



**The Pace of PACE at the Environmental Protection Agency**

Rich Iovanna, Kelly Maguire, and Al McGartland

Working Paper Series

Working Paper # 03-07  
August, 2003



U.S. Environmental Protection Agency  
National Center for Environmental Economics  
1200 Pennsylvania Avenue, NW (MC 1809)  
Washington, DC 20460  
<http://www.epa.gov/economics>

## **The Pace of PACE at the Environmental Protection Agency**

Rich Iovanna, Kelly Maguire, and Al McGartland

Correspondence:

Kelly Maguire  
U.S. Environmental Protection Agency  
1200 Pennsylvania Ave., NW (1809T)  
Washington, DC 20460  
phone: (202) 566-2273  
[maguire.kelly@epa.gov](mailto:maguire.kelly@epa.gov)

NCEE Working Paper Series

Working Paper # 03-07  
August, 2003

### **DISCLAIMER**

The views expressed in this paper are those of the author(s) and do not necessarily represent those of the U.S. Environmental Protection Agency. In addition, although the research described in this paper may have been funded entirely or in part by the U.S. Environmental Protection Agency, it has not been subjected to the Agency's required peer and policy review. No official Agency endorsement should be inferred.

## The Pace of PACE at the Environmental Protection Agency

Rich Iovanna, Kelly Maguire, and Al McGartland<sup>1</sup>  
National Center for Environmental Economics  
U.S. Environmental Protection Agency

**Abstract:** The Pollution Abatement Costs and Expenditures (PACE) Survey provides the only comprehensive source of data on pollution costs by manufacturing facilities in the U.S. Collected historically by the Bureau of Census until 1994, the U.S. Environmental Protection Agency's (EPA) National Center for Environmental Economics initiated an agreement with the Bureau of Census to reinstitute the survey with the collection of 1999 data. This paper provides a brief history of the survey, including uses of the data by the EPA. We then discuss the issues we encountered with regard to scope and measurement concerns when redesigning the 1999 survey. The paper concludes with thoughts regarding the future direction of the PACE survey at the EPA.

Subject Area Codes: 17. Costs of Pollution Control, 65. Cross Media Pollution  
Keywords: pollution abatement, pollution costs, manufacturing survey

---

1

The views in this paper are those of the authors and do not represent those of the U.S. Environmental Protection Agency. We thank Randy Becker, Carl Pasurka and Ron Shadbegian for helpful comments. In addition, Lori Snyder and other session participants provided useful comments when this paper was presented at the 2003 ASSA Meetings in Washington, DC.

## ***Introduction***

Understanding pollution abatement costs is requisite to sound environmental decision-making. According, the U.S. Environmental Protection Agency's (EPA) National Center for Environmental Economics (NCEE) initiated an agreement in 1998 with the Bureau of Census to reinstate the dormant Pollution Abatement Costs and Expenditures (PACE) survey. Because the need for the estimates provided by the survey had, if anything, increased since the survey was discontinued in 1994, EPA committed funds to collect 1999 data.

PACE provides estimates of the annual pollution prevention, treatment, disposal and recycling expenditures by manufacturing facilities in the U.S. As such, the survey is an invaluable insight into the costs of environmental protection and it is not surprising that the PACE survey has been taken under the wing of the EPA's National Center for Environmental Economics. However, while the goal of the PACE survey is simple enough, to accurately estimate private manufacturing sector pollution abatement costs and expenditures in the U.S., interpretation of this goal and implementation of the plan to achieve it has turned out to be a formidable challenge. In the process of re-instituting the PACE survey, NCEE has encountered a host of challenges, some previously unresolved but many new. These issues relate to the scope of the survey, the measurement of the concepts that are in scope and the editing and validation of results. This paper first provides a brief description of the survey's history and the uses of the PACE data at EPA. It then presents the issues encountered in developing the 1999 survey and their implication for estimating PACE. The paper concludes with some of EPA's intentions

regarding future PACE survey efforts.

### ***History and Process***

Excepting 1987, the Bureau of Census collected annual pollution abatement costs and expenditures data from 1973 through 1994, when the survey was discontinued due to budget cuts. Recognizing a continued need for the data both within and outside the EPA, the survey was re-instituted by EPA via an inter-agency agreement with Census to collect 1999 data. It was felt that the lengthy hiatus could serve as an opportunity for reflect and to effect clean break from the past as required to address concerns with the survey that had become increasingly apparent over time. These concerns, which will be discussed in the sections that follow, related largely to the fact that the survey had not kept abreast of the evolution of the regulatory environment and of industry responses to it.

To launch the effort, NCEE held a workshop internal to EPA to discuss issues relating to PACE information generally and the survey specifically. The purpose was to gather information regarding ways in which the survey could be changed to better serve program office needs. The meeting stimulated enough interest to permit a first draft of the survey instrument to be attempted. At EPA's behest, Resources for the Future (RFF) then hosted a day-long meeting with data users, researchers and other interested parties to discuss further relevant issues in context of the draft survey. In a report that followed the meeting, RFF came out in strong support of the effort and identified additional issues to be addressed in designing the survey questionnaire (Burtraw, et al. 2001). Informed by this and ongoing deliberation with staff throughout EPA, NCEE revised the survey

instrument and requested comment from industry representatives who could potentially be among those in the sampling frame.

This series of meetings and discussions, along with an obligatory review by the Office of Management and Budget (OMB), culminated in an instrument significantly different from the 1994 survey. The survey was implemented in the Fall 2000, data collected, and the results subjected to an intensive review by Census and EPA staff. This review included developing an imputation scheme, addressing reporting errors, and creating tables for a final report. The data were released in late 2002 (U.S. Census Bureau, 2002).

### ***Uses of PACE Data at EPA***

EPA made the decision to revive the PACE survey for two major reasons. The first rests on the public good aspects of information. It is the government's responsibility to collect information where the private sector cannot do so efficiently.<sup>2</sup> There are many researchers in academic institutions and consulting firms using the PACE data and producing research that serves better public policy. Were the data not collected by the government it is doubtful that the private sector would take on this task given the huge costs involved. In effect, by providing the PACE data EPA leverages a large part of the economic research community and the public benefits by these efforts. EPA's Environmental Economics Advisory Committee of the Science Advisory Board

---

<sup>2</sup>

Specifically, if the social benefits of the information across all users exceed the costs, then there is a case for the government to sponsor the collection of the data.

confirmed this conclusion in letters to former Administrator's Browner and Whitman (USEPA, 1999b and 2002). These letters urged EPA to undertake PACE sponsorship.<sup>3</sup> They assert that collective benefits of having the PACE data available far exceed the survey's costs. Without the EPA sponsorship, this important area of research would cease and the insights and understanding of the role of environmental expenditures on firm behavior and performance would suffer.

However, EPA is not supporting the PACE simply to support academic research or even in the hope that benefits to the Agency will ultimately accrue from this research. Indeed, EPA is the largest single user of this data, which brings us to the second major reason for supporting the data. Increasingly, Congress and the Administration are demanding that EPA and other agencies provide better information about the costs, benefits and economic ramifications of programs and regulations. The PACE data are an important source of information needed to meet these requests.

For example, Former Senator Thompson sponsored amendments to budget legislation that requires the Office of Management and Budget to submit annual reports to Congress on the costs and benefits of regulatory programs (e.g., Federal Register, 2003). The PACE data serve as the cornerstone of the estimates for the costs of environmental regulations in these reports.

More recently, OMB requested estimates of the social costs of goals outlined in EPA's 2003 Strategic Plan (USEPA, 2003). Much of the analysis for this report relied on

---

3

The EPA's Environmental Economics Advisory Committee is comprised of roughly a dozen academic environmental and other economists.

the 1999 PACE survey. Since this request will likely become a standard part of the Strategic Plan, the need for updated PACE data will continue.

PACE data have also been used to satisfy provisions inherent to EPA's enabling statutes, themselves. Section 812 of the 1990 Clean Air Act Amendments, for instance, requires EPA to submit a detailed report on the costs, benefits, and economic impacts of all air pollution regulations. The first of these reports looked retrospectively at efforts to reduce air pollution from 1970 to 1990 (USEPA, 1997). This report used the PACE data as the basis for the manufacturing industries' expenditures for reduced air pollution. EPA subsequently did a prospective study, which will be periodically updated (USEPA, 1999a).

One of the well-cited uses of the PACE data is the 1990 report EPA sent to Congress, *Environmental Investments: The Cost of a Clean Environment* (USEPA, 1990). This report was motivated, in part, by provisions in the Clean Water Act and Clean Air Act, requiring EPA to report to Congress on the costs of air and water regulations. The "Cost of Clean" report went further and covered the costs of all pollution abatement activities. Without the PACE data available at the time, it is unlikely that such a report could have been completed.

At the regulatory level, PACE results are used to assess costs of a particular rule or rule option under consideration, particularly to satisfy Executive Order 12866 (Federal Register, 1993).<sup>4</sup> At the very least, PACE survey data serve as a means to corroborate

---

4

Executive Order 12866 requires federal agencies to estimate the costs and benefits of all economically significant regulatory actions. E.O. 12866 has been amended by E.O. 13258.

the detailed engineering cost studies conducted by EPA's regulatory programs for the sake of a rule. More generally, the cost information serves as input into other strategic planning and program evaluation efforts performed inside and outside of EPA.

### ***Scope and Design Issues***

In an effort to redesign the survey to address some of the current and anticipated uses of PACE, several challenging issues regarding the scope and subsequent design of the survey emerged. The most fundamental scope consideration is that of whether or not to limit inquiry to out-of-pocket costs. Were the survey to also garner information such as lost productivity, EPA would be closer to a metric more meaningful for decision making at the National level: social costs. This is because, not only would the survey results be more comprehensive in terms of the true costs faced by a facility, but such information would facilitate estimation of dead-weight losses as well. Wisely, given the challenges associated with requesting information on even relatively straightforward out-of-pocket costs, the 1999 survey does not stray from previous ones in assuming that respondents can successfully deal with lost productivity concerns. Note, too, the survey relates to production only, and does not consider actions taken by facilities to ensure consumer products meet environmental standards and the associated costs to consumers (e.g., the CAA-related installation of catalytic converters in automobiles).

Forks later in the road include the decision as to whether the focus should fall exclusively upon regulatory costs or more broadly upon pollution abatement. Historically, the PACE survey has encompassed, though not differentiated among, costs

attributable to regulatory requirements, non-regulatory programs, and those incurred voluntarily. The survey also made no distinction between costs imposed by Federal, state and local levels of government. Such disaggregation would allow a regulatory agency such as EPA to access just those costs for which it is responsible, improving its ability to justify actions taken. Even better from this standpoint would have been reporting by regulatory program or even statute. Nevertheless, EPA chose the same route for the 1999 survey as that taken historically since reporting on costs at such a fine level is a task for which facility record keeping is yet manifestly unsuited.

The sampling frame for the 1999 survey, however, did change. The sampling frame for 1999 is based on the North American Industry Classification System (NAICS), whereas previous surveys were based on the Standard Industry Classification (SIC) system. The U.S. adopted the NAICS as an industry classification system in 1997 to replace the SIC system. The NAICS includes expanded industry classifications and organizes industries according to processes. Along with the switch to the NAICS, the 1999 survey expands sectoral coverage slightly; NAICS identified over 350 new industries, some of which are reflected in the PACE sampling frame. However, it is not obvious how to close the significant gaps that remain (e.g., the agricultural sector) in the foreseeable future, as the sampling frame employed by Census still is limited largely to manufacturing.<sup>5</sup>

---

5

The PACE sample does include the mining and electric utility industries, which are non-manufacturing industries.

### *Measurement Issues*

Once the scope of the survey for the 1999 survey had been settled upon, various issues relating to the accurate measurement of sought values remained, each with implications for omitting or double-counting relevant costs. While there was recognition that past terms and definitions had strayed from the relevant idiom and were likely responsible for measurement error, the 1999 survey falls short of the ideal. The varied and unique features of establishments and the relatively new attention on pollution abatement have precluded the development of a universal language or understanding. Further, given the limited degree of guidance that the research literature provides for improving collection of these data, refinements in some cases were limited to ad hoc attempts to clarify instructions as questions were raised. The most general and vexing issue is the potential for abatement data to simply not exist at the facility level, effectively precluding the reporting of costs. While it is conceivable that they are, rather, available at the firm level, particularly with the advent of environmental accounting systems, the available insight on the subject is not hopeful. Joshi, Krishnan, and Lave (2001) report that managers have difficulty in identifying the portion of costs, particularly operating costs, which are attributable to environmental regulation.

The second measurement issue relates to the treatment of situations when pollution is prevented incidentally, such as when capital turnover occurs and a more efficient production process is adopted (see Berman and Bui 2001). Abatement in this case is purely an artifact of profit maximization or technological change, rather than the consequence of a commitment to environmental protection. Although there are no

incremental costs (there may be even cost savings) attributable to emission and/or discharge reductions, respondents can assume just the opposite and erroneously equate and report the entire costs of the new production technology with pollution abatement cost. Although initial versions of the 1999 survey included both some discussion of this issue and an opportunity to offer estimates of costs savings, some commentators found any treatment at all so unrealistic that they were struck from the final version of the survey.

Third, even when changes in process are undertaken with pollution abatement in mind, distinguishing the increment of the total cost of the new, “integrated technology” attributable to pollution abatement from the production cost component is inherently difficult to discern. Historically, industries have relied on “end-of-pipe” technologies, whose sole purpose is to “treat” away the threat pollution poses, to achieve pollution reductions. De Boo (1993) refers to these as “visible costs” because their purpose is readily apparent and easily distinguishable from the production process. Joshi, Krishnan, and Lave (2001) likewise use this term, in their case because visible costs are often reported in accounting ledgers under environmental cost categories. In addition, even when not reported in ledgers, their sheer visibility makes them easier to recall. What is unfortunate from the standpoint of data collection is that this easily measured regime of pollution treatment and end-of-pipe technologies is being overtaken by one involving the use of integrated technologies to achieve pollution prevention. For example, practices such as fuel substitution and the reuse/recirculation of harmful inputs are integrated into the production process, making it difficult to tease out the incremental cost of pollution

abatement. Rather than visible, these costs are increasingly “hidden” in other cost categories, such as materials or operating expenses.<sup>6</sup>

With regard to its treatment in the 1999 instrument, there was some discussion as to whether respondents could provide the incremental cost estimates associated with pollution prevention by making comparisons between technological alternatives. And again, the final version of the 1999 survey fell short of original intentions. In light of reviewer insistence, the decision was made to demur on any guidance on estimating pollution prevention costs. Moreover, those pollution prevention figures that were collected did not even distinguish pollution prevention capital expenditures from operating costs, unlike previous surveys.

Fourth, a serious shortcoming of earlier efforts was how the costs of basic or public health services and those of environmental protection were conflated. The preponderance of historical solid waste costs were more accurately that of disposal, i.e., the transport of wastes away from the facility, rather than their abatement. The short-term fix for the 1999 survey was that of separating out disposal costs from those associated with abatement. A true solution would include a means by which to obtain data on costs of activities undertaken by landfills to comply with the Resource Conservation and Recovery Act (RCRA).

Fifth, recycling was identified during the 1999 effort as a potentially confusing term. On one hand, in-process recycling is essentially a pollution prevention approach

---

<sup>6</sup>

During interviews conducted by Joshi, Krishnan, and Lave (2001), facility managers affirmed that distinguishing the environmental feature from others for certain costs (e.g., production changes) is a challenge.

that reuses inputs, thereby eliminating pollution by minimizing the production inputs that generate it in the first place. On the other hand, off-site recycling is something between disposal and treatment, with pollution being deferred by the redirection of “used-up” inputs by an off-site recycler to other, typically lower-grade, purposes. To resolve this confusion, the 1999 survey treats the latter as a distinct category, though the instructions may not have been clear in this respect.

Sixth, the treatment of depreciation historically has been problematic because depreciation was included as part of a facility’s operating costs. Hence, care would need to be taken when efforts were made to examine a facility’s overall costs so as to avoid double counting. Nevertheless, analyses have made the mistake of neglecting to net out depreciation when capital costs (calculated from amortized expenditures) were added to operating costs (e.g., USEPA, 2000). Moreover, firms may report “accounting” depreciation, rather than “physical” depreciation, the former being subject to arbitrary tax guidelines and bearing little relation to actual wear-and-tear. This issue will likely be the subject of future revisions of the survey as we attempt to better ascertain how firms actually respond to questions. In the 1999 survey, depreciation was excluded from the data collected.

### ***Editing Issues***

Once the data are collected, the processes used to edit and validate the results of the survey also affect the degree to which the estimates accurately reflect intentions. There are three such issues that we faced with the 1999 survey: incorrect units,

interpretation of blanks, and imputation. Each is addressed in turn.

The survey asks respondents to report costs in thousands. The form itself provides three zeros in each cell to further alert respondents to report in thousands, as opposed to actual values. Nonetheless, review of the responses indicates that some respondents reported actual values. Identifying such cases is difficult at best, however. Questionable cases were typically identified by reviewing the distribution of costs across sectors. Census then compared the values for these aberrant cases to either their total capital expenditures reported in the Annual Survey of Manufacturers or other values reported in the survey, itself, to determine whether values were reported in the correct basis or not. Since reporting in incorrect units can dramatically affect even aggregate totals, errant responses were “corrected” by dividing by 1000. There are plans to introduce a design change in future forms to help rectify the incidence of this issue.

A second issue is the interpretation of blank responses. Blanks could represent zero expenditures or they could represent a missing observation. If missing, it may have been that the respondent did not know such expenditures existed or had no way of estimating such expenditures, electing to leave the cell blank. This is becoming an increasingly serious issue: Streitweiser (1996, 1997) reports an increased incidence of blank cells in the PACE survey, from 29 percent during the years 1984-1986 to 57 percent from 1988 to 1992.

One method of addressing this issue would have been to ask respondents to insert a zero when no expenditures exist and to leave the cell blank when they were uncertain or unable to provide an estimate. Another approach, the one used in 1999, is to provide an

option for respondents to indicate if they are uncertain or unable to provide a response. While these boxes were checked on the 1999 form, they are still difficult to interpret because they may represent uncertainty about whether costs were incurred or about how to estimate such costs. Further, there was concern that respondents would simply check this box, rather than make an effort to estimate a value. Finally, to make matters worse, Census protocol led (for this and earlier surveys) to the treatment of all blanks in the PACE survey as zeros, rather than leaving them as missing. Efforts were made to correct these cases, but these corrections were imperfect at best.

The final issue addresses imputation. Historically, the PACE data are imputed when estimates are not provided but pollution abatement costs are deemed to exist. Because the institutional knowledge on PACE has diminished significantly since the survey was last implemented in 1994, limited knowledge was available regarding past imputation schemes. If industry averages from previous years' estimates were used for imputation, the conversion from SIC to NAICS now effectively precludes this approach. As a consequence, imputations for 1999 relied upon information contained within the survey, itself. Because capital expenditures are infrequent cash outlays, only operating costs were imputed.<sup>7</sup>

---

7

The inability to impute capital expenditures will almost certainly become a more serious problem from now on since the survey has not been reinstated as an annual survey. Without the ability to interpolate for missing years' data, simply estimating capital costs from capital expenditures will prove problematic.

### *Next Steps*

There is a desire to ascertain the degree to which PACE survey responses deviate from “true” pollution abatement expenditures. While research exists on validity tests of household data, there have been few published formal efforts regarding establishment survey data. We speculate that the paucity of research reflects the fact that establishment surveys typically report confidential data not readily accessible at the establishment level (aggregate statistics are published) and the costs associated with conducting such tests, say via on-site visits, are prohibitive. Nonetheless, there are two means by which establishment survey data can be validated: plant visits or modeling the values of interest. The Toxic Release Inventory (TRI) Data Quality Report (USEPA, 1998) appears to be the singular example of the former. This report reflects an independent, engineering assessment of toxic releases from TRI firms. The results from these visits are compared to reported results for the same plant. Discrepancies are reported as errors, calculated as the simple difference between the reported and actual release. This type of approach is based on the actual survey instrument combined with an independent reporter (the contractor is unaffiliated with the facility and presumed to have no interest in misrepresenting release figures). Results show that TRI releases are often under-reported by facilities.

Alternatively, a modeling approach could be used to independently validate the survey results. While this approach has been widely applied in the context of PACE, the standard assumption that production and abatement decisions are separable contradicts the current state of affairs and renders most models ill-suited to measure any but the most

obvious of abatement costs. More recent work, however, acknowledges that establishments are now operating in a pollution prevention paradigm, whereby decisions are made jointly. Researchers have augmented both production and cost functions in order to estimate both visible and hidden costs. For example, Färe, Grosskopf, and Pasurka (2002) compare PACE data reported by electric utility firms in the EIA-767 Survey administered by the Department of Energy to estimates derived from modeling the joint production of both good and bad (i.e., pollution) outputs. Their results show that the survey data provide lower costs than those derived from a modeling approach. Joshi, Krishnan, and Lave (2001) incorporate a measure of regulatory stringency into a cost function to ascertain the impact it has on traditional cost pools. They, too, find that estimated costs exceed reported costs.

After considering various options, EPA has elected to take a two-pronged, though limited, approach to assessing the PACE survey. On one hand, based on recommendations formed at the RFF workshop, EPA will be establishing an expert-review panel of individuals from outside EPA who are conversant with PACE data and/or establishment surveys. These individuals will opine at critical junctures during the development of the next phase of the PACE survey. The hope is that, by eliciting an independent group's input, we will resolve some of the outstanding issues regarding the survey. On the other hand, EPA intends to elicit the support of environmental engineers who are familiar with the production processes used by the major industry groups in the PACE sample. The purpose of the engineering support is to assist EPA in designing a survey that will reflect processes in ways familiar to industry respondents, such as by

suggesting nomenclature, definitions, and illustrative examples. The hope is that the combined effect will result in a survey that is both familiar to the respondents and captures the full scope of pollution abatement costs.

Once the next survey has been developed, we will subject it to cognitive interviews with potential respondents to identify areas where the questionnaire may be confusing or misleading. The penultimate step will be to essentially pre-test the revised instrument by administering it to a small sample. Finally, based on the results of the pre-test, the survey will be finalized in hope of administering it on a full-scale basis.

### ***Conclusions***

While EPA did manage with the 1999 survey to resolve some of the issues hampering earlier versions, such as outdated nomenclature and unnecessary detail, there remain a variety of outstanding issues that are likely to invite criticism. While these changes were intended to increase the accuracy of the data in terms of measuring true pollution abatement costs, there is a trade-off in deviating from previous survey instruments. Extensive changes render longitudinal analysis difficult, if not impossible, an issue that will remain a concern as we move forward with future survey development efforts.

Much of the work ahead is in terms of honing survey definitions and design, particularly as regards pollution prevention, and implementing the survey on a more frequent basis. Further improvements to the survey will undoubtedly enhance the ability of the PACE survey to measure pollution abatement costs comprehensively. Measuring

pollution prevention is a particularly difficult challenge. However, the research and public policy benefits are high. The PACE data will provide a basis to understand firms' responses to pollution control, the pattern of expenditures on abatement, and the productivity of reducing pollution per unit of abatement.

## References

- Berman, Eli and Linda T. Bui. 2001. Environmental Regulation and Labor Demand: Evidence from the South Coast Air Basin. *Journal of Public Economics* 79(2): 265-295.
- Burtraw, Dallas; Alan Krupnick; Richard Morgenstern; William Pizer; and Jhih-Shyang Shih. 2001. Workshop Report: Pollution Abatement Costs and Expenditures (PACE) Survey Design for 2000 and Beyond. *Resources for the Future Discussion Paper*, Number 01-09.
- DeBoo, Abraham J. 1993. The Costs of Integrated Environmental Control. *Statistical Journal of the United Nations Economic Commission for Europe* 10(1): 47-64.
- Färe, Rolf; Shawna Grosskopf, and Carl Pasurka. 2002. Estimating Pollution Abatement Costs: A Comparison of 'Stated' and 'Revealed' Approaches. Working Paper, [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=358700](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=358700).
- Federal Register. 1993. "Executive Order 12866 - Regulatory Planning and Review." *Federal Register* 58: 51735. September 30, 1993.
- Federal Register. 2003. "Draft 2003 Report to Congress of the Costs and Benefits of Federal Regulations; Notice." *Federal Register* 68(22): 5492-5495, February 3, 2003.
- Joshi, Satish; Ranjani Krishnan; and Lester Lave. 2001. Estimating the Hidden Costs of Environmental Regulation. *The Accounting Review* 76(2): 171-198.
- Streitwieser, Mary L. 1996. Evaluation and Use of the Pollution Abatement Costs and Expenditures Survey Micro Data. *Center for Economic Studies*, CES 96-1, (<http://www.ces.census.gov/ces/php/papers>).
- Streitwieser, Mary L. 1997. Using the Pollution Abatement Costs and Expenditures Micro Data for Descriptive and Analytic Research. *Journal of Economic and Social Measurement* 23(1): 1-25.
- U.S. Census Bureau. 2002. *Pollution Abatement Costs and Expenditures: 1999*, MA200(99), U.S. Government Printing Office, Washington, DC.
- U.S. Environmental Protection Agency (USEPA). 1990. *Environmental Investments: The Cost of a Clean Environment*. Policy Planning and Evaluation, EPA-230-1 1-90-083 (November).
- U.S. Environmental Protection Agency (USEPA). 1997. *The Benefits and Costs of the Clean Air Act: 1970 to 1990*. Office of Administration and Resources Management,

Office of Policy, Planning and Environment (October).

U.S. Environmental Protection Agency (USEPA). 1998. *1996 Toxic Release Inventory Data Quality Report*. Office of Pollution Prevention and Toxics, EPA-745-R-98-016.

U.S. Environmental Protection Agency (USEPA). 1999a. *The Benefits and Costs of the Clean Air Act: 1990-2010*. Office of Air and Radiation and Office of Policy, EPA-410-R-99-001.

U.S. Environmental Protection Agency (USEPA). 1999b. Letter from Dr. Robert N. Stavins, Chair of Environmental Economics Advisory Committee of the Science of Advisory Board and Dr. Joan M. Daisy, Chair of the Science Advisory Board to The Honorable Carol Browner, EPA-SAB-EEAC-COM-99-001.

U.S. Environmental Protection Agency (USEPA). 2000. *A Retrospective Assessment of the Costs of the Clean Water Act: 1972-1997*. Office of Water, Office of Policy, Economics and Innovation, EPA-67-W7-0018.

U.S. Environmental Protection Agency (USEPA). 2002. Letter from Dr. Robert N. Stavins, Chair of Environmental Economics Advisory Committee of the Science of Advisory Board and Dr. William Glaze, Chair of the Science Advisory Board to Governor Christine Todd Whitman, EPA-SAB-EEAC-COM-02-001.

U.S. Environmental Protection Agency (USEPA). 2003. 2003 Strategic Plan: U.S. Environmental Protection Agency, Draft.