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PACE Survey: Background, Applications, and Data Quality Issues

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and
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Abstract: The only comprehensive source of the actual costs of environmental abatement activities in the United States has been the Pollution Abatement Costs and Expenditures (PACE) survey. This survey collects facility-level data on capital and operating costs of pollution abatement, focusing on facilities in the manufacturing, mining, and electric utility industries. The cost information reflects most environmentally related expenditures, including compliance with local, state, and federal regulations, and voluntary or market-driven pollution abatement activities. Between 1973 and 1994 (but excluding 1987), the Bureau of Census conducted the PACE survey annually. After a 5-year lapse, it was reinstated in 2000, following a redesign, and collected data on 1999 expenditures. Subsequent to the 1999 PACE survey, no further surveys have been conducted. This report discusses the PACE survey and issues surrounding it, and offers suggestions for how to address some of these issues. This report is part of a larger project under contract with US EPA to redesign the PACE Survey with the goal of developing a survey that will be implemented on an annual basis.

Keywords: pollution abatement, survey design, costs, expenditures

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PACE Survey: Background, Applications, and Data Quality Issues

Draft Report

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*RTI International is a trade name of Research Triangle Institute.

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INTRODUCTION

1.1 Overview

Ex post, or retrospective, analyses of the economic effects of environmental policies and programs rely, in large part, on data regarding the actual costs of these abatement activities. This information is useful both for answering questions such as what has been the economic cost of Section 812 of the Clean Air Act (CAA) or what has been the impact of the Act on productivity growth or international trade. It is also an important source of information for developing better *ex ante*, or prospective, estimates of the costs of proposed environmental regulations. Accurate projections of these costs are essential, because they may influence the selection of regulatory options, and the information will facilitate improvements in design of regulations, which may improve their cost-effectiveness.

The only comprehensive source of the actual costs of environmental abatement activities in the United States has been the Pollution Abatement Costs and Expenditures (PACE) survey. This survey collects facility-level data on capital and operating costs of pollution abatement, focusing on facilities in the manufacturing, mining, and electric utility industries. The cost information reflects most environmentally related expenditures, including

compliance with local, state, and federal regulations, and voluntary or market-driven pollution abatement activities.[1] Between 1973 and 1994 (but excluding 1987), the Bureau of Census conducted the PACE survey annually. After a 5-year lapse, it was reinstated in 2000, following a redesign, and collected data on 1999 expenditures. Subsequent to the 1999 PACE survey, no further surveys have been conducted.

Collecting accurate information on pollution-related expenditures from a wide variety of diverse facilities poses a range of challenges, especially as the actions taken by businesses to abate or prevent pollution become ever more complex. Over time, government and academic users of data collected by the PACE surveys have identified a number of issues with the survey design. In March 2000, as part of the effort to improve the survey instrument, Resources for the Future (RFF) hosted a workshop to discuss these concerns. This report discusses the PACE survey and issues surrounding it, including those highlighted by the RFF workshop. One other notable source is an article titled "A Change of PACE: Comparing the 1994 and 1999 Pollution Abatement Costs and Expenditures Surveys" by Becker and Shadbegian (2004), which includes recommendations for future revisions of the PACE survey. These suggestions are combined with those from other experts to propose methods of addressing difficulties faced by the survey.

[1]Because cost data are collected at the facility level, costs incurred at the corporate level (such as research and development) are not included in the survey.

This report is part of a larger project under contract with US EPA to redesign the PACE Survey with the goal of developing a survey that will be implemented on an annual basis.

1.2 Expenditure Data from the PACE Survey

The PACE survey collects expenditure data related to pollution abatement, which consists of *pollution treatment* (actions to reduce or eliminate pollution that has been generated during production processes), *pollution prevention* (actions to prevent creation of pollution in the first place), *recycling*, and *disposal*.[2] Pollution treatment typically revolves around retrofit technologies. These equipment and activities are designed to change the character or composition of pollutants prior to their release into the environment and are also referred to as end-of-line activities. Examples of pollution treatment include costs associated with scrubbers, filters, baghouses, and wastewater treatment. In contrast, pollution prevention covers modifications to equipment or production processes that are designed to lower releases through product redesigns, reuse of material inputs, or substitutions among types of inputs. Examples of pollution prevention include costs associated with fuel substitution, leak prevention, and process or equipment modification. Recycling is the on-site (post-production) processing or off-site processing of waste for an alternative use. Disposal, in an environmentally sound

[2]Pollution treatment and prevention are the most significant components and therefore are discussed in more detail in this background document relative to recycling and disposal.

manner, is the final placement, destruction, or disposition of waste after pollution treatment or recycling has occurred, not including disposal of municipal solid wastes.[3]

Pollution abatement expenditures are classified as either capital expenditures or operating costs, depending on whether they were related to purchasing and installing pollution abatement equipment or annual costs for operating and maintaining pollution abatement technology. According to the latest PACE survey, for treatment and prevention combined, the manufacturing, mining, and electric utility industries collectively spent $5.8 billion on capital expenditures and $11.9 billion on operating costs in 1999 for pollution abatement. Of the $5.8 billion in capital expenditures, the manufacturing sector spent $4.4 billion, which accounted for almost 3 percent of all capital investments made by manufacturers (U.S. Census Bureau, 2002).

In addition, expenditures are classified as being associated with a particular medium (air, water, and solid wastes)[4] and by hazardous versus nonhazardous pollutants. This information can be useful in supporting efficiency or benefit-cost analysis of specific types of regulations or programs.

[3]Note that some confusion has resulted from definitions of pollution abatement, treatment, and prevention used in previous versions of the survey. For this report, the terms as defined here are used throughout.

[4]The 1999 survey also included multimedia as a medium category.

Only expenditures and costs incurred during the past year are collected by the survey. Focusing on a single year of expenditures and costs can be problematic, because pollution abatement costs reported in the year a regulation is enacted will be higher due to one-time expenditures and installation costs. As illustrated in Figure 1-1,[5] these factors tend to cause substantial variations in expenditures (current dollars) over time and across industries. For example, although pollution expenditures are concentrated in industries such as pulp and paper, chemicals, and petroleum refining, within these industries the costs vary significantly across years, reflecting the introduction or phase-in of specific environmental regulations. This need to compare data across years emphasizes the importance of maintaining longitudinal integrity of the data on pollution abatement capital and operating costs.

[5]Data from the 1999 survey are not included in the figure, because longitudinal comparisons are not recommended between the 1999 and earlier surveys. Significant changes occurred in the 1999 survey that reduced longitudinal integrity. For this reason, 1999 data are excluded from Figures 1-1, 1-2, and 1-3.

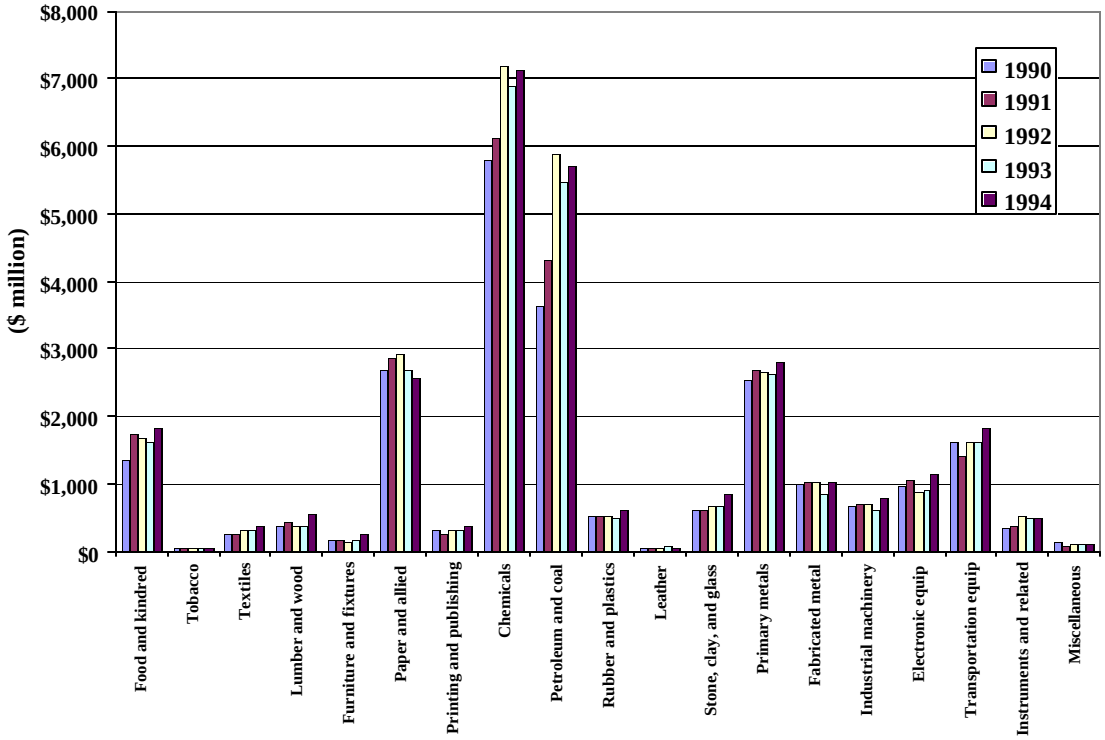

Figure 1-1. PACE Pollution Abatement Cost and Expenditures by Manufacturing Industries

Source: U.S. Census Bureau. 1996. *Pollution Abatement Cost and Expenditures: 1994, MA200(94)-1*. Washington, DC: U.S. Government Printing Office. Table 1.

On average, between 1990 and 1994, PACE capital expenditures and operating costs were approximately $27 billion per year in current dollars. The 1999 survey reported that these costs were approximately $15 billion.[6] However, this differential is in large part due to the significant differences between the 1999 form and earlier surveys. Becker and Shadbegian (2004) compare the 1999 and 1994 surveys after attempting to adjust for these differences

[6]This figure excludes electric utilities ($2.6 billion) and mining companies ($0.7 billion), which were not included in the 1994 and previous survey versions.

(inclusion of more industries in the 1999 survey, use of NAICS classifications in 1999 versus SIC codes used earlier, depreciation not included in 1999 operating costs, etc.). They find that adjusted expenditures in declined by 27 percent from 1994 to 1999 relative to value added. Becker and Shadbegian conclude that this drop is most likely due to the survey methodology and design of the 1999 survey (among other reasons), listing possible reasons such as the hiatus between surveys, use of "information not available checkboxes," "less-than-explicit" instructions, and changes in the overall structure of questions. For these reasons, longitudinal comparisons using the 1999 data are not recommended.

Measured as a percentage of the value of shipments by manufacturing industries, PACE capital plus operating expenditures show a similar pattern over time. In Figure 1-2, this metric highlights how costs are distributed across industries, with most industries spending less than one-half of 1 percent of the value of their output on pollution controls. Taking into consideration higher spending by a few industries, the 1990 through 1994 PACE surveys show that an average 0.9 percent of the total value of shipments by manufacturing industries was spent on reducing or preventing releases.

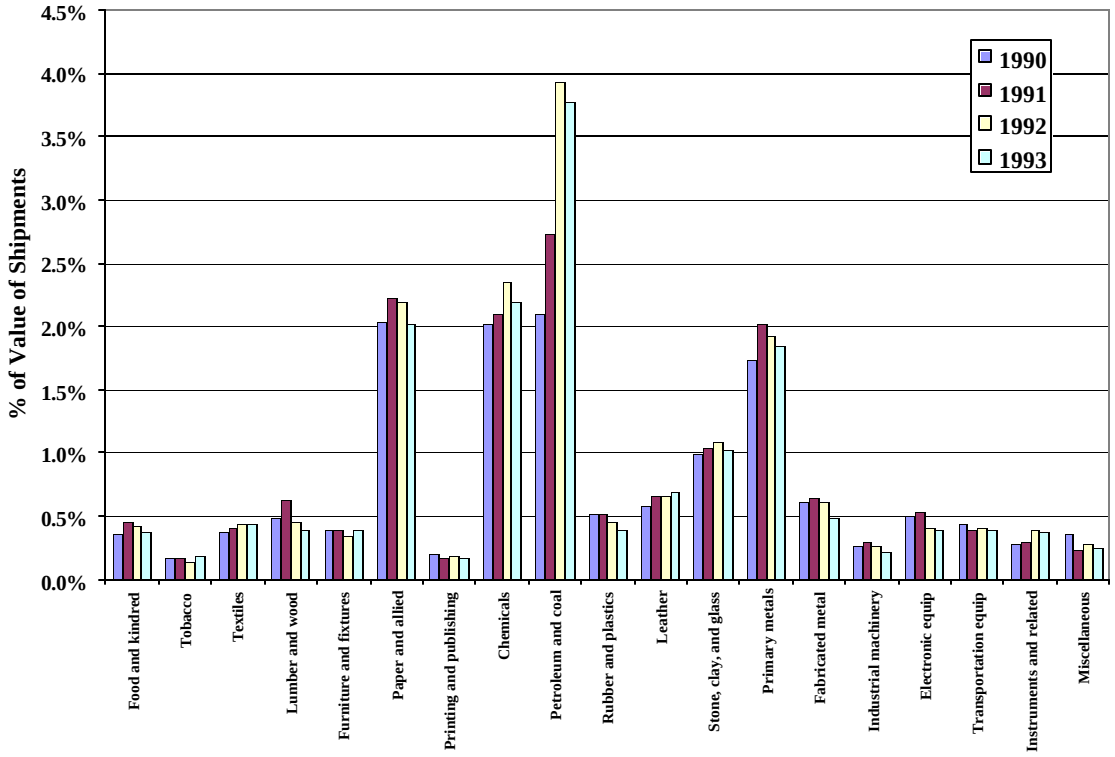

Figure 1-2. PACE Pollution Abatement Cost and Expenditures as Percentage of Shipment Values

Source: U.S. Census Bureau. 1996. *Pollution Abatement Cost and Expenditures: 1994, MA200(94)-1*. Washington, DC: U.S. Government Printing Office. Table 1.

Another method used to put the PACE data in context is to compare capital investments for pollution equipment to total industrial investment. As with the previous two figures, Figure 1-3 illustrates how pollution investments compare across industries and time. Although most industries make less than 5 percent of their capital purchases for environmental reasons, some industries, such as petroleum and coal, spend much more. On average between

1990 and 1994, pollution-equipment expenditures represented over 7 percent of all investments made by manufacturing industries.

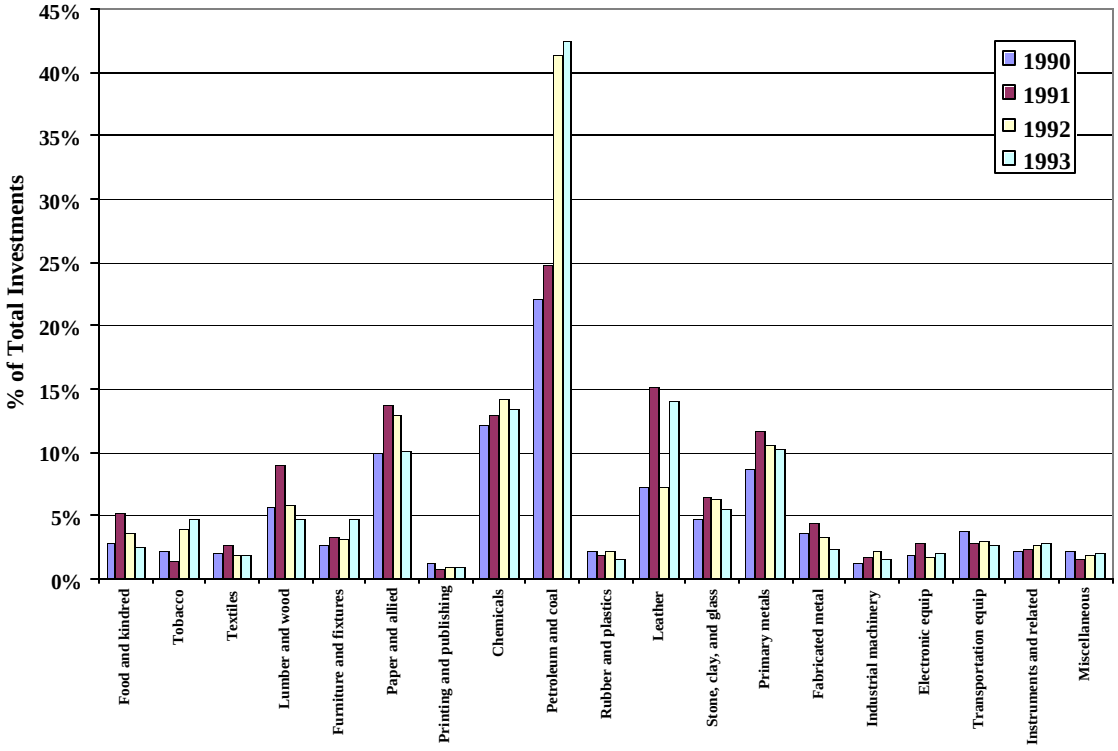

Figure 1-3. PACE Capital Expenditures as Percentage of Total Investments

Source: U.S. Census Bureau. 1996. *Pollution Abatement Cost and Expenditures: 1994, MA200(94)-1*. Washington, DC: U.S. Government Printing Office. Table 1.

1.3 Objectives of This Report

The National Center for Environmental Economics (NCEE) and academic researchers rely heavily on the PACE survey as the primary source of facility-level pollution abatement expenditures and costs. However, identifying and collecting data on pollution abatement

expenditures are both conceptually and operationally complex, and previous versions of the PACE survey had several short comings. For this reason, the PACE survey is being redesigned.

The objective of this report is to provide background discussion on the history of the PACE survey. The survey has been restructured on several occasions in the past, which has implications for current design considerations. In addition, many concerns about the survey instrument have been described both in the literature relying on PACE data and by participants of the RFF workshop. Both of these sources of information are reviewed to provide insights into survey design. Finally, the report combines these findings and suggests methods for developing a new survey instrument to more accurately capture the costs associated with pollution abatement.

The PACE survey gathers facility-level data on the expenditures and costs of activities whose primary purpose is to protect the environment. With pollution treatment, this task is relatively straightforward conceptually, because many of the technologies are standalone, end-of-pipe systems that are easy to identify. However, even with these processes, the availability of cost information is frequently limited by an individual facility's cost accounting and tracking systems.

The situation becomes even more complicated when measuring pollution prevention expenditures. Pollution prevention activities are frequently an inseparable part of a larger

project that includes aspects not environmentally motivated (such as production process enhancements solely for economic benefit) and not readily tracked as a dedicated abatement expense similar to pollution treatment. Partly due to this difficulty, little data have been collected by past PACE surveys on pollution prevention. However, more detail on pollution prevention (such as by capital and operating costs or types of pollution prevention) is needed, because prevention is an important and growing category of costs. In addition, facilities may find it easier to estimate specific components of pollution prevention and could potentially use a disaggregation of cost categories to build up a total estimate of pollution prevention expenditures. In this event, government data users and other researchers would be provided with more information on pollution prevention and gain insights into which types of cost components facilities are able to estimate and which they can not.

Redesigning the survey to better address the question "How much did facilities spend on pollution abatement, above and beyond what they would have spent in the absence of any efforts to control pollution?" brings to light a number of issues. Among these issues are how and by how much to disaggregate data collected by the survey (by media, hazardous/ nonhazardous, etc.), what are the best methods for looking at pollution prevention activities, and what are the appropriate baselines to use when measuring pollution abatement costs (i.e., what expenses would have been incurred in the absence of environmental concerns because they were profitable).

A number of recommendations relating to overall survey design and implementation are presented in the report, which are briefly summarized as follows:

- Maintain longitudinal integrity with surveys prior to 1999.
- Facilitate linkages of PACE data with other databases.
- Elicit more disaggregated data.
- Add questions on prevention activities or variables that could be used to proxy for these costs.
- Improve verification and data accuracy.
- Clarify the appropriate baseline to consider when responding to the survey.
- Describe what should and should not be included in each cost category in instructions and examples.
- Consider additional questions on other types of costs.
- Lower burden imposed on respondents by the PACE survey.

Section 2 outlines the history of the PACE survey and the types of data it gathers. Section 3 discusses ways in which PACE data have been used in research and issues

surrounding the PACE survey that have been raised in the literature and by participants at RFF workshop. Section 4 then presents some potential methods of addressing the issues raised in Section 3 and examines additional types of information that might be gathered by the PACE survey. Finally, Appendix A reviews a sample of the literature that has used PACE data and Appendix B suggests some additional reading.

SECTION 2

HISTORY OF THE PACE SURVEY

2.1 Overview

The PACE survey collects facility-level data on pollution treatment and prevention costs from manufacturing facilities.[1] The survey has been conducted annually between 1973 and 1994, with the exception that there was no survey in 1987.[2] After a 5-year lapse due to budgetary reasons, the PACE survey was reinstituted in 2000 to collect data for the year 1999, but the survey has not been conducted in subsequent years.

Over its history, the PACE sample selection methodology has changed, although it remains skewed toward medium and large facilities and typically draws a sample of around 20,000 facilities. The 1999 survey was the first since the late 1970s to include facilities with less than 20 employees in the sample. Prior to 1994, the PACE survey was a subsample of the Annual Survey of Manufactures (ASM), which is in turn a sample of the economic Census of

[1]Electric utilities and mining facilities were included in the 1999 PACE survey. Prior to 1999 the "Plant and Equipment Supplement for Pollution Abatement" (survey form PA-2) collected firm level data on only capital expenditures of pollution abatement for mining, petroleum, and electric utilities.

[2]The microdata for 1973 to 1978 and 1983 are missing. However, the aggregate data for these years are available in PACE publications.

Manufacturers (CM).[3] The 1994 survey was drawn from the 1992 Census, rather than the ASM. The 1999 survey, which was based on North American Industry Classification System (NAICS) industry classifications instead of the Standard Industrial Classification (SIC) system, came from the 1997 CM, the Census of Mining, and the universe of electric utilities.

Survey data are characterized as *treatment* (installation, retrofit, and operation of equipment intended to remove pollutants generated during manufacturing processes), *prevention* (changes in equipment or production processes that reduce formation of pollutants), *recycling*, and *disposal* expenditures. For most years of the PACE survey, these data are distinguished by capital expenditures for equipment and structures versus annual operating costs for running the equipment. In many years, these costs are separated by media: air, water, or solid wastes and by hazardous versus nonhazardous pollutants.

2.2 Design of Past Surveys

Although the basic design of the PACE survey has remained relatively unchanged over the years, some alterations have occurred, generally with the intention of collecting more detailed information. In a few cases, however, redesigns of the survey have resulted in collecting less data. Table 2-1 summarizes these changes over time by category: annual

[3]A guiding principle of the redesign of the survey will be consistency with the Annual Survey of Manufactures (ASM). Consistency of definitions (capital, depreciation, etc.) and certain aspects of the ASM structure are desirable to use in the PACE survey. Because respondents are familiar with the ASM, this familiarity may lower respondent burden, lower administrative burden for Census, and to increase response rate. Using the same sampling framework as the ASM also allows for easier matching to other Census variables (materials, energy, transportation, etc.) and hence results in better validation.

operating costs, capital expenditures, cost recovery/offsets, assets, emissions, and other types of information. For some variables, questions are essentially constant over time, while other categories only appear in specific years.

The first PACE survey in 1973 collected data on expenditures for three media: air, water, and solid wastes. Air expenditures were separated into particulates, sulfur oxides, nitrogen oxides/hydrocarbons/carbon monoxide, and heavy metals/radioactive/toxic/other categories. Costs recovered from abatement activities (i.e., savings from environmentally motivated actions) were classified as either value of materials or energy reclaimed. Annual costs for pollution control for the three media were distinguished as depreciation, labor, equipment leasing, materials and supplies, or other costs. Data were collected on the effectiveness of control equipment by specifying on the survey the amounts of air pollutants removed by type, reductions in solid wastes by weight, and reductions in water pollutants by weight.

Table 2-1. History of PACE Survey

Category	Questions	Timeline								
		1973	1974 to 1981	1979 to 1981	1982	1983	1986	1989 to 1991	1992 to 1994	1999
Annual Costs	**By Media** (air, water, solid waste)	x	x		x					*
	By Type (depreciation, labor, equipment leasing, materials/supplies/other)	x	x		x					
	By Media (air, water, solid waste) **and Type** (depreciation, labor, equipment leasing, materials/Supplies/other)			x		x	x	x	x	
	Hazardous by Media (air, water, solid waste)								x	
	Other Pollutants (noise, radiation, multimedia)								x	
	Site Cleanup								x	**
	Disposal and Recycling									x
Capital Expenditures	**Air** (particulates, sulfur oxides, nitrogen oxides/ hydrocarbon/carbon monoxide, heavy metals/ radioactive-toxic/other)	x	x	x	x	x	x	x	x	*
	Air (lead, hazardous)					x	x	x	x	
	Water (aggregated)	x	x	x	x	x	x	x		
	Water (hazardous, nonhazardous)								x	*
	Solid Waste (aggregated)	x	x	x	x					
	Solid Waste (hazardous, nonhazardous)					x	x	x	x	*
	Other Pollutants (noise, radiation, multimedia)								x	x
	Site Cleanup								x	**
	Underground Storage Tanks								x	**
	Disposal and Recycling									x
Cost Recovery	**Costs Recovered** (aggregated)	x	x							
	Costs Recovered by Media (air, water, solid waste)			x	x	x	x	x	x	
Assets	**Total Value of Depreciable Assets for Abatement**			x						
	Cost of Assets for Air Abatement by Purchase Year						x			
	Cost of Assets for Water Abatement by Purchase Year						x			
	Lifetime of Air Pollution Assets (electrostatic precipitator, baghouse, wet scrubber)						x			
Emissions	**Air Pollution Abated by Weight and Type** (particulates, sulfur oxides, nitrogen oxides/ hydrocarbon/carbon monoxide, heavy metals/ radioactive-toxic/other)	x	x	x	x	x				
	Air Pollution Abated (lead, hazardous)					x				
	Solid Waste Abated by Weight (aggregated)	x	x	x	x					
	Solid Waste Abated by Weight (hazardous, nonhazardous)					x				
	Water Pollutants Abated by Weight (total suspended solids, biochemical oxygen demand, chemical oxygen demand, other)			x	x					
	Water Pollutants Abated by Weight (conventional, nonconventional, toxic metals, toxic organics)					x				
Government	**Payments for Public Sewage and Solid Waste Removal**	x	x	x	x	x	x	x	x	
Other	**Total Number of Operating Days**	x								
	Yes/No Responses on Types of Activities Undertaken									x
	Voluntary Programs (yes/no)									x
	Tax Credits and Subsidies (yes/no)									x

Since 1973, the main alterations in design can be summarized as follows:

- Inclusion of water pollutants abated by weight in 1979 Reporting annual costs in a matrix covering both medium and cost categories, starting in 1979 (except for 1982 and 1999)

- Distinguishing cost recovery by medium starting in 1979 (dropped in 1999)

- Dropping abated emissions by weight reporting in 1986

- Adding site cleanup costs in 1992

- Dropping depreciation from operating costs in 1999

- Using binary yes/no questions on activities in 1999 to help facilities understand the types of expenditures and cost covered by the survey

- Less detail on costs (only totals for pollution prevention and none on cost recovery), not including depreciation as part of operating costs, and expanding industry coverage of the MA-200 survey form, among other changes

Expanding on the 1973 design, the 1979 PACE survey added cost recovery (such as revenue from recycling, also referred to as cost offsets) categories distinguished by air, water, and solid wastes entries. The 1979 survey also covered water pollutants abated by weight for

four categories (total suspended solids, biochemical oxygen demand, chemical oxygen demand, and other). The 1983 form then rearranged the water pollutant reporting into quantities of conventional, nonconventional, toxic metals, and toxic organics groups. New categories for lead and hazardous air pollutants were also added.

In the 1986 survey, all questions on abatement of emissions by weight were dropped, making it harder to link costs with benefits. This version of the survey had questions on assets installed to abate air and water pollution through end-of-line techniques over the previous several decades. This version also queried the expected lifetime of some types of technologies used to reduce air pollution (electrostatic precipitators, baghouses, and wet scrubbers). By the 1989 survey, all questions on assets and lifetimes had been discontinued. The version used in 1992 expanded the list of example expenditures and clarified distinctions between end-of-line techniques and production process changes in the instructions. Also included were new categories for underground storage tanks and other pollutant costs to reduce noise, radiation, and multimedia emissions. Instructions in 1992 were also revised, based on input from the Bureau of Economic Analysis and other data users, to clarify definitions of concepts and the types of data collected.

In 1999, several of the detailed cost questions were dropped. Remaining costs were still designated as falling into one of several broad categories: pollution treatment, pollution

prevention, and other types of expenditures and payments.[4] The section titled "Pollution Abatement, Disposal and Recycling" began with a series of yes/no questions on the types of techniques used to lower emissions in several media categories (air, water, solid wastes, and multimedia). These general inquiries focused on pollution abatement activities in general with the purpose of educating respondents about what types of activities should be reported. These questions were not used in data analysis, however. This section was followed by questions on the dollar values of capital expenditures and operating costs for the equipment used, separated into hazardous and nonhazardous releases, for pollution treatment. In 1999, depreciation was not considered an operating cost. Capital and operating costs for disposal and recycling were also collected in this section.

Pollution prevention questions on the 1999 survey form also began with binary questions on the types of activities that occurred, but then only reported a total expenditure figure covering all capital and operating costs for these activities. Dollar values for other environmental protection expenditures were separated into categories such as site cleanup, habitat protection, monitoring/testing, and administration (new to the 1999 survey). Voluntary programs and tax credits and subsidies were reported through yes/no responses. The final cost section examined any payments to government and added new questions on the values of any tradable permits bought or sold.

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[4]The costs referred to as pollution abatement costs in the 1999 survey actually collected costs on pollution treatment as defined in this report. Discussion on the 1999 survey in this report uses the terminology as defined here, not as defined in the 1999 survey instructions.

SECTION 3

THE PACE SURVEY AND DATA ISSUES

Data from the PACE survey have been used to analyze a wide variety of policy questions, ranging from the overall costs of government environmental regulations to how these costs influence economic variables such as international competitiveness and facility location decisions. During these investigations, a variety of issues have arisen with respect to the PACE data and survey instrument. These issues include

- varying interpretations of the terminology used to distinguish between pollution abatement, treatment, and prevention,
- longitudinal consistency of the data on pollution abatement capital and operating costs with past survey forms,
- lack of a validation capability or method for checking the accuracy of the reported costs,
- ability to distinguish between a blank data field (missing) and zero costs, and
- concern over double counting some costs.

This section highlights how PACE data have been used, summarizes concerns raised in this literature and by the Census Bureau, and details the recommendations of the RFF workshop participants in 2000. (See Appendix A for further reviews of the literature.)

3.1 Methods of Using PACE Data

The ways in which PACE data have been used in the past can provide insights into how redesigning the survey can facilitate future investigations, although it should be noted that the types of past studies conducted are also a function of the data collected and published. First, the specific components of the PACE information used vary depending on the nature of the study. Second, the level of aggregation across the facility-level data has implications for how access to the PACE data affects researchers' ability to conduct investigations (a concern mentioned at the RFF workshop). Finally, how the PACE data are linked to other data sources and which sources are used may highlight additional needs of researchers.

Although the survey collects a wide range of information, data users may concentrate on particular components of the PACE data. This concentration underscores the level of detail required for the survey to be of value to a wide audience. Some analyses separate out costs for particular media (e.g., Becker and Henderson, 2000, and Shadbegian and Gray, 2003, which both look exclusively at air pollution abatement costs). Others use only some parts of the PACE database. For example, many analyses include abatement capital costs (e.g., Jaffe and Palmer, 1997; Barbera and McConnell, 1986), but others are based on both capital and

operating costs or operating costs alone (e.g., Joshi, Krishnan, and Lave, 2001; Keller and Levinson, 1999). Appendix A provides a review of studies using the PACE data providing information and concerns regarding how the data impacts research findings.

Another important data issue is how PACE statistics are aggregated in studies. Some papers (e.g., Jorgenson and Wilcoxen, 1990) use total national expenditures for pollution controls, because their goal is to estimate macroeconomic or productivity effects of these costs in general. In these cases, the aggregated statistics published by the Census Bureau are sufficient to fulfill data requirements, and little regional- or facility-level detail is needed. However, other authors focus on specific industries (e.g., Berman and Bui, 2001; Boyd and McClelland, 1999; Becker and Henderson, 2001; Gray and Shadbegian, 2002; Gray and Shadbegian, 2003) or on location decisions across states within the United States (e.g., Levinson, 1996; Dean and Brown, 1995). These types of investigations require facility-level data, or at least data at the industry-by-state level, that is not publicly available without special access privileges.[1]

Many of the studies based on PACE data incorporate additional information from other data sources. To examine how pollution-related expenditures have affected business decisions, many other data components are needed. Among these components are industrial output, employment, labor costs, production input prices (materials and energy), and tax rates. The

[1]Due to the confidential nature of the survey data, analysis of micro- (facility-) level data can only be conducted at Census Bureau Research Data Centers.

linkage to the Longitudinal Research Database (LRD) and its ASM/CM data provides some of this information, but other sources have also been utilized. Some studies (e.g., Becker and Henderson, 2001; Keller and Levinson, 1999) have included Bureau of Economic Analysis data (e.g., Survey of Current Business). Additional Census Bureau sources, such as the Current Industrial Reports, have also been used (e.g., Joshi, Krishnan, and Lave, 2001). More detailed facility-level information, such as types of products manufactured, has been gathered from publications such as the Lockwood Directory (e.g., Gray and Shadbegian, 1998).

3.2 Center for Economic Studies (CES) Longitudinal Research Database

The CES at the U.S. Census Bureau developed the Longitudinal Research Database (LRD). The LRD can be used to link the PACE data to facility-level information on production, total expenditures, employment, and other economic characteristics collected in the ASM, CM, and other Census surveys. This association facilitates research on questions relating to how pollution abatement expenditures influence economic performance by linking environmental variables to facility decisions and total costs.

However, the LRD-PACE linkage does not cover 100 percent of respondents for a variety of reasons (after 1989 the matching rate averaged around 95 percent). In the early years of the PACE survey, selected facilities were drawn from ASM and CM surveys prior to the actual year that the PACE survey was conducted. CES also uses permanent plant numbers (PPN) to identify facilities and link surveys, but some PACE surveys only identify firms by

"Census file numbers" that may not correspond to PPNs. Finally, the process of tracking ownership changes in PACE is separate from methods used in other surveys.

3.3 Concerns Raised by CES

CES at the Census Bureau has raised a number of issues, loosely related to survey design, with the PACE data (Streitwieser, 1995). First, the 1973 to 1978 and 1983 micro-(facility-) level data files have been lost, hampering efforts at time-series analysis.[2] Second, comparing responses over time can be problematic because of changes in survey design (see Section 2.2). The micro data show conflicting state locations and industry classifications when comparing the PACE data to the LRD on facilities characteristics developed by the Census Bureau. Location conflicts at the state level generally average less than 1 percent of the database population. However, differences in industrial classifications tend to be higher, though usually less than 10 percent.

Some PACE data are also imputed by CES, similar to procedures used for the LRD data, and hence are typically deleted from micro analyses. Prior to 1989, little is known about how these imputed data points were calculated. There are also a substantial number of blank data fields, for example, between 1988 and 1992 (when blank fields were no longer filled with imputed data) the percentage of blanks was 57.2 percent of the data fields. These blank data are treated as zeros when calculating published total expenditure figures. This handling can

[2]The published aggregate data are available for the years missing micro data (1973 to 1978 and 1983).

cause substantial underestimates of pollution abatement costs and, as many researchers will attest, needs to be remedied. General measurement errors are possible as well in cases where responses are not accurate, although proper survey design (which is also consistent across years) will help limit this effect. Indications of these errors include facilities reporting more environmental capital expenditures than total capital expenditures (6 percent of facilities that reported investment in capital for pollution abatement, though this could be due to problems in the ASM data) and facilities reporting more depreciation of environmental capital than total depreciation (5 to 10 percent of facilities).

Streitwieser (1995) makes a number of recommendations regarding the PACE survey: draw the PACE sample from the concurrent ASM, have facilities report total employment and shipment values on PACE to assist matching to other sources, maintain all methods of identifying facilities, and have consistency between PACE and the ASM/CM surveys. Streitwieser also makes several general recommendations about flagging missing and imputed data and reviewing the survey instrument and maintaining consistency among government branches conducting the various data collection efforts.

3.4 Concerns Raised in the Literature

Users of PACE data in the research community have raised a number of concerns about its information, in addition to those discussed by CES. A brief listing of these issues includes the following:

- All pollution-related costs may not be captured by the PACE survey for a variety of reasons, such as costs hidden due to the facility's cost accounting structure and unmeasured changes in productivity due to switching to a less polluting raw material (Joshi, Krishnan, and Lave, 2001; Jorgenson and Wilcoxen, 1990; Epstein, 1996; Levinson, 1996; Gray and Shadbegian, 2002).

- Facilities may have a difficult time estimating the appropriate baseline against which to compare costs (Berman and Bui, 2001; Jaffe et al., 1995; Levinson, 1996).

- There is no information on benefits of environmental investments (Berman and Bui, 2001; Jaffe et al., 1995; Morgenstern, Pizer, and Shih, 2001).

- It may be hard to determine if an expenditure should be classified as "environmental" (Jaffe et al., 1995).

Specific comments and concerns about the PACE survey are occasionally included in research literature. For example, Becker and Henderson (2001) note that the survey may not accurately measure some pollution abatement costs, such as costs associated with pollution prevention. They attribute this inaccuracy in part to the lack of documentation of certain costs, inability of facilities to estimate some costs, and the lack of an obvious baseline. As a methodological issue, oversampling of larger facilities also implies oversampling of older facilities. Findings of this study suggest survey data underestimate costs, especially the costs of

environmental regulations for younger facilities. Studies such as Boyd and McClelland (1999), Joshi, Krishnan, and Lave (2001), Gray and Shadbegian (2002), and Gray and Shadbegian (2003) find that $1 dollar of pollution abatement spending leads to more than $1 of actual environmental cost which could be because abatement spending reduces the productivity of non-abatement inputs (real negative productivity effect) or because plants under-report PACE expenditures. In a production function framework, Shadbegian and Gray (2004) distinguish between these two effects and find evidence in favor of under-reporting. This finding is consistent with Becker and Henderson (2001).

Berman and Bui (2001) analyze the effects of air quality regulations on oil refinery productivity in the Los Angeles Air Basin. Their results indicated that the investments in abatement capital were productivity enhancing. Unlike Becker and Henderson (2001), Berman and Bui's results suggest that abatement cost measures may overestimate the economic cost of environmental regulations, because these expenditures can increase productivity. These contradictory findings on whether the survey data under or over estimates pollution abatement costs can be found throughout the literature. One of the main reasons for this debate lies in the difficulty of accurately estimating pollution prevention costs. Some argue that these costs are underestimated due to the exclusion of activities that include some aspect of pollution abatement but are not conducted with the primary purpose of protecting the environment. This issue is more prominent in pollution prevention activities than in treatment activities, because most prevention activities are part of a larger project, but most treatment activities are only for

pollution treatment. Others suggest that even those activities that meet the above criteria and are included still result in some increase in profitability due to more efficient process techniques—implying that cost are over estimated. This argument underscores the need for more detailed and accurate data on pollution prevention.

Using facility-level data from 55 steel mills, Joshi, Krishnan, and Lave (2001) study the visible and hidden cost of environmental regulations. PACE survey data on annual pollution abatement operating expenditure data were used as a substitute for a measure of environmental regulation stringency. Joshi, Krishnan, and Lave found that every $1 increase in visible cost of regulation represents a $9 to $10 increase in marginal total cost, suggesting that managerial accounting systems do not account for indirect costs of environmental regulations; consequently, these costs are assigned to other cost pools. Through interviews, managers revealed they were aware of the hidden costs but greatly underestimated them. The authors suggest overhauling and restructuring accounting systems and greatly increasing the number of cost pools to create better estimates of the cost of environmental regulation. Other studies have found smaller effects than Joshi, Krishnan, and Lave (2001) that suggest pollution abatement costs are understated. For instance, Gray and Shadbegian (2002) found that a $1 increase in pollution abatement costs led to the equivalent of $3.28 in lower productivity at steel mills.

Other studies also mention the problems with using the PACE survey data to analyze costs and benefits of pollution-related expenditures. Levinson (1996) states that it is difficult for

respondents to assess the true economic cost (such as inefficiencies due to input substitution or altered production processes) of regulation, which can cause abatement operating costs to be either overstated or understated. Morgenstern, Pizer, and Shih (2001) and Gray and Shadbegian (1998) note that changes in production processes in general, and specific costs associated with installing and maintaining the equipment used in these changes, make it hard to determine the true costs of environmental compliance.

3.5 RFF Workshop on the PACE Survey

RFF convened a workshop of experts in March 2000 to discuss the PACE survey. The workshop was convened through funding from EPA to discuss the PACE survey, issues, and resolutions. The gap in data collection from 1994 to 1999 was seen as an opportunity for visiting some of the issues that were raised in the literature, much of which is mentioned above. This expert workshop (Burtraw et al., 2001) highlighted a number of issues concerning the existing design of the PACE survey and suggested potential changes (which could be made with varying levels of effort and probabilities of success). The experts' suggestions on survey design can be roughly separated into two categories: eliciting additional information on expenditures not currently covered by the survey and redesigning the survey to obtain more accurate and more disaggregated data. Other general recommendations, such as creating an advisory panel to review the survey, along with ideas for extending survey coverage to additional industries,

were also discussed. Some of these suggestions, such as including utilities and mining, were instituted in the 1999 survey (conducted in 2000).

A summary of the broad RFF recommendations taken from Burtraw et al. (2001) includes the following:

- Focus additional attention on capital expenditures and cost recovery (also referred to as offsets). Offsets were dropped in the 1999 survey.
- Link the PACE cost data to U.S. Environmental Protection Agency emissions data and other types of information.
- Assess the validity and accuracy of the survey, and examine outlying responses.
- Maintain a consistent structure from year to year.
- Consider using both short and long forms for particular industries of interest, and possibly use industry-specific questions.

More-specific recommendations include the following:

- Ask binary yes/no questions.
- Distinguish between zeros and blanks.

- Ask for more disaggregation of costs by pollutant and possibly the regulation prompting the expenditures.

- Provide additional examples of costs.

- Include measures of cost savings experienced by facilities.

The numerous RFF recommendations and additional recommendations suggested by other sources accentuate the need for the redesign of the PACE survey. In view of the fact that the survey has not been administered since 1999 and the issues surrounding the longitudinal integrity of the 1999 data, it is evident that this is an opportune time to redesign the survey. Section 4 discusses possible ways to address all of the concerns previously described while ensuring longitudinal consistency with the 1994 and prior survey data.

SECTION 4

POTENTIAL SOLUTIONS TO PACE SURVEY AND DATA ISSUES

When examining the PACE survey, it is important to keep in mind its main goal—collecting facility-level data on pollution abatement capital expenditures and operating costs in order to facilitate analyses of the impacts of environmental programs and regulations. One implication of this orientation is that the survey is not well designed to examine some types of costs such as research and development (R&D), which are typically experienced at the corporate level, and remediation, which is typically episodic and location specific (see Section 4.3). Another implication is that the survey should consider the needs of both the respondents and data users during its redesign. Overarching recommendations based on the large body of literature on PACE include: ensuring consistency across years, facilitating linkages with other databases, improving verification and data accuracy, collecting more-detailed data, and lowering the burden imposed on respondents by the PACE survey. These implications lead to a set of recommendations and solutions, both general and specific, discussed in this section.

4.1 Longitudinal Integrity

Time-series consistency of PACE data is crucial for a variety of reasons. First, respondents answering the same question year after year may be more likely to answer

accurately and maintain records in a manner conducive to producing those answers. Second, many questions that policy makers and researchers have are likely to involve intertemporal comparisons. For example, policy makers could assess pollution abatement costs associated with a specific regulation imposed in a particular year by comparing the increase in costs from previous years for facilities both affected and not affected by the regulation. Third, many of the analyses face obstacles related to unobserved heterogeneity. Facilities that pollute more are likely to be in nonattainment counties, face more stringent standards, and spend more on pollution abatement. A cross-sectional analysis of this situation may well find that facilities spending more on pollution abatement also pollute more. However, time-series analyses can sort out this simultaneity by examining whether facilities whose pollution abatement costs increase have declines in emissions. As a result, the time-series aspect of the PACE survey is arguably as important to data users as are detailed cross-sectional analyses. This judgment favors leaving survey questions unchanged year to year. If additional questions are necessary, a fraction of the facilities in the sample for a given year could be sent longer forms, leaving the core survey (short form) the same. Broad questions on the long survey forms should correspond to the more-generalized questions on the short versions as well. Though this concern is not currently a priority in the survey redesign, use of long forms could be considered once the core survey has been well established.

4.2 Linkages

Many of the analyses conducted using the PACE data rely on linkages to other information sources. To estimate the effects of abatement costs on facility behavior, it is important to be able to combine cost findings in PACE with other decisions made by facilities. A linkage between PACE and ASM, as developed by CES in the past, would allow better investigation of the effects of environmental regulation on business decisions by tying environmental expenditures to other actions of facilities. Similarly, a link between EPA pollutant release data (e.g., TRI, AIRS) and PACE cost data would help with examining costs by pollutant and costs of specific regulations.

Linkages with other data sources may be especially important for particular industries such as electric utilities. The Energy Information Administration (EIA) at the Department of Energy and the Federal Energy Regulatory Commission (FERC) collect a wealth of information on topics such as fuel use and pollution treatment retrofits that may be essential in determining abatement costs and appropriate baselines (see Section 4.6). Identifying facilities by latitude and longitude (as well as by facility identifier) would also improve the usefulness of the survey and allow researchers to look at relationships between costs, emissions, and ambient environmental quality.

Agency personnel and researchers charged with quality control of survey data can use this process of linking PACE data to other sources (such as EPA, EIA, or FERC) in order to

disaggregate and check the data without imposing burdens on survey respondents. It may also help distinguish costs by pollutant if releases by facilities are linked to abatement expenditures.

EPA's Office of Air Quality Planning and Standards' (OAQPS) *Air Pollution Control Cost Manual* (EPA, 2002) provides a list of the major cost elements for capital and operating costs. If respondents provide distinctions among types of pollution equipment installations, either with or without associated costs, other researchers could use such data sources to estimate expected costs.

These linkages could be accomplished by including standard questions, such as requiring the respondent to list the facilities' *physical* address or their Employer Identifying Number (EIN), and would allow the PACE data to be linked to other sources, thus increasing the amount of data available without greatly increasing respondent burden. Allowing researchers access to the PACE data will be necessary to utilize effectively the value embedded in linkages. The linkages to other data sources will also help verify data accuracy.

4.3 Disaggregation of Data

The possibility of producing more disaggregated data raises a number of conflicting issues:

- Policy makers and researchers would benefit from more detailed information on costs.

- Different types of data (e.g., by cost categories, pollutants) could be collected to enhance the comprehensiveness of the survey.

- Additional data collection increases costs (e.g., burden) associated with completing the survey.

Old versions of the survey have provided some division of operating expenses by category and type of pollutant reduced. Some past surveys have included information on expenditures by type of pollutant (e.g., particulates, sulfur oxides, nitrogen oxides, and heavy metals). Operating costs have also been separated into components, such as the following from the 1994 survey: depreciation, salaries and wages, fuel and electricity, contract work/services, and materials/leasing/miscellaneous. However, the 1999 PACE survey only distinguished between costs associated with hazardous and nonhazardous emissions by medium (air, water, solid wastes, and multimedia) and did not distinguish operating costs by category.

Treatment equipment costs tend to vary significantly depending on the type of existing facility configuration: retrofit of an existing facility, part of a new installation, or an upgrade of existing controls. Retrofits can be very expensive compared to new installations where there is the opportunity to install turnkey operations that do not require additional downtime for installation. Similarly, more detailed information on capital cost elements would be useful, as would be information on site-specific factors, such as lack of available/suitable land to site a pollution control system or restrictions on water discharges.

In general, if separate cost components are likely to be highly correlated with more difficult to measure costs, these cost components can serve as proxies for total abatement costs in empirical work. Also, providing expense information on a pollutant basis, to the extent feasible, would make it possible to conduct more thorough investigations into the costs of regulations and their effectiveness, especially if changes in pollutants were linked to these expenditures.

The RFF workshop participants provided a wide range of suggestions, described previously, for redesigning the current categories in the PACE survey in order to elicit more accurate and detailed information. The participants were, however, concerned about the feasibility of asking detailed questions and about the burden that would be imposed on respondents.

4.4 Availability of Expenditure Data

One perception is that the PACE survey questions have become increasingly more difficult to answer over time. Even if the questions themselves remain the same, it can become harder to estimate abatement costs for a variety of reasons. Allocating capital and operating costs between environmental and nonenvironmental motivations can be complicated if investments in new equipment have multiple objectives. These difficulties may, in part, explain the finding that pollution abatement capital costs per dollar of value added have been decreasing over time, while regulations have generally become more stringent. It may be that

investments have become more difficult to designate as pollution abatement, leading to an underreporting of pollution abatement costs. In spite of this difficulty, the abatement cost data yield logically consistent patterns across industries and states over time for the years 1994 and before.[1]

Because some facilities will not be able to estimate certain costs, it is important to distinguish between answers that should be interpreted as zero and those that should be interpreted as missing. The 1999 survey allowed respondents to opt out of estimating costs by checking boxes labeled "information not available" and "don't know." This change may have increased item nonresponse (Becker and Shadbegian, 2004). Instead, other methods could be used to address difficulties in obtaining cost information. Use of binary questions on the survey that cover broad categories with follow-up questions on more detailed issues would allow facilities to provide general information on pollution abatement activities that could be used to calculate a general estimate of costs, even if the facility is unable to answer more specific questions. By beginning topics with general binary questions, the survey can also encourage a high response rate. Researchers support a survey structure that persuades facilities to answer questions on key expenditures, such as total capital expenditures and total operating costs, even if they are unable to provide estimates of specific cost categories. This encouragement could be offered by placing questions on key expenditures at prominent positions in the survey

[1]Longitudinal integrity was not maintained with the 1999 survey, and results from this survey are not comparable to earlier years.

instrument (Becker and Shadbegian, 2004). Subsequent details on costs can then be provided by respondents who are able to access the information.

4.5 Pollution Prevention Costs

The need for more detailed information on pollution prevention expenditures and costs is becoming increasingly important as abatement moves away from prescriptive (command and control) activities and toward more flexible process modifications. Issues related to pollution prevention costs include the following:

- Measuring pollution prevention costs (such as those from process changes) is much more difficult than measuring costs for pollution treatment.

- Pollution prevention techniques can have a variety of implications for businesses other than direct expenditures for treatment and prevention (e.g., process and design changes, changes in material costs, or permitting requirements).

In spite of concerns about measuring the costs associated with pollution treatment, it is much easier to determine spending on equipment than it is to estimate costs of pollution abatement through process enhancement. A host of effects fall into this category, most within the following components: input substitution, leak and spill prevention, and process or equipment modification or redesign. The 1999 PACE survey covers these costs in the pollution prevention category through a group of binary choice questions and an estimated total cost for

all prevention activities (not distinguishing between capital and operating costs). Prior years had attempted to distinguish any benefits received from abatement activities with explicit questions about costs recovered (often referred to as offsets).

Potential solutions for obtaining more information on pollution prevention costs include the following:

- Additional categories of questions on surveys
- General questions about pollution prevention costs and activities
- More detailed examples and instructions on what should and should not be included as pollution prevention costs

The format of the 1999 survey with binary responses about pollution prevention could be extended to include a breakdown of costs in each category only mentioned in the yes/no responses of the 1999 survey. Other types of questions might help determine prevention costs as well. For example, survey respondents may be able to provide information on the number of pollution control techniques installed during the year, even if they are unable to estimate the costs associated with these devices. EPA and researchers could then use estimated capital costs of the controls and standard cost projections for operating the controls to compute an approximation of pollution prevention costs at the facility. This approximation could then be

used either to validate costs that are reported or to impute costs for facilities that do not report an estimate. Questions on offsets could also be reinstituted in the future.

4.6 Appropriate Baselines

Issues of accurately measuring treatment and prevention costs also include the following:

- Establishing the appropriate baseline against which to compare expenditures is difficult.

- Similar nonexpenditure-related concerns to those surrounding pollution prevention costs arise when considering baseline issues.

- Baseline issues are fairly industry-specific.

Although survey instructions in some years attempted to distinguish between profit-motivated expenditures and costs specifically associated with environmental concerns, the expenditures may be difficult to separate out in practice. For example, accurately estimating pollution prevention costs requires extensive knowledge of the affected manufacturing processes on the part of the respondent (if it is possible to distinguish at all). To determine these costs, it is necessary to understand what would have occurred in the absence of the environmental concern. In addition, deviations from the baseline should also capture the impact

that installation, maintenance, and operation of abatement equipment has on the efficiency of other equipment used by a business. The installation of a scrubber to reduce SO_2 emissions from electricity generation, for instance, lowers the maximum capacity of a boiler and increases the amount of fuel necessary to produce electricity. Therefore, respondents face the task of whether and how to estimate these cost increases induced by abatement activities.

Companies may also choose a different mix of inputs when faced with environmental regulations and experience higher manufacturing costs as a result. An example of this scenario is utilities switching to low-sulfur coal, rather than installing a scrubber, which has implications for coal costs and affects generating efficiency. Between 1990 and 2000, there was a dramatic shift to low-sulfur coal use by electric utilities in response to SO_2 restrictions in the CAA. Shipments of subbituminous coal, the main type of low-sulfur coal, rose 67 percent (U.S. EIA, 2002). However, this distinction by itself does not necessarily imply coal expenditures have risen since subbituminous coal has a low price relative to the previously used coal. Estimating the effects of this shift in coal consumption may require combining survey responses with other data sources, like the coal-shipment data collected on the FERC Form 423, which reports costs and quantities of utility fuels.

Another example of an important pollution-reduction technique of utilities has been a shift to gas-fired electricity generation. Natural gas produces far fewer emissions of SO_2 and NO_x per unit of output than coal generation, but natural gas is more expensive and requires

constructing new gas units or modifying existing units. This switch in generating techniques in response to environmental policies can be seen in the results of utility-sector models like EPA's Integrated Planning Model and DOE/EIA's NEMS model.

Potential solutions to baseline determination include the following:

- Use of industry-specific survey forms or industry-specific examples on how to respond to questions
- Additional clarification on forms about appropriate baselines
- General questions about technologies
- Linkages to other data sources

Issues surrounding baseline expenditures, such as those discussed above for electric utilities, are fairly industry specific. Because of this specificity, it may be difficult to design a survey capable of distinguishing baseline costs from additional abatement expenditures. Tailoring survey instructions and providing examples describing appropriate baselines that are specific to the broad industry of interest may help respondents complete the survey accurately.

Asking general questions about the types of pollution treatment/prevention technologies used (e.g., installing a scrubber on a boiler) will allow data users to combine facility responses with other information on the costs and effects of the technologies.

Other issues, such as how facility construction has been influenced by environmental regulations, would be very hard to incorporate in the PACE survey. However, linkages to the appropriate data sources would facilitate researchers' efforts to estimate them or develop appropriate proxies.

4.7 Recycling and Voluntary Programs

EPA and other agencies have encouraged participation in recycling and voluntary activities over the last several decades. Collecting data on these efforts and any associated costs or offsets raises several issues related to survey design. For example, in some versions of the survey instrument, costs and benefits of recycling and voluntary programs were covered in the 1999 survey by a single yes/no question on participation. Similarly, tax credits and subsidies are covered by a yes/no response. At issue is whether this information is sufficient to make inferences about costs

The timing of abatement expenditures is an important factor for accurately assessing costs. Voluntary measures may simply reflect early installation, because the facility knows that an EPA rule is under development that will require them to undertake pollution control measures in the near future. Timing also leads to issues of depreciation and capital recovery, along with early retirement of equipment or processes. Unlike other areas, recycling may represent an area in which a business has a good idea of the costs and/or benefits (e.g., offsets), especially if their recycling efforts are contracted to outside firms. In general, it may be

desirable to expand the survey participation questions on voluntary programs and recycling to include costs in order to reflect the effects of these activities.

4.8 Payments to Government (Permits, Fees, and Fines)

One major environment-related cost that facilities incur is payments to governments. These payments can be in the form of permits or licenses, fines for violating those permits, or more recently the payment of pollution taxes or the purchase of tradable permits. Because payments to governments are an important part of polluters' costs and will vary across industries and states, it is critical that these payments be part of the PACE survey. Payments to governments differ, however, from the rest of the PACE costs in that they represent the cost of polluting rather than the cost of abating. As such, they must be kept separate from the other operating and capital costs collected by the PACE.

In the case of tradable permits (such as the SO_2 permits that utilities can trade under the 1990 CAA), the permit purchase is not the relevant expenditure, because purchased permits can be resold later, like any other liquid asset. Rather, the cost is incurred at the time the permit is exercised, and its cost is the current market price, regardless of whether the permit was awarded to the facility at zero cost, whether the facility had banked the permit from a previous year, or whether the facility had only recently purchased the permit. This topic has not been well-defined in past surveys. The instructions for the redesigned survey will need to make clear what costs should be reported for tradable permits.

4.9 Collection of Other Types of Information

The focus of the current survey is on facility-level costs of purchasing and operating pollution control equipment. As a result, the PACE survey does not collect information on a variety of expenses associated with environmental protection, such as R&D expenditures and remediation incurred or accounted for at the corporate level that are not allocated to the facility level.

Survey instructions specifically state that reported expenditures should not include R&D. However, industries expend a significant amount of effort investigating the effects of equipment before any physical installation occurs. For example, the electric utility industry is currently engaged in determining the implications that scrubbers (designed to lower SO_2 emissions) and combustion controls (designed to lower NO_x emissions) have for mercury emissions. Although such efforts are not currently covered by the PACE survey, any R&D costs borne by the pollution equipment and service industry will be captured to the extent that they are reflected in the prices paid for pollution control equipment.

Another area of interest to the RFF workshop participants is any benefits experienced by facilities as the result of pollution reduction efforts. There may be direct savings from improvements in productivity, the installation of new equipment, or recycling programs. Nonmarket benefits may also accrue to a facility from reducing emissions or participating in voluntary programs. There will also be spillover benefits to other areas of the economy as

efforts by businesses improve the knowledge base of other facilities and the economy as a whole. It should be noted that, although the RFF Advisory Panel considered these to be potentially important effects, the participants also believed that measuring savings would be relatively difficult in practice.

Transaction costs and expenses associated with capital purchases are also not in the survey. Transaction costs can include various types of expenses, like the costs of administering permit trading programs or the opportunity costs associated with production delays arising from environmental compliance. Appropriate measurement of costs incurred by businesses to purchase capital equipment requires information on financing costs and depreciation rates, for example. Capital depreciation costs used to be collected by the PACE survey but were not included in the 1999 survey. It should be noted that, for years in which total depreciation expenses were available in CES's LRD, reported environmental capital depreciation exceeded 100 percent of total capital depreciation for 5 to 10 percent of facilities.[2]

4.10 Summary/Next Steps

The discussion in this background report will be used as a starting point for the current redesign of the PACE survey. Along with the information provided by the sources mentioned in this report, an expert panel has been convened to guide and provide feedback on each stage

[2]EPA's *OAQPS Control Cost Manual* provides guidance to industries on developing cost data for reporting purposes (capital, operating, and maintenance). This or similar detailed information could be combined with PACE survey instructions to educate respondents on calculating capital costs.

of the process. Further suggestions and solutions will be investigated during on-site visits to facilities in four key industries: pulp and paper, electric utility, primary metals, and petroleum. Facilities will be asked to provide additional input, such as how to improve data quality while reducing respondent burden. Based on all of these resources, a draft survey instrument and guidance document will be prepared. The expert panel and a new set of (pre-test) facilities will review the draft instrument and guidance document and provide comments. After these comments have been incorporated, and OMB approval obtained, the revised PACE survey will be fielded as a pilot survey to approximately 1,000 facilities. The results from this pilot will be used to prepare the final versions of the annual PACE survey.

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APPENDIX A

REVIEW OF STUDIES USING PACE DATA

Data from the PACE survey have been used to analyze a wide variety of economic questions, ranging from the overall costs of government regulations to how these costs influence economic variables such as international competitiveness and facility locations. This appendix provides an overview of this literature. Across much of the research, studies that use PACE time-series data and account for unobserved heterogeneity using geographic or industry-specific fixed effects often find statistically significant effects of abatement expenditures on facility decisions. However, cross-sectional analyses of the data are generally less likely to measure similar impacts.

A.1 Cost Analyses of Specific Environmental Regulations

PACE data have been used to examine costs of environmental regulations. Becker (2001) investigates costs to manufacturing firms associated with the Clean Air Act. The results indicate that companies subject to more regulation did have higher costs. It appears that federal and state regulations played a much larger role in expenditures than local rules, even though criteria air pollutant nonattainment areas are designated at the county level. The availability of facility-level data also permitted examination of a variety of other issues, including

how facility age affected costs, relationships between county income and abatement expenditures, and "environmental justice" concerns relating to facility location decisions.

Berman and Bui (2001) analyze the effects of air quality regulations on oil refinery productivity in the Los Angeles Air Basin to determine whether pollution abatement expenditures are a reliable measure of the cost of environmental regulations. Initial compliance with the regulation is found to cost about $3 million per facility while increased stringency adds $5 million. Abatement cost measures may overestimate the economic cost of environmental regulations, because increased productivity may also result. Results for the South Coast Air Quality Management District suggest that the investments in abatement capital were productivity enhancing. The implication is that abatement costs do not adequately reflect net costs of regulations.

Using facility-level data from 55 steel mills, Joshi, Krishnan, and Lave (2001) study the visible and hidden cost of environmental regulations. PACE survey data on annual pollution abatement operating expenditure data were used as a substitute for a measure of environmental regulation stringency. Joshi, Krishnan, and Lave found that every $1 increase in visible cost of regulation represents a $9 to $10 increase in marginal total cost. This relationship suggests that managerial accounting systems do not account for indirect costs of environmental regulations, so these costs are assigned to other cost pools. Through interviews, managers revealed that they were aware of the hidden costs but greatly underestimated the value associated with them.

The authors suggest overhauling and restructuring accounting systems and greatly increasing the number of cost pools to create better estimates of the cost of environmental regulation.

Unlike much of the previous literature, including Gray and Shadbegian (2002), Morgenstern, Pizer, and Shih (2001) find that the reported expenditures data may actually overstate the true costs of environmental regulations. For an additional $1 of reported environmental expenditures, $0.82 in total production costs is actually incurred.

A.2 Facility-Level Decisions (Location and Size)

Dean and Brown (1995) analyze the potential for positive and negative impacts of environmental regulations on new firm entry. The analysis suggests that the relationship between pollution abatement intensity and gross entry of new firms, using a broad sample of 306 industries with data from the late 1970s, was negative, implying environmental costs are a barrier to entry. The authors suggest further study on which and to what degree different mechanisms could limit new entry, as well as how this trend has held up since the 1970s.

Work by Levinson (1996) studies how manufacturers' location choices were influenced by environmental regulations. Unlike previous articles on the topic, Levinson looked at most manufacturing industries and many measures of environmental stringency. PACE data were used to generate aggregate abatement costs (gross aggregated abatement cost divided by the number of production workers in the state) and for raw facility-level data. Although little

evidence was found to support the hypothesis that stringent environmental regulations deterred new facilities from locating in a state, the analysis did show that branch facilities of large firms are more sensitive to environmental regulations. The results also demonstrated the importance of including multiple industries and measures of stringency.

On the other hand, Gray (1997) finds a significant negative relationship between state regulations and new facility openings. However, a lack of evidence of stronger impacts on high-pollution industries may indicate that other state characteristics besides the stringency of environmental regulations might be influencing facility openings.

Becker and Henderson (2000) study differences in facility locations, births, sizes, and investment patterns as a result of nonuniform environmental regulations, particularly ground-level ozone regulations. County-level attainment/nonattainment information and 1991 PACE data are used to study four industries (industrial organic chemicals, metal containers, plastics, and wood furniture). Findings show that fewer facilities enter nonattainment areas, and, in general, business structures shift towards nonaffiliates from a corporate setup. Grandfathering in, or the exempting of older facilities from regulatory requirements, raises survival rates, prolonging lives of older, presumably dirtier, facilities.

A.3 Employment

Duffy-Deno (1992) finds weak support that environmental regulations negatively affect economic activity by analyzing the relationship between pollution compliance costs and employment/earnings levels of regional manufacturing sectors. The analysis used PACE data from 1974, 1978, and 1982, picking those years because of data availability for per-unit compliance costs at the Standard Metropolitan Statistical Area (SMSA) level. Some weak results, which are not highly significant and are small in magnitude, suggest a negative effect of abatement costs on manufacturing employment and earnings levels in the Sun Belt SMSAs, with slightly stronger results for Frost Belt SMSAs.

A.4 International Trade

Abatement costs may also have significant implications for the competitive position of the United States in international markets. The effect of industrial pollution-abatement costs on the U.S. balance of trade is analyzed in Robison (1988). Using PACE data, the study found an increase in imports of high abatement-cost goods and an increase in exports of low abatement-cost goods, suggesting a shift in comparative advantage between the United States and the rest of the world. However, there was no shift in the balance of trade with Canada, which might be explained by Canada's adoption of similar environmental regulations. Consequently, as more countries adopt environmental regulations, shifts in trade may decrease in magnitude or disappear. The authors attributed some of the reduction in the balance of trade

to an inefficient regulatory system, claiming that negative effects of environmental regulations could be much less severe if regulatory systems were improved.

Ederington, Levinson, and Minier (2003) recently used PACE results to explore the contention that environmental regulations have made U.S. firms less competitive than foreign firms. They measure a significant effect of pollution abatement costs on imports from developing countries and in pollution-intensive, foot-loose industries. This conclusion is similar to arguments put forth in other works, most notably Copeland and Taylor (1994) and Robison (1988).

A.5 Productivity

Barbera and McConnell (1986) analyze the paper, chemical, primary metal, and stone/clay/glass industries, because environmental regulations are thought to have significant effects on these industries. The findings show that, in three out of these four industries, abatement requirements slow average capital productivity and average labor productivity. In addition, the authors determine that, for overall economic productivity to fall a fraction of a percent because of abatement expenditures, the most heavily regulated industries such as these four must experience relatively large changes in productivity.

Barbera and McConnell (1990) study the indirect effects of environmental regulations on productivity. Their findings suggest that the effects can be either positive or negative and can

vary substantially by industry. During the 1970s, between 10 percent and 30 percent of the productivity declines in the five polluting manufacturing industries most affected by environmental regulations could be attributed to those regulations. Because these industries made up only a small part of total manufacturing, there was only a small net impact on total factor productivity growth.

Boyd and McClelland (1999) investigate the connection between productivity and pollution abatement costs, focusing on opportunities to reduce input use and pollution output without decreasing productivity. Boyd and McClelland also examined the size of production losses from environmental constraints. For integrated paper mills (the industry analyzed), the findings show a 9.4-percent loss in efficiency due to pollution controls, of which 2.7 percent was attributed to abatement constraints and 6.7 percent to indirect effects of environmental constraints. The evidence showed that there were opportunities to reduce production inputs and pollution simultaneously, ranging from a 2-percent to 8-percent reduction according to modeling, without reducing productivity.

Gray and Shadbegian (2003) find similar results for a broader sample of pulp and paper mills. Using Census Bureau data on over a hundred pulp and paper mills, the authors find a significant negative relationship between pollution abatement costs and productivity levels due in most part to integrated mills. The study found 5.4 percent decrease in productivity at integrated mills for one standard deviation increase in pollution abatement costs. This study

furthers the analysis of Gray and Shadbegian (2002) which concluded that $1 of pollution abatement costs resulted in the equivalent of a $1.74 in lower productivity at paper mills, $1.35 in lower productivity at oil refineries, and $3.28 in lower productivity at steel mills, suggesting that the estimates of pollution abatement costs in these industries may be understated.

A.6 Investment

Focusing on paper mills, Gray and Shadbegian (1998) test the effects of environmental regulations on investment. Their study analyzes regulatory stringency's connection with levels of investment in various technologies. A facility was required to have completed PACE data on productive investment and its timing to be included in their sample, limiting it to 68 facilities. Facilities located in states with stricter environmental regulations were found to be less likely to have "dirtier" technology. After adjusting for intra-firm reallocation of investment, the authors found approximately a dollar-for-dollar crowding out of productive investment by pollution abatement capital investment.

Becker and Henderson (2001) analyze how investments and operating costs of facilities in the chemicals and plastics industries are related to ground-level ozone regulation. Production costs for newer facilities are shown to increase more than indicated by the PACE data. The results indicate that facilities in nonattainment counties have higher costs than those in attainment areas. Facilities in attainment areas are found to stay small, possibly to avoid threats of regulation. The paper criticizes the PACE survey for not accurately measuring pollution

abatement costs associated with equipment that enhances the production process while reducing pollution. The authors also question whether the survey captures all operating expenses and imply that some potential costs are not included in PACE at all, such as the negative impacts of environmental regulations on facility output. The oversampling by the PACE survey of larger facilities also causes an oversampling of older facilities. Findings of this study suggest survey data underestimate costs, especially the costs of environmental regulations for younger facilities.

On a more general topic, Jaffe and Palmer (1997) used PACE data to analyze the Porter hypothesis that environmental regulations can have a positive effect through increased innovation. Two measures of innovation, research and development (R&D) investment and successful patent applications, were used as a proxy of innovation. A positive effect was found for R&D investment, though its size was small and varied by industry. No connection was found between environmental expenditures and successful patent applications.

Keller and Levinson (1999) examine how state pollution regulations affect investment flows from foreign countries into the United States. PACE survey data from 1977 to 1994 were used to determine the stringency of states' controls. The authors do not find strong evidence to support that environmental regulations are decreasing foreign direct investment (FDI) overall. There is some support that the industries most affected by pollution abatement controls do experience effects. A more recent analysis, Keller and Levinson (2002), also found

that high environmental costs in a state can have moderate deterrent effects on foreign investment.

A.7 Economic Growth

Capital expenditures for pollution abatement are theorized to be one of the many causes for the slowdown of labor productivity in the article by Norsworthy, Harper, and Kunze (1979). The study found no major impact of investment in pollution abatement capital on labor productivity growth; however, the minimal impacts estimated were negative. In the 1973 to 1978 study segment, labor productivity growth was found to be more affected by investment in pollution abatement capital, but, counter intuitively, the effects were smaller in manufacturing industries. Denison (1979) also includes the effect of pollution abatement as a small part of a growth accounting analysis.

Crandall (1980) looks into whether environmental policy, either intentionally or as an unforeseen consequence of the design, is harmful to economic growth. PACE data were used in the preliminary state comparison and in the more detailed analysis. Because of the poor initial data, 1976 data were used. The study found that industries highly affected by pollution control have slowed productivity growth relative to the average industry. The author claimed it was difficult to determine the size of the slowdown without total factor productivity data and additional years of high pollution abatement cost data. The cause of the productivity slowdown

was also unclear. In fact, it was unclear if the slowdown was attributable to environmental regulations at all, based on the results of the analysis.

Along with implications for business investment decisions, environmental regulations have the potential to affect the aggregate productivity of the U.S. economy. Jorgenson and Wilcoxen (1990) simulate economic growth in the United States with and without environmental regulations using the PACE data. The authors include all sectors of the economy in a computable general equilibrium model, subdividing the business sector into 35 industries. The primary metals, paper, and chemical industries were found to have the largest gains in output when hypothetically removing operating costs for pollution abatement. The paper, petroleum refining, and primary metals industries were found to have spent over 20 percent of their investments in 1975 on pollution control devices. Combining operating and capital facility expenditures with the cost of motor vehicle emissions to value all pollution control regulations, the article finds that the motor vehicle and coal mining industries are hit hardest, followed by the primary metals and petroleum refining industries. Approximately half of the other industries in the model had output increases in the 1-percent to 5-percent range, assuming pollution controls were removed. Remaining industries were mainly unaffected by environmental regulations. Overall, they found that, between 1973 and 1985, abatement expenditures reduced the U.S. gross national product by 2.59 percent and lowered annual economic growth by 0.191 percent.

In contrast, an earlier study on the relationship between abatement expenditures and economic growth by Denison (1985) estimated a reduction in growth of only 0.07 percent between 1973 and 1982. Gray (1987) also used PACE data to examine productivity changes in the 1970s from environmental protection and Occupational Safety and Health Administration (OSHA) regulation. Gray found that these regulations collectively lowered productivity growth in manufacturing by 0.44 percent per year, although most of the effects came from OSHA rules, not environmental compliance.

APPENDIX B

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