second to measure how units of the intermediate product affects the ultimate policy goal. The full analysis would shed light on how funding—as filtered through the chosen intermediate product—affects the ultimate policy goal.[190]

While we have argued that greater accumulation and analysis of quantitative data would help answer these questions, researchers might find qualitative analysis useful as well. As described above, agency officials over time have likely developed strategies for responding to budget changes, and been forced to do so when faced with budget cuts. Even if these strategies are based on anecdotal evidence, it would be helpful to know how agencies in fact make these decisions under conditions of limited access to data.

4. Allocating Among Institutional Actors

The preceding research projects have focused primarily on the agency. Congress, too, would benefit from a more developed regulatory production function. There is a great deal of scholarship on specific policies of institutions, whether cap-and-trade, product certification, taxes, et cetera, as well as case studies of

190. We are grateful to Elizabeth Anderson for this suggestion.

their application.[191] There has been remarkably little consideration, though, over how to allocate *among* the institutional actors undertaking these initiatives. Which institution does a better job at production?

Armed with a better handle on which intermediate products provide the best return and which institutions are most capable and efficient at producing them, macro-level research could begin to focus on broader comparisons of overall institutional performance over time. We anticipate that there remain today many high-yield options that represent low-hanging fruit. For example, the EPA might be more efficient at providing educational materials, but industry more efficient at providing training.

Private governance initiatives, such as contractual supply-chain control,[192] are relatively new, but can yield significant gains in environmental quality. We have learned a lot about the private certification of forest products and which programs are more effective than others, for example,[193] but we still know little about the appropriate balance between private certification programs and public regulation of forests. Research could be devoted to identifying such opportunities and tracking investment and returns.

Over time, of course, as an institution's low-hanging fruit is picked off, the overall marginal yield of further investment in that institution should fall and eventually level off. Indeed, this may be precisely what has happened with EPA—why its budget and environmental quality do not appear correlated in any significant way. It may be that over time different institutions level off at different marginal yields, which could help guide investment decisions going forward. Institutions with persistently lower marginal yields could then begin experimentation with new, innovative intermediate products and production methods which, if they produce high marginal yields, would be a focal point for new budget investment. Research as to which institutional actors have the best innovation track record can support

191. *See, e.g.*, Nash & Revesz, *supra* note 81, at 582–614 (providing a case study of tradeable air-pollution emission-permit regimes).

192. *See, e.g.*, Vandenbergh, *supra* note 85, at 147 (discussing how "private supply chain contracts" sometimes "include provisions that are designed to reduce the environmental harms arising from the suppliers' operations").

193. *See, e.g.*, Susan E. Moore, Frederick Cubbage & Celia Eicheldinger, *Impacts of Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI) Forest Certification in North America*, 110 J. FORESTRY 79 (2012).

that investment decision as well. Again, cost-benefit analysis cannot produce the information needed to guide these kinds of decisions. This is not easily done, to be sure, but of fundamental importance in a world of scarce resources.

CONCLUSION

While difficult to study, the relationship between regulatory agency funding and regulatory benefit outcomes is a research area of fundamental importance, raising questions that bear on major issues of public debate and regulatory design. Importantly, while our focus has been on the environment, our larger point holds true for any agency whose mission centers on improvement of social welfare. Developing methods to measure budget yield, assessing and maintaining resilience, evaluating and comparing intermediate products, and allocating between institutional actors are no less relevant for OSHA, the Securities Exchange Commission (SEC), and the Department of Health and Human Services, as for EPA. This Article's exploration of the issues and promising research topics provides a foundation upon which future scholarship can build.

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