The Benefits and Costs of the Clean Air Act, 1970 to 1990

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Abstract

Section 812 of the Clean Air Act Amendments of 1990 requires the Environmental Protection Agency (EPA) to periodically assess the effect of the Clean Air Act on the "public health, economy, and environment of the United States," and to report the findings and results of its assessments to the Congress. Section 812 further directs EPA to evaluate the benefits and costs of the Clean Air Act's implementation, taking into consideration the Act's effects on public health, economic growth, the environment, employment, productivity, and the economy as a whole. This EPA Report to Congress presents the results and conclusions of the first section 812 assessment, a retrospective analysis of the benefits and costs of the Clean Air Act from 1970 to 1990. Future reports will detail the findings of prospective analyses of the benefits and costs of the Clean Air Act Amendments of 1990, as required by section 812.

This retrospective analysis evaluates the benefits and costs of emissions controls imposed by the Clean Air Act and associated regulations. The focus is primarily on the criteria pollutants sulfur dioxide, nitrogen oxides, carbon monoxide, particulate matter, ozone, and lead since essential data were lacking for air toxics. To determine the range and magnitude of effects of these pollutant emission reductions, EPA compared and contrasted two regulatory scenarios. The "control scenario" reflects the actual conditions resulting from the historical implementation of the 1970 and 1977 Clean Air Acts. In contrast, the "no-control" scenario reflects expected conditions under the assumption that, absent the passage of the 1970 Clean Air Act, the scope, form, and stringency of air pollution control programs would have remained as they were in 1970. The no-control scenario represents a hypothesized "baseline" against which to measure the effects of the Clean Air Act. The differences between the public health, air quality, and economic and environmental conditions resulting from these two scenarios represent the benefits and costs of the Act's implementation from 1970 to 1990.

To identify and quantify the various public health, economic, and environmental differences between the control and no-control scenarios, EPA employed a sequence of complex modeling and analytical procedures. Data for direct compliance costs were used in a general equilibrium macroeconomic model to estimate the effect of the Clean Air Act on the mix of economic and industrial activity comprising the nation's economy. These differences in economic activity were used to model the corresponding changes in pollutant emissions, which in turn provided the basis for modeling resulting differences in air quality conditions. Through the use of concentration-response functions derived from the scientific literature, changes in air quality provided the basis for calculating differences in physical effects between the two scenarios (e.g, reductions in the incidence of a specific adverse health effect, improvements in visibility, or changes in acid deposition rates). Many of the changes in physical effects were assigned an economic value on the basis of a thorough review and analysis of relevant studies from the economics, health effects, and air quality literature. The final analytical step involved aggregating these individual economic values and assessing the related uncertainties to generate a range of overall benefits estimates.

Comparison of emissions modeling results for the control and no-control scenarios indicates that the Clean Air Act has yielded significant pollutant emission reductions. The installation of stack gas scrubbers and the use of fuels with lower sulfur content produced a 40 percent reduction in 1990 sulfur dioxide emissions from electric utilities; total suspended particulate emissions were 75 percent lower as a result of controls on industrial and utility smokestacks. Motor vehicle pollution controls adopted under the Act were largely responsible for a 50 percent reduction in carbon monoxide emissions, a 30 percent reduction in emissions of nitrogen oxides, a 45

percent reduction in emissions of volatile organic compounds, and a near elimination of lead emissions. Several of these pollutants (primarily sulfur dioxide, nitrogen oxides, and volatile organic compounds) are precursors for the formation of ozone, particulates, or acidic aerosols; thus, emissions reductions have also yielded air quality benefits beyond those directly associated with reduced concentrations of the individual pollutants themselves.

The direct benefits of the Clean Air Act from 1970 to 1990 include reduced incidence of a number of adverse human health effects, improvements in visibility, and avoided damage to agricultural crops. Based on the assumptions employed, the estimated economic value of these benefits ranges from $5.6 to $49.4 trillion, in 1990 dollars, with a mean, or central tendency estimate, of $22.2 trillion. These estimates do not include a number of other potentially important benefits which could not be readily quantified, such as ecosystem changes and air toxics-related human health effects. The estimates are based on the assumption that correlations between increased air pollution exposures and adverse health outcomes found by epidemiological studies indicate causal relationships between the pollutant exposures and the adverse health effects.

The direct costs of implementing the Clean Air Act from 1970 to 1990, including annual compliance expenditures in the private sector and program implementation costs in the public sector, totaled $523 billion in 1990 dollars. This point estimate of direct costs does not reflect several potentially important uncertainties, such as the degree of accuracy of private sector cost survey results, that could not be readily quantified. The estimate also does not include several potentially important indirect costs which could not be readily quantified, such as the possible adverse effects of Clean Air Act implementation on capital formation and technological innovation.

Thus, the retrospective analysis of the benefits and costs of implementing the Clean Air Act from 1970 to 1990 indicates that the mean estimate of total benefits over the period exceeded total costs by more than a factor of 42. Taking into account the aggregate uncertainty in the estimates, the ratio of benefits to costs ranges from 10.7 to 94.5.

The assumptions and data limitations imposed by the current state of the art in each phase of the modeling and analytical procedure, and by the state of current research on air pollution's effects, necessarily introduce some uncertainties in this result. Given the magnitude of difference between the estimated benefits and costs, however, it is extremely unlikely that eliminating these uncertainties would invalidate the fundamental conclusion that the Clean Air Act's benefits to society have greatly exceeded its costs. Nonetheless, these uncertainties do serve to highlight the need for additional research into the public health, economic, and environmental effects of air pollution to reduce potential uncertainties in future prospective analyses of the benefits and costs of further pollution controls mandated by the Clean Air Act Amendments of 1990.

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Acronyms and Abbreviations

μeq/L	microequivalents per liter
μg/m^3	micrograms per cubic meter
μg	micrograms
μm	micrometers, also referred to as microns
ACCACAPERS	SAB Advisory Council on Clean Air Compliance Analysis Physical Effects Review Subcommittee
AGSIM	AGricultural SImulation Model
AIRS	EPA Aerometric Information Retrieval System
Al^{3+}	aluminum
ANC	acid neutralizing capacity
ANL	Argonne National Laboratories
APPI	Argonne Power Plant Inventory
AQCR	Air Quality Control Region
ARGUS	Argonne Utility Simulation Model
ASI	Acid Stress Index
ATERIS	Air Toxic Exposure and Risk Information System
ATLAS	Aggregate Timberland Assessment System
AUSM	Advanced Utility Simulation Model
BEA	Bureau of Economic Analysis
b_{ext}	total light extinction
BG/ED	Block Group / Enumeration District
BI	atherothrombotic brain infarction
BID	Background Information Document
BP	blood pressure
BTU	British Thermal Unit
c.i.	confidence interval
CA	cerebrovascular accident
CAA	Clean Air Act
CAAA90	Clean Air Act Amendments of 1990
CAPMS	EPA's Criteria Air Pollutant Modeling System
CARB	California Air Resources Board
CASAC	SAB Clean Air Scientific Advisory Committee
CDC	Centers for Disease Control (now CDCP, Centers for Disease Control and Prevention)
CERL	EPA/ORD Corvallis Environmental Research Laboratory (old name; see NERL)
CEUM	ICF Coal and Electric Utility Model
CHD	coronary heart disease
CIPP	changes in production processes
CO	carbon monoxide
CO_2	carbon dioxide
COH	coefficient of haze
COHb	blood level of carboxyhemoglobin
COPD	chronic obstructive pulmonary disease
Council	SAB Advisory Council on Clean Air Compliance Analysis
CPUE	catch per unit effort

CR	concentration-response
CRESS	Commercial and Residential Simulation System model
CSTM	Coal Supply and Transportation Model
CTG	Control Techniques Guidelines
CV	contingent valuation
CVM	contingent valuation method
D.C.	District of Columbia
DBP	diastolic blood pressure
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
$DFEV_1$	decrement of forced expiratory volume (in one second)
dL	deciliter
DOC	Department of Commerce
DOE	Department of Energy
DOI	Department of Interior
DRI	Data Resources Incorporated
dV	DeciView Haze Index
DVSAM	Disaggregate Vehicle Stock Allocation Model
EC	extinction coefficient
EDB	ethylene dibromide
EDC	ethylene dichloride
EFI	Electronic Fuel Injection
EI	Electronic Ignition
EIA	Energy Information Administration
EKMA	Empirical Kinetics Modeling Approach
ELI	Environmental Law Institute
EOL	end-of-line
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ESEERCO	Empire State Electric Energy Research Corporation
ESP	electrostatic precipitator
FERC	Federal Energy Regulatory Commission
FEV_1	forced expiratory volume (in one second)
FGD	flue gas desulfurization
FHWA	Federal Highway Administration
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIP	Federal Information Processing System
FR	Federal Register
FRP	Forest Response Program
GDP	gross domestic product
GEMS	Graphical Exposure Modeling System
GM	geometric mean
GNP	Gross National Product
GSD	geometric standard deviation
H_2SO_4	sulfuric acid
ha	hectares
HAP	Hazardous Air Pollutant
HAPEM-MS	Hazardous Air Pollutant Exposure Model - Mobile Source
HNO_3	nitric acid
hp	horsepower
HTCM	Hedonic Travel-Cost Model
ICARUS	Investigation of Costs and Reliability in Utility Systems

ICD-9	International Classification of Diseases, Ninth Version (1975 Revision)
ICE	Industrial Combustion Emissions model
IEc	Industrial Economics, Incorporated
IEUBK	EPA's Integrated Exposure Uptake Biokinetic model
IMS	Integrated Model Set
IPF	iterative proportional fitting
IQ	intelligence quotient
ISCLT	Industrial Source Complex Long Term air quality model
J/W	Jorgenson / Wilcoxen
kg	kilograms
km	kilometers
lbs	pounds
LRI	lower respiratory illness
m/s	meters per second
m	meters
m^3	cubic meters
Mm	megameters
MMBTU	million BTU
MOBILE5a	EPA's mobile source emission factor model
mpg	miles per gallon
MRAD	minor restricted activity day
MSCET	Month and State Current Emission Trends
MTD	metric tons per day
MVATS	EPA's Motor Vehicle-Related Air Toxics Study
MVMA	Motor Vehicle Manufacturers Association
Mwe	megawatt equivalent
N	nitrogen
NA	not available
NAAQS	National Ambient Air Quality Standard
NAPAP	National Acid Precipitation Assessment Program
NARSTO	North American Research Strategy for Tropospheric Ozone
NATICH	National Air Toxics Information Clearinghouse
NCLAN	National Crop Loss Assessment Network
NEA	National Energy Accounts
NERA	National Economic Research Associates
NERC	North American Electric Reliability Council
NERL	EPA/ORD National Exposure Research Laboratory (new name for CERL)
NESHAP	National Emission Standard for Hazardous Air Pollutants
NHANES	First National Health and Nutrition Examination Survey
NHANES II	Second National Health and Nutrition Examination Survey
NIPA	National Income and Product Accounts
NMOCs	nonmethane organic compounds
NO	nitric oxide
NO_2	nitrogen dioxide
NO_3-	nitrate ion
NO_x	nitrogen oxides
NPTS	Nationwide Personal Transportation Survey
NSPS	New Source Performance Standards
NSWS	National Surface Water Survey
O&M	operating and maintenance
O_3	ozone

OAQPS	EPA/OAR Office of Air Quality Planning and Standards
OAR	EPA Office of Air and Radiation
OMS	EPA/OAR Office of Mobile Sources
OPAR	EPA/OAR Office of Policy Analysis and Review
OPPE	EPA Office of Policy Planning and Evaluation
ORD	EPA Office of Research and Development
OZIPM4	Ozone Isopleth Plotting with Optional Mechanism-IV
PACE	Pollution Abatement Costs and Expenditures survey
PAN	peroxyacetyl nitrate
PAPE	Pollution Abatement Plant and Equipment survey
Pb	lead
PbB	blood lead level
PCB	polychlorinated biphenyl
PES	Pacific Environmental Services
pH	the logarithm of the reciprocal of hydrogen ion concentration, a measure of acidity
PIC	product of incomplete combustion
PM_{10}	particulates less than or equal to 10 microns in aerometric diameter
$PM_{2.5}$	particulates less than or equal to 2.5 microns in aerometric diameter
POP	population
Pop_{mild}	exposed population of exercising mild asthmatics
Pop_{mod}	exposed population of exercising moderate asthmatics
ppb	parts per billion
PPH	people per household
pphm	parts per hundred million
ppm	parts per million
PPRG	Pooling Project Research Group
PRYL	percentage relative yield loss
PURHAPS	PURchased Heat And Power
PVC	polyvinyl chloride
r^2	statistical correlation coefficient, squared
RAD	restricted activity day
RADM	Regional Acid Deposition Model
RADM/EM	RADM Engineering Model
RAMC	Resource Allocation and Mine Costing model
RfD	reference dose
RIA	Regulatory Impact Analysis
ROM	Regional Oxidant Model
RRAD	respiratory restricted activity day
RUM	Random Utility Model
s.e.	standard error
SAB	Science Advisory Board
SAI	Systems Applications International
SAQM	SARMAP Air Quality Model
SARA	Superfund Amendment Reauthorization Act
SARMAP	SJVAQS/AUSPEX Regional Modeling Adaptation Project
SCC	Source Classification Code
SEDS	State Energy Data System
SIC	Standard Industrial Classification
SIP	State Implementation Plan
SJVAQS	San Joaquin Valley Air Quality Study
SMSA	Standard Metropolitan Statistical Area

SO_2	sulfur dioxide
SO_4^{2-}	sulfate ion
SOS/T	State of Science and Technology (refers to a series of NAPAP reports)
SRaw	Specific Airway Resistance
STAR	Stability Array weather database
TAMM90	Timber Assessment Market Model (revised version)
TEEMS	Transportation Energy and Emissions Modeling System
TIUS	Truck Inventory and Use Surveys
TRI	Toxic Release Inventory
TSP	total suspended particulate
U.S.	United States
UAM	Urban Airshed Model
URI	upper respiratory illness
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
VC	vinyl chloride
VMT	vehicle miles traveled
VOC	volatile organic compounds
VOP	Vehicle Ownership Projection
VR	visual range
W126	index of peak weighted average of cumulative ozone concentrations
WLD	Work Loss Day
WTP	willingness to pay

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