AN ECONOMIC ANALYSIS OF THE BENEFITS AND COSTS OF THE CLEAN AIR ACT 1970 TO 1990

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of Results and Findings

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Executive Summary

The Clean Air Act and its subsequent amendments to 1990 were legislative initiatives designed to improve air quality and reduce the adverse consequences of air pollution. As a result, they imposed costs on producers and consumers as economic activities were brought into compliance with their statutory requirements. However, they also secured improvements in air quality by reducing the lead content in gasoline and pollutant emissions to the ambient atmosphere. In turn, these lead to improvements in the health and well-being of the population. The analyses covered in this report examine the consequences of these costs and benefits for overall economic performance and welfare. They are based on the application of a multi-sector, inter-temporal general equilibrium model of the U.S. economy. The approach taken is to develop a counter-factual view of how the economy might have evolved had there been no Clean Air Act.

The costs arising from the Clean Air Act, analyzed absent of the economic benefits from improvements in environmental quality, adversely affect economic performance. Real consumption and income ultimately are one percent lower due to its enactment. The causes of these effects are the policy's impact on capital formation and its impact on productivity at the industry level. For compliance, a portion of each new dollar of invested capital now is devoted to pollution abatement. In addition, capital and other resources are diverted from their previously productive uses to the retrofitting of existing capital and to the operation and maintenance of both new and existing capital, the latter being the productivity effect.

The benefits arising from the Clean Air Act, analyzed absent of cost considerations, enhance economic performance. Real consumption and income ultimately are almost three percent higher in its presence. Here, the cause is principally the policy's favorable impact on reducing the illnesses, intellectual costs and pre-mature deaths associated with air pollution. As these directly affect the availability of labor inputs to production and the availability of consumers as purchasers, the presence of the clean air act implies a larger economy from both the perspectives of supply and demand.

In combining these effects, the Clean Air Act provides the economy undeniable net economic benefits. Ultimately, real consumption and income are two percent higher than they would be without its enactment. Initially, there are economic losses as the private costs of compliance exceed the benefits of the avoided damages to life and health. However, there soon are annual net benefits as the consequences of avoided deaths and work-loss days more than compensate the long-run cost implications of the Act's provisions. By the mid-1990s, there are cumulative net benefits that continue to grow as the time horizon is extended.

Over the simulation period and beyond, these net benefits accumulate to sizeable amounts. From a welfare perspective (computed as *present value equivalent variations and willingness-to-pay*), there are cumulative net gains of $(1990) 26.2 trillion. The benefits of the CAA far outweigh its costs. Mortality benefits accumulate to $(1990) 21.1 trillion while the benefits associated with morbidity and productivity improvements total $(1990) 6.8 trillion. Compliance with the provisions of the CAA entails a welfare loss of $(1990) 1.7 trillion in terms of the market values of goods, services and leisure foregone.

The Clean Air Act also has important implications for the structure of the U.S. economy and its patterns of energy use. The sectors most affected by it are petroleum refining, motor vehicles production and electric utilities. Lesser impacts are observed for mining, chemicals, primary metals and gas utilities. In the presence of the Clean Air Act, the economy is much less petroleum-, auto- and electric-intensive than it otherwise would be and much more coal- and gas-intensive than it otherwise would be. The energy- and pollution-intensities of the economy are significantly reduced through the Act's provisions. However, there is a major irony arising from its enactment. Because the economy is larger in its presence, the levels of energy use and (carbon) emissions are ultimately about 0.5 percent higher than they would be in absence of the Act. Moreover, the carbon-intensity of fossil fuel use is higher under the Act due to the reduced petroleum- and increased coal-intensity of the nation's energy-consuming capital stock.

1. Introduction

This analysis examines the benefits and costs of the 1970 Clean Air Act (CAA) and its 1977 Amendments in an effort to determine an overall value of the policy's merits. Upon its passage, the great bulk of the nation's energy-consuming capital stock was misaligned with the objectives of improved air quality through reductions in lead content and emissions of criteria pollutants. The enactment of the CAA imposed clear and tangible costs on producers and consumers as the nation was forced to bring new and existing capital into compliance with the Act's provisions. Its enactment also gave rise, perhaps less visible and immediate, to improvements in the health and welfare of the U.S. citizenry and to benefits to the nation's ecological and economic systems. As part of the 1990 CAA Amendments, Congress required the U.S. Environmental Protection Agency (EPA) to conduct "periodic, scientifically reviewed studies to assess the benefits and costs of the Clean Air Act (U.S. EPA, 1997)."

In 1993, Dale Jorgenson Associates reported on their detailed analyses of the economic costs associated with compliance to the 1970 and 1977 act and amendments (Jorgenson, et. al., 1993). Using a multi-sector, dynamic general equilibrium model of the U.S. economy, it was determined that these enactments adversely affected economic performance. Real consumption and income ultimately would have been one percent higher in their absence. The impacts on producers were not uniform. Sectors like motor vehicles, petroleum refining and electric utilities were most affected. Distributionally, for an infinitely-lived family of size four headed by a white male, age 35-44, living in the urban Northeast, the willingness to pay for not having to absorb the costs of compliance was estimated to be almost \$(1990) 8,300 per household in present value terms or 0.8 percent of lifetime consumption. This translates to an annual tax of \$(1990) 230 per household in perpetuity. Aggregating across all households, the estimated willingness to pay for society as a whole was in the range of \$(1990) 500 to 700 billion in terms of lifetime consumption. Finally, the compliance costs were found to be regressive to income and expenditure (Jorgenson, et. al., 1993). Two-thirds of these damages arose from the costs associated with stationary sources of air pollution; the remaining one-third was related to the costs arising from mobile source initiatives.

The analysis reported herein extends this earlier work. In particular, the aforementioned model, absent of distributional considerations, is used to evaluate the estimated benefit stream arising from the 1970 and 1977 act and amendments and to perform a net benefit analysis incorporating the costs previously assessed. As before, the costs and benefits of the CAA were analyzed independently. In turn, these were quantified in a manner that allows their introduction into the modeling framework in appropriate ways so as to isolate and measure the policy's direct and indirect consequences. As the model was estimated over an interval that encompasses the enactment period, the method of analysis is to observe how the economy might have evolved had there been no Clean Air Act and to provide measures of the consequences attendant to compliance with it.

The remainder of this report is organized as follows. Section 2 provides a brief description of the model employed in this analysis. Sections 3 and 4 discuss the costs and benefits of the CAA, respectively. They also cover the manner in which the costs and benefits were introduced into the model. Sections 5, 6 and 7 present the simulation results. Section 5 focuses on the macroeconomic impacts as measured by real Gross Domestic Product (GDP), consumption and investment. The primary inputs of capital and labor also are discussed, as are the welfare implications in terms of foregone consumption. Section 6 addresses the energy and environmental impacts of the CAA at the aggregate level. Energy changes are examined in terms of total fossil fuel use while environmental effects are evaluated in terms of the resulting carbon emissions. Finally, Section 7 reports on the industry details as reflected in the prices paid by producers and consumers and changes in the composition of domestic output.

2. Methodology

The results of this analysis are based on simulations conducted with the Intertemporal General Equilibrium Model or IGEM developed by Ho, Jorgenson and Wilcoxen. This is a multi-sector, multi-period model of the U.S. economy. It is one of a class of models called computable general equilibrium (CGE) models because it solves for the market-clearing prices and quantities of each sector and market in each time period. The parameters (or coefficients) of the equations in IGEM are estimated statistically from historical data spanning 50 years. The model consists of 35 producing sectors, the household or consumer sector, a business investment sector, the federal, state and local governments sector, and a foreign sector. Formal descriptions of the methodology and its components are numerous and appear in Ho (1989), Jorgenson and Slesnick (1985 and 1987), Jorgenson, *et al.* (1992) and Wilcoxen (1988).

In the IGEM model, production is disaggregated into 35 separate commodities produced by one or more of 35 industries. The industries (see Table 2.1) generally match two-digit sectors in the Standard Industrial Classification (SIC). Each industry or producing sector produces one primary product and may produce one or more additional goods or services. Each producing sector is modeled by a set of equations that fully represent possible substitutions among its inputs or factors—i.e., capital, labor, non-competing imports, and the 35 commodities.

Within each producing sector, changes in input demand (i.e., substitutions) occur because relative prices change, encouraging more or less use of that input. In addition, historical data invariably reveal trends (or biases) in input use that are independent of input prices. This means there is either increasing or decreasing input usage over time, even after accounting for the changes arising from relative price incentives. For example, historical data may indicate that particular industries are increasingly labor-saving, energy-saving, or capital-using over time, independent of relative prices. The equations used to model production in IGEM account for both price- and trend-related substitution effects. Industry-level productivity growth also is part of the specification for each of the 35 producing sectors estimated statistically from observed changes in input prices and observed technological trends.

These equations, along with others in the model, are organized in an inter-industry framework in which the demands for and supplies of each commodity, as well as those of capital and labor, must balance in terms of both quantity and value (i.e., price times quantity). The organization of annual "use" and "make" tables is illustrated in Figure 2.1. These are "spreadsheets" at the industry and commodity level of detail. The "cells" in each use table depict commodity purchases (the rows) by each industry and final demand (the columns). The "cells" in each make table show the commodities produced by each industry. Figure 2.1 also shows the inputs of capital and labor into each producing and consuming sector.

Figure 2.2 depicts production and supply. Inputs of the 35 commodities plus capital, labor and non-competing imports are combined to produce domestic industrial outputs. In turn, these outputs are mapped into domestic commodity outputs through the use and make tables. Combining the domestic commodities with competitive foreign imports gives rise to the available supplies, which are purchased as intermediate inputs or finished goods (final demand).

The model is solved iteratively until the prices of all commodities and inputs are such that demand equals supply in all product and factor (input) markets. Model solutions depict, among other things, all prices and quantities, the complete structure of inputs to production, and industry-level rates of technological change. As a result, economy-wide changes in energy or capital intensity, for example, are calculated by adding up industry-level details. There are none of the so-called autonomous "economy-wide" energy efficiency improvements (i.e., assumed declines in the amount of energy required to produce a given level of output over time, with labor and capital unchanged), except those arising from the assumed continuation of independent technological trends. (Experimentation has shown that these technological trends in the use of such factors as energy or capital comprise around twenty percent of the overall adjustment to new energy conditions, with substitution or relative price effects explaining the remaining eighty percent [Jorgenson, *et.al.*, 1993]).

Household consumption by commodity is the result of a three-stage, multi-period decision process (see Figure 2.3) involving price and demand equations like those of the producing sectors. First, households decide their levels of "full consumption" over time. Full consumption, comprising goods, services *and* leisure, is the amount of financial wealth "consumed" in each period and is dependent on relative prices, current and future, and on the time path of interest rates (both of which are known to households with perfect foresight). Financial wealth is the (present) value of household capital wealth (private, government and foreign) and the household time endowment.

The household time endowment is a population-based, monetary estimate of the amount of time available to the working-age population (those 14 through 74 years old) for work and leisure. It assumes that there are 14 hours per day of discretionary time for work and leisure with appropriate allowances for weekends, holidays and hours spent in school. The time endowment is evaluated at the prevailing wage or after-tax rate of labor compensation, including benefits and is adjusted for quality (i.e., educational attainment and experience). Leisure is defined as the uncompensated use of time (i.e., that portion of the 14 hours that people use for activities other than paid work). (This is not the ideal measure of leisure in that it includes commuting, illness and many other uses of time that would not be considered "leisure" in the usual sense of the word. However, construction of a pure measure of leisure is probably beyond available data.)

Once households decide each period's full consumption, they then decide the split between the consumption of goods and services and the demand for leisure. This decision is based on the price of consumption relative to the wage rate (the opportunity cost, or price of leisure). When households decide their leisure demand, they simultaneously determine their labor supply and, so too, their labor income. Finally, households choose the allocation of total consumption among capital, labor, and the various categories of goods and services. Like production, these stages of household behavior are estimated statistically from historical data, and the equations capture both price- and income-driven changes in observed spending patterns.

In the model, capital accumulation is the outcome of a series of decisions over time by households and firms. Households and businesses determine the amount of saving available in each period as the difference between their income and expenditures. Households and firms invest until the returns on additional investment are no longer greater than the cost of new capital goods. Capital is assumed to be perfectly mobile across households and corporate and non-corporate enterprises; in other words, capital flows to where it is needed. (In the real world, there are, most likely, severe constraints on the near-term mobility of capital.) Investment is structured according to a statistically estimated model allowing substitutions among different types of capital goods. The total supply of capital at any time is fixed by the accumulated investment in these capital goods.

Government purchases are calculated to balance the available government revenues and a predetermined budget deficit. Government revenues arise by applying tax rates, both historical and projected, to the levels of income and wealth generated by the model. The composition of government spending – for example, spending on automobiles, computers, highways, schools, and employees – is fixed by assumption.

Finally, the international exchange rate of the dollar against other currencies adjusts to bring net exports (exports less imports) into line with a predetermined trade balance in goods and services. This means that net foreign saving is insensitive to changes in U.S. prices and interest rates. Imports are considered imperfect substitutes for similar domestic commodities and compete on price, which in turn depends on the value of the relevant foreign currency. Export demands depend on assumed foreign incomes and the foreign prices of U.S. exports, which, in turn, are determined by domestic prices and the exchange rate.

The assumptions regarding the budget and trade deficits drive important aspects of the process of capital formation. In combination, they imply that no "crowding-out" of private investment occurs as a result of changes in investment by either the government or foreign sectors. Holding the budget and trade deficits constant across simulations means that neither governments nor foreigners influence the level of investment spending beyond what is assumed for the base case. As a result, investment changes from one simulation to another depend entirely on changes in saving by households and businesses.

On the supply side, overall economic growth in IGEM, as in the real world, arises from three sources. These are productivity, accumulated capital, and the availability of labor. The model itself determines two of these – productivity and capital. Productivity depends on emerging trends in relative prices combined with the continuation of observed technological trends. Capital accumulation occurs as a result of the saving and investment behavior of producers and consumers. Labor supply is determined as households allocate their discretionary time between work and leisure. All of these, therefore, are products of the model. U.S. population growth by age, race, sex, and educational attainment is projected through 2050 using demographic assumptions consistent with U.S. Social Security Administration forecasts; after 2050, population is held constant. As indicated above, the population projection is used to calculate a projection of the economy's "time endowment" in dollar terms by applying historical wage patterns to estimates of the working-age population. Since the model largely determines productivity and capital accumulation, these population projections effectively determine the size of the economy in the distant future.

Models are necessarily an abstraction of the environment they portray, and IGEM is no exception. In characterizing the results from this methodology, three features merit consideration. Two of these are assumptions, while the third derives from the source of the model's parameters. First, as indicated above, consumers and producers in IGEM are assumed to have perfect foresight and are able to react today to expected future price changes. This means that they behave according to so-called "rational expectations." There are no surprises in the form of price shocks. Since producers and consumers immediately plan for and adopt new technologies, there are no losses associated with equipment becoming prematurely obsolete when technology or relative prices change repeatedly. Second, capital income and the corresponding stock of capital goods and services are assumed to be perfectly mobile among industries, households, and governments. This implies that capital can migrate from sector to sector with little or no adjustment cost. Moreover, there are no capacity shortages or supply-demand imbalances associated with this migration. Instead, equipment is effortlessly transformed into some other use.

Finally, the model parameters in IGEM are based on 50 years of historical data. Much has changed in these 50 years and these parameters reflect and embody these changes. Hence, model adjustments and reactions to changing economic conditions are based on observed long-term trends and any short-run constraints on or lags in adjustment behavior that are part of this history.

Taken together, these features imply that IGEM is more likely than other models are to produce "best" case outcomes (least losses or greatest gains) when confronted with significant economic changes. Households and businesses are fully aware of these changes through perfect foresight, substitution possibilities are long-run in nature and occur quickly and easily, and capital readily migrates and mutates to new uses. Conversely, myopia, inflexibility in production and consumption, and low capital stock turnover are conditions that lead to "worst" case outcomes (greatest losses or least gains). In comparing model estimates of the economy's response to environmental policies, those from IGEM will appear less damaging (or, more beneficial) than those from models in which there are more rigidities or higher adjustment costs.

Table 2.1: Definitions of Industries-Commodities

Number	*Description*
1	Agriculture, forestry and fisheries
2	Metal mining
3	Coal Mining
4	Crude petroleum and natural gas extraction
5	Non-metallic mineral mining
6	Construction
7	Food and kindred products
8	Tobacco manufactures
9	Textile mill products
10	Apparel and other textile products
11	Lumber and wood products
12	Furniture and fixtures
13	Paper and allied products
14	Printing and publishing
15	Chemicals and allied products
16	Petroleum refining
17	Rubber and plastic products
18	Leather and leather products
19	Stone, clay and glass products
20	Primary metals
21	Fabricated metal products
22	Non-electrical machinery
23	Electrical machinery
24	Motor vehicles
25	Other transportation equipment
26	Instruments
27	Miscellaneous manufacturing
28	Transportation and warehousing
29	Communications
30	Electric utilities (services)
31	Gas utilities (services)
32	Wholesale and retail trade
33	Finance, insurance and real estate
34	Other personal and business services
35	Government enterprises

Figure 2.1: Organization of the Use and Make Tables

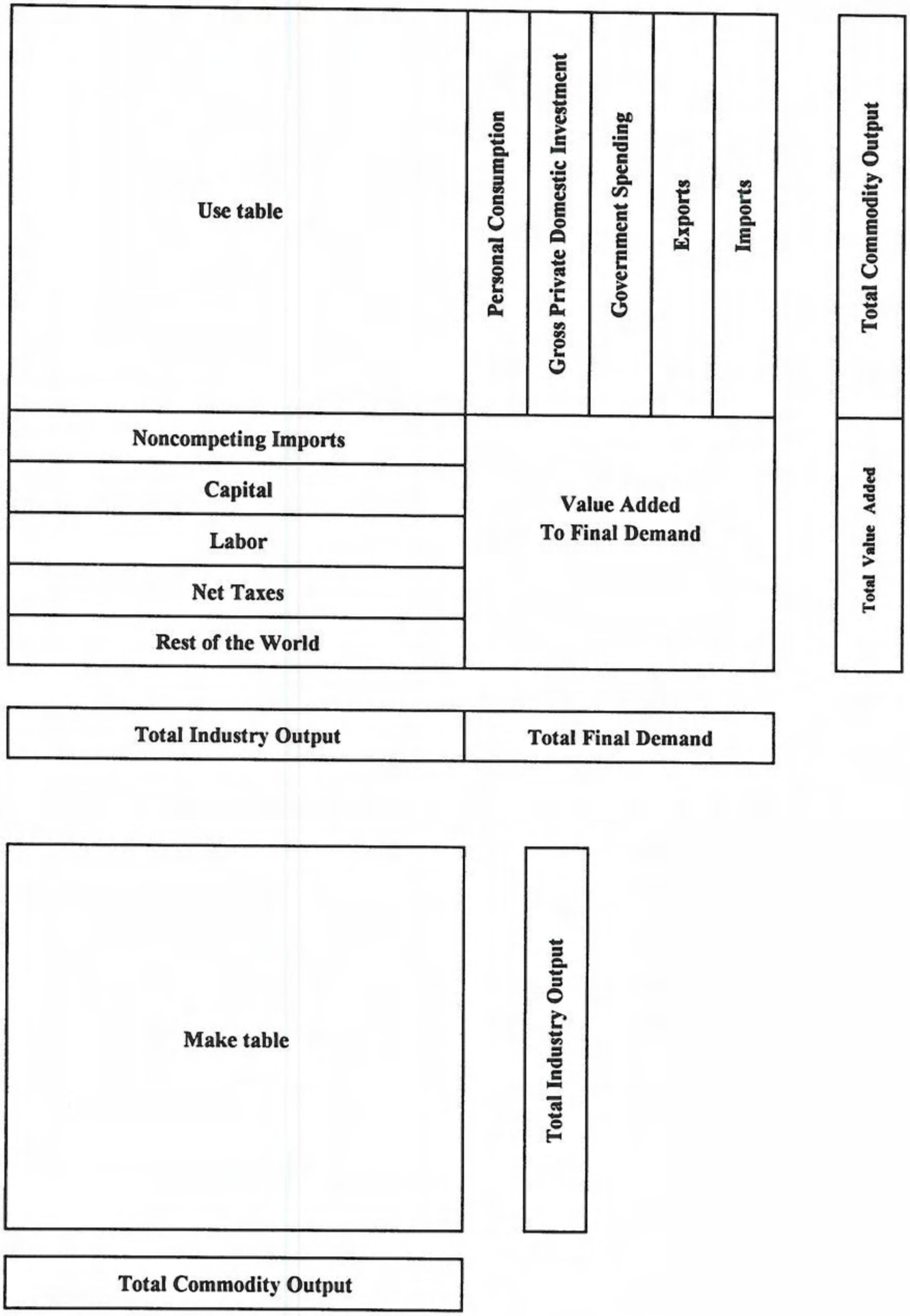


Figure 2.2: The Model Flows of Production and Commodity Supply

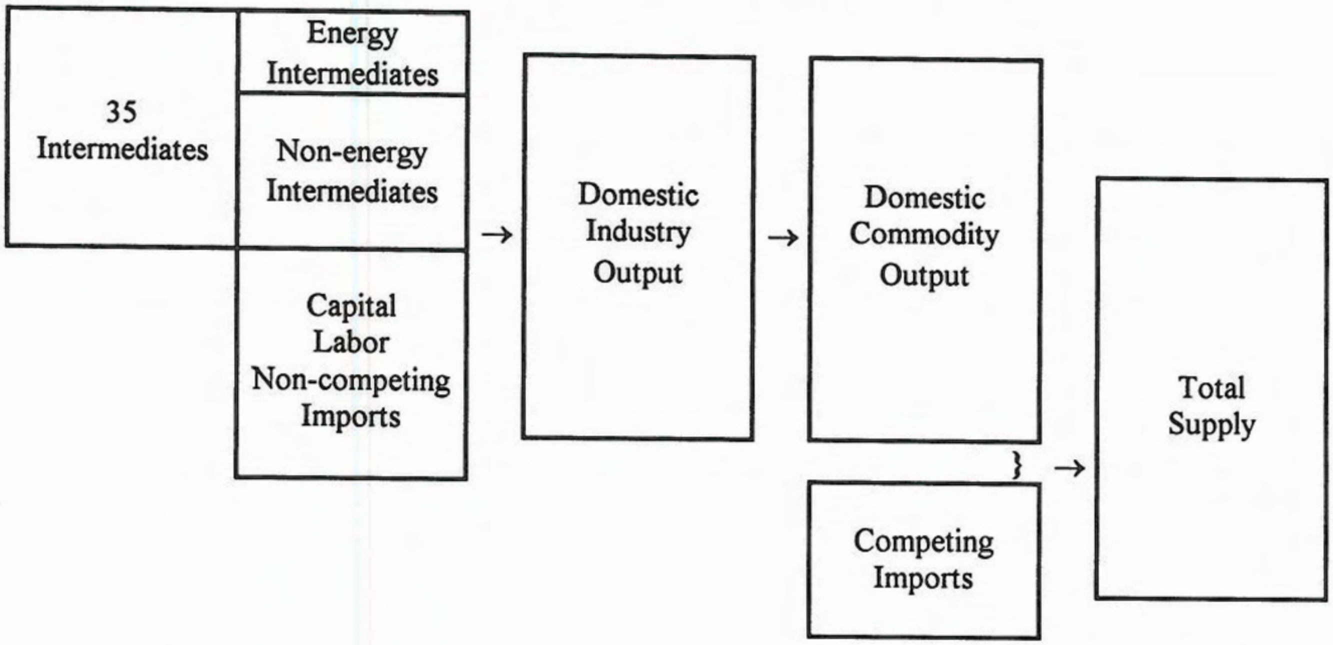
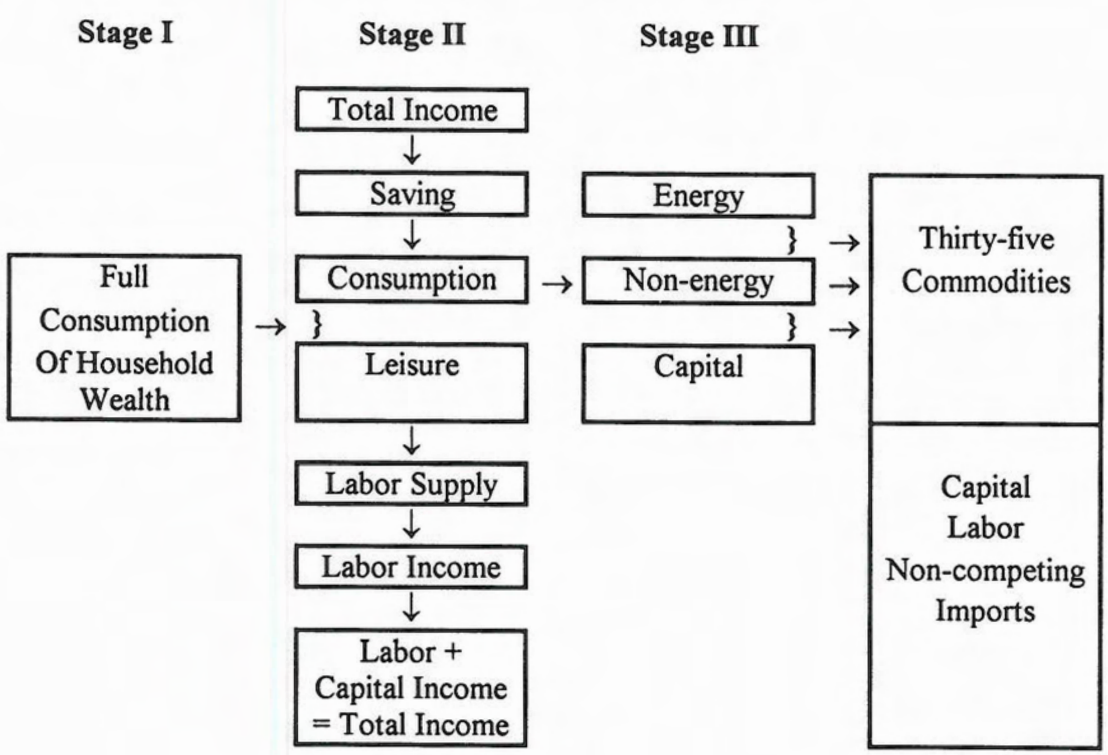


Figure 2.3: The Model Flows of Household Behavior



3. The Costs of Compliance

The CAA compliance costs included in this analysis cover capital and operating and maintenance (O&M) outlays for non-farm stationary sources. Recovered costs associated with pollution control in manufacturing are subtracted from O&M outlays. Capital, maintenance and fuel-related charges for mobile source air pollution control complete the compliance cost data. The fuel-related charges for mobile sources combine the fuel price and fuel economy penalties associated with lead-free gasoline. The compliance costs for government expenditures for pollution abatement, research and development, and regulation and monitoring are not included in these simulations as they have an almost negligible impact on the overall results. Private R&D outlays also are omitted from consideration since there is no basis for allocating them to specific industries or specific purchases. The sources of these data and the database of air pollution control expenditures developed for this analysis are discussed in Jorgenson, et. al. (1993) and EPA (1997). A summary of the aggregate cost information appears below in Table 3.1.

Table 3.1: The Direct Costs Of Compliance
Compliance Costs in Millions

	Stationary Sources		Recovered	Mobile Sources			TOTAL
	Capital	O&M	Costs	Capital	O&M&Fuel	Other	COSTS
1972	2,235						
1973	3,050	1,436	199	276	1,765	836	7,164
1974	3,432	1,895	296	242	2,351	866	8,490
1975	4,016	2,240	389	1,570	2,282	897	10,616
1976	3,954	2,665	496	1,961	2,060	1,009	11,153
1977	4,008	3,223	557	2,248	1,786	1,174	11,882
1978	4,182	3,724	617	2,513	908	1,325	12,035
1979	4,898	4,605	750	2,941	1,229	1,448	14,371
1980	5,449	5,568	862	2,949	1,790	1,410	16,304
1981	5,586	6,123	997	3,534	1,389	1,348	16,983
1982	5,594	5,815	857	3,551	555	1,299	15,957
1983	4,577	6,292	822	4,331	-155	1,297	15,520
1984	4,698	6,837	870	5,679	-326	1,314	17,332
1985	4,469	7,186	768	6,387	337	1,488	19,099
1986	4,402	7,256	867	6,886	-1,394	1,548	17,831
1987	4,456	7,599	987	6,851	-1,302	1,594	18,211
1988	4,510	7,474	1,107	7,206	-1,575	1,670	18,178
1989	4,995	7,916	1,122	7,053	-1,636	1,788	18,994
1990	4,395	8,842	1,256	7,312	-1,816	1,542	19,019

Sources: Appendix A, Jorgenson, et. al. (1993) and Table A-8, EPA (1997). Costs prior to 1973 were determined by linear interpolation, 1970 being zero.

Annual CAA compliance costs average almost $15.0 billion over the period 1973-1990. Of this, stationary source capital and net operating expenditures average $4.5 billion and $4.6 billion, respectively. The total compliance costs for mobile sources account for over thirty percent of all compliance costs or $4.5 billion of the average total expenditure. Government outlays and private R&D expenditures average $1.3 billion, 1973-1990, and are not included in these simulations. Government outlays are excluded because they are very small in magnitude and their effects are negligible. Private R&D expenditures are excluded because there is no basis for allocating them to specific industries or identifying the benefits arising from them. Thus, the CAA costs omitted from consideration are about 15% of the costs for all stationary sources and about 9% of total compliance costs.

Two points regarding the compliance cost series merit discussion. First, all non-mobile source costs were based on U.S. Department of Commerce, Bureau of Economic Analysis (BEA) surveys and analyses through the early 1990's. In the mid-1990's, BEA published "final" adjusted data on these cost series. For comparability to earlier analytical efforts, these final series were not considered in this assessment. Second, the cost series above represent all air pollution abatement expenditures, including those that would have occurred even in the absence of the CAA. However, the benefit estimates reflect only the changes in air quality due to the CAA, thus biasing any benefit-cost conclusions. It is known that industry incurred expenses for air pollution control prior to 1970 and, presumably, would have continued to do so without the Act's impetus. Unfortunately, there is no basis for isolating the costs only attributable to the Clean Air Act. Accordingly, benefit-cost attributions remain so qualified.

The costs included for analysis average over four tenths of one percent of total domestic output over the period 1973-1990. However, they are front-loaded, comprising over one-half of one percent of total output in the early years and falling to three tenths of one percent by 1990. In terms of disposable household income, the costs average just under six tenths of one percent from 1973-1990.

As environmental regulations are imposed, investment funds are allocated to pollution control activities. If the supply of savings is fixed and if expenditures on pollution control confer no benefits beyond compliance with the law, then there is a loss in ordinary, productive capital accumulation. This occurs for two reasons. First, there is a permanent loss due to the fact that each new unit of capital has a pollution control component embodied in it. Second, there is a transitory loss due to the need to bring existing capital into compliance.

To eliminate the capital portion of the CAA compliance costs, the percentage of air pollution abatement investment in total investment first was determined. This then was split in order to separate the windfall loss of having to install abatement equipment on old capital from the permanent effect of the control equipment required for each new unit of capital. It was assumed that the 1990 share of pollution control investment in total investment was a reasonable measure of the permanent effect. This meant that the outfitting of old capital was largely achieved by 1990. This 1990 percentage then was deducted from the overall share of abatement investment in total investment to determine the windfall loss accruing to the owners of existing sources.

The permanent effect was introduced into IGEM as a reduction in the price of investment goods. This follows from the idea that under the CAA purchasers of capital goods had to buy a certain amount of abatement capital in each unit of new productive capital, thereby increasing the price of new capital goods.

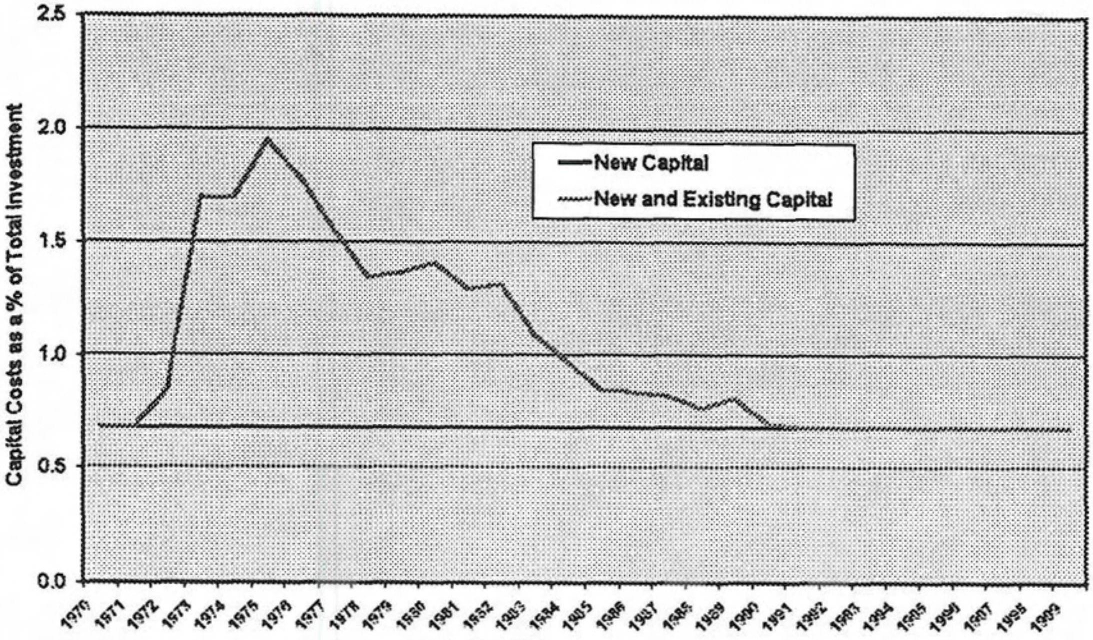
The windfall or transitory effect was applied to the capital accumulation process. In each of the transitory years, 1973-1989, the outlays on abatement equipment for existing sources were returned to increase the ordinary capital formation that occurred that year.

These percentages for these effects are shown below in Table 3.2 and Figure 3.1. In 1975, for example, 1.95 percent of total investment was devoted to pollution control equipment; of this 0.70 percent related to new capital (the permanent effect) while the remaining 1.25 percent brought existing capital into compliance (the transitory effect).

Table 3.2:
Pollution Control Capital Expenditures for Stationary Sources as a Percent of Total Investment

Year	Pollution Control Component for New Capital in Percent	Pollution Control Component for Existing Capital in Percent
1973	0.70	1.00
1974	0.70	1.00
1975	0.70	1.25
1976	0.70	1.09
1977	0.70	0.86
1978	0.70	0.65
1979	0.70	0.67
1980	0.70	0.71
1981	0.70	0.59
1982	0.70	0.62
1983	0.70	0.39
1984	0.70	0.27
1985	0.70	0.15
1986	0.70	0.14
1987	0.70	0.12
1988	0.70	0.07
1989	0.70	0.11
1990	0.70	0.00

Figure 3.1: Pollution Control Capital Expenditures
Stationary Sources, New and Existing Capital



The operation and maintenance of air pollution control devices increases the factor input requirements per unit of output for each affected producing sector. The first step in eliminating the operating portion of the CAA compliance costs was to compute the share of these in the total costs of each industry. For the manufacturing sectors, these costs were net of any recovered costs associated with the operation of pollution control equipment. Reducing the unit cost functions in the production model by these proportions then simulated removal of these costs. The (net) additional resources required to operate and maintain this equipment were released in a Hicks-neutral fashion; that is, for a given amount of output at fixed factor prices, each industry's input demands declined in the same proportion.

Unlike the stationary source abatement expenditures, the mobile source compliance costs are borne by the users rather than the producers of selected products. The CAA altered the purchase prices of motor vehicles (sector 24) and other transportation equipment (sector 25), refined petroleum products (sector 16) and vehicle repair and maintenance (sector 34). Removal of these costs is accomplished in a manner identical to the removal of the stationary source operating costs. First, in each category, the abatement cost share of total expenditure was determined. For motor vehicles and refined petroleum, total expenditures included purchases from domestic and foreign sources. Also, the refined petroleum effect includes a fuel price penalty that is always a cost in these data and a fuel economy penalty that initially is a cost but ultimately becomes a benefit. Finally, vehicle maintenance (part of sector 34, personal and business services) benefits from the Clean Air Act in that automobiles are less costly to service; thus, removal of the CAA harms this sector whereas all other aforementioned sectors benefit.

The unit cost functions for the affected sectors along with the relevant import prices then were additionally altered in proportion to the mobile source cost shares.

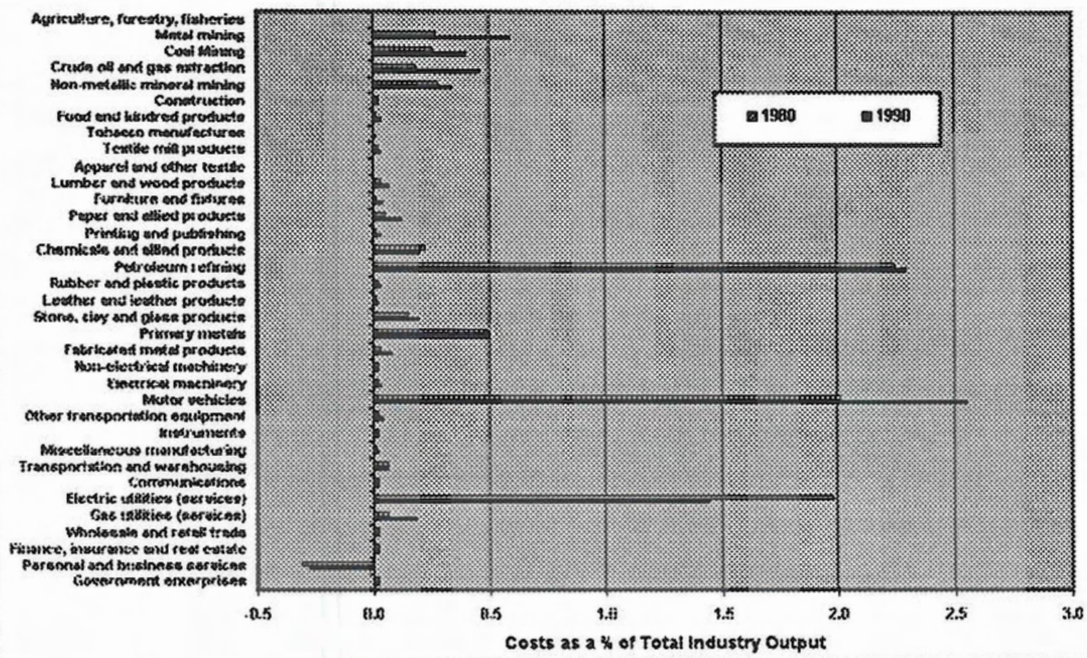
A summary of the net operating and maintenance and mobile compliance cost information appears below in Table 3.3 and Figure 3.2.

Table 3.3:
Pollution Control Expenditures
as a Percent of the Value of Industry Output

Sector	Industry Name	1980	1990
1	Agriculture, forestry, fisheries	0.00	0.00
2	Metal mining	0.27	0.59
3	Coal Mining	0.26	0.40
4	Crude oil and gas extraction	0.18	0.46
5	Non-metallic mineral mining	0.28	0.34
6	Construction	0.02	0.02
7	Food and kindred products	0.01	0.03
8	Tobacco manufactures	0.00	0.01
9	Textile mill products	0.02	0.03
10	Apparel and other textile products	0.00	0.00
11	Lumber and wood products	0.03	0.07
12	Furniture and fixtures	0.01	0.04
13	Paper and allied products	0.05	0.12
14	Printing and publishing	0.01	0.03
15	Chemicals and allied products	0.22	0.20
16	Petroleum refining	2.24	2.29
17	Rubber and plastic products	0.02	0.03
18	Leather and leather products	0.01	0.02
19	Stone, clay and glass products	0.15	0.19
20	Primary metals	0.49	0.50
21	Fabricated metal products	0.03	0.08
22	Non-electrical machinery	0.02	0.02
23	Electrical machinery	0.02	0.03
24	Motor vehicles	2.01	2.55
25	Other transportation equipment	0.02	0.04
26	Instruments	0.02	0.02
27	Miscellaneous manufacturing	0.01	0.02
28	Transportation and warehousing	0.06	0.06
29	Communications	0.02	0.02
30	Electric utilities (services)	1.98	1.44
31	Gas utilities (services)	0.06	0.18
32	Wholesale and retail trade	0.02	0.02
33	Finance, insurance and real estate	0.02	0.02
34	Personal and business services	-0.31	-0.28
35	Government enterprises	0.02	0.02

Figure 3.2 Industry Compliance Costs

Stationary Source O&M Costs (Net of Recovered Costs) and All Mobile Source Costs



4. The Benefits from Compliance

The Clean Air Act secured improvements in the general health and welfare of the population through reductions in lead concentrations and emissions of particulate matter (total suspended particulates), sulfur dioxide, nitrogen oxides, volatile organic compounds and carbon monoxide. These benefits are organized under three broad categories: mortality effects, morbidity effects, and expenditure effects. Mortality effects are associated with the pre-mature deaths of men, women and children as a consequence of exposures to lead and the other pollutants. Morbidity effects are associated with the restricted activity and workdays lost arising from illnesses related to these same exposures. The illnesses considered include chronic bronchitis and other respiratory ailments, heart disease and congestive heart failure, stroke and hypertension. Lost IQ points due to exposures to lead also are viewed as affecting the quality and quantity of available labor inputs. Expenditure effects are associated with household spending that arises in absence of the protections afforded by the Clean Air Act. These include physician and hospital admissions expenses, home maintenance expenditures related to soiling damages and compensatory outlays for needed education.

Appendix D of EPA's 1997 *The Benefits and Costs of the Clean Air Act, 1970 to 1990* formed the basis of the benefit measures considered here. This appendix collected and summarized the human health and welfare effects that were estimated for the criteria pollutants identified in the Clean Air Act. With these data as starting points, the staff at EPA's National Center for Environmental Economics interpolated the benefits for intervening years, 1970-1990, and provided "best estimate" extrapolations of the benefit streams to the year 2100, the terminal year of analysis. These extrapolations were necessary because, logically, the benefits of compliance, unlike the costs that are presumed to reach a steady state by 1990, continue to grow well into the future serving both current and future generations as they age and come into existence, respectively. The documentation and benefit estimates developed by EPA appear as Appendices A, B and C to this report.

Of interest in this assessment are the relative contributions of lead and non-lead pollutants in the mix of overall benefits. As it turns out, these vary by benefit category. For mortality effects, lead contributes but a small fraction of the overall damages, rising from 2.4 percent of avoided deaths in 1971 to a steady-state 10.0 percent by 1990. For the morbidity effects, lead is more important as its growing adverse consequences do not materialize until the early 1990's. From 1970 to 1993, activity days lost related to lead concentrations are in the range of 4.0 to 6.0 percent of all pollution-related days lost. Beginning in 1993, this percentage rises steadily to 13.0 percent by 2000, to 29.0 percent by 2010, to 41.0 percent by 2020 and to a steady state of around 57.0 percent by 2050. Lead is most significant as a percentage of avoided expenditures. Here, lead's share rises from 27.0 percent in 1971 to almost 59.0 percent by 1990. Lead's percentage of avoided expenditure hovers in the sixty percent range over the remainder of the simulation period.

Introducing EPA's benefit estimates into the IGEM methodology requires certain actuarial adjustments. These are shown in Table 4.1 below. In that persons both die and retire, there comes a point in time in which an avoided death or activity day lost no longer appears as a cumulative benefit because the individual in question has either died or is no longer working age. Accordingly, the EPA benefits were adjusted to account for normal deaths and aging. Mortality affects both the population (the number of household equivalent members or consumers) and the time endowment of labor in IGEM. The time endowment of labor comprises fourteen hours per day devoted to work and leisure for each member of the working-age population, ages 14 to 74. It is adjusted for hours spent in school and for quality related to educational attainment. It is expressed in dollars, reflecting the prevailing after-tax compensation received per unit of labor services provided to employers. For the population adjustment, it was assumed that persons no longer contribute avoided-death benefits past their middle- to late-eighties; thus, each age-cohort series in the EPA data was lagged an actuarially appropriate number of years to assure its removal from the benefit stream. The avoided deaths in any given year thus represent EPA's estimated cumulative avoided deaths to this date less any cumulative deaths to this date that would have occurred anyway. The mortality effects on labor's time endowment were determined similarly, the only differences being that persons over 75 were not considered part of the labor force (and, hence, were not considered avoided-death benefits) and that persons were assumed to retire by age 75 (and, hence, should no longer be counted as an avoided-death benefit). Retirement at 75 is consistent with IGEM's construct of the available pool of quality-adjusted hours for work and leisure. It also appears reasonable insofar as less than three percent of 1990's civilian labor force was 65 and over with those 75 and over accounting for one third of these at most.

Table 4.1:
Year after which Persons No Longer
Appear in the CAA Mortality Benefit Stream

Age Category	Population Losses	Workday Losses
Infant	86	73
30-34	57	44
35-44	49	36
45-54	39	26
55-64	29	16
65-74	19	6
75-84	9	
85 and over	5	

An actuarial adjustment also was applied to EPA's workdays lost for reasons of illness or IQ loss. In the EPA data, morbidity-related workdays lost rise to over 2.0 percent of total workdays available by the early 2020's and continue to rise to just over 3.0 percent by century's end. A person's working life was assumed to be 47 years in the EPA analysis or, equivalently, ages 18 through 65. If the EPA series were adjusted in the manner above to account for normal retirements, then the workdays lost benefits peak at just over 2.0 percent in the early 2020's and gradually decline thereafter, falling to just under 1.0 percent by 2100. Since there are no age-cohort details available for the morbidity damages, a mid-point, terminal value of just over 2.0

percent of total workdays available was assumed. Essentially, the morbidity benefit trajectory tracks the EPA adjusted (and unadjusted) series to it peak of 2.0 percent where it remains for the balance of the simulation period.

It is useful to understand the composition of the morbidity damages. These initially are driven by chronic bronchitis arising from exposures to non-lead pollutants. In 1971, fifty percent of the unadjusted damages are due to chronic bronchitis. This proportion increases to 82 percent by 1980 and to 89 percent by 1990. It peaks at 93 percent in 1993 when the lagged effects of lead-related IQ point losses first appear. These, then, begin to exert more influence and, ultimately, dominate the morbidity damages. In the long run, chronic bronchitis accounts for 41 percent of the morbidity effects while the embodied productivity consequences of reduced IQ's among the workforce account for 56 percent of the effects; together, they comprise almost 97 percent of the non-expenditure morbidity benefit.

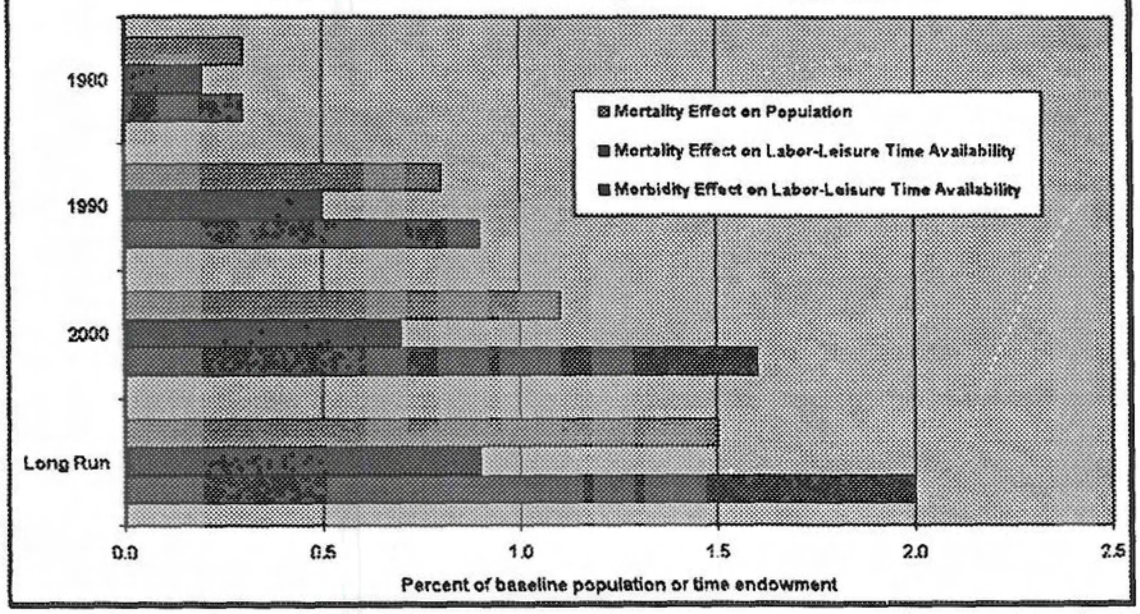
The direct benefits from the Clean Air Act are presented in Figures 4.1 and 4.2 below. Figure 4.1 summarizes the mortality and morbidity effects. Even in the near term, the estimated benefits from compliance with the Act are not trivial. By 1990, net avoided deaths are 0.8 percent of the population and, by 2100, they are 1.5 percent of the population. These deaths reduce labor availability by 0.5 and 0.9 percent, respectively. The morbidity effects add to these. By 1990, morbidity adds another 0.9 percent in activity days lost and, by 2100, morbidity accounts for an additional 2.0 percent reduction in labor's time endowment. The combined impacts on labor availability total 0.5 percent in 1980, 1.4 percent in 1990, 2.3 percent in 2000 and 2.9 percent by 2100.

The *1993 Statistical Abstract of the United States* (Table 126) reports death rates due to major cardiovascular diseases, chronic obstructive pulmonary diseases, pneumonia and influenza, and acute bronchitis of approximately 1.1 million persons in each of the years 1980 and 1990. The premature deaths (unrelated to lead exposure) underlying Figure 4.1 were estimated at 145,884 and 183,539 persons in 1980 and 1990, respectively. (These are 94 and 90 percent, respectively, of the total mortality effects.) These data imply that the Clean Air Act reduced the deaths due to the aforementioned illnesses by 12 and 15 percent in 1980 and 1990, respectively.

A similar perspective can be developed for the morbidity effects. By 1990, the morbidity effect has risen to almost 1 percent of the household time endowment. These damages are introduced as reductions in the discretionary, quality-adjusted time available (14 hours per day, 7 days per week and 52 weeks per year) for work and leisure. The morbidity benefits focus on avoiding restricted activity days and not simply avoiding work-loss days. While it turns out that the proportionate reductions in labor services (work) demanded and supplied mirror these damages, the labor-leisure decision is an internal model outcome. The *1993 Statistical Abstract of the United States* (Table 199) reports on disability days. In 1970, there were 2109 million restricted activity days associated with the 135.0 million non-school-aged persons under 65 years of age. In 1990, there were 2522 million restricted activity days associated with the 170.3 million non-school-aged persons under 65 years of age. This segment of the population, comprising around 90 percent of the working-age population, averaged 15.6 and 14.8 days of restricted activity per person in 1970 and 1990, respectively. On an annual basis, these figures indicate an activity loss (for both work and leisure) due to injury and illness of slightly more than 4 percent of all available days for almost 70 percent of the population. Moreover, this loss declined by over 5 percent between 1970 and 1990. In magnitude, EPA's morbidity benefits are in the range of 20 to 25 percent of these figures implying that the absence of the Clean Air Act would be responsible for an increase in excess of 20 percent in restricted activity days due to injury and illness. (Actual workdays lost averaging 5.4 and 5.3 days per civilian employee in 1970 and 1990, respectively, are only partially relevant here as the benefit focus is on the time available for work *and* leisure and the model ultimately determines the allocation of time to each.)

The expenditure effects portrayed in Figure 4.2 are relatively small, reaching a peak of less than 0.8 percent of all spending on personal and business services. Initially, the avoided expenditures rise in comparison to the underlying spending. However, by the early to middle 1990's, the pace of total spending on services begins to outstrip the estimated avoided expenditures on healthcare, home maintenance and education. For the period beyond 2000, it was assumed that avoided expenditures would remain at 0.7 percent of annual spending.

Figure 4.1: Mortality and Morbidity Effects
Counterfactual Scenario: No Adoption of the Clean Air Act



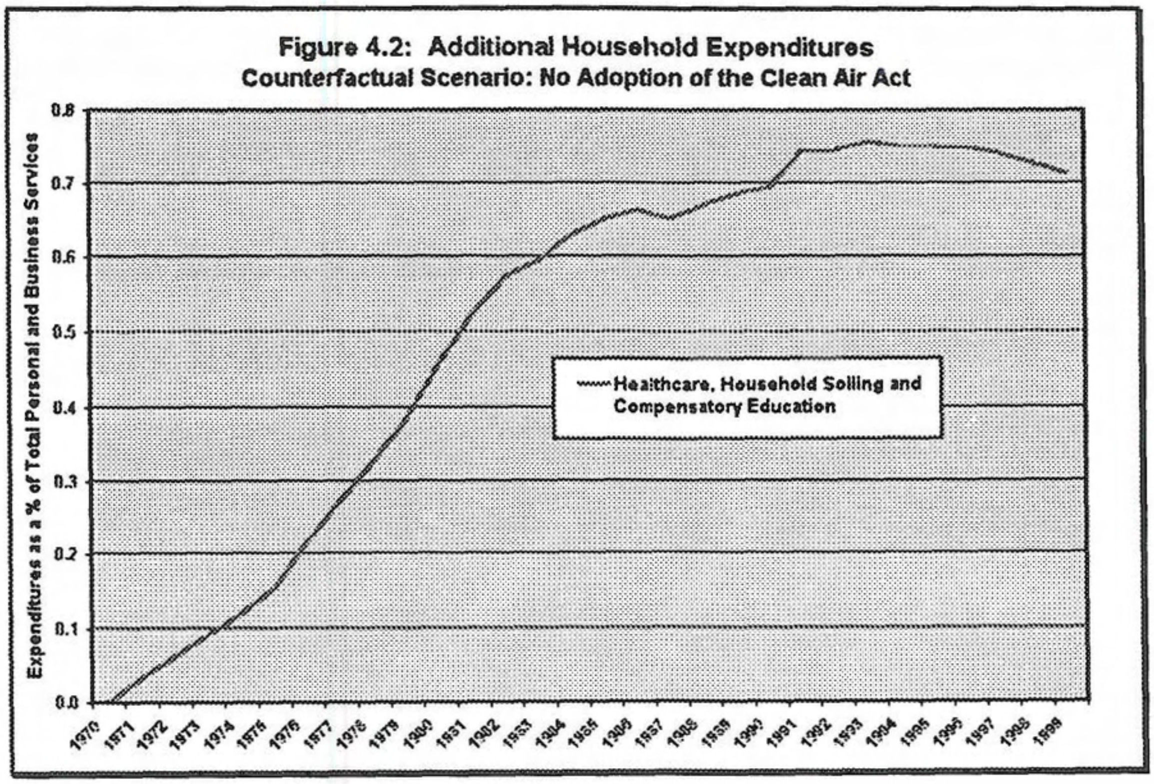


Figure 4.2: Additional Household Expenditures
Counterfactual Scenario: No Adoption of the Clean Air Act
Expenditures as a % of Total Personal and Business Services
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Healthcare, Household Soiling and Compensatory Education
1970
1971
1972
1973
1974
1975
1976
1977
1978
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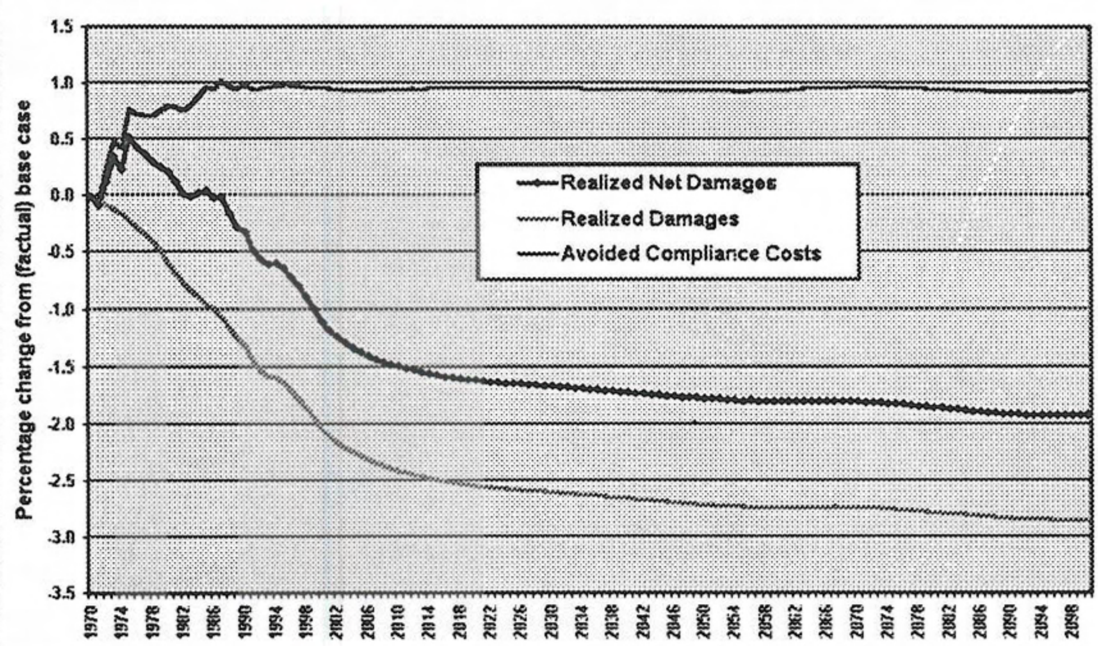
1999

5. Economic Performance and Welfare

Economic Performance

The Clean Air Act provides sustained, long-run economic benefits. Real GDP ultimately is as much as 2.0 percent higher as a consequence of its enactment. Figure 5.1 summarizes these results. Note that in this figure and the ones to follow, economic costs appear as gains whiles economic benefits appear as losses; this is due to the counter-factual procedures adopted for the model simulations. Were the economy to avoid the costs of compliance, final spending eventually would be almost 1.0 percent greater. However, this ignores the benefits arising from the Act. Were these to be avoided, final spending eventually would be almost 3.0 percent lower. On balance, there are initial net economic losses as the private costs of compliance, operating through the "crowding out" of productive investment and through productivity decline, exceed the benefits of the avoided damages to life and health. By the late 1980's, there are annual net benefits as the ongoing avoidance of deaths and health-related workdays lost more than compensate the permanent costs of ongoing compliance. By the middle 1990's, there are cumulative net benefits that continue to grow as the time horizon is extended.

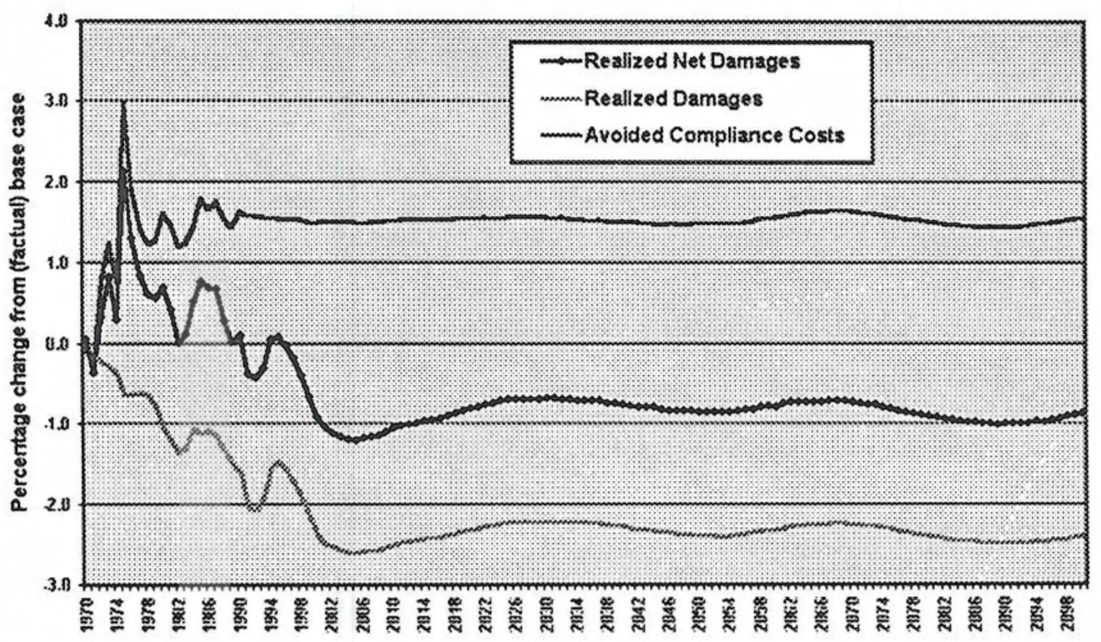
Figure 5.1: Impacts on Real GDP
Counterfactual Scenario: No Adoption of the Clean Air Act



The macroeconomic adjustments to CAA compliance are somewhat more intricate than the benefit adjustments. The principal impacts of compliance are on investment and capital accumulation and the economic restructuring associated with them. (See Figures 5.2 and 5.3.)

Adding a pollution control component to new capital is equivalent to raising the marginal price of investment goods. Combining this with the windfall loss of having to bring existing capital into compliance reduces the economy's rate of return on saving and investment. In turn, this reduces the level of real investment by producers and consumers. The price- and return-effects and less rapid (ordinary) capital accumulation imply a higher rental price for capital services and a corresponding lower demand. The capital rental price increases also serve to raise the prices of goods and services and, so, the overall price level.

Figure 5.2: Impacts on Real Investment
Counterfactual Scenario: No Adoption of the Clean Air Act



The price effects from investment changes are augmented by the cost increases associated with diverting resources to the operation and maintenance of pollution control equipment and by the higher prices caused by regulations on mobile sources. As a result of higher prices, each dollar flow supports fewer quantity purchases. Real consumption, real investment and real purchases by governments all fall. Ultimately, real income (Figure 5.1) and consumption (Figure 5.4) fall by one percent while real investment (Figure 5.2) and the capital stock (Figure 5.3) decrease by one and one half percent.

Figure 5.3: Impacts on Capital Stock
Counterfactual Scenario: No Adoption of the Clean Air Act

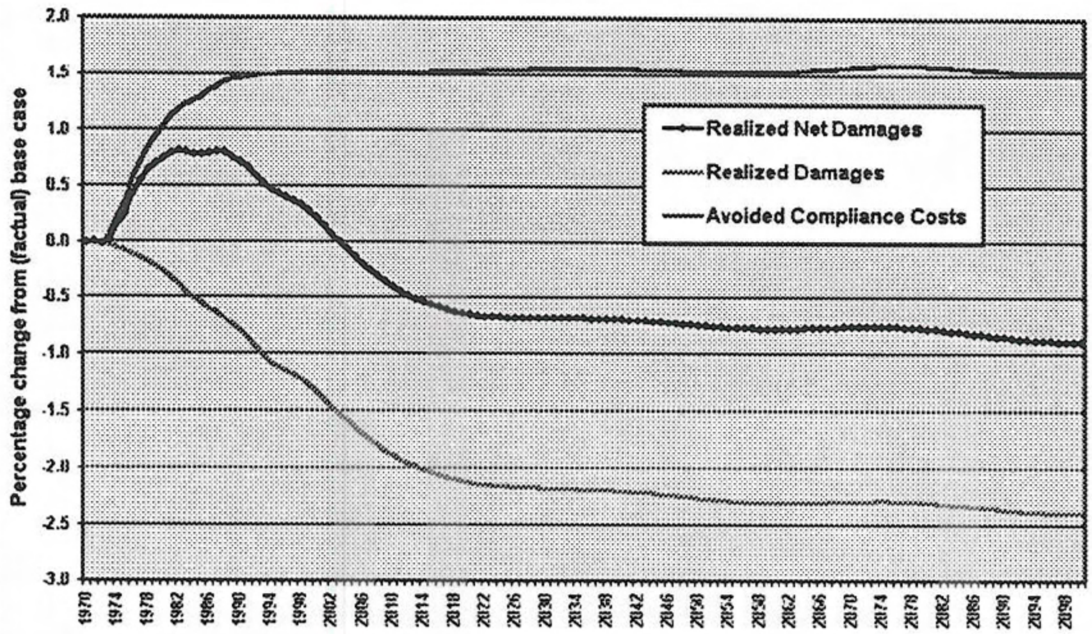
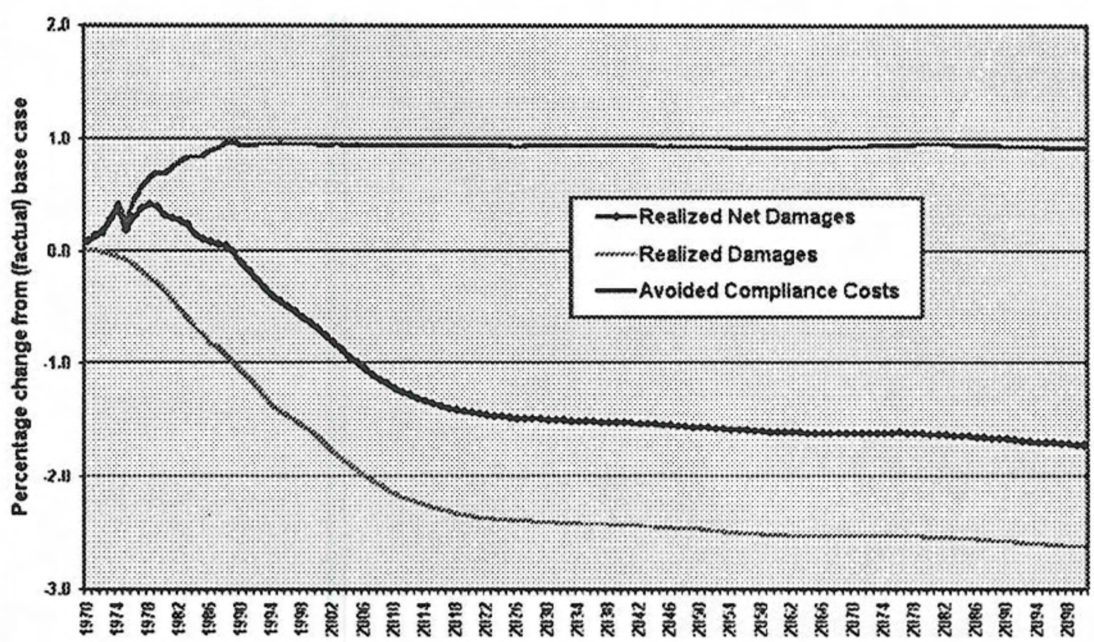
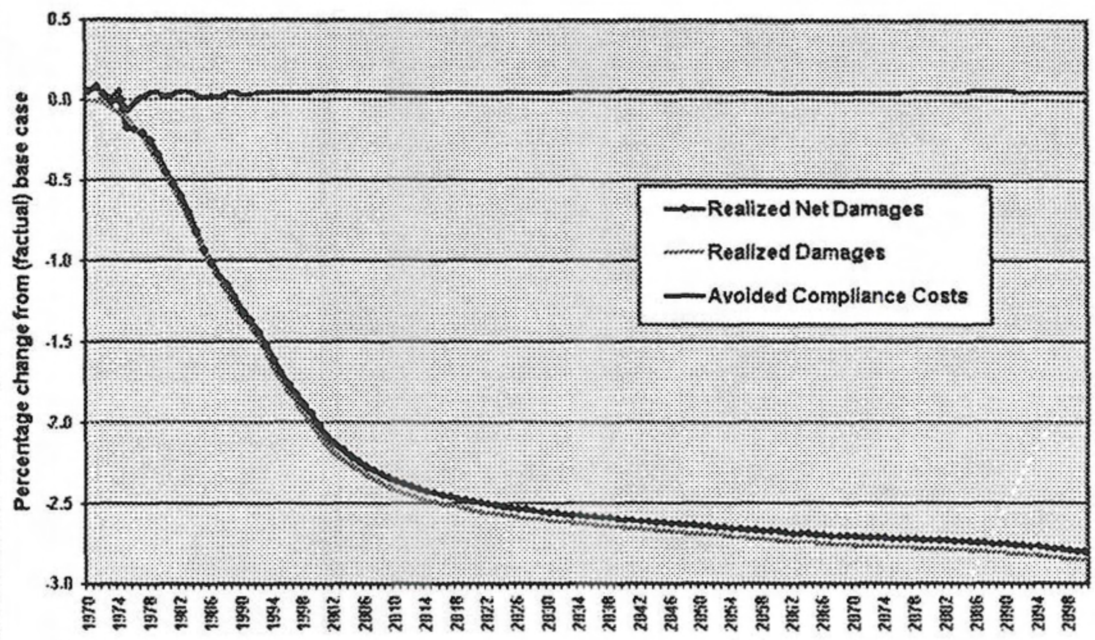


Figure 5.4: Impacts on Real Consumption
Counterfactual Scenario: No Adoption of the Clean Air Act



To households, CAA compliance costs act to reduce permanent future real earnings (income) through their price effects. This leads to a decrease in real consumption in all periods (Figure 5.4) and, generally, to decreases in household saving and the demand for leisure (Figure 5.5). Households marginally increase their offer of labor services (Figure 5.6) as the income effects of lower real earnings dominate the substitution effects of higher goods prices. The income effects arise as lower income leads to lower consumption of goods, services *and* leisure, thus increasing labor supply. The substitution effects arise as higher prices for goods and services promote less consumption of them and a greater consumption of leisure, thus reducing labor supply.

Figure 5.5: Impacts on Leisure Demand
Counterfactual Scenario: No Adoption of the Clean Air Act



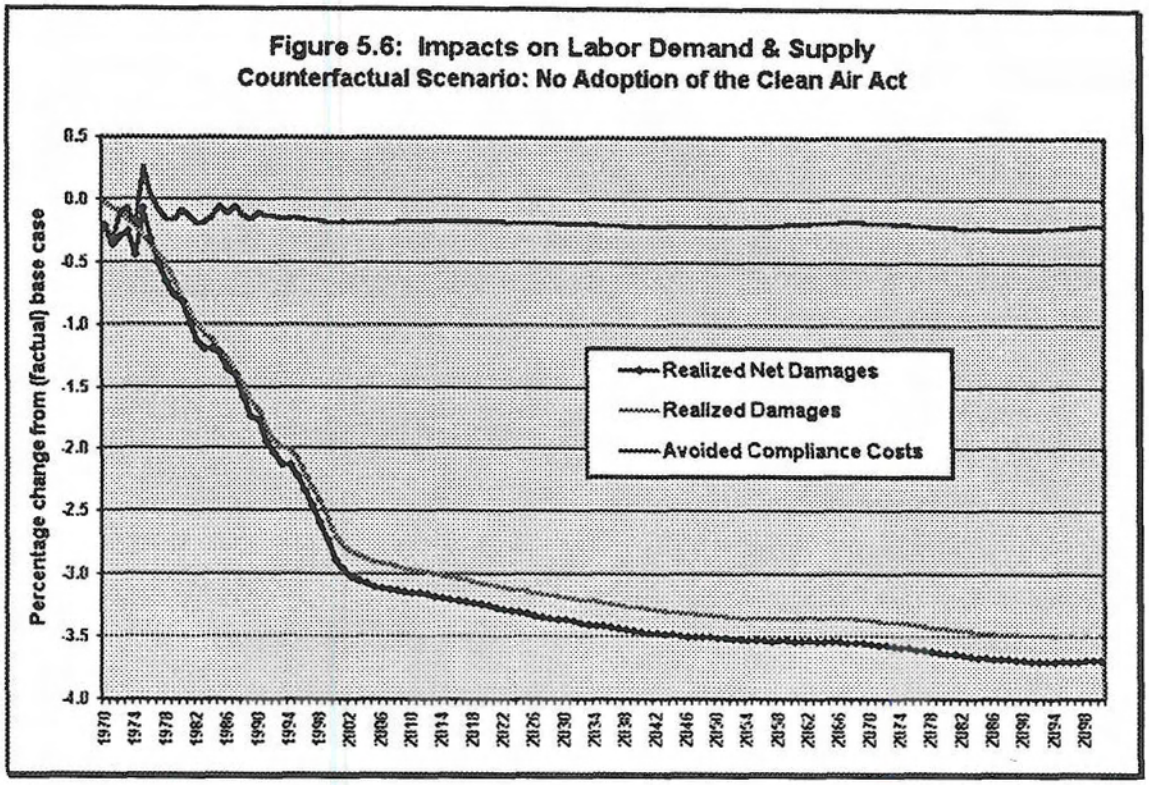
Real spending by governments falls as a consequence of higher commodity prices and the adjustments that hold spending in line with changes in tax revenues and maintain (by assumption) government deficit at previous levels. Real net exports rise. This occurs as the dollar weakens by an amount that is sufficient to keep the current account surplus unchanged. Within this overall adjustment, real exports fall as the U.S. becomes less competitive. Real imports also fall because of the weaker dollar and, more importantly, because of the increases in motor vehicle and refined petroleum import prices that accompany CAA compliance.

Finally, productivity effects offer additional supply-side costs to the economy. These arise mainly from the input and output restructuring that takes place. Relative price changes alter the input patterns within each producing sector and change the level of input-to-output productivity. Relative prices changes and the altered structure of final demand, both within and across spending categories, change the output composition of the economy. Since productivity differs among industries, this compositional change affects overall productivity. This output effect on overall productivity also appears in the input-to-output relation between the intermediate use of goods and services and final demand (value added). Lastly, there are smaller effects as higher factor prices decrease the endogenous rates of productivity growth in those industries that are factor using. Higher rental prices for capital harm the capital-using sectors, higher materials prices harm the materials-using sectors and higher energy prices harm the energy-using sectors. Thus, the principal effects arising from the costs associated with clean air initiatives are to slow the economy's rate of capital accumulation and, by restructuring economic activity, its overall rate of productivity growth.

The macroeconomic adjustments to CAA benefits are more straightforward. There is a small productivity benefit leading to lower prices as resources in the services sector are released from healthcare, home maintenance and compensatory education activities. There is a much larger benefit from having a larger population and time endowment. These affect the scale of the economy and the broad categories of spending within it. As shown in Figures 5.5 above and 5.6 below, the impacts on leisure demand and labor supply follow directly from the avoided deaths and workdays lost attributed to the Clean Air Act. These add primary inputs to production and consumers to purchase this output. Production and spending are simply greater, with increases approximately equal to the proportionate increases in people and time. More people and time favor labor supply and consumption proportionally more than saving and investment. For reasons of both demand-pull and cost-push, prices related solely to the benefits are higher under the CAA, the exception being services as noted above. Greater labor availability relative to capital encourages substitution of the former relative to the latter. Saving and investment and, hence, the nation's capital stock increase substantially but proportionally less so than labor supply and consumption. Labor and primary-factor productivity fall while capital productivity rises. The declining capital-labor ratio also contributes to slower overall productivity growth. Thus, the benefits of the Clean Air Act derive from its effects on the primary inputs to production, labor and, to a somewhat lesser extent, capital.

The net benefits of the CAA combine the early capital and productivity losses of compliance with the subsequent labor and capital gains associated with fewer deaths and workdays lost. In the short run, the Clean Air Act proves costly to the economy. A lower capital stock and reduced productivity more than offset the induced and benefit-driven gains from labor. However, over time, the benefits continue to mount while the compliance costs stabilize. Ultimately, under the CAA, the economy is larger with a larger population, a larger pool of labor and a greater capital stock.

It is interesting to note that much of the 1970's and 1980's were characterized by a relatively rapid growth in labor supply accompanied by comparatively slower rates of growth in capital accumulation and productivity. The 1990's experienced a significant reversal in the slowdowns in capital formation and productivity while continuing the strong trends in job growth. The nature and timing of the adjustments described above are entirely consistent with these observed patterns. Clearly, the Clean Air Act was not wholly responsible for the trends of the last thirty years. However, given the remarkable consistency of historic trends and the aforementioned adjustments, the Clean Air Act clearly exerted identifiably measurable influences on observed economic performance.



Welfare Considerations

The 1970 Clean Air Act and its 1977 Amendments secure a net benefit to economic welfare in the amount of $(1990) 26.2 trillion. A cumulative benefit of $(1990) 27.9 trillion is partially offset by market costs of $(1990) 1.7 trillion. The former arise as a consequence of the mortality, morbidity and productivity effects of the CAA while the latter reflect the direct and indirect costs of compliance. Table 5.1 summarizes the details of net welfare under the assumptions that benefits and costs accrue indefinitely and are discounted at IGEM's social rate of time preference of approximately 2.9%.

Table 5.1:
The Impacts on Household Welfare
Present Value to 1990 at 2.9%
Trillions of 1990 Dollars

Welfare Coverage	Net Benefit Calculation	Decomposition of Net Benefit Calculation
Total CAA Benefits	**$27.9**	
CAA mortality benefits based on the value of a statistical life (life-year) saved		$21.1

CAA morbidity and productivity benefits in terms of the market values of goods, services and leisure		+6.8
Less CAA costs in terms of the market values of goods, services and leisure	**-1.7**	-1.7
Equals CAA Net Benefits	**$26.2**	$26.2

Note: CAA mortality benefits in terms of the market values of goods, services and leisure are estimated at $(1990) 3.0 trillion.

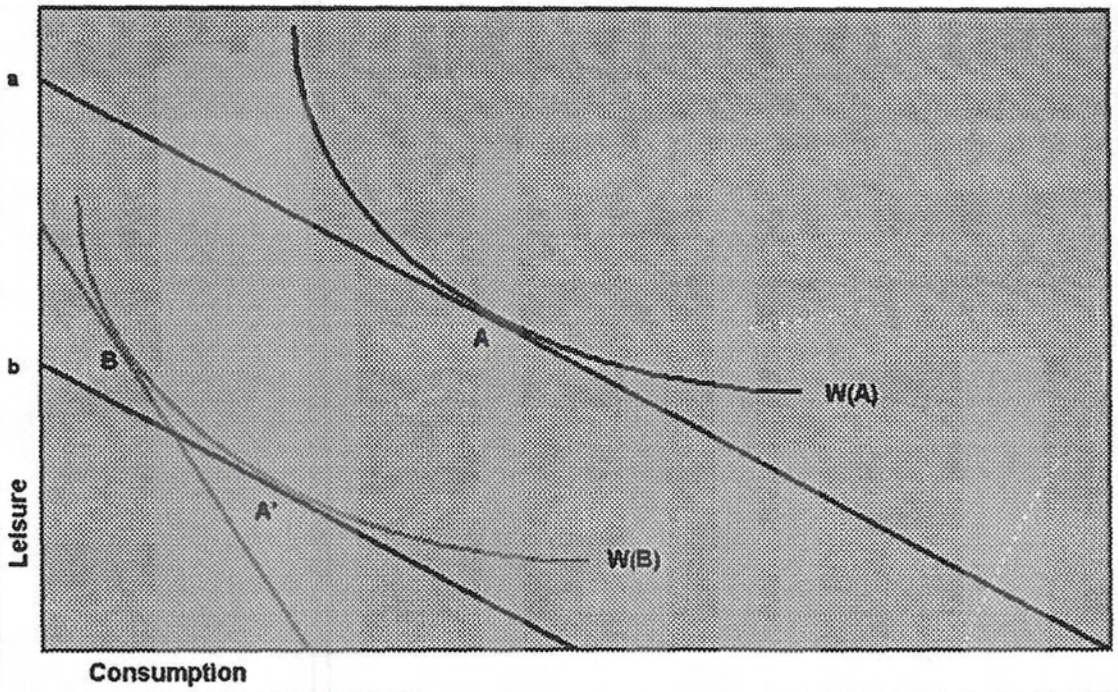
The mortality benefits of $(1990) 21.1 trillion combine EPA's value of a statistical life (VSL) saved with the cumulative, discounted population change attributable to the CAA. In assessing the mortality benefits of environmental policies, EPA employs a literature-based valuation for a statistical life saved of $(1990) 4.8 million (EPA 1997 and 2000). This figure goes beyond purely market considerations and measures the willingness-to-pay to avoid a premature death. As such, it incorporates not only a market-based willingness-to-pay in terms of foregone consumption and leisure but also an insurance or option premium willingly paid to avoid a foregone life. Valuations of a statistical life-year (VSLY) saved are easily determined from the lifetime value by computing annuities under various discount rates and time horizons. The $(1990) 21.1 trillion mortality benefit results from applying an annuity value of about $138,500 to the change in the discounted, present value population or, equivalently, from applying the 4.8 million to the discounted present value of the change in additions to the population. In the case of the former, an annuity value is used because benefits (i.e., particular avoided deaths) appear in multiple periods (i.e., until these same deaths would have occurred naturally). In the case of the latter, the lifetime valuation is used because benefits appear only once in the benefit stream (i.e., in the period in which the deaths were avoided).

IGEM offers a purely market view of economic welfare. Within IGEM, indirect utility functions are recoverable from the systems of household demand functions involving goods and services (i.e., consumption by commodity) and aggregate consumption and leisure (i.e., full consumption). These can be inverted to give the level of expenditure necessary to achieve a given level of welfare at a prevailing set of prices. From these, equivalent variations or households' willingness-to-pay are computed. These provide a broad market-based perspective of general equilibrium welfare in that all factor and product markets are considered on a national scale. However, this perspective is limited in that it does not consider welfare valuations beyond those reflected in market prices and transactions (e.g., the option value of an avoided premature death).

Although model structures differ greatly, the metrics in IGEM are conceptually identical to the work of Sieg, et. al. (2000) which estimates the welfare benefits of large scale reductions in ozone in Southern California taking into account the general equilibrium consequences for housing prices and location choice. (IGEM, of course, offers a broader notion of general equilibrium in that all factor and product markets are considered and in that its scale is national. However, the paths from theory to practice are the same.)

Figure 5.7 illustrates the market implications of a policy change for social welfare. (These features are illustrated for a static two-good world involving aggregate consumption and leisure. In IGEM, the actual welfare calculations are present value equivalent variations determined from the time paths of interest rates and the prices for goods, services and leisure.) Figure 5.7 involves a move from situation A to B in which there is a welfare loss from W(A) to W(B). Implicitly, there is an increase in the relative price of consumption and a general equilibrium reduction in national income. The loss in social expenditure (or, money metric loss) conditional on the prices and interest rates of situation A and the welfare level of situation B, denoted as {A', W(B)} is given by the vertical distance {b-a}. This represents the market compensation that is necessary to achieve the new welfare level at the original prices and is the social equivalent variation or the measure of society's willingness to pay.

Figure 5.7: Changes in Social Welfare



IGEM permits two aggregate views of household welfare. Each represents the present-value compensation that is necessary to achieve the welfare levels of a new situation at common base-case prices and interest rates; each is a present-value equivalent variation. The two measures differ in terms of what is included in the underlying welfare function. The broader measure covers full consumption or the aggregate of goods, services *and* leisure. The narrower measure covers consumption or the aggregate of goods and services alone. The former is more relevant to this analysis. This is because of its inclusion of leisure and the fact that the benefits of the CAA predominantly influence the availability of people and time.

In considering only the cost-side adjustments, CAA compliance leads to a market loss in social welfare of $(1990) 1.7 trillion as shown in Table 5.1. This loss reflects the present-value changes in consumption and leisure that arise from the impacts on capital and productivity following enactment. It is this loss that partially offsets the $(1990) 27.9 trillion gain, leaving a net welfare benefit of $(1990) 26.2 trillion.

In considering the non-mortality benefits, the Clean Air Act secures a market gain in social welfare of $(1990) 6.8 trillion. This gain reflects the present-value changes in consumption and leisure that arise from the CAA-induced improvements in productivity and reductions in morbidity. The gains in productivity arise from reductions in environmentally related healthcare expenditures, household soiling costs that are no longer necessary and decreases in compensatory education expenditures associated with reduced lead concentrations. Adding this to the $(1990) 21.1 trillion in mortality benefits yields total CAA benefits of $(1990) 27.9 trillion.

Finally, and only for completeness, the mortality benefits of the CAA in terms of market gains in consumption and leisure are estimated at $(1990) 3.0 trillion. This measure is not employed in computing the social benefits of the CAA because it fails to reflect an all-important determinant of mortality valuation, namely, the insurance premium or option value willingly paid to avoid premature death. Instead, it is presumed to be part of the $(1990) 21.1 trillion in total CAA mortality benefits.

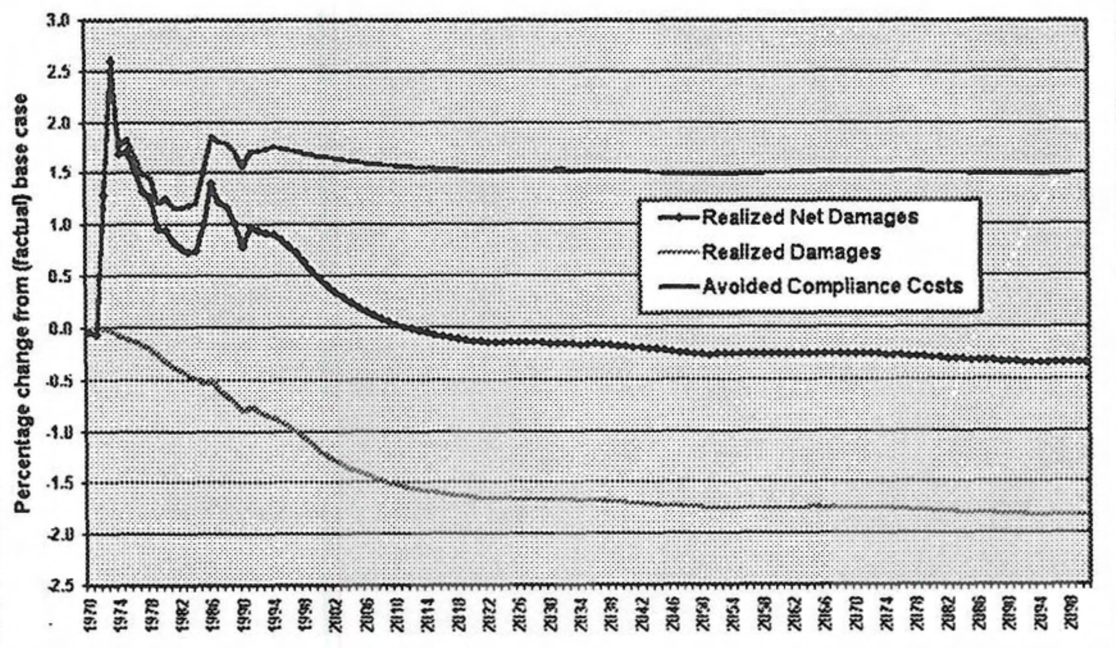
A perspective on IGEM's market valuation of mortality lies in the foundations of EPA's estimate of the value of a statistical life (VSL) saved. In the literature survey underlying EPA's $(1990) 4.8 million mean value, the range of valuations is from $(1990) 600,000 to 13.5 million or from 13 to 181% of the mean amount. The standard deviation from this range of observations is $(1990) 3.2 million or 67% of the mean amount. In addition, sensitivity analyses conducted by EPA on mortality benefits find the 5th percentile estimates to lie in the range of 15 to 25% of the mean and the 95th percentile estimates to lie in the range of 120 to 150% of the mean. The $(1990) 3.0 trillion market value of benefits from IGEM corresponds to a VSL of about $(1990) 700,000. This is toward the low end of EPA's range of data and analyses which is not surprising since it is based solely on market considerations. Were the CAA benefits to comprise only the market valuations from IGEM, a total market-based benefit of $(1990) 9.8 trillion also would more than compensate the $1.7 trillion cost, leaving a net welfare gain of $(1990) 8.1 trillion in terms of additional consumption and leisure. This is consistent in sign and magnitude with the economic findings discussed above. Still, it is not an appropriate welfare valuation because it does not fully capture the considerations of willingness-to-pay that are common in the VSL and mortality-benefit literature. On balance, the conclusion that the insurance premium or option value on a statistical life adds significantly to the net welfare gain in purely market terms seems well justified and, therefore, the net welfare gain of $(1990) 26.2 trillion for the CAA appears quite defensible.

The welfare results become more readily identifiable when expressed on an annual basis. At IGEM's social rate of time preference of 2.9%, the CAA net benefit of $(1990) 26.2 trillion corresponds to a benefit of $(1990) 756 billion annually. Real GDP in the year 2000 was about $(1990) 7,980 billion. In percentage terms, the CAA net benefit represents less than ten percent of current income. As significant as this seems, the benefits are far smaller proportions of overall economic activity than some have portrayed them (e.g., Sieg, et. al., 2000). Moreover, these results reflect the magnitudes of the avoided premature deaths and adverse health consequences attributed to the CAA. As described in Section 4, the CAA is estimated to save lives in the range of 15.0 percent of those dying from cardiac and respiratory/pulmonary diseases and to reduce restricted activity days in excess of 20.0 percent leaving more time for work and leisure. Accordingly, in the long run, the absence of the CAA leads to a population that is 1.5 percent smaller and to a time endowment of labor that is almost three percent smaller. Thus, the magnitudes of net welfare benefits cannot be considered too surprising in view of the direct environmental consequences upon which they are based.

6. Energy and the Environment

IGEM features two physical indicators for energy and the environment that are driven by economic variables within its structure. These are aggregate fossil fuel use and carbon emissions. Figures 6.1 and 6.2 show the effects on these for the cost, benefit and combined benefit-cost simulations. The Clean Air Act secures substantial reductions in fossil fuel use and carbon emissions through the early years of the 21st century. Isolating the costs, energy reductions follow from the patterns of energy price increases and stabilize at 1.5 percent of base use. Emissions reductions follow a similar pattern but are slightly smaller in magnitude. Isolating the benefits, energy use and emissions increase gradually reflecting the increasingly larger economy. By 2010 or so, both fossil fuel use and carbon emissions are slightly higher than they would be in absence of the Clean Air Act. The long-run increases are in the range of 0.5 percent of base levels.

Figure 6.1: Impacts on Fossil Fuel Use
Counterfactual Scenario: No Adoption of the Clean Air Act



Figures 6.3 and 6.4 show, respectively, the relations of fossil fuel use and carbon emissions changes to changes in real GDP for the combined benefit-cost simulation. It is clear that the Clean Air Act secures permanent and significant reductions in the energy- and emissions-intensities of economy activity. However, as shown in Figure 6.5, the emissions-intensity of fossil fuel use increases under the act. As will be discussed in Section 7, this arises because of the reduced petroleum-intensity and increased coal-intensity of the nation's energy-consuming capital stock.

Figure 6.2: Impacts on Carbon Emissions
Counterfactual Scenario: No Adoption of the Clean Air Act

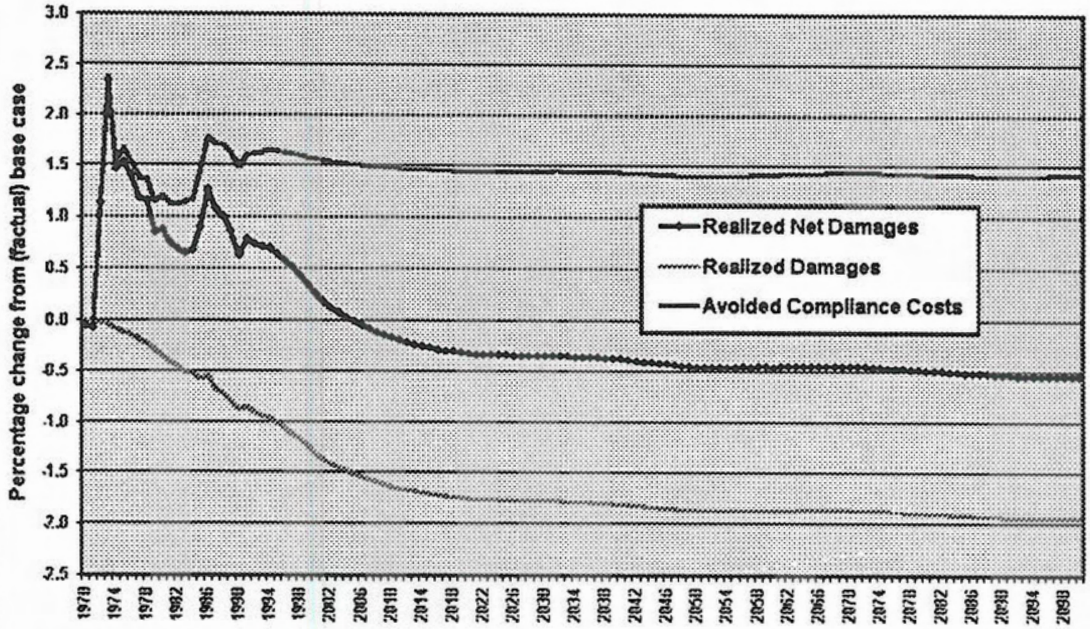


Figure 6.3: Net Impacts on the Fossil Fuel Intensity of the Economy
Counterfactual Scenario: No Adoption of the Clean Air Act

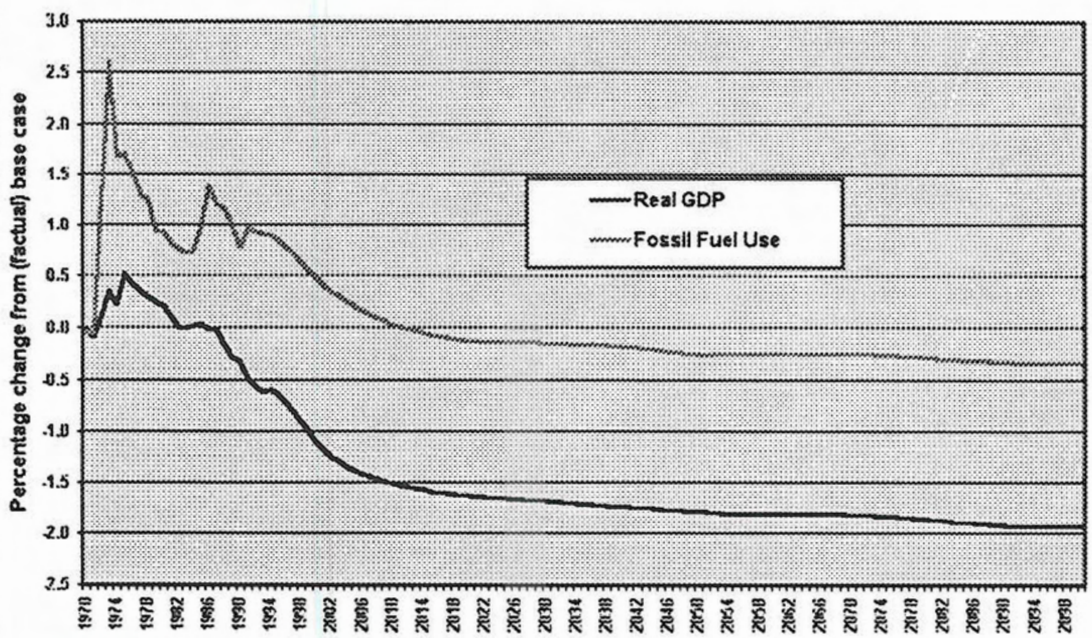


Figure 6.4: Net Impacts on the Carbon Intensity of the Economy
Counterfactual Scenario: No Adoption of the Clean Air Act

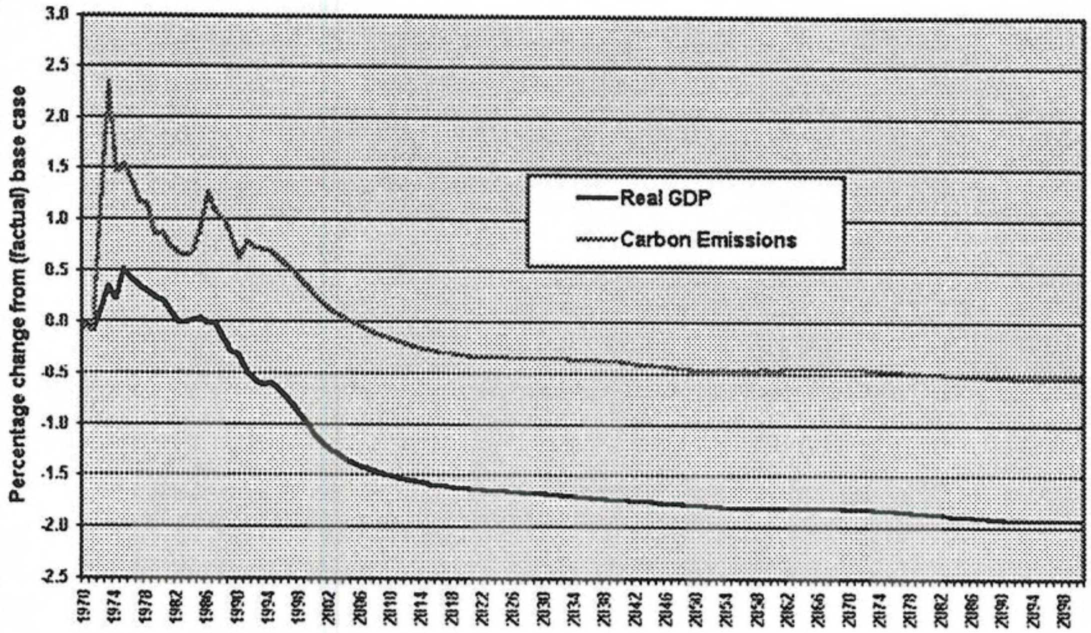
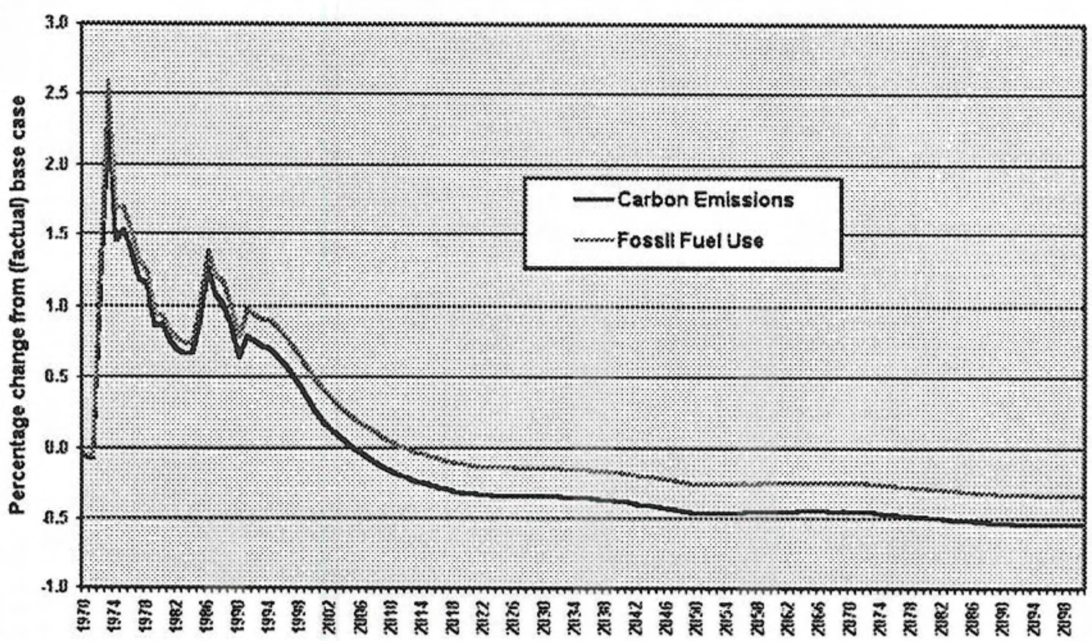


Figure 6.5: Net Impacts on the Carbon Intensity of Fossil Fuel Use
Counterfactual Scenario: No Adoption of the Clean Air Act



7. The Structure of Economic Activity

The Clean Air Act has its biggest direct impacts on the petroleum refining, motor vehicle and electric utility sectors (see Tables 3.1 and 3.3). To lesser extents, metal and coal mining, chemicals, primary metals and gas utilities also are affected directly. Operating through influences on price and productivity, these impacts are illustrated in Figure 7.1. This shows industry supply prices for 1990 as compliance costs were counter-factually eliminated. Figure 7.2 shows the output consequences of cost-side adjustments. Clearly, the CAA costs affect the composition of domestic supply. The mechanisms are as follows. Relative price changes follow from the CAA cost impacts and, in turn, alter the input patterns within each producing sector (compare Figures 3.2 and 7.1). For example, the direct effects in 1990 on the prices of refined petroleum, motor vehicles and electricity utilities are in the range of 1.5 to 2.5 percent and account for a majority of the general equilibrium price effects observed in Figure 7.1. These changes combine with the altered structure of final spending, both within and across the categories of final demand (consumption, investment, government and net foreign purchases), to change the output composition of the economy (see Section 4). As expected, those commodities whose cost structures are most affected by the CAA experience the largest comparative decreases in demand and supply under the Act. These include chemical and petroleum products, motor vehicles and other transportation equipment, and electricity and gas supply. Indirectly, these decreases and the decreased relative importance of investment goods adversely affect mining (energy and non-energy alike), the metals industries, and transportation services.

There are a few sectors that comparatively expand upon introduction of the CAA compliance costs. These include food and tobacco, furniture and fixtures, rubber and plastics, electronic equipment and high technology instruments, and services. For services, the expansive indirect effects of economic restructuring complement the benefits arising from reduced vehicle maintenance costs. In broad terms, compliance with the CAA appears partly responsible for accelerating the transition of the U.S. industrial landscape - a transition that is marked by the declining relative importance of basic industries and the increasing relative importance of technology and services.

The patterns of price and output changes associated with the Clean Air Act's benefits are much more uniform in nature. (See Figures 7.3 and 7.4.) The lone exception to this is the services sector that, here, reflects the productivity consequences of additional spending on healthcare, home maintenance and compensatory education. Beyond this, industry price and output changes are similar in magnitude and identical in direction. These mainly reflect the scale of activity, the economy being over one percent larger, and broad compositional changes as in proportionally greater increases in investment than in consumption.

Combining the benefits and costs of the Clean Air Act as in Figures 7.5 through 7.8 makes the mix of industrial winners and losers all the more visible. Figures 7.5 and 7.6 show the dynamic impacts on selected industries from the combined effects of CAA costs and benefits while Figures 7.7 and 7.8 are as above. In the presence of this legislation, the economy is larger but is much less intensive in mining, crude oil and gas extraction, petroleum refining, primary metals and motor vehicle production, and electric generation. However, electric generation is more coal- and gas-intensive and less oil intensive, which accounts for the increasing (carbon) emissions-intensity of fossil fuel use. Finally, the economy is much more intensive in the production of consumer non-durable goods, high technology capital equipment and services, the latter being aided by reduced housing and vehicle maintenance costs and avoided healthcare and educational expenses.

Figure 7.1: Impacts on Domestic Supply Prices, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act

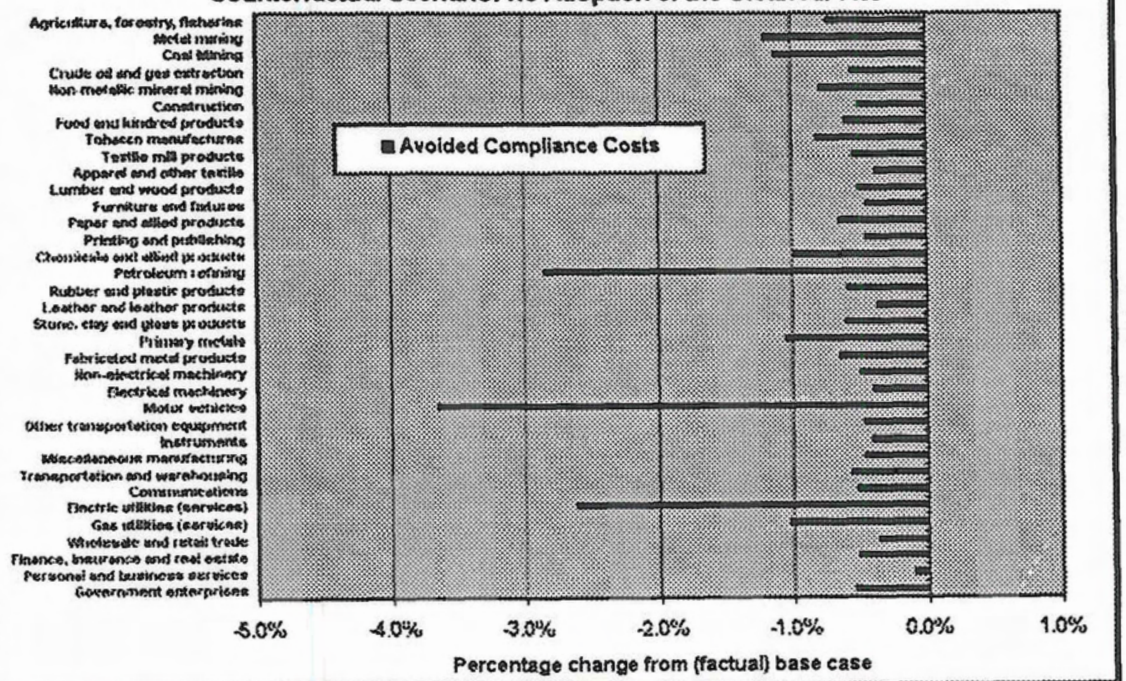


Figure 7.2: Impacts on Domestic Output, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act

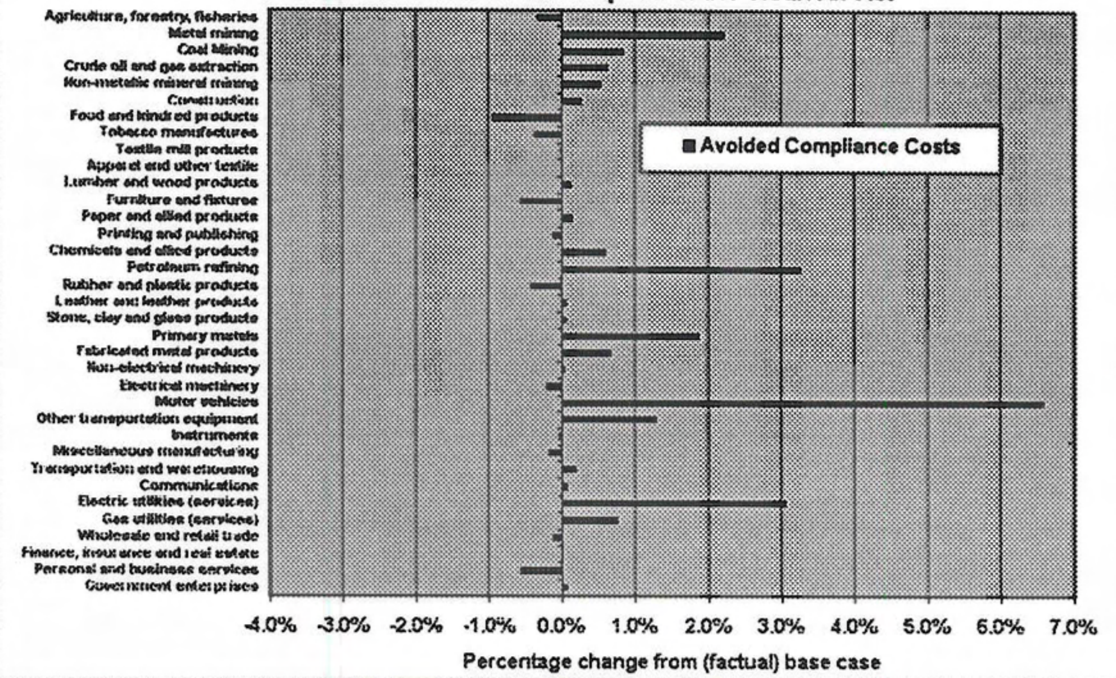


Figure 7.3: Impacts on Domestic Supply Prices, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act

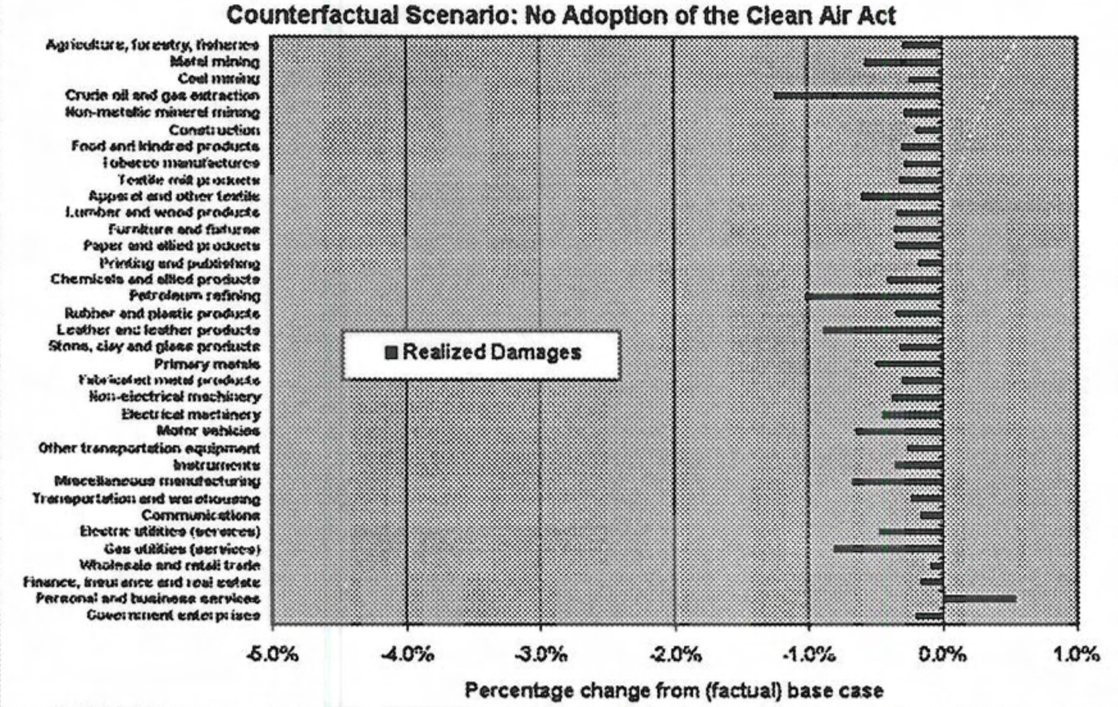


Figure 7.4: Impacts on Domestic Output, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act

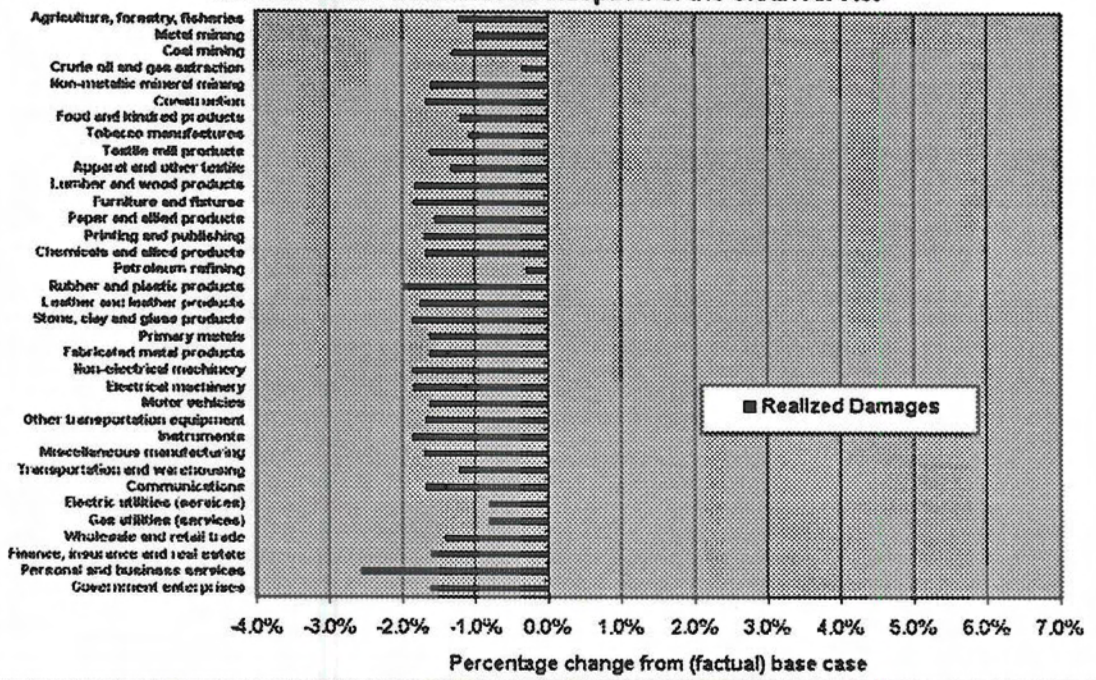


Figure 7.5: Realized Net Impacts on Domestic Supply Prices
Counterfactual Scenario: No Adoption of the Clean Air Act

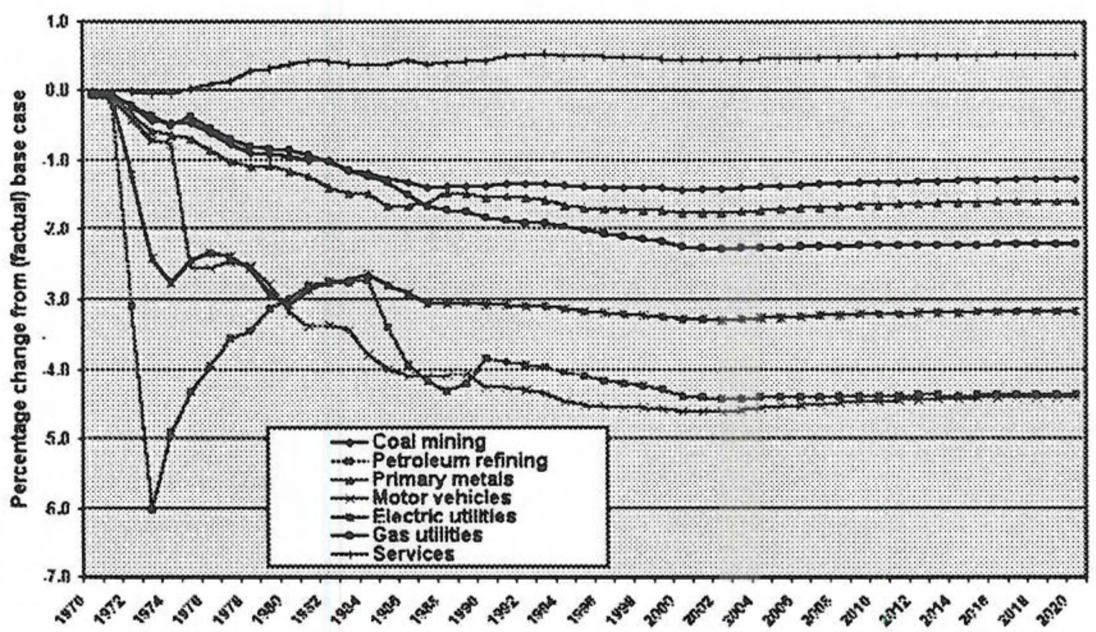


Figure 7.6: Realized Net Impacts on Domestic Output
Counterfactual Scenario: No Adoption of the Clean Air Act

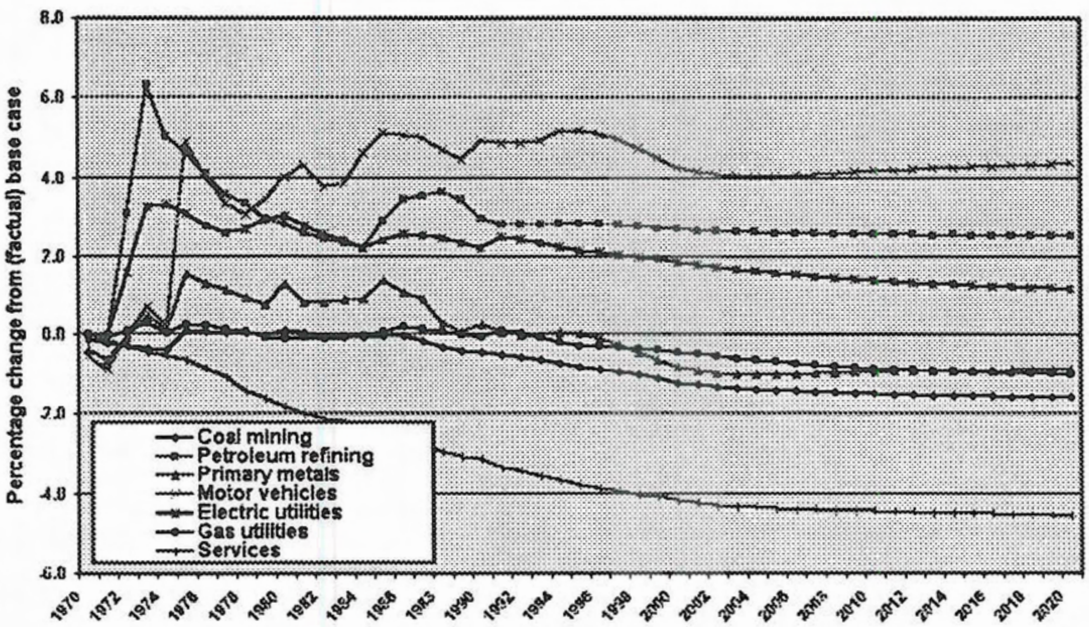


Figure 7.7: Impacts on Domestic Supply Prices, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act

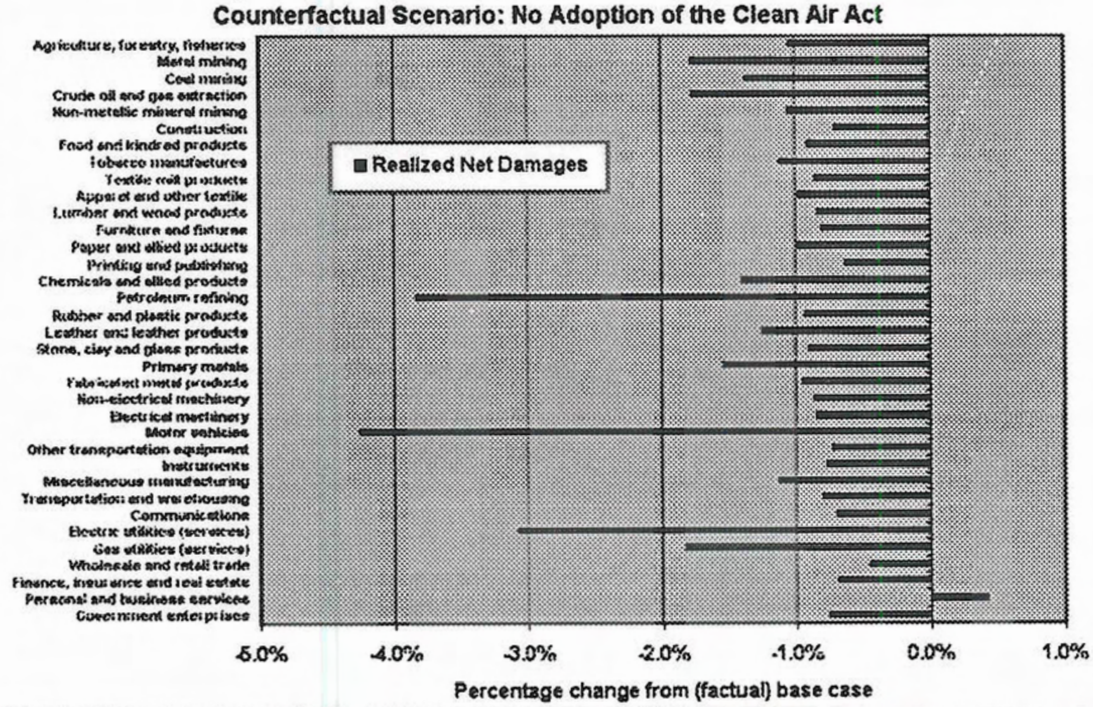
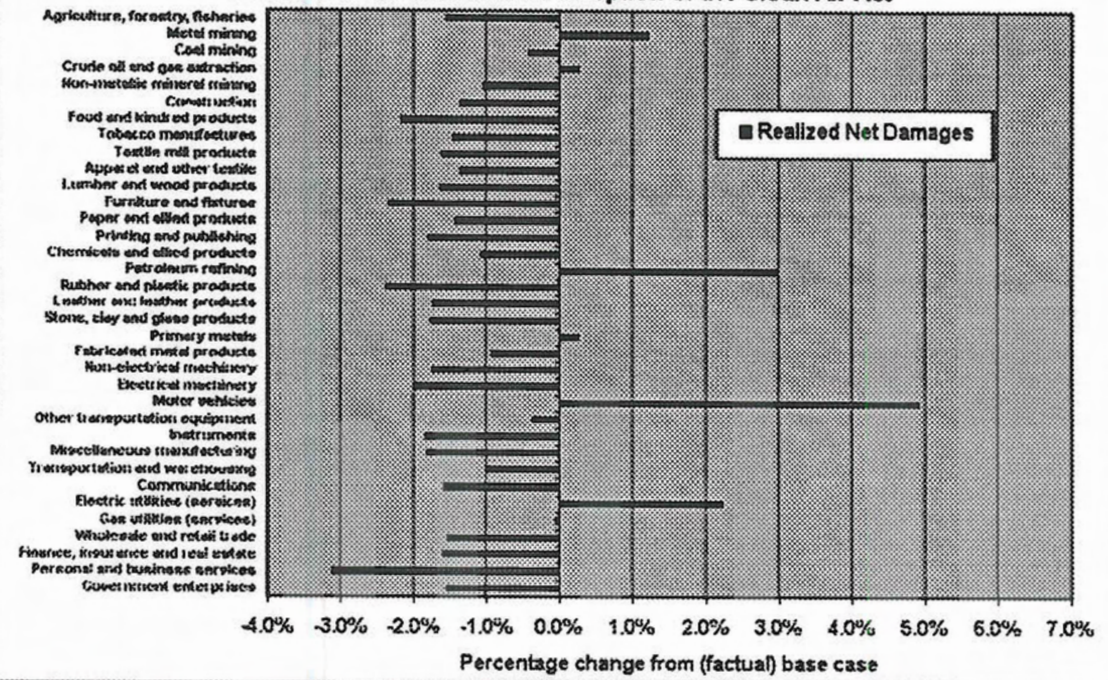


Figure 7.8: Impacts on Domestic Output, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act



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Appendix A

Benefits:
Sources, Methods and Data

Benefit Information from the Section 812 Retrospective Report for CGE Model Use

1. Mortality

PM-Related mortality

Total avoided premature mortality data presented in Table 1 for years 1975, 1980, 1985, and 1990 are taken from 812 Table D-13 (page D-45) (e.g., 58,764 for 1975). Total avoided deaths in other years in Table 1 are calculated by straight-line interpolation.. Breakouts by age group are based on the information in 812 Table D-14 (page D-46). The percentage of all premature mortalities attributed to each age group is noted above each age group category in Table 1. That percentage is applied to total mortalities each year to derive age group-specific mortalities.

Table 1. PM Mortality (avoided premature mortalities per year)

		AGE GROUP						
		2%	4%	6%	13%	24%	29%	22%
	total	30-34	35-44	45-54	55-64	65-74	75-84	85+
1970	0	0	0	0	0	0	· 0	0
1971	11,753	235	470	705	1,528	2,821	3,408	2,586
1972	23,506	470	940	1,410	3,056	5,641	6,817	5,171
1973	35,258	705	1,410	2,116	4,584	8,462	10,225	7,757
1974	47,011	940	1,880	2,821	6,111	11,283	13,633	10,342
1975	58,764	1,175	2,351	3,526	7,639	14,103	17,042	12,928
1976	76,188	1,524	3,048	4,571	9,904	18,285	22,095	16,761
1977	93,612	1,872	3,744	5,617	12,170	22,467	27,147	20,595
1978	111,036	2,221	4,441	6,662	14,435	26,649	32,200	24,428
1979	128,460	2,569	5,138	7,708	16,700	30,830	37,253	28,261
1980	145,884	2,918	5,835	8,753	18,965	35,012	42,306	32,094
1981	150,636	3,013	6,025	9,038	19,583	36,153	43,684	33,140
1982	155,387	3,108	6,215	9,323	20,200	37,293	45,062	34,185
1983	160,139	3,203	6,406	9,608	20,818	38,433	46,440	35,231
1984	164,890	3,298	6,596	9,893	21,436	39,574	47,818	36,276
1985	169,642	3,393	6,786	10,179	22,053	40,714	49,196	37,321
1986	172,421	3,448	6,897	10,345	22,415	41,381	50,002	37,933
1987	175,201	3,504	7,008	10,512	22,776	42,048	50,808	38,544
1988	177,980	3,560	7,119	10,679	23,137	42,715	51,614	39,156
1989	180,760	3,615	7,230	10,846	23,499	43,382	52,420	39,767
1990	183,539	3,671	7,342	11,012	23,860	44,049	53,226	40,379

Pb-Related mortality

For Pb-related effects, the 812 results were based on four separate analyses -- two sets of additive analyses (for Pb emissions from industrial processes, boilers, and electric utilities; and for Pb emissions from leaded gasoline), and two sets of alternative baselines (one holding all other Pb emissions at 1970 levels, the other at 1990 levels). Tables G-6, G-7, G-9, and G-10 give the four sets of results for male mortality by age group (40-54, 55-64, and 65-74), and Table D-13 gives infant mortality and adult female (age 45-74) mortality for the years 1975, 1980, 1985, and 1990. The D-13 results are reproduced in Table 2 below. The G-6 and G-7 results (for adult male mortality) were averaged, as were the G-9 and G-10 results, the two averages were then summed, with the sum reported in Table 2, below.[1] [For example, 1975 age 40-54 male mortality from Tables G-6,7,9,and 10 (0.1, 0.3, 309, and 476 respectively) is reported as 393 in Table 2]. Avoided deaths in other years in Table 2 are calculated by straight-line interpolation.

Table 2. Pb-Related Mortality (avoided premature mortalities per year)

		MEN				WOMEN			
	infant	40-54	55-64	65-74	total (40-74)	45-54	55-64	65-74	total (45-74)
1970	0	0	0	0	0	0	0	0	0
1971	91	79	56	21	156	23	17	6	46
1972	182	157	112	42	311	47	33	12	92
1973	274	236	169	63	467	70	50	19	139
1974	365	314	225	84	623	93	67	25	185
1975	456	393	281	105	778	117	83	31	231
1976	833	801	585	224	1,610	239	174	67	480
1977	1,210	1,209	888	344	2,442	361	265	103	728
1978	1,588	1,618	1,191	464	3,273	483	356	139	977
1979	1,965	2,026	1,495	584	4,105	605	446	174	1,225
1980	2,342	2,434	1,798	704	4,936	727	537	210	1,474
1981	2,660	2,897	2,120	852	5,869	865	633	254	1,752
1982	2,978	3,359	2,443	999	6,801	1,003	729	298	2,031
1983	3,297	3,822	2,765	1,147	7,734	1,141	826	342	2,309
1984	3,615	4,284	3,088	1,294	8,666	1,279	922	386	2,588
1985	3,933	4,747	3,410	1,442	9,599	1,417	1,018	430	2,866
1986	4,135	5,009	3,523	1,528	10,060	1,494	1,051	456	3,000
1987	4,337	5,271	3,636	1,614	10,521	1,570	1,083	481	3,134
1988	4,540	5,533	3,749	1,700	10,982	1,647	1,116	506	3,269
1989	4,742	5,795	3,862	1,786	11,444	1,723	1,148	531	3,403
1990	4,944	6,058	3,975	1,872	11,905	1,800	1,181	556	3,537

[1] Note that the D-13 results for infants and adult females sometimes differ from the Appendix G results. This is because the D-13 results are the mean values from a Monte-Carlo simulation using the Appendix G inputs, rather than a simple reporting of the Appendix G results.

Conversion of total adult female mortality to mortality by age group is accomplished by assuming the same age distribution associated with adult male mortality (i.e., if 50% of male mortalities in a year were in the 55-64 age group, then it is assumed that 50% of female mortalities in that year were in the 55-64 age group). Note that the female distribution might be skewed somewhat because the youngest age cohort (45-54) is smaller than the corresponding youngest male age cohort (40-54).

Total Mortality Effects

Table 3 sums the results presented in the first two tables, with one modification to the ealready-presented data. In Table 2, the youngest male age cohort is 40-54. Here, it is assumed that 1/3 of the age 40-54 mortalities occur in the 40-44 group, with 2/3 occuring in the 45-54 group.

Table 3. All Mortality Effects, 1970-1990 (avoided premature mortalities per year)

		AGE GROUP						
	infant	30-34	35-44	45-54	55-64	65-74	75-84	85+
1970	0	0	0	0	0	0	0	0
1971	91	235	496	781	1,601	2,848	3,408	2,586
1972	182	470	993	1,562	3,202	5,696	6,817	5,171
1973	274	705	1,489	2,343	4,802	8,543	10,225	7,757
1974	365	940	1,985	3,123	6,403	11,391	13,633	10,342
1975	456	1,175	2,481	3,904	8,004	14,239	17,042	12,928
1976	833	1,524	3,315	5,344	10,663	18,576	22,095	16,761
1977	1,210	1,872	4,148	6,784	13,322	22,914	27,147	20,595
1978	1,588	2,221	4,981	8,223	15,981	27,252	32,200	24,428
1979	1,965	2,569	5,814	9,663	18,641	31,589	37,253	28,261
1980	2,342	2,918	6,647	11,103	21,300	35,927	42,306	32,094
1981	2,660	3,013	6,991	11,834	22,336	37,259	43,684	33,140
1982	2,978	3,108	7,335	12,566	23,373	38,590	45,062	34,185
1983	3,297	3,203	7,680	13,297	24,409	39,922	46,440	35,231
1984	3,615	3,298	8,024	14,029	25,445	41,254	47,818	36,276
1985	3,933	3,393	8,368	14,761	26,482	42,586	49,196	37,321
1986	4,135	3,448	8,567	15,179	26,989	43,365	50,002	37,933
1987	4,337	3,504	8,765	15,597	27,495	44,143	50,808	38,544
1988	4,540	3,560	8,964	16,015	28,002	44,921	51,614	39,156
1989	4,742	3,615	9,162	16,433	28,509	45,700	52,420	39,767
1990	4,944	3,671	9,361	16,850	29,016	46,478	53,226	40,379

2. Non-Mortality Effects

Chronic Bronchitis

Table D-13 in the 812 report presents two estimates of new cases of chronic bronchitis per year, one based on a study by Schwartz, the other on a study by Abbet et al. Consistent with the 812 approach, Table 4 presents an average of the two as a mean estimate of the number of new cases per year. New cases for years other than 1970, 1975, 1980, 1985, and 1990 are derived by straight-line interpolation. It is assumed that the affected population contracts chronic bronchitis by middle age (i.e., by age 45), would not have died by 1990 (the expected remaining lifespan for a 40-year old is 38 years (from 812 Table D-14)), and would have continued emloyment at least until 1990 had chronic bronchitis not been contracted. The cumulative number of cases of chronic bronchitis in any year is then the sum of all new cases since 1970.

Table 4. Chronic Bronchitis Effects (thousands of $1990, and work-loss-days per year)

	Abbey	Schwartz	Avg	cumulative	($1000s) med expend.	wld
1970	0	0	0	0	0	0
1971	39,795	34,714	37,254	37,254	9,798	1,604,632
1972	79,589	69,428	74,509	111,763	29,394	4,813,897
1973	119,384	104,143	111,763	223,526	58,787	9,627,794
1974	159,178	138,857	149,018	372,544	97,979	16,046,323
1975	198,973	173,571	186,272	558,816	146,969	24,069,484
1976	270,105	229,719	249,912	808,728	212,695	34,833,753
1977	341,237	285,866	313,551	1,122,279	295,159	48,339,130
1978	412,368	342,014	377,191	1,499,470	394,361	64,585,614
1979	483,500	398,161	440,831	1,940,301	510,299	83,573,206
1980	554,632	454,309	504,471	2,444,772	642,975	105,301,905
1981	587,739	476,398	532,068	2,976,840	782,909	128,219,305
1982	620,846	498,487	559,666	3,536,506	930,101	152,325,405
1983	653,952	520,575	587,264	4,123,770	1,084,551	177,620,205
1984	687,059	542,664	614,862	4,738,632	1,246,260	204,103,706
1985	720,166	564,753	642,460	5,381,091	1,415,227	231,775,908
1986	724,488	572,400	648,444	6,029,535	1,585,768	259,705,879
1987	728,810	580,048	654,429	6,683,964	1,757,882	287,893,622
1988	733,131	587,695	660,413	7,344,377	1,931,571	316,339,134
1989	737,453	595,343	666,398	8,010,775	2,106,834	345,042,417
1990	741,775	602,990	672,383	8,683,158	2,283,670	374,003,471

The 812 report used a modified CV-based willingness-to-pay estimate to value an avoided chronic bronchitis case. In an earlier valuation document produced by IEc,[2] however, a COI estimate for chronic bronchitis was developed. Based on a 1990 Cropper & Krupnick paper, annual medical cost is assumed to be ($1990) $263, and total COI is $3,838 per year (of which $3,575 is lost income, and $263 is medical expense). Since the 812 report values a lost work day at $83, then $3,575 of lost income represents, on average, [$3575/$83] 43.07 work loss days.

Table 4 (above) converts annual cases of chronic bronchitis into medical expenditures and work loss days. Each case is assumed to entail $263 of annual expenditure on medical care, and involve 43.07 work loss days per year. Thus, the cumulative 8.7 million cases avoided in 1990 resulted in $2.3 billion of avoided medical expense and 374 million work loss days in 1990.

[2] *Review of Existing Value of Morbidity Avoidance Estimates: Draft Valuation Document*, 30 Sept. 1993.

Non Pb-Related Hospital Admissions

Table 5 presents Non Pb-related hospital admissions for 1975, 1980, 1985, and 1990 from 812 table D-13. Admissions for other years are derived by linear interpolation (and assuming 0 for 1970). Where more than one source study for concentration-response functions are available, the "total" used to calculate 812 benefits is the mean of the results from the individual studies.

To derive expenditures on hospital admissions, the following per-incident valuations are assumed (from 812 Table I-2):

COPD & Pneumonia:	$ 8,100
Congestive Heart Failure:	$ 8,300
All Respiratory:	$ 6,100
Ischemic Heart Disease:	$10,300

In the 812 benefits analysis, the "COPD/pneumonia" and "all respiratory" results are assumed to be alternative measurements of a single health effect (rather than separate, additive health effects). Thus, in the 812 benefits estimate, expenditures for the two categories are averaged rather than summed. The total expenditure reported in Table 5 is:

$EXP = 8.3(\#CHF) + 10.3\ (\#IHD) + 0.5(8.1(\#COPD) + 6.1(\#resp))$.

Table 5. Non Pb-Related Hospital Admissions and Medical Expenditures (number of cases, and thousands of $1990 annually)

	COPD & Pneumonia					Congestive Heart Failure		
	Schwartz 94c	Schwartz spok	Schwartz 94a	Schwartz 94b	total	Schwartz & Morris	Morris	total
1970	0	0	0	0	0	0	0	0
1971	4,380	3,954	3,388	2,601	3,581	1,147	604	1,751
1972	8,759	7,908	6,777	5,202	7,162	2,293	1,209	3,502
1973	13,139	11,861	10,165	7,804	10,742	3,440	1,813	5,253
1974	17,518	15,815	13,554	10,405	14,323	4,586	2,418	7,004
1975	21,898	19,769	16,942	13,006	17,904	5,733	3,022	8,755
1976	28,304	25,274	21,730	16,541	22,962	7,259	4,126	11,386
1977	34,710	30,779	26,518	20,075	28,021	8,786	5,230	14,016
1978	41,116	36,284	31,306	23,610	33,079	10,312	6,335	16,647
1979	47,522	41,789	36,094	27,144	38,137	11,839	7,439	19,277
1980	53,928	47,294	40,882	30,679	43,196	13,365	8,543	21,908
1981	55,986	50,458	42,564	32,030	45,259	13,840	10,240	24,080
1982	58,044	53,623	44,245	33,381	47,323	14,316	11,937	26,253
1983	60,101	56,787	45,927	34,732	49,387	14,791	13,634	28,425
1984	62,159	59,952	47,608	36,083	51,451	15,267	15,331	30,598
1985	64,217	63,116	49,290	37,434	53,514	15,742	17,028	32,770
1986	65,479	66,515	50,477	38,629	55,275	16,066	17,989	34,055
1987	66,741	69,915	51,665	39,824	57,036	16,390	18,951	35,341
1988	68,004	73,314	52,852	41,020	58,797	16,714	19,912	36,626
1989	69,266	76,714	54,040	42,215	60,558	17,038	20,874	37,912
1990	70,528	80,113	55,227	43,410	62,320	17,362	21,835	39,197

	All Respiratory Admissions						Ischemic Heart Disease	Total Expend. ($1000s)
	Schwartz tacoma	Schwartz spokane	Pope	Shwartz NHaven	Thurston	total		
1970	0	0	0	0	0	0	0	0
1971	6,401	5,879	6,196	4,627	2,749	5,170	1,270	57,703
1972	12,802	11,757	12,393	9,255	5,498	10,341	2,539	115,406
1973	19,202	17,636	18,589	13,882	8,248	15,511	3,809	173,109
1974	25,603	23,514	24,786	18,510	10,997	20,682	5,078	230,813
1975	32,004	29,393	30,982	23,137	13,746	25,852	6,348	288,516
1976	41,169	37,404	39,404	29,529	17,473	32,996	8,020	369,594
1977	50,333	45,415	47,826	35,921	21,201	40,139	9,692	450,673
1978	59,498	53,427	56,249	42,312	24,928	47,283	11,365	531,752
1979	68,662	61,438	64,671	48,704	28,656	54,426	13,037	612,831
1980	77,827	69,449	73,093	55,096	32,383	61,570	14,709	693,909
1981	81,349	74,187	75,756	57,354	33,245	64,378	15,225	734,075
1982	84,870	78,924	78,419	59,612	34,106	67,186	15,741	774,241
1983	88,392	83,662	81,081	61,869	34,968	69,994	16,257	814,407
1984	91,913	88,399	83,744	64,127	35,829	72,803	16,773	854,572
1985	95,435	93,137	86,407	66,385	36,691	75,611	17,289	894,738
1986	97,703	98,368	88,223	67,876	38,555	78,145	17,651	923,907
1987	99,972	103,598	90,039	69,368	40,420	80,679	18,013	953,076
1988	102,240	108,829	91,854	70,859	42,284	83,213	18,374	982,244
1989	104,509	114,059	93,670	72,351	44,149	85,747	18,736	1,011,413
1990	106,777	119,290	95,486	73,842	46,013	88,282	19,098	1,040,581

Pb-Related Health Impacts (excluding IQ)

Hypertension and Coronary Heart Disease

Table 6 presents cases of Pb-related hypertension and coronary heart disease for 1975, 1980, 1985, and 1990 from 812 table D-13. Cases for other years are derived by linear interpolation (and assuming 0 for 1970).

In the 812 report, a case of hypertension is valued at $681 (since the "cases" of hypertension are really "numbers of people with hypertension in any year" (as opposed to, e.g., "individuals first diagnosed with hyperension"), then the valuation is $681 per year). This valuation includes physician care, drugs, and hospitalization costs ("avoided costs" in Table 6), as well as lost work days. On average, each case of hypertension causes 0.8 lost work days (see pg. G-9 of the 812 report). Since the 812 study values WLDs at $83 per day, the implicit WLD component of the $681 value is 0.8*$83 (or $66.40), and the remainder ($614.60) represents avoided costs. In Table 6, each hypertension case produces $614.60 in costs and 0.8 work-loss days.

Table 6. Avoided Costs and Work-Loss-Days from Pb-Related Hypertension and Coronary Heart Disease

	Hypertension			Coronary Heart Disease		
	(d-13) cases	avoided costs ($1000s)	WLDs	(d-13) cases	avoided costs ($1000s)	WLDs
1970	0	0	0	0	0	0
1971	166,060	102,060	132,848	263	13,655	11,292
1972	332,120	204,121	265,696	525	27,310	22,584
1973	498,179	306,181	398,544	788	40,966	33,875
1974	664,239	408,241	531,391	1,050	54,621	45,167
1975	830,299	510,302	664,239	1,313	68,276	56,459
1976	1,719,639	1,056,890	1,375,711	2,739	142,438	117,786
1977	2,608,979	1,603,478	2,087,183	4,165	216,601	179,112
1978	3,498,319	2,150,067	2,798,655	5,592	290,763	240,439
1979	4,387,659	2,696,655	3,510,127	7,018	364,926	301,765
1980	5,276,999	3,243,244	4,221,599	8,444	439,088	363,092
1981	6,239,022	3,834,503	4,991,218	10,089	524,649	433,844
1982	7,201,045	4,425,763	5,760,836	11,735	610,210	504,596
1983	8,163,069	5,017,022	6,530,455	13,380	695,770	575,349
1984	9,125,092	5,608,281	7,300,073	15,026	781,331	646,101
1985	10,087,115	6,199,541	8,069,692	16,671	866,892	716,853
1986	10,599,067	6,514,187	8,479,254	17,551	912,631	754,676
1987	11,111,019	6,828,833	8,888,816	18,430	958,370	792,499
1988	11,622,972	7,143,478	9,298,377	19,310	1,004,110	830,321
1989	12,134,924	7,458,124	9,707,939	20,189	1,049,849	868,144
1990	12,646,876	7,772,770	10,117,501	21,069	1,095,588	905,967

The valuation for coronary heart disease (CHD) in the 812 report, $52,000 per case, is a COI estimate that excludes forgone earnings due to WLDs. The report provides some discussion of possible magnitude of foregone earnings (noting that the magnitude varies inversely with the age of the affected person, and that it could be as great as the COI estimate for some age groups), but does not provide a "best estimate."

Tolley (1994) provides an estimate of "restricted activity days" for a variety of diseases, including an estimate of 43 RADs for CHD.[3] Kenkel (the author of the relevant chapter) notes that a RAD can "range from reduced activity alone to a day of work loss to a day of bed disability," but that "the RADs for the more serious conditions may reflect a greater restriction of activity than the RADs for the minor conditions." Based on the assertion that CHD is "one of the more serious conditions," I've assumed that Kenkel's CHD RAD is equivalent to a WLD in the 812 study. Thus, each case of CHD is associated with 43 WLDs as well as $52,000 in expenditure. Note that, at $83 per WLD, this implies $3,600 in lost income per CHD case, a magnitude somewhat smaller than those discussed in the "CHD-related lost earnings" paragraph of the 812 study (see page G-11).

Stroke

Table 7 presents cases of Pb-related initial cerebrovascular accident and atherothrombotic brain infarction (the two types of stroke are summed in Table 7) for men and for women for 1975, 1980, 1985, and 1990 taken from 812 table D-13. Cases for other years are derived by linear interpolation (and assuming 0 for 1970). The 812 study values avoided stroke for men as $200,000 per case, and for women as $150,000 per case (see 812 Table I-2). The valuation includes medical expenditures and reduced earnings – presumably, the gender-based difference is due to differences in labor market participation (although it is possible that there are differences in medical expenditure). For computational simplification, each female stroke case (valued at 75% of a male stroke case) has been redefined here as 3/4 of a male case (valued at 100% of a male stroke case). For example, 100 female stroke cases valued at $150,000 per case (for a total value of $15 million) would be redefined as 75 cases valued at $200,000 (for a total value of $15 million). The two types of cases are then summed (see the "m+3/4f" column in Table 7), to be valued at $200,000 per case.

The source study used for stroke valuation in the 812 report[4] divided lifetime cost of a first stroke into four components: Indirect costs (i.e., reduced earnings) and three categories of direct medical expenditure ("acute care", "long-term ambulatory care", and "nursing home" costs). In Table 7, below, each stroke case is assumed to cause two years of acute care, followed by ten years of ambulatory care, followed by ten years of nursing home care. Therefore, in 1972 (for example), there are 356 acute care cases, which is the sum of 1971 and 1972 stroke cases (from

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[3] Tolley, Kenkel, and Fabian (eds), "Valuing Health for Policy: An Economic Approach," 1994. See esp. pps. 69-70.

[4] Taylor, et al., Lifetime Cost of Stroke in the United States. *Stroke*, 1996; 27:1459-1466.

the column "m+3/4f"). In 1973, there are 594 acute care cases (which is the sum of 1972 and 1973 stroke cases), and 119 ambulatory care cases (i.e., stroke cases from 1971).

Table 7. Avoided Costs and Work-Loss-Days from Pb-Related Stroke

	(d-13) cases men	(d-13) cases women	m+3/4f	(2 yrs) acute cases	(3-12 yrs) amb. cases	(13-22 yrs) NH cases	(10 yrs) wld cases	avoided costs ($1000s)	WLDs
1970	0	0	0	0	0	0	0	0	0
1971	88	41	119	119	0	0	119	2,245	16,603
1972	176	82	238	356	0	0	356	6,736	49,810
1973	265	122	356	594	119	0	713	11,576	99,620
1974	353	163	475	832	356	0	1,188	16,765	166,034
1975	441	204	594	1,069	713	0	1,782	22,304	249,051
1976	905	421	1,221	1,815	1,188	0	3,003	37,793	419,675
1977	1,370	637	1,848	3,069	1,782	0	4,851	63,235	677,908
1978	1,834	854	2,475	4,322	3,003	0	7,325	90,519	1,023,749
1979	2,299	1,070	3,101	5,576	4,851	0	10,427	119,646	1,457,198
1980	2,763	1,287	3,728	6,830	7,325	0	14,155	150,616	1,978,254
1981	3,274	1,527	4,419	8,148	10,427	0	18,455	184,643	2,579,288
1982	3,785	1,767	5,110	9,530	14,155	0	23,328	221,725	3,260,299
1983	4,297	2,006	5,801	10,912	18,455	119	28,773	260,690	4,021,287
1984	4,808	2,246	6,492	12,294	23,328	356	34,790	301,537	4,862,252
1985	5,319	2,486	7,184	13,676	28,773	713	41,380	344,266	5,783,194
1986	5,578	2,601	7,529	14,712	34,790	1,188	47,688	382,343	6,664,794
1987	5,838	2,715	7,874	15,403	41,380	1,782	53,714	415,768	7,507,052
1988	6,097	2,830	8,220	16,094	47,688	3,003	59,459	449,419	8,309,967
1989	6,357	2,944	8,565	16,784	53,714	4,851	64,923	483,295	9,073,541
1990	6,616	3,059	8,910	17,475	59,459	7,325	70,105	517,397	9,797,772
1991				8,910	64,923	10,427	65,685	376,793	9,180,135
1992					70,105	14,155	60,575	229,888	8,465,918
1993					65,685	18,455	54,774	224,120	7,655,120
1994					60,575	23,328	48,281	217,282	6,747,741
1995					54,774	28,773	41,098	209,373	5,743,782
1996					48,281	34,790	33,569	200,394	4,691,557
1997					41,098	41,380	25,695	190,345	3,591,067
1998					33,569	47,688	17,475	178,808	2,442,310
1999					25,695	53,714	8,910	165,782	1,245,288
2000					17,475	59,459	0	151,268	0
2001					8,910	64,923	0	135,266	0
2002					0	70,105	0	117,776	0
2003					0	65,685	0	110,352	0
2004						60,575	0	101,766	0
2005						54,774	0	92,020	0
2006						48,281	0	81,113	0
2007						41,098	0	69,044	0
2008						33,569	0	56,396	0
2009						25,695	0	43,167	0
2010						17,475	0	29,358	0
2011						8,910	0	14,969	0

Taylor et al. found that indirect costs accounted for 58% of lifetime stroke cost. Acute care costs account for 45% of lifetime medical costs, while long-term ambulatory care and nursing home costs account for 35% and 17.5% (respectively) of lifetime costs.[5] Assuming a total valuation per stroke case of $200,000, lifetime medical costs would be $84,000 (i.e., 42% of the total), and reduced earnings would be $116,000 (i.e., 58%). Acute care accounts for 45% of medical costs, which is $37,800 over two years, or $18,900 per year for two years. Ambulatory care accounts for 35% of medical costs, which is $29,400 over ten years, or $2,940 per year for ten years. Nursing home care is assumed to account for 20% of medical costs, which is $16,800 over ten years, or $1,680 per year for ten years. The avoided costs (thousands) per year in Table 7 is equal to:

[(acute cases)*18.9] + [(amb cases)* 2.94] + [(nh cases)*1.68].

Table 7 assumes that the work loss days associated with stroke are spread evenly over a ten-year period. The reported "WLD cases" for 1979 (for example) would be the sum of all stroke cases (in column "m+3/4f") from 1971 to 1979 (i.e., the number of people who suffer WLDs during a year is equal to the numer of inital stroke cases during that year and the preceding nine years). Applying the "ten year" assumption, $116,000 of lost income per stroke case is equal to $11,600 per case per year for ten years. At $83 per work-loss day (which is the value used in the 812 study), $11,600 in reduced annual earnings represents almost 140 WLDs per year. The final column in Table 7 ("WLDs") gives WLD cases/year times $11,600/WLDcase/year divided by $83/WLD.

[5]Note that Table 7 reflects an assumed **20%** share for nursing home costs, thus allowing the three components to sum to 100%.

Pb / IQ Effects

Avoided Costs of Compensatory Education

The Section 812 report presents an estimate of reduced lifetime expenditure on compensatory education due to reduced Pb-related IQ decrements (the 812 report assumes that children with IQ scores more than two deviations below the mean score (IQ scores are normalized with a mean=100 and standard deviation=15) require special compensatory education during their school years). Table 8 presents cases of Pb-related "IQ<70" for 1975, 1980, 1985, and 1990 from 812 table D-13. Cases for other years are derived by linear interpolation (and assuming 0 for 1970).

Annual IQ<70 "cases" in the 812 report are the number of infants (i.e., less than one year old) affected by airborn Pb in that year. It is assumed that education expenditures are affected for each child for the 12-year period of ages seven to eighteen. The "cumulative cases" column in Table 8 presents the number of children (each year) for whom compensatory education costs have changed (for that year). For example, in 1978, education costs differ only for that cohort born in 1971; while the 1979 result is for 1971 cases plus 1972 cases. By 2009, compensatoty education costs are no longer affected, since those born in 1990 are 19 years old in 2009.

The Section 812 report assumed a per-year cost of compensatory education of $6,318. That per-unit cost is multiplied by the number of "cumulative cases" to derive the "cost avoided" in Table 8.

Table 8. Avoided Compensatory Education Costs Due To Reduced Exposure to Pb (number of cases, and thousands of $1990)

Year	(d-13) cases	cumulative cases	($1000) cost avoided
1970	0	0	0
1971	756	0	0
1972	1,512	0	0
1973	2,268	0	0
1974	3,024	0	0
1975	3,780	0	0
1976	7,039	0	0
1977	10,298	0	0
1978	13,556	756	4,776
1979	16,815	2,268	14,329
1980	20,074	4,536	28,658
1981	23,363	7,560	47,764
1982	26,652	11,340	71,646
1983	29,942	18,379	116,117
1984	33,231	28,676	181,177
1985	36,520	42,233	266,827
1986	38,295	59,048	373,065
1987	40,069	79,122	499,893
1988	41,844	102,485	647,501
1989	43,618	129,138	815,891
1990	45,393	158,323	1,000,286
1991		190,042	1,200,685
1992		224,294	1,417,089
1993		259,565	1,639,929
1994		295,854	1,869,204
1995		330,659	2,089,102
1996		363,980	2,299,623
1997		395,816	2,500,767
1998		379,001	2,394,528
1999		358,927	2,267,701
2000		335,564	2,120,092
2001		308,911	1,951,702
2002		278,970	1,762,531
2003		245,739	1,552,579
2004		209,219	1,321,846
2005		170,924	1,079,900
2006		130,855	826,743
2007		89,011	562,374
2008		45,393	286,793
2009		0	0

Earnings, IQ, and Pb Exposure

The Section 812 report presents an estimate of increased lifetime earnings due to reduced Pb-related IQ decrements (reductions in airborne Pb cause reductions in blood-lead levels, resulting in improved IQ scores, which are then associated with greater lifetime income). Table 9 (to the right) presents the Pb-related avoided aggregate IQ point decrements for 1975, 1980, 1985, and 1990 from 812 table D-13. Point decrements for other years are derived by linear interpolation (and assuming 0 for 1970).

Table 9. Pb-Related IQ Decrements in Children, and Lagged Effects in Adults, 1970-1990

Year	(D-13) Points	Cumulative Points (adults)
1970	0	0
1971	205,698	0
1972	411,397	0
1973	617,095	0
1974	822,794	0
1975	1,028,492	0
1976	1,829,025	0
1977	2,629,558	0
1978	3,430,091	0
1979	4,230,624	0
1980	5,031,157	0
1981	5,736,811	0
1982	6,442,465	0
1983	7,148,118	0
1984	7,853,772	0
1985	8,559,426	0
1986	8,923,194	0
1987	9,286,963	0
1988	9,650,731	0
1989	10,014,500	205,698
1990	10,378,268	617,095

Annual IQ point loss "cases" in the 812 report are the number of infants (i.e., those less than one year old) affected by airborn Pb in that year, times the average number of IQ points (eventually) lost per child (i.e., it is the aggregate number of IQ points, rather than the number of children affected). It is assumed that Pb exposure (on infants) has no effect on income until adulthood (i.e., age 18), and the effect continues until age 65. The "cumulative points (adults)" column in Table 9 reflects this lagged effect. There is no impact until 1989, at which time those exposed in 1971 are affected (as 18-year olds). In 1990, adults born in 1971 and 1972 are affected.

Table 10 is a continuation of and extension of Table 9. The first data column, "Cumulative Points (adults)," is also found in Table 9 (note that the data entries for 1989 and 1990 are identical in the two tables). The table ends in the year 2056, when those exposed (as infants) to airborne Pb in 1990 would be more than 65 years old, and presumably out of the labor force. Between 2008 and 2036, all of those exposed (as infants) between 1971 and 1990 would be between 18 and 65 years old – therefore, the "cumulative points (adults)" measure is unchanged during those years (i.e., at 104,230,179 points).

The Section 812 report assumes a discounted lifetime income change (i.e., discounted to the time of exposure as an infant) of $2,957 per IQ point (using a 5% discount rate). Converting to an annual undiscounted flow from age 18 to age 65 (and assuming, for simplicity, a constant per-year flow) gives an annuity of $377 per IQ point per year. The "Income Lost" column of Table 10 converts the cumulative IQ point effect on adults to an income measure, by multiplying the data in the "Cumulative Points (adults)" column by $377/point. For example, reduced Pb exposure of infants in 1971 resulted in an aggregate 205,698 IQ point increase among 18-year-olds in 1980, which caused an increased income of $77,548,000 in 1989.

Increased income due to a reduction in Pb-exposure can be thought of as either a change in productivity or as a change in quantity of work. In the third data column of Table 10, the annual income change is converted to "avoided work loss days" by applying a valuation of $83 per work-loss day. Thus, for example, the $77,548,000 income increase in 1989 is the equivaent of [$77,548,000/$83 =] 934,317 avoided work loss days.

Table 10. Pb-Related Income Changes and Work Loss Days

	Cumulative Points (adults)	($1000s) Income Lost	Work Loss Days
1989	205,698	77,548	934,317
1990	617,095	232,645	2,802,950
1991	1,234,190	465,290	5,605,901
1992	2,056,984	775,483	9,343,168
1993	3,085,476	1,163,224	14,014,752
1994	4,914,501	1,852,767	22,322,492
1995	7,544,059	2,844,110	34,266,388
1996	10,974,150	4,137,255	49,846,440
1997	15,204,774	5,732,200	69,062,648
1998	20,235,931	7,628,946	91,915,012
1999	25,972,742	9,791,724	117,972,574
2000	32,415,206	12,220,533	147,235,335
2001	39,563,325	14,915,373	179,703,295
2002	47,417,097	17,876,246	215,376,453
2003	55,976,523	21,103,149	254,254,809
2004	64,899,717	24,467,193	294,785,463
2005	74,186,680	27,968,378	336,968,415
2006	83,837,411	31,606,704	380,803,664
2007	93,851,911	35,382,170	426,291,210
2008	104,230,179	39,294,777	473,431,054
...			
...			
2036	104,230,179	39,294,777	473,431,054
2037	104,024,481	39,217,229	472,496,737
2038	103,613,084	39,062,133	470,628,104
2039	102,995,989	38,829,488	467,825,153
2040	102,173,195	38,519,295	464,087,886
2041	101,144,703	38,131,553	459,416,302
2042	99,315,678	37,442,011	451,108,562
2043	96,686,120	36,450,667	439,164,666
2044	93,256,029	35,157,523	423,584,614
2045	89,025,405	33,562,578	404,368,406
2046	83,994,248	31,665,831	381,516,042
2047	78,257,437	29,503,054	355,458,480
2048	71,814,973	27,074,245	326,195,719
2049	64,666,854	24,379,404	293,727,759
2050	56,813,082	21,418,532	258,054,601
2051	48,253,656	18,191,628	219,176,245
2052	39,330,462	14,827,584	178,645,591
2053	30,043,499	11,326,399	136,462,639
2054	20,392,768	7,688,073	92,627,390
2055	10,378,268	3,912,607	47,139,844
2056	0	0	0

Miscellaneous Effects

Direct Work-Loss Days

The Section 812 report presents an estimate of Work-Loss Day (WLD) decrements due to improved ambient PM concentrations. Table 11 (to the right) presents the PM-related avoided WLDs for 1975, 1980, 1985, and 1990 from 812 table D-13. WLD decrements for other years are derived by linear interpolation (and assuming 0 for 1970). It is *possible* that there is some overlap (i.e., double-counting) between these results and the implied WLDs from chronic bronchitis (which is also related to PM exposure).

Table 11. PM-Related Work Loss Days and Household Soiling Expenditures (number of days, and thousands of $1990)

	(d13) direct WLD	(I-6) ($1000) Soiling
1970	0	0
1971	1,393,355	244,795
1972	2,786,710	489,591
1973	4,180,065	734,386
1974	5,573,420	979,182
1975	6,966,775	1,223,977
1976	9,016,136	1,584,025
1977	11,065,497	1,944,073
1978	13,114,859	2,304,121
1979	15,164,220	2,664,168
1980	17,213,581	3,024,216
1981	17,900,646	3,144,925
1982	18,587,711	3,265,634
1983	19,274,776	3,386,343
1984	19,961,841	3,507,052
1985	20,648,906	3,627,761
1986	21,031,675	3,695,009
1987	21,414,444	3,762,256
1988	21,797,214	3,829,504
1989	22,179,983	3,896,752
1990	22,562,752	3,964,000

Household Soiling Expenditures

Table I-6 in the Section 812 Report includes the estimate for avoided PM-soiling-related expenditures for 1990 ($3,964 million). Unfortunately, there is no year-by-year breakdown of avoided soiling expenditures elsewhere in the 812 report. Furthermore, there is insufficient detail in the 812 Report's air quality modeling results to allow a recalculation of the soiling expenditure estimate. Therefore, an indirect estimation approach is taken here: it is assumed that avoided soiling expenditures vary each year in linear relation to the change in work loss days (which, like soiling, is dependent only on ambient PM concentrations).[6] Specifically, soiling expenditures in year X are assumed to be equal to WLDs in year X, times the ratio of 1990 soiling expenditure divided by 1990 WLDs ($3,964,000/22,562,752 days).

[6] This is an inexact estimate, since incremental soiling expenditures are linear with changes in PM concentrations (relative to the baseline case) (see 812 Table I-2, page I-15) while incremental WLDs are log-linear to changes in PM concentrations (relative to the baseline case) (see 812 Table D-6, pages D-20 and D-25).

Changes in Productivity of Workers Engaged in Strenuous Outdoor Labor

Table I-3 (page I-17) of the 812 Study reports the 1990 present value (@ 5%) of the 1970 - 1990 flow of avoided ozone-related productivity losses for workers engaged in strenuous outdoor labor (e.g., agricultural workers). Unfortunately, no single-year estimate is presented in the 812 study, so an indirect estimation for single-year productivity losses is employed here: annual productivity loss is assumed to vary linearly with annual "15% FEV decrease" (both productivity loss and FEV decrease depend exclusively on ozone concentrations).

The Section 812 report presents an estimate of avoided pulmonary function decrements (measured by "forced expiratory volume in one second" (FEV)) due to improved ambient ozone concentrations. Table 12 (to the right) presents the ozone-related avoided "million person-days with decreased FEV by 15% or more" for 1975, 1980, 1985, and 1990 from 812 table D-15 (page D-47). Avoided pulmonary function decrements for other years are derived by linear interpolation (and assuming 0 for 1970).

Table 12. Avoided Ozone-Related Productivity Decreases and Work-Loss Days

	(d-15) 15% FEV decrease	(I-3) prod. ($million)	annual prod. ($1,000)	@83/day WLD
1970	0		0	0
1971	11		8	101
1972	21		17	202
1973	32		25	302
1974	42		33	403
1975	53		42	504
1976	67		53	633
1977	80		63	763
1978	94		74	892
1979	107		85	1,021
1980	121		95	1,151
1981	136		107	1,293
1982	151		119	1,436
1983	166		131	1,578
1984	181		143	1,721
1985	196		155	1,864
1986	219		173	2,084
1987	242		191	2,305
1988	266		210	2,525
1989	289		228	2,746
1990	312		246	2,967
PV(1990)	3,801	3	3,000	

The final row of Table 12 (labeled "PV(1990)") gives the 1990 present value of the 1970-1990 stream of "million person days with decreased FEV (15%)."[7] This figure (i.e., 3,801 million) is used in conjuction with the annual "pulmonary function decrements" and the 1990 PV of the annual productivity loss (i.e., $3 billion, as reported in Table I-3 of the 812 report) to derive year-by-year productivity changes. For example, the avoided productivity loss in 1990 ($246,000) is assumed to be the product of the 1990 pulmonary function decrement measure (312) and the ratio 3000/3801.

The final data column in Table 12 converts productivity loss to work loss days by applying the per-WLD of $83. For example, in 1990, $246,000 in lost productivity divided by $83 per WLD results in 2,967 work loss days.

[7] This PV is used for computation only – it has little meaning by itself.

Table 13. SUMMARY – Avoided Expenditures From Non-Fatal Health Impacts (Millions of $1990)

	Not Pb-Related			Pb-Related				Total
	chronic bronchitis	hospital admissions	household soiling	hyper-tension	congestive heart disease	stroke	compensatory education	
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1971	9.8	57.7	244.8	102.1	13.7	2.2	0.0	430
1972	29.4	115.4	489.6	204.1	27.3	6.7	0.0	873
1973	58.8	173.1	734.4	306.2	41.0	11.6	0.0	1,325
1974	98.0	230.8	979.2	408.2	54.6	16.8	0.0	1,788
1975	147.0	288.5	1,224.0	510.3	68.3	22.3	0.0	2,260
1976	212.7	369.6	1,584.0	1,056.9	142.4	37.8	0.0	3,403
1977	295.2	450.7	1,944.1	1,603.5	216.6	63.2	0.0	4,573
1978	394.4	531.8	2,304.1	2,150.1	290.8	90.5	4.8	5,766
1979	510.3	612.8	2,664.2	2,696.7	364.9	119.6	14.3	6,983
1980	643.0	693.9	3,024.2	3,243.2	439.1	150.6	28.7	8,223
1981	782.9	734.1	3,144.9	3,834.5	524.6	184.6	47.8	9,253
1982	930.1	774.2	3,265.6	4,425.8	610.2	221.7	71.6	10,299
1983	1,084.6	814.4	3,386.3	5,017.0	695.8	260.7	116.1	11,375
1984	1,246.3	854.6	3,507.1	5,608.3	781.3	301.5	181.2	12,480
1985	1,415.2	894.7	3,627.8	6,199.5	866.9	344.3	266.8	13,615
1986	1,585.8	923.9	3,695.0	6,514.2	912.6	382.3	373.1	14,387
1987	1,757.9	953.1	3,762.3	6,828.8	958.4	415.8	499.9	15,176
1988	1,931.6	982.2	3,829.5	7,143.5	1,004.1	449.4	647.5	15,988
1989	2,106.8	1,011.4	3,896.8	7,458.1	1,049.8	483.3	815.9	16,822
1990	2,283.7	1,040.6	3,964.0	7,772.8	1,095.6	517.4	1,000.3	17,674
1991						376.8	1,200.7	1,577
1992						229.9	1,417.1	1,647
1993						224.1	1,639.9	1,864
1994						217.3	1,869.2	2,086
1995						209.4	2,089.1	2,298
1996						200.4	2,299.6	2,500
1997						190.3	2,500.8	2,691
1998						178.8	2,394.5	2,573
1999						165.8	2,267.7	2,433
2000						151.3	2,120.1	2,271
2001						135.3	1,951.7	2,087
2002						117.8	1,762.5	1,880
2003						110.4	1,552.6	1,663
2004						101.8	1,321.8	1,424
2005						92.0	1,079.9	1,172
2006						81.1	826.7	908
2007						69.0	562.4	631
2008						56.4	286.8	343
2009						43.2	0.0	43
2010						29.4		29
2011						15.0		15
2012						0.0		0

Table 14. SUMMARY – Avoided Work-Loss Days From Non-Fatal Health Impacts, 1970-1990 (millions of avoided WLDs)

	Not Pb-Related			Pb-Related				Total	
	chronic bronchitis	direct WLD	pro-ductivity	hyper-tension	congestive heart disease	stroke	IQ-related prod. loss	WLD (millions)	@83/day ($millions)
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1971	1.6	1.4	0.0	0.1	0.0	0.0	0.0	3.2	262
1972	4.8	2.8	0.0	0.3	0.0	0.0	0.0	7.9	659
1973	9.6	4.2	0.0	0.4	0.0	0.1	0.0	14.3	1,190
1974	16.0	5.6	0.0	0.5	0.0	0.2	0.0	22.4	1,856
1975	24.1	7.0	0.0	0.7	0.1	0.2	0.0	32.0	2,657
1976	34.8	9.0	0.0	1.4	0.1	0.4	0.0	45.8	3,798
1977	48.3	11.1	0.0	2.1	0.2	0.7	0.0	62.3	5,175
1978	64.6	13.1	0.0	2.8	0.2	1.0	0.0	81.8	6,786
1979	83.6	15.2	0.0	3.5	0.3	1.5	0.0	104.0	8,633
1980	105.3	17.2	0.0	4.2	0.4	2.0	0.0	129.1	10,714
1981	128.2	17.9	0.0	5.0	0.4	2.6	0.0	154.1	12,792
1982	152.3	18.6	0.0	5.8	0.5	3.3	0.0	180.4	14,977
1983	177.6	19.3	0.0	6.5	0.6	4.0	0.0	208.0	17,266
1984	204.1	20.0	0.0	7.3	0.6	4.9	0.0	236.9	19,661
1985	231.8	20.6	0.0	8.1	0.7	5.8	0.0	267.0	22,161
1986	259.7	21.0	0.0	8.5	0.8	6.7	0.0	296.6	24,621
1987	287.9	21.4	0.0	8.9	0.8	7.5	0.0	326.5	27,099
1988	316.3	21.8	0.0	9.3	0.8	8.3	0.0	356.6	29,596
1989	345.0	22.2	0.0	9.7	0.9	9.1	0.9	387.8	32,188
1990	374.0	22.6	0.0	10.1	0.9	9.8	2.8	420.2	34,876

Table 15. SUMMARY – Avoided Work-Loss Days From Non-Fatal Health Impacts, 1991-2056 (millions of avoided WLDs)

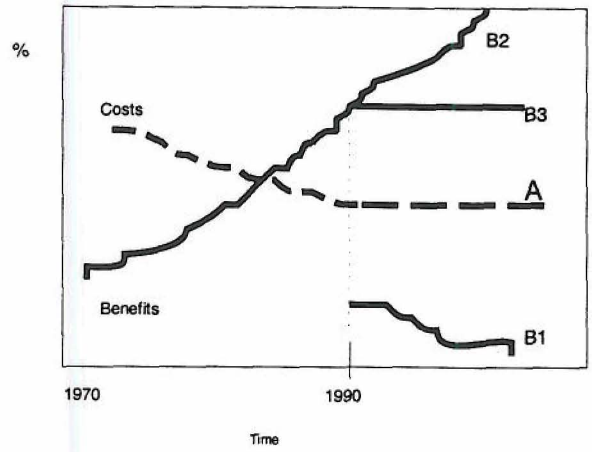
	Not Pb-Related			Pb-Related				Total	
	chronic bronchitis	direct WLD	pro-ductivity	hyper-tension	congestive heart disease	stroke	IQ-related prod. loss	WLD (millions)	@83/day ($millions)
1991						9.2	5.6	14.8	1,227
1992						8.5	9.3	17.8	1,478
1993						7.7	14.0	21.7	1,799
1994						6.7	22.3	29.1	2,413
1995						5.7	34.3	40.0	3,321
1996						4.7	49.8	54.5	4,527
1997						3.6	69.1	72.7	6,030
1998						2.4	91.9	94.4	7,832
1999						1.2	118.0	119.2	9,895
2000						0.0	147.2	147.2	12,221
2001							179.7	179.7	14,915
2002							215.4	215.4	17,876
2003							254.3	254.3	21,103
2004							294.8	294.8	24,467
2005							337.0	337.0	27,968
2006							380.8	380.8	31,607
2007							426.3	426.3	35,382
2008							473.4	473.4	39,295
2036							473.4	473.4	39,295
2037							472.5	472.5	39,217
2038							470.6	470.6	39,062
2039							467.8	467.8	38,829
2040							464.1	464.1	38,519
2041							459.4	459.4	38,132
2042							451.1	451.1	37,442
2043							439.2	439.2	36,451
2044							423.6	423.6	35,158
2045							404.4	404.4	33,563
2046							381.5	381.5	31,666
2047							355.5	355.5	29,503
2048							326.2	326.2	27,074
2049							293.7	293.7	24,379
2050							258.1	258.1	21,419
2051							219.2	219.2	18,192
2052							178.6	178.6	14,828
2053							136.5	136.5	11,326
2054							92.6	92.6	7,688
2055							47.1	47.1	3,913
2056							0.0	0.0	0

* Results are unchanged from 2008 to 2036.

Appendix B

Benefit Extensions to 2100: Analytical Alternatives

The graphic below outlines different possible scenarios for the treatment of costs (pollution control expenditures) and benefits (avoided medical expenditures and lost labor productivity)



Scenario for Environmental Expenditures = A

Scenario for Avoided Damages (Benefits) = B1 or B2 or B3

At issue is
how to handle future projections of costs and benefits in the model.

Costs represent pollution control expenditures (as a percent of total production costs).

Benefits represent avoided medical expenditures, productivity losses, and decreased labor supply (as percents of totals).

For costs, the model incorporates initial large investment in pollution control capital (new and retrofits of existing capital) that decline with time to the marginal level of new or replacement capital by 1990. For future years, additional capital investment is replacing capital that wears out, so the 1990 capital investment in pollution control (expressed as a percent of total investment) is used to project future pollution control investments (Line A in the figure above). Operating and maintenance expenditures by sector were expressed as fractions of total production costs and this fraction also was presumed to reach a steady-state magnitude by 1990. Hence, compliance to the CAA involves a continuing but constant fraction of each dollar invested in new capital goods (with this new capital devoted strictly to pollution control) and a continuing but constant diversion of unit production costs to operate and maintain this equipment.

For benefits, there are several options.

Since the goal is to show what the market would look like absent the pollution control investments, foregone benefits (damages) are introduced into the model.

The damages increase in time relative to foregone improvements in air quality conditions. When the model reaches 1990, there is the need to decide how to treat the stream of future benefits beyond 1990.

B1 = assumes that all damages other than some Pb health effects stop. The IQ, compensatory education and stroke health effects continue though at a decreasing rate for each age cohort affected in the benefits model. The data appearing in Appendix A follows this convention.

B2 = assumes that all damages continue to grow into the future as the economy, population and emissions grow into the future unchecked. These calculations have not been prepared under the 1970-1990 retrospective scenario. (NOTE: As far as can be determined from the prospective report, the benefits estimates prepared under the 1990-2010 analysis did not develop separate streams of benefits for the pre-1990 CAAA pattern of regulations and the post-1990 CAAA regulations. There are data reported on the differences in emissions, but there appears no information showing incremental changes in health effects or monetary benefit estimates.)

B3 = assumes that damages continue into the future, but remain fixed at the 1990 level. This would imply that a presumed "threshold" of damages had been reached (e.g., factors in the economy would constrain damages to some fixed level, in this case arbitrarily equated with 1990 conditions).

Of these three, the second (B2) offers the most meaningful way to represent the long-run consequences foregoing the Clean Air Act's enactment. This is particularly the case in view of the long-term continuation of policy costs.

Appendix C

Benefit Extensions to 2100: Data

PM MORTALITY

								AGE GROUP
		2%	4%	6%	13%	24%	29%	22%
	total	30-34	35-44	45-54	55-64	65-74	75-84	85+
1970	0	0	0	0	0	0	0	0
1971	11,753	235	470	705	1,528	2,821	3,408	2,586
1972	23,506	470	940	1,410	3,056	5,641	6,817	5,171
1973	35,258	705	1,410	2,116	4,584	8,462	10,225	7,757
1974	47,011	940	1,880	2,821	6,111	11,283	13,633	10,342
1975	58,764	1,175	2,351	3,526	7,639	14,103	17,042	12,928
1976	76,188	1,524	3,048	4,571	9,904	18,285	22,095	16,761
1977	93,612	1,872	3,744	5,617	12,170	22,467	27,147	20,595
1978	111,036	2,221	4,441	6,662	14,435	26,649	32,200	24,428
1979	128,460	2,569	5,138	7,708	16,700	30,830	37,253	28,261
1980	145,884	2,918	5,835	8,753	18,965	35,012	42,306	32,094
1981	150,636	3,013	6,025	9,038	19,583	36,153	43,684	33,140
1982	155,387	3,108	6,215	9,323	20,200	37,293	45,062	34,185
1983	160,139	3,203	6,406	9,608	20,818	38,433	46,440	35,231
1984	164,890	3,298	6,596	9,893	21,436	39,574	47,818	36,276
1985	169,642	3,393	6,786	10,179	22,053	40,714	49,196	37,321
1986	172,421	3,448	6,897	10,345	22,415	41,381	50,002	37,933
1987	175,201	3,504	7,008	10,512	22,776	42,048	50,808	38,544
1988	177,980	3,560	7,119	10,679	23,137	42,715	51,614	39,156
1989	180,760	3,615	7,230	10,846	23,499	43,382	52,420	39,767
1990	183,539	3,671	7,342	11,012	23,860	44,049	53,226	40,379
1991	185,517	3,710	7,421	11,131	24,117	44,524	53,800	40,814
1992	187,627	3,753	7,505	11,258	24,392	45,031	54,412	41,278
1993	189,651	3,793	7,586	11,379	24,655	45,516	54,999	41,723
1994	191,523	3,830	7,661	11,491	24,898	45,965	55,542	42,135
1995	193,344	3,867	7,734	11,601	25,135	46,403	56,070	42,536
1996	195,129	3,903	7,805	11,708	25,367	46,831	56,587	42,928
1997	197,008	3,940	7,880	11,820	25,611	47,282	57,132	43,342
1998	198,888	3,978	7,956	11,933	25,855	47,733	57,678	43,755
1999	200,743	4,015	8,030	12,045	26,097	48,178	58,215	44,163
2000	202,572	4,051	8,103	12,154	26,334	48,617	58,746	44,566
2001	204,409	4,088	8,176	12,265	26,573	49,058	59,279	44,970
2002	206,251	4,125	8,250	12,375	26,813	49,500	59,813	45,375
2003	208,085	4,162	8,323	12,485	27,051	49,940	60,345	45,779
2004	209,901	4,198	8,396	12,594	27,287	50,376	60,871	46,178
2005	211,703	4,234	8,468	12,702	27,521	50,809	61,394	46,575
2006	213,497	4,270	8,540	12,810	27,755	51,239	61,914	46,969
2007	215,285	4,306	8,611	12,917	27,987	51,668	62,433	47,363
2008	217,070	4,341	8,683	13,024	28,219	52,097	62,950	47,755
2009	218,856	4,377	8,754	13,131	28,451	52,525	63,468	48,148
2010	220,641	4,413	8,826	13,238	28,683	52,954	63,986	48,541
2011	222,435	4,449	8,897	13,346	28,916	53,384	64,506	48,936
2012	224,248	4,485	8,970	13,455	29,152	53,819	65,032	49,334
2013	226,077	4,522	9,043	13,565	29,390	54,258	65,562	49,737

PM MORTALITY

	total	30-34	35-44	45-54	55-64	65-74	75-84	85+
								AGE GROUP
		2%	4%	6%	13%	24%	29%	22%
2014	227,918	4,558	9,117	13,675	29,629	54,700	66,096	50,142
2015	229,769	4,595	9,191	13,786	29,870	55,145	66,633	50,549
2016	231,627	4,633	9,265	13,898	30,112	55,590	67,172	50,958
2017	233,490	4,670	9,340	14,009	30,354	56,038	67,712	51,368
2018	235,355	4,707	9,414	14,121	30,596	56,485	68,253	51,778
2019	237,221	4,744	9,489	14,233	30,839	56,933	68,794	52,189
2020	239,084	4,782	9,563	14,345	31,081	57,380	69,334	52,598
2021	240,953	4,819	9,638	14,457	31,324	57,829	69,876	53,010
2022	242,837	4,857	9,713	14,570	31,569	58,281	70,423	53,424
2023	244,735	4,895	9,789	14,684	31,815	58,736	70,973	53,842
2024	246,644	4,933	9,866	14,799	32,064	59,195	71,527	54,262
2025	248,567	4,971	9,943	14,914	32,314	59,656	72,084	54,685
2026	250,499	5,010	10,020	15,030	32,565	60,120	72,645	55,110
2027	252,439	5,049	10,098	15,146	32,817	60,585	73,207	55,537
2028	254,388	5,088	10,176	15,263	33,070	61,053	73,773	55,965
2029	256,349	5,127	10,254	15,381	33,325	61,524	74,341	56,397
2030	258,320	5,166	10,333	15,499	33,582	61,997	74,913	56,830
2031	260,291	5,206	10,412	15,617	33,838	62,470	75,484	57,264
2032	262,250	5,245	10,490	15,735	34,092	62,940	76,052	57,695
2033	264,198	5,284	10,568	15,852	34,346	63,408	76,617	58,124
2034	266,138	5,323	10,646	15,968	34,598	63,873	77,180	58,550
2035	268,069	5,361	10,723	16,084	34,849	64,336	77,740	58,975
2036	269,993	5,400	10,800	16,200	35,099	64,798	78,298	59,398
2037	271,913	5,438	10,877	16,315	35,349	65,259	78,855	59,821
2038	273,829	5,477	10,953	16,430	35,598	65,719	79,410	60,242
2039	275,744	5,515	11,030	16,545	35,847	66,178	79,966	60,664
2040	277,657	5,553	11,106	16,659	36,095	66,638	80,520	61,085
2041	279,571	5,591	11,183	16,774	36,344	67,097	81,075	61,506
2042	281,487	5,630	11,259	16,889	36,593	67,557	81,631	61,927
2043	283,406	5,668	11,336	17,004	36,843	68,017	82,188	62,349
2044	285,328	5,707	11,413	17,120	37,093	68,479	82,745	62,772
2045	287,258	5,745	11,490	17,235	37,343	68,942	83,305	63,197
2046	289,194	5,784	11,568	17,352	37,595	69,406	83,866	63,623
2047	291,138	5,823	11,646	17,468	37,848	69,873	84,430	64,050
2048	293,091	5,862	11,724	17,585	38,102	70,342	84,996	64,480
2049	295,057	5,901	11,802	17,703	38,357	70,814	85,567	64,913
2050	297,036	5,941	11,881	17,822	38,615	71,289	86,140	65,348
2051	299,029	5,981	11,961	17,942	38,874	71,767	86,718	65,786
2052	301,039	6,021	12,042	18,062	39,135	72,249	87,301	66,228
2053	303,067	6,061	12,123	18,184	39,399	72,736	87,889	66,675
2054	305,115	6,102	12,205	18,307	39,665	73,228	88,483	67,125
2055	307,183	6,144	12,287	18,431	39,934	73,724	89,083	67,580
2056	309,273	6,185	12,371	18,556	40,205	74,226	89,689	68,040
2057	311,387	6,228	12,455	18,683	40,480	74,733	90,302	68,505
2058	313,525	6,271	12,541	18,812	40,758	75,246	90,922	68,976
2059	315,688	6,314	12,628	18,941	41,040	75,765	91,550	69,451

PM MORTALITY

		AGE GROUP						
		2%	4%	6%	13%	24%	29%	22%
	total	30-34	35-44	45-54	55-64	65-74	75-84	85+
2060	317,877	6,358	12,715	19,073	41,324	76,290	92,184	69,933
2061	320,092	6,402	12,804	19,205	41,612	76,822	92,827	70,420
2062	322,333	6,447	12,893	19,340	41,903	77,360	93,477	70,913
2063	324,601	6,492	12,984	19,476	42,198	77,904	94,134	71,412
2064	326,893	6,538	13,076	19,614	42,496	78,454	94,799	71,917
2065	329,212	6,584	13,168	19,753	42,798	79,011	95,471	72,427
2066	331,555	6,631	13,262	19,893	43,102	79,573	96,151	72,942
2067	333,920	6,678	13,357	20,035	43,410	80,141	96,837	73,462
2068	336,309	6,726	13,452	20,179	43,720	80,714	97,530	73,988
2069	338,719	6,774	13,549	20,323	44,034	81,293	98,229	74,518
2070	341,149	6,823	13,646	20,469	44,349	81,876	98,933	75,053
2071	343,598	6,872	13,744	20,616	44,668	82,464	99,644	75,592
2072	346,064	6,921	13,843	20,764	44,988	83,055	100,359	76,134
2073	348,547	6,971	13,942	20,913	45,311	83,651	101,079	76,680
2074	351,046	7,021	14,042	21,063	45,636	84,251	101,803	77,230
2075	353,558	7,071	14,142	21,213	45,963	84,854	102,532	77,783
2076	356,084	7,122	14,243	21,365	46,291	85,460	103,264	78,339
2077	358,623	7,172	14,345	21,517	46,621	86,069	104,001	78,897
2078	361,173	7,223	14,447	21,670	46,953	86,682	104,740	79,458
2079	363,734	7,275	14,549	21,824	47,285	87,296	105,483	80,022
2080	366,307	7,326	14,652	21,978	47,620	87,914	106,229	80,588
2081	368,890	7,378	14,756	22,133	47,956	88,534	106,978	81,156
2082	371,484	7,430	14,859	22,289	48,293	89,156	107,730	81,726
2083	374,089	7,482	14,964	22,445	48,632	89,781	108,486	82,300
2084	376,703	7,534	15,068	22,602	48,971	90,409	109,244	82,875
2085	379,330	7,587	15,173	22,760	49,313	91,039	110,006	83,453
2086	381,967	7,639	15,279	22,918	49,656	91,672	110,770	84,033
2087	384,615	7,692	15,385	23,077	50,000	92,308	111,538	84,615
2088	387,275	7,746	15,491	23,237	50,346	92,946	112,310	85,201
2089	389,947	7,799	15,598	23,397	50,693	93,587	113,085	85,788
2090	392,630	7,853	15,705	23,558	51,042	94,231	113,863	86,379
2091	395,326	7,907	15,813	23,720	51,392	94,878	114,645	86,972
2092	398,033	7,961	15,921	23,882	51,744	95,528	115,430	87,567
2093	400,754	8,015	16,030	24,045	52,098	96,181	116,219	88,166
2094	403,485	8,070	16,139	24,209	52,453	96,836	117,011	88,767
2095	406,229	8,125	16,249	24,374	52,810	97,495	117,806	89,370
2096	408,984	8,180	16,359	24,539	53,168	98,156	118,605	89,976
2097	411,750	8,235	16,470	24,705	53,528	98,820	119,408	90,585
2098	414,528	8,291	16,581	24,872	53,889	99,487	120,213	91,196
2099	417,315	8,346	16,693	25,039	54,251	100,156	121,021	91,809
2100	420,112	8,402	16,804	25,207	54,615	100,827	121,832	92,425

PB MORTALITY

		MEN				WOMEN			
	infant	40-54	55-64	65-74	total (40-74)	45-54	55-64	65-74	total (45-74)
1970	0	0	0	0	0	0	0	0	0
1971	91	79	56	21	156	23	17	6	46
1972	182	157	112	42	311	47	33	12	92
1973	274	236	169	63	467	70	50	19	139
1974	365	314	225	84	623	93	67	25	185
1975	456	393	281	105	778	117	83	31	231
1976	833	801	585	224	1,610	239	174	67	480
1977	1,210	1,209	888	344	2,442	361	265	103	728
1978	1,588	1,618	1,191	464	3,273	483	356	139	977
1979	1,965	2,026	1,495	584	4,105	605	446	174	1,225
1980	2,342	2,434	1,798	704	4,936	727	537	210	1,474
1981	2,660	2,897	2,120	852	5,869	865	633	254	1,752
1982	2,978	3,359	2,443	999	6,801	1,003	729	298	2,031
1983	3,297	3,822	2,765	1,147	7,734	1,141	826	342	2,309
1984	3,615	4,284	3,088	1,294	8,666	1,279	922	386	2,588
1985	3,933	4,747	3,410	1,442	9,599	1,417	1,018	430	2,866
1986	4,135	5,009	3,523	1,528	10,060	1,494	1,051	456	3,000
1987	4,337	5,271	3,636	1,614	10,521	1,570	1,083	481	3,134
1988	4,540	5,533	3,749	1,700	10,982	1,647	1,116	506	3,269
1989	4,742	5,795	3,862	1,786	11,444	1,723	1,148	531	3,403
1990	4,944	6,058	3,975	1,872	11,905	1,800	1,181	556	3,537
1991	4,997	6,123	4,018	1,893	12,033	1,819	1,194	562	3,575
1992	5,054	6,193	4,064	1,914	12,170	1,840	1,207	569	3,616
1993	5,109	6,259	4,107	1,935	12,301	1,860	1,220	575	3,655
1994	5,159	6,321	4,148	1,954	12,423	1,878	1,232	580	3,691
1995	5,208	6,381	4,187	1,972	12,541	1,896	1,244	586	3,726
1996	5,256	6,440	4,226	1,991	12,657	1,913	1,256	591	3,760
1997	5,307	6,502	4,267	2,010	12,779	1,932	1,268	597	3,797
1998	5,357	6,564	4,307	2,029	12,901	1,950	1,280	603	3,833
1999	5,407	6,625	4,348	2,048	13,021	1,968	1,292	608	3,869
2000	5,457	6,686	4,387	2,067	13,140	1,986	1,303	614	3,904
2001	5,506	6,746	4,427	2,085	13,259	2,004	1,315	620	3,939
2002	5,556	6,807	4,467	2,104	13,378	2,022	1,327	625	3,975
2003	5,605	6,868	4,507	2,123	13,497	2,040	1,339	631	4,010
2004	5,654	6,928	4,546	2,141	13,615	2,058	1,351	636	4,045
2005	5,703	6,987	4,585	2,160	13,732	2,076	1,362	642	4,080
2006	5,751	7,046	4,624	2,178	13,848	2,093	1,374	647	4,114
2007	5,799	7,105	4,663	2,196	13,964	2,111	1,385	652	4,149
2008	5,847	7,164	4,701	2,214	14,080	2,129	1,397	658	4,183
2009	5,895	7,223	4,740	2,233	14,196	2,146	1,408	663	4,218
2010	5,943	7,282	4,779	2,251	14,311	2,164	1,420	669	4,252
2011	5,992	7,341	4,817	2,269	14,428	2,181	1,431	674	4,287
2012	6,041	7,401	4,857	2,288	14,545	2,199	1,443	680	4,321
2013	6,090	7,462	4,896	2,306	14,664	2,217	1,455	685	4,357
2014	6,139	7,522	4,936	2,325	14,784	2,235	1,467	691	4,392

PB MORTALITY

		MEN				WOMEN			
	infant	40-54	55-64	65-74	total (40-74)	45-54	55-64	65-74	total (45-74)
2015	6,189	7,583	4,976	2,344	14,904	2,253	1,478	696	4,428
2016	6,239	7,645	5,016	2,363	15,024	2,271	1,490	702	4,464
2017	6,290	7,706	5,057	2,382	15,145	2,290	1,502	708	4,500
2018	6,340	7,768	5,097	2,401	15,266	2,308	1,514	713	4,536
2019	6,390	7,829	5,138	2,420	15,387	2,326	1,526	719	4,572
2020	6,440	7,891	5,178	2,439	15,508	2,344	1,538	725	4,607
2021	6,491	7,953	5,218	2,458	15,629	2,363	1,550	730	4,643
2022	6,541	8,015	5,259	2,477	15,751	2,381	1,563	736	4,680
2023	6,592	8,077	5,300	2,497	15,874	2,400	1,575	742	4,716
2024	6,644	8,140	5,342	2,516	15,998	2,419	1,587	748	4,753
2025	6,696	8,204	5,383	2,536	16,123	2,437	1,599	753	4,790
2026	6,748	8,268	5,425	2,555	16,248	2,456	1,612	759	4,827
2027	6,800	8,332	5,467	2,575	16,374	2,475	1,624	765	4,865
2028	6,852	8,396	5,509	2,595	16,500	2,494	1,637	771	4,902
2029	6,905	8,461	5,552	2,615	16,628	2,514	1,649	777	4,940
2030	6,958	8,526	5,595	2,635	16,755	2,533	1,662	783	4,978
2031	7,011	8,591	5,637	2,655	16,883	2,552	1,675	789	5,016
2032	7,064	8,655	5,680	2,675	17,010	2,572	1,687	795	5,054
2033	7,117	8,720	5,722	2,695	17,137	2,591	1,700	801	5,091
2034	7,169	8,784	5,764	2,715	17,263	2,610	1,712	807	5,129
2035	7,221	8,847	5,806	2,735	17,388	2,629	1,725	812	5,166
2036	7,273	8,911	5,847	2,754	17,513	2,647	1,737	818	5,203
2037	7,325	8,974	5,889	2,774	17,637	2,666	1,750	824	5,240
2038	7,376	9,038	5,930	2,793	17,761	2,685	1,762	830	5,277
2039	7,428	9,101	5,972	2,813	17,886	2,704	1,774	836	5,314
2040	7,479	9,164	6,013	2,832	18,010	2,723	1,787	842	5,351
2041	7,531	9,227	6,055	2,852	18,134	2,741	1,799	847	5,388
2042	7,582	9,290	6,096	2,872	18,258	2,760	1,811	853	5,425
2043	7,634	9,354	6,138	2,891	18,383	2,779	1,824	859	5,462
2044	7,686	9,417	6,180	2,911	18,507	2,798	1,836	865	5,499
2045	7,738	9,481	6,221	2,930	18,632	2,817	1,848	871	5,536
2046	7,790	9,545	6,263	2,950	18,758	2,836	1,861	877	5,573
2047	7,842	9,609	6,305	2,970	18,884	2,855	1,873	882	5,611
2048	7,895	9,673	6,348	2,990	19,011	2,874	1,886	888	5,648
2049	7,948	9,738	6,390	3,010	19,138	2,893	1,899	894	5,686
2050	8,001	9,803	6,433	3,030	19,267	2,913	1,911	900	5,724
2051	8,055	9,869	6,476	3,051	19,396	2,932	1,924	906	5,763
2052	8,109	9,936	6,520	3,071	19,526	2,952	1,937	912	5,801
2053	8,164	10,003	6,564	3,092	19,658	2,972	1,950	919	5,840
2054	8,219	10,070	6,608	3,113	19,791	2,992	1,963	925	5,880
2055	8,275	10,138	6,653	3,134	19,925	3,012	1,977	931	5,920
2056	8,331	10,207	6,698	3,155	20,060	3,033	1,990	937	5,960
2057	8,388	10,277	6,744	3,177	20,198	3,053	2,004	944	6,001
2058	8,445	10,348	6,790	3,198	20,336	3,074	2,017	950	6,042
2059	8,504	10,419	6,837	3,220	20,477	3,096	2,031	957	6,084
2060	8,563	10,491	6,884	3,243	20,619	3,117	2,045	963	6,126

PB MORTALITY

	infant	MEN 40-54	MEN 55-64	MEN 65-74	MEN total (40-74)	WOMEN 45-54	WOMEN 55-64	WOMEN 65-74	WOMEN total (45-74)
2061	8,622	10,564	6,932	3,265	20,762	3,139	2,060	970	6,169
2062	8,683	10,638	6,981	3,288	20,908	3,161	2,074	977	6,212
2063	8,744	10,713	7,030	3,311	21,055	3,183	2,089	984	6,255
2064	8,806	10,789	7,080	3,335	21,203	3,205	2,103	991	6,300
2065	8,868	10,865	7,130	3,358	21,354	3,228	2,118	998	6,344
2066	8,931	10,943	7,181	3,382	21,506	3,251	2,133	1,005	6,389
2067	8,995	11,021	7,232	3,406	21,659	3,274	2,149	1,012	6,435
2068	9,059	11,100	7,284	3,431	21,814	3,298	2,164	1,019	6,481
2069	9,124	11,179	7,336	3,455	21,970	3,321	2,179	1,027	6,527
2070	9,190	11,259	7,388	3,480	22,128	3,345	2,195	1,034	6,574
2071	9,256	11,340	7,441	3,505	22,287	3,369	2,211	1,041	6,622
2072	9,322	11,422	7,495	3,530	22,447	3,393	2,227	1,049	6,669
2073	9,389	11,504	7,549	3,556	22,608	3,418	2,243	1,056	6,717
2074	9,456	11,586	7,603	3,581	22,770	3,442	2,259	1,064	6,765
2075	9,524	11,669	7,657	3,607	22,933	3,467	2,275	1,072	6,813
2076	9,592	11,752	7,712	3,633	23,097	3,492	2,291	1,079	6,862
2077	9,660	11,836	7,767	3,658	23,261	3,517	2,308	1,087	6,911
2078	9,729	11,920	7,822	3,684	23,427	3,542	2,324	1,095	6,960
2079	9,798	12,005	7,878	3,711	23,593	3,567	2,340	1,102	7,010
2080	9,867	12,090	7,933	3,737	23,760	3,592	2,357	1,110	7,059
2081	9,937	12,175	7,989	3,763	23,927	3,617	2,374	1,118	7,109
2082	10,007	12,261	8,045	3,790	24,096	3,643	2,390	1,126	7,159
2083	10,077	12,347	8,102	3,816	24,265	3,668	2,407	1,134	7,209
2084	10,147	12,433	8,158	3,843	24,434	3,694	2,424	1,142	7,259
2085	10,218	12,520	8,215	3,870	24,605	3,720	2,441	1,150	7,310
2086	10,289	12,607	8,272	3,897	24,776	3,745	2,458	1,158	7,361
2087	10,360	12,694	8,330	3,924	24,947	3,771	2,475	1,166	7,412
2088	10,432	12,782	8,387	3,951	25,120	3,798	2,492	1,174	7,463
2089	10,504	12,870	8,445	3,978	25,293	3,824	2,509	1,182	7,515
2090	10,576	12,959	8,503	4,005	25,467	3,850	2,526	1,190	7,566
2091	10,649	13,048	8,562	4,033	25,642	3,876	2,544	1,198	7,618
2092	10,722	13,137	8,620	4,060	25,818	3,903	2,561	1,206	7,671
2093	10,795	13,227	8,679	4,088	25,994	3,930	2,579	1,215	7,723
2094	10,869	13,317	8,738	4,116	26,171	3,956	2,596	1,223	7,776
2095	10,943	13,407	8,798	4,144	26,349	3,983	2,614	1,231	7,828
2096	11,017	13,498	8,858	4,172	26,528	4,010	2,632	1,240	7,882
2097	11,091	13,590	8,917	4,200	26,707	4,038	2,649	1,248	7,935
2098	11,166	13,681	8,978	4,229	26,888	4,065	2,667	1,256	7,988
2099	11,241	13,773	9,038	4,257	27,068	4,092	2,685	1,265	8,042
2100	11,317	13,866	9,099	4,286	27,250	4,120	2,703	1,273	8,096

PM+PB MORTALITY

AGE GROUP

	infant	30-34	35-44	45-54	55-64	65-74	75-84	85+
1970	0	0	0	0	0	0	0	0
1971	91	235	496	781	1,601	2,848	3,408	2,586
1972	182	470	993	1,562	3,202	5,696	6,817	5,171
1973	274	705	1,489	2,343	4,802	8,543	10,225	7,757
1974	365	940	1,985	3,123	6,403	11,391	13,633	10,342
1975	456	1,175	2,481	3,904	8,004	14,239	17,042	12,928
1976	833	1,524	3,315	5,344	10,663	18,576	22,095	16,761
1977	1,210	1,872	4,148	6,784	13,322	22,914	27,147	20,595
1978	1,588	2,221	4,981	8,223	15,981	27,252	32,200	24,428
1979	1,965	2,569	5,814	9,663	18,641	31,589	37,253	28,261
1980	2,342	2,918	6,647	11,103	21,300	35,927	42,306	32,094
1981	2,660	3,013	6,991	11,834	22,336	37,259	43,684	33,140
1982	2,978	3,108	7,335	12,566	23,373	38,590	45,062	34,185
1983	3,297	3,203	7,680	13,297	24,409	39,922	46,440	35,231
1984	3,615	3,298	8,024	14,029	25,445	41,254	47,818	36,276
1985	3,933	3,393	8,368	14,761	26,482	42,586	49,196	37,321
1986	4,135	3,448	8,567	15,179	26,989	43,365	50,002	37,933
1987	4,337	3,504	8,765	15,597	27,495	44,143	50,808	38,544
1988	4,540	3,560	8,964	16,015	28,002	44,921	51,614	39,156
1989	4,742	3,615	9,162	16,433	28,509	45,700	52,420	39,767
1990	4,944	3,671	9,361	16,850	29,016	46,478	53,226	40,379
1991	4,997	3,710	9,462	17,032	29,329	46,979	53,800	40,814
1992	5,054	3,753	9,569	17,226	29,662	47,513	54,412	41,278
1993	5,109	3,793	9,672	17,412	29,982	48,026	54,999	41,723
1994	5,159	3,830	9,768	17,583	30,278	48,500	55,542	42,135
1995	5,208	3,867	9,861	17,751	30,566	48,961	56,070	42,536
1996	5,256	3,903	9,952	17,915	30,848	49,413	56,587	42,928
1997	5,307	3,940	10,048	18,087	31,145	49,889	57,132	43,342
1998	5,357	3,978	10,144	18,260	31,443	50,365	57,678	43,755
1999	5,407	4,015	10,238	18,430	31,736	50,835	58,215	44,163
2000	5,457	4,051	10,331	18,598	32,025	51,298	58,746	44,566
2001	5,506	4,088	10,425	18,767	32,316	51,763	59,279	44,970
2002	5,556	4,125	10,519	18,936	32,607	52,229	59,813	45,375
2003	5,605	4,162	10,613	19,104	32,897	52,694	60,345	45,779
2004	5,654	4,198	10,705	19,271	33,184	53,154	60,871	46,178
2005	5,703	4,234	10,797	19,436	33,469	53,610	61,394	46,575
2006	5,751	4,270	10,889	19,601	33,752	54,064	61,914	46,969
2007	5,799	4,306	10,980	19,765	34,035	54,517	62,433	47,363
2008	5,847	4,341	11,071	19,929	34,317	54,969	62,950	47,755
2009	5,895	4,377	11,162	20,093	34,599	55,421	63,468	48,148
2010	5,943	4,413	11,253	20,257	34,882	55,873	63,986	48,541
2011	5,992	4,449	11,344	20,421	35,165	56,328	64,506	48,936
2012	6,041	4,485	11,437	20,588	35,452	56,787	65,032	49,334
2013	6,090	4,522	11,530	20,756	35,741	57,250	65,562	49,737
2014	6,139	4,558	11,624	20,925	36,032	57,716	66,096	50,142

PM+PB MORTALITY

AGE GROUP

	infant	30-34	35-44	45-54	55-64	65-74	75-84	85+
2015	6,189	4,595	11,719	21,095	36,325	58,185	66,633	50,549
2016	6,239	4,633	11,813	21,265	36,618	58,655	67,172	50,958
2017	6,290	4,670	11,908	21,436	36,913	59,127	67,712	51,368
2018	6,340	4,707	12,003	21,608	37,208	59,600	68,253	51,778
2019	6,390	4,744	12,099	21,779	37,503	60,072	68,794	52,189
2020	6,440	4,782	12,194	21,950	37,797	60,544	69,334	52,598
2021	6,491	4,819	12,289	22,122	38,093	61,017	69,876	53,010
2022	6,541	4,857	12,385	22,295	38,391	61,494	70,423	53,424
2023	6,592	4,895	12,482	22,469	38,691	61,975	70,973	53,842
2024	6,644	4,933	12,579	22,644	38,992	62,458	71,527	54,262
2025	6,696	4,971	12,677	22,821	39,296	62,945	72,084	54,685
2026	6,748	5,010	12,776	22,998	39,602	63,434	72,645	55,110
2027	6,800	5,049	12,875	23,176	39,909	63,926	73,207	55,537
2028	6,852	5,088	12,974	23,355	40,217	64,419	73,773	55,965
2029	6,905	5,127	13,074	23,535	40,527	64,916	74,341	56,397
2030	6,958	5,166	13,175	23,716	40,838	65,415	74,913	56,830
2031	7,011	5,206	13,275	23,897	41,150	65,914	75,484	57,264
2032	7,064	5,245	13,375	24,077	41,460	66,410	76,052	57,695
2033	7,117	5,284	13,474	24,256	41,768	66,903	76,617	58,124
2034	7,169	5,323	13,573	24,434	42,074	67,395	77,180	58,550
2035	7,221	5,361	13,672	24,611	42,380	67,884	77,740	58,975
2036	7,273	5,400	13,770	24,788	42,684	68,371	78,298	59,398
2037	7,325	5,438	13,868	24,964	42,987	68,857	78,855	59,821
2038	7,376	5,477	13,966	25,140	43,290	69,342	79,410	60,242
2039	7,428	5,515	14,063	25,316	43,593	69,827	79,966	60,664
2040	7,479	5,553	14,161	25,491	43,895	70,312	80,520	61,085
2041	7,531	5,591	14,259	25,667	44,198	70,796	81,075	61,506
2042	7,582	5,630	14,356	25,843	44,501	71,282	81,631	61,927
2043	7,634	5,668	14,454	26,019	44,804	71,767	82,188	62,349
2044	7,686	5,707	14,552	26,196	45,108	72,254	82,745	62,772
2045	7,738	5,745	14,651	26,373	45,413	72,743	83,305	63,197
2046	7,790	5,784	14,749	26,550	45,719	73,233	83,866	63,623
2047	7,842	5,823	14,848	26,729	46,027	73,725	84,430	64,050
2048	7,895	5,862	14,948	26,908	46,335	74,220	84,996	64,480
2049	7,948	5,901	15,048	27,089	46,646	74,718	85,567	64,913
2050	8,001	5,941	15,149	27,270	46,959	75,219	86,140	65,348
2051	8,055	5,981	15,251	27,453	47,274	75,724	86,718	65,786
2052	8,109	6,021	15,353	27,638	47,592	76,233	87,301	66,228
2053	8,164	6,061	15,457	27,824	47,913	76,746	87,889	66,675
2054	8,219	6,102	15,561	28,012	48,236	77,265	88,483	67,125
2055	8,275	6,144	15,667	28,202	48,563	77,789	89,083	67,580
2056	8,331	6,185	15,773	28,394	48,894	78,318	89,689	68,040
2057	8,388	6,228	15,881	28,588	49,228	78,853	90,302	68,505
2058	8,445	6,271	15,990	28,784	49,566	79,395	90,922	68,976
2059	8,504	6,314	16,101	28,983	49,908	79,943	91,550	69,451
2060	8,563	6,358	16,212	29,184	50,254	80,497	92,184	69,933

PM+PB MORTALITY

AGE GROUP

	infant	30-34	35-44	45-54	55-64	65-74	75-84	85+
2061	8,622	6,402	16,325	29,387	50,604	81,058	92,827	70,420
2062	8,683	6,447	16,439	29,593	50,958	81,625	93,477	70,913
2063	8,744	6,492	16,555	29,801	51,317	82,199	94,134	71,412
2064	8,806	6,538	16,672	30,012	51,679	82,780	94,799	71,917
2065	8,868	6,584	16,790	30,225	52,046	83,367	95,471	72,427
2066	8,931	6,631	16,910	30,440	52,416	83,960	96,151	72,942
2067	8,995	6,678	17,030	30,657	52,790	84,559	96,837	73,462
2068	9,059	6,726	17,152	30,876	53,168	85,164	97,530	73,988
2069	9,124	6,774	17,275	31,097	53,549	85,775	98,229	74,518
2070	9,190	6,823	17,399	31,320	53,933	86,390	98,933	75,053
2071	9,256	6,872	17,524	31,545	54,320	87,010	99,644	75,592
2072	9,322	6,921	17,650	31,772	54,710	87,635	100,359	76,134
2073	9,389	6,971	17,776	32,000	55,103	88,263	101,079	76,680
2074	9,456	7,021	17,904	32,229	55,498	88,896	101,803	77,230
2075	9,524	7,071	18,032	32,460	55,895	89,532	102,532	77,783
2076	9,592	7,122	18,161	32,692	56,294	90,172	103,264	78,339
2077	9,660	7,172	18,290	32,925	56,695	90,815	104,001	78,897
2078	9,729	7,223	18,420	33,159	57,099	91,461	104,740	79,458
2079	9,798	7,275	18,551	33,394	57,504	92,109	105,483	80,022
2080	9,867	7,326	18,682	33,630	57,910	92,761	106,229	80,588
2081	9,937	7,378	18,814	33,867	58,319	93,415	106,978	81,156
2082	10,007	7,430	18,946	34,105	58,729	94,072	107,730	81,726
2083	10,077	7,482	19,079	34,345	59,140	94,731	108,486	82,300
2084	10,147	7,534	19,212	34,585	59,554	95,393	109,244	82,875
2085	10,218	7,587	19,346	34,826	59,969	96,059	110,006	83,453
2086	10,289	7,639	19,481	35,068	60,386	96,726	110,770	84,033
2087	10,360	7,692	19,616	35,311	60,805	97,397	111,538	84,615
2088	10,432	7,746	19,752	35,555	61,225	98,071	112,310	85,201
2089	10,504	7,799	19,888	35,801	61,648	98,747	113,085	85,788
2090	10,576	7,853	20,025	36,047	62,072	99,427	113,863	86,379
2091	10,649	7,907	20,162	36,294	62,498	100,109	114,645	86,972
2092	10,722	7,961	20,300	36,543	62,926	100,795	115,430	87,567
2093	10,795	8,015	20,439	36,793	63,356	101,484	116,219	88,166
2094	10,869	8,070	20,578	37,043	63,788	102,175	117,011	88,767
2095	10,943	8,125	20,718	37,295	64,222	102,870	117,806	89,370
2096	11,017	8,180	20,859	37,548	64,657	103,568	118,605	89,976
2097	11,091	8,235	21,000	37,802	65,094	104,268	119,408	90,585
2098	11,166	8,291	21,142	38,057	65,534	104,972	120,213	91,196
2099	11,241	8,346	21,284	38,313	65,974	105,678	121,021	91,809
2100	11,317	8,402	21,426	38,570	66,416	106,386	121,832	92,425

AVOIDED EXPENDITURES ($millions)

	NON-Pb			Pb				Total
	chronic bronchitis	hospital admissions	household soiling	hyper-tension	congestive heart disease	stroke	compensatory education	
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1971	9.8	57.7	244.8	102.1	13.7	2.2	0.0	430
1972	29.4	115.4	489.6	204.1	27.3	6.7	0.0	873
1973	58.8	173.1	734.4	306.2	41.0	11.6	0.0	1,325
1974	98.0	230.8	979.2	408.2	54.6	16.8	0.0	1,788
1975	147.0	288.5	1,224.0	510.3	68.3	22.3	0.0	2,260
1976	212.7	369.6	1,584.0	1,056.9	142.4	37.8	0.0	3,403
1977	295.2	450.7	1,944.1	1,603.5	216.6	63.2	0.0	4,573
1978	394.4	531.8	2,304.1	2,150.1	290.8	90.5	4.8	5,766
1979	510.3	612.8	2,664.2	2,696.7	364.9	119.6	14.3	6,983
1980	643.0	693.9	3,024.2	3,243.2	439.1	150.6	28.7	8,223
1981	782.9	734.1	3,144.9	3,834.5	524.6	184.6	47.8	9,253
1982	930.1	774.2	3,265.6	4,425.8	610.2	221.7	71.6	10,299
1983	1,084.6	814.4	3,386.3	5,017.0	695.8	260.7	116.1	11,375
1984	1,246.3	854.6	3,507.1	5,608.3	781.3	301.5	181.2	12,480
1985	1,415.2	894.7	3,627.8	6,199.5	866.9	344.3	266.8	13,615
1986	1,585.8	923.9	3,695.0	6,514.2	912.6	382.3	373.1	14,387
1987	1,757.9	953.1	3,762.3	6,828.8	958.4	415.8	499.9	15,176
1988	1,931.6	982.2	3,829.5	7,143.5	1,004.1	449.4	647.5	15,988
1989	2,106.8	1,011.4	3,896.8	7,458.1	1,049.8	483.3	815.9	16,822
1990	2,283.7	1,040.6	3,964.0	7,772.8	1,095.6	517.4	1,000.3	17,674
1991	2,452.6	1,051.8	4,006.7	7,856.5	1,107.4	547.0	1,200.7	18,223
1992	2,613.8	1,063.8	4,052.3	7,945.9	1,120.0	572.3	1,417.1	18,785
1993	2,767.1	1,075.2	4,096.0	8,031.6	1,132.1	596.8	1,639.9	19,339
1994	2,912.5	1,085.8	4,136.4	8,110.9	1,143.2	620.3	1,869.2	19,878
1995	3,049.8	1,096.2	4,175.8	8,188.0	1,154.1	642.8	2,089.1	20,396
1996	3,172.0	1,106.3	4,214.3	8,263.6	1,164.8	664.5	2,299.6	20,885
1997	3,279.4	1,116.9	4,254.9	8,343.2	1,176.0	685.4	2,500.8	21,357
1998	3,371.8	1,127.6	4,295.5	8,422.8	1,187.2	705.2	2,684.4	21,794
1999	3,449.3	1,138.1	4,335.6	8,501.3	1,198.3	723.7	2,850.8	22,197
2000	3,511.8	1,148.5	4,375.1	8,578.8	1,209.2	740.9	2,999.5	22,564
2001	3,568.8	1,158.9	4,414.8	8,656.6	1,220.2	757.0	3,130.4	22,907
2002	3,620.3	1,169.3	4,454.5	8,734.6	1,231.2	771.7	3,243.3	23,225
2003	3,666.4	1,179.7	4,494.1	8,812.3	1,242.1	785.5	3,338.3	23,518
2004	3,706.9	1,190.0	4,533.4	8,889.2	1,252.9	798.2	3,415.4	23,786
2005	3,741.9	1,200.3	4,572.3	8,965.5	1,263.7	809.9	3,484.2	24,038
2006	3,777.0	1,210.4	4,611.0	9,041.5	1,274.4	820.6	3,544.7	24,280
2007	3,812.4	1,220.6	4,649.6	9,117.2	1,285.1	830.2	3,596.9	24,512
2008	3,847.8	1,230.7	4,688.2	9,192.8	1,295.7	839.3	3,640.7	24,735
2009	3,883.4	1,240.8	4,726.8	9,268.4	1,306.4	848.1	3,676.2	24,950
2010	3,919.2	1,250.9	4,765.3	9,344.0	1,317.1	856.3	3,711.5	25,164
2011	3,954.7	1,261.1	4,804.0	9,420.0	1,327.8	864.2	3,746.3	25,378
2012	3,990.0	1,271.4	4,843.2	9,496.8	1,338.6	871.6	3,780.7	25,592
2013	4,025.1	1,281.8	4,882.7	9,574.2	1,349.5	879.1	3,815.1	25,807

AVOIDED EXPENDITURES ($millions)

	NON-Pb			Pb				Total
	chronic bronchitis	hospital admissions	household soiling	hyper-tension	congestive heart disease	stroke	compensatory education	
2014	4,060.2	1,292.2	4,922.5	9,652.2	1,360.5	886.5	3,849.4	26,023
2015	4,095.3	1,302.7	4,962.5	9,730.6	1,371.5	894.0	3,883.6	26,240
2016	4,130.4	1,313.2	5,002.6	9,809.3	1,382.6	901.5	3,917.8	26,457
2017	4,165.6	1,323.8	5,042.8	9,888.2	1,393.8	909.0	3,951.8	26,675
2018	4,200.7	1,334.4	5,083.1	9,967.2	1,404.9	916.5	3,985.7	26,892
2019	4,235.9	1,344.9	5,123.4	10,046.2	1,416.0	924.0	4,019.5	27,110
2020	4,271.0	1,355.5	5,163.6	10,125.1	1,427.1	931.5	4,053.4	27,327
2021	4,306.2	1,366.1	5,204.0	10,204.2	1,438.3	939.0	4,087.2	27,545
2022	4,341.5	1,376.8	5,244.7	10,284.0	1,449.6	946.6	4,121.1	27,764
2023	4,376.8	1,387.5	5,285.7	10,364.4	1,460.9	954.2	4,155.1	27,984
2024	4,412.2	1,398.4	5,326.9	10,445.2	1,472.3	961.8	4,189.1	28,206
2025	4,447.7	1,409.3	5,368.4	10,526.7	1,483.8	969.4	4,223.3	28,429
2026	4,483.4	1,420.2	5,410.2	10,608.5	1,495.3	977.1	4,257.5	28,652
2027	4,519.2	1,431.2	5,452.1	10,690.7	1,506.9	984.8	4,291.9	28,877
2028	4,555.1	1,442.3	5,494.2	10,773.2	1,518.5	992.5	4,326.5	29,102
2029	4,591.3	1,453.4	5,536.5	10,856.2	1,530.2	1,000.3	4,361.2	29,329
2030	4,627.6	1,464.6	5,579.1	10,939.7	1,542.0	1,008.1	4,396.0	29,557
2031	4,664.0	1,475.7	5,621.7	11,023.2	1,553.7	1,016.0	4,431.0	29,785
2032	4,700.6	1,486.8	5,664.0	11,106.1	1,565.4	1,023.8	4,466.1	30,013
2033	4,737.4	1,497.9	5,706.0	11,188.6	1,577.1	1,031.7	4,501.4	30,240
2034	4,774.2	1,508.9	5,747.9	11,270.8	1,588.6	1,039.5	4,536.9	30,467
2035	4,811.1	1,519.8	5,789.6	11,352.5	1,600.2	1,047.4	4,572.4	30,693
2036	4,848.1	1,530.7	5,831.2	11,434.0	1,611.7	1,055.2	4,608.1	30,919
2037	4,885.1	1,541.6	5,872.7	11,515.4	1,623.1	1,063.1	4,644.0	31,145
2038	4,922.2	1,552.5	5,914.0	11,596.5	1,634.6	1,070.9	4,680.1	31,371
2039	4,959.3	1,563.3	5,955.4	11,677.6	1,646.0	1,078.8	4,716.3	31,597
2040	4,996.4	1,574.2	5,996.7	11,758.6	1,657.4	1,086.6	4,752.6	31,823
2041	5,033.6	1,585.0	6,038.1	11,839.7	1,668.8	1,094.4	4,789.0	32,049
2042	5,070.9	1,595.9	6,079.4	11,920.8	1,680.3	1,102.3	4,825.5	32,275
2043	5,108.1	1,606.8	6,120.9	12,002.1	1,691.7	1,110.1	4,861.9	32,502
2044	5,145.4	1,617.7	6,162.4	12,083.5	1,703.2	1,118.0	4,898.4	32,729
2045	5,182.7	1,628.6	6,204.1	12,165.2	1,714.7	1,125.9	4,934.9	32,956
2046	5,220.0	1,639.6	6,245.9	12,247.2	1,726.3	1,133.7	4,971.3	33,184
2047	5,257.3	1,650.6	6,287.9	12,329.5	1,737.9	1,141.6	5,007.7	33,412
2048	5,294.5	1,661.7	6,330.1	12,412.2	1,749.5	1,149.5	5,043.9	33,642
2049	5,331.8	1,672.8	6,372.5	12,495.5	1,761.3	1,157.5	5,080.1	33,872
2050	5,369.1	1,684.1	6,415.3	12,579.3	1,773.1	1,165.4	5,116.3	34,102
2051	5,406.5	1,695.4	6,458.3	12,663.7	1,785.0	1,173.4	5,152.3	34,335
2052	5,443.8	1,706.7	6,501.7	12,748.8	1,797.0	1,181.4	5,188.4	34,568
2053	5,481.3	1,718.3	6,545.5	12,834.7	1,809.1	1,189.5	5,224.4	34,803
2054	5,518.8	1,729.9	6,589.7	12,921.4	1,821.3	1,197.6	5,260.4	35,039
2055	5,556.5	1,741.6	6,634.4	13,009.0	1,833.7	1,205.7	5,296.5	35,277
2056	5,594.4	1,753.4	6,679.6	13,097.5	1,846.1	1,213.9	5,332.7	35,518
2057	5,632.4	1,765.4	6,725.2	13,187.1	1,858.7	1,222.2	5,368.9	35,760
2058	5,670.7	1,777.5	6,771.4	13,277.6	1,871.5	1,230.5	5,405.3	36,005

AVOIDED EXPENDITURES ($millions)

	NON-Pb			Pb				Total
	chronic bronchitis	hospital admissions	household soiling	hyper-tension	congestive heart disease	stroke	compensatory education	
2059	5,709.1	1,789.8	6,818.1	13,369.2	1,884.4	1,238.9	5,441.9	36,251
2060	5,747.9	1,802.2	6,865.4	13,461.9	1,897.5	1,247.4	5,478.6	36,501
2061	5,786.9	1,814.8	6,913.2	13,555.7	1,910.7	1,256.0	5,515.5	36,753
2062	5,826.3	1,827.5	6,961.6	13,650.6	1,924.1	1,264.6	5,552.7	37,007
2063	5,866.0	1,840.3	7,010.6	13,746.6	1,937.6	1,273.3	5,590.1	37,265
2064	5,906.0	1,853.3	7,060.1	13,843.7	1,951.3	1,282.2	5,627.8	37,524
2065	5,946.4	1,866.5	7,110.2	13,941.9	1,965.1	1,291.1	5,665.8	37,787
2066	5,987.3	1,879.8	7,160.8	14,041.1	1,979.1	1,300.1	5,704.2	38,052
2067	6,028.5	1,893.2	7,211.9	14,141.3	1,993.2	1,309.1	5,742.9	38,320
2068	6,070.1	1,906.7	7,263.5	14,242.5	2,007.5	1,318.3	5,782.0	38,591
2069	6,112.2	1,920.4	7,315.5	14,344.6	2,021.9	1,327.6	5,821.5	38,864
2070	6,154.7	1,934.2	7,368.0	14,447.5	2,036.4	1,337.0	5,861.5	39,139
2071	6,197.6	1,948.0	7,420.9	14,551.2	2,051.0	1,346.4	5,901.9	39,417
2072	6,241.0	1,962.0	7,474.2	14,655.6	2,065.7	1,355.9	5,942.7	39,697
2073	6,284.8	1,976.1	7,527.8	14,760.8	2,080.6	1,365.5	5,984.1	39,980
2074	6,329.1	1,990.3	7,581.8	14,866.6	2,095.5	1,375.2	6,025.8	40,264
2075	6,373.8	2,004.5	7,636.0	14,973.0	2,110.5	1,385.0	6,068.1	40,551
2076	6,418.9	2,018.8	7,690.6	15,080.0	2,125.6	1,394.9	6,110.8	40,839
2077	6,464.4	2,033.2	7,745.4	15,187.5	2,140.7	1,404.8	6,154.0	41,130
2078	6,510.3	2,047.7	7,800.5	15,295.5	2,155.9	1,414.8	6,197.6	41,422
2079	6,556.6	2,062.2	7,855.8	15,403.9	2,171.2	1,424.8	6,241.6	41,716
2080	6,603.2	2,076.8	7,911.3	15,512.9	2,186.6	1,434.9	6,286.1	42,012
2081	6,650.3	2,091.4	7,967.1	15,622.3	2,202.0	1,445.1	6,330.9	42,309
2082	6,697.6	2,106.1	8,023.2	15,732.1	2,217.5	1,455.4	6,376.2	42,608
2083	6,745.3	2,120.9	8,079.4	15,842.4	2,233.0	1,465.7	6,421.8	42,909
2084	6,793.3	2,135.7	8,135.9	15,953.2	2,248.6	1,476.0	6,467.8	43,210
2085	6,841.6	2,150.6	8,192.6	16,064.4	2,264.3	1,486.4	6,514.0	43,514
2086	6,890.1	2,165.6	8,249.6	16,176.1	2,280.1	1,496.9	6,560.6	43,819
2087	6,939.0	2,180.6	8,306.8	16,288.2	2,295.9	1,507.4	6,607.5	44,125
2088	6,988.1	2,195.7	8,364.2	16,400.9	2,311.7	1,518.0	6,654.6	44,433
2089	7,037.5	2,210.8	8,421.9	16,514.0	2,327.7	1,528.6	6,702.0	44,743
2090	7,087.1	2,226.0	8,479.9	16,627.7	2,343.7	1,539.2	6,749.7	45,053
2091	7,136.9	2,241.3	8,538.1	16,741.8	2,359.8	1,550.0	6,797.6	45,365
2092	7,187.0	2,256.7	8,596.6	16,856.5	2,376.0	1,560.7	6,845.7	45,679
2093	7,237.3	2,272.1	8,655.3	16,971.7	2,392.2	1,571.5	6,894.0	45,994
2094	7,287.8	2,287.6	8,714.3	17,087.4	2,408.5	1,582.4	6,942.5	46,310
2095	7,338.5	2,303.1	8,773.6	17,203.6	2,424.9	1,593.3	6,991.2	46,628
2096	7,389.5	2,318.7	8,833.1	17,320.2	2,441.3	1,604.3	7,040.2	46,947
2097	7,440.7	2,334.4	8,892.8	17,437.4	2,457.8	1,615.3	7,089.3	47,268
2098	7,492.1	2,350.2	8,952.8	17,555.0	2,474.4	1,626.3	7,138.7	47,590
2099	7,543.7	2,366.0	9,013.0	17,673.1	2,491.1	1,637.4	7,188.3	47,913
2100	7,595.6	2,381.8	9,073.4	17,791.5	2,507.7	1,648.6	7,238.1	48,237

AVOIDED WORK LOSS DAYS (millions of worker-days)

	NON-Pb			Pb				TOTAL	
	chronic bronchitis	direct WLD	worker product-ivity	hyper-tension	congestive heart disease	stroke	IQ-related prod. loss		@83/day ($millions)
1970	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
1971	1.6	1.4	0.0	0.1	0.0	0.0	0.0	3.2	262
1972	4.8	2.8	0.0	0.3	0.0	0.0	0.0	7.9	659
1973	9.6	4.2	0.0	0.4	0.0	0.1	0.0	14.3	1,190
1974	16.0	5.6	0.0	0.5	0.0	0.2	0.0	22.4	1,856
1975	24.1	7.0	0.0	0.7	0.1	0.2	0.0	32.0	2,657
1976	34.8	9.0	0.0	1.4	0.1	0.4	0.0	45.8	3,798
1977	48.3	11.1	0.0	2.1	0.2	0.7	0.0	62.3	5,175
1978	64.6	13.1	0.0	2.8	0.2	1.0	0.0	81.8	6,786
1979	83.6	15.2	0.0	3.5	0.3	1.5	0.0	104.0	8,633
1980	105.3	17.2	0.0	4.2	0.4	2.0	0.0	129.1	10,714
1981	128.2	17.9	0.0	5.0	0.4	2.6	0.0	154.1	12,792
1982	152.3	18.6	0.0	5.8	0.5	3.3	0.0	180.4	14,977
1983	177.6	19.3	0.0	6.5	0.6	4.0	0.0	208.0	17,266
1984	204.1	20.0	0.0	7.3	0.6	4.9	0.0	236.9	19,661
1985	231.8	20.6	0.0	8.1	0.7	5.8	0.0	267.0	22,161
1986	259.7	21.0	0.0	8.5	0.8	6.7	0.0	296.6	24,621
1987	287.9	21.4	0.0	8.9	0.8	7.5	0.0	326.5	27,099
1988	316.3	21.8	0.0	9.3	0.8	8.3	0.0	356.6	29,596
1989	345.0	22.2	0.0	9.7	0.9	9.1	0.9	387.8	32,188
1990	374.0	22.6	0.0	10.1	0.9	9.8	2.8	420.2	34,876
1991	401.7	22.8	0.0	10.2	0.9	10.4	5.6	451.7	37,488
1992	428.1	23.1	0.0	10.3	0.9	11.0	9.3	482.7	40,068
1993	453.2	23.3	0.0	10.5	0.9	11.5	14.0	513.4	42,610
1994	477.0	23.5	0.0	10.6	0.9	11.9	22.3	546.2	45,336
1995	499.5	23.8	0.0	10.7	1.0	12.2	34.3	581.3	48,247
1996	519.5	24.0	0.0	10.8	1.0	12.4	49.8	617.5	51,252
1997	537.1	24.2	0.0	10.9	1.0	12.7	69.1	654.9	54,354
1998	552.2	24.4	0.0	11.0	1.0	12.9	91.9	693.4	57,553
1999	564.9	24.7	0.0	11.1	1.0	13.0	118.0	732.7	60,810
2000	575.1	24.9	0.0	11.2	1.0	13.2	147.2	772.6	64,127
2001	584.5	25.1	0.0	11.3	1.0	13.3	179.7	814.9	67,636
2002	592.9	25.4	0.0	11.4	1.0	13.4	215.4	859.5	71,335
2003	600.4	25.6	0.0	11.5	1.0	13.6	254.3	906.3	75,226
2004	607.1	25.8	0.0	11.6	1.0	13.7	294.8	954.0	79,179
2005	612.8	26.0	0.0	11.7	1.0	13.8	337.0	1,002.3	83,194
2006	618.6	26.2	0.0	11.8	1.1	13.9	380.8	1,052.4	87,348
2007	624.4	26.5	0.0	11.9	1.1	14.1	426.3	1,104.1	91,641
2008	630.2	26.7	0.0	12.0	1.1	14.2	473.4	1,157.5	96,073
2009	636.0	26.9	0.0	12.1	1.1	14.3	521.1	1,211.4	100,549
2010	641.9	27.1	0.0	12.2	1.1	14.4	569.3	1,265.9	105,072
2011	647.7	27.3	0.0	12.3	1.1	14.5	618.0	1,320.9	109,635
2012	653.5	27.6	0.0	12.4	1.1	14.7	667.2	1,376.3	114,235
2013	659.2	27.8	0.0	12.5	1.1	14.8	716.8	1,432.2	118,872

AVOIDED WORK LOSS DAYS (millions of worker-days)

	NON-Pb			Pb				TOTAL	
	chronic bronchitis	direct WLD	worker product-ivity	hyper-tension	congestive heart disease	stroke	IQ-related prod. loss		@83/day ($millions)
2014	664.9	28.0	0.0	12.6	1.1	14.9	766.9	1,488.5	123,546
2015	670.7	28.2	0.0	12.7	1.1	15.0	817.5	1,545.3	128,262
2016	676.5	28.5	0.0	12.8	1.1	15.2	868.6	1,602.6	133,018
2017	682.2	28.7	0.0	12.9	1.2	15.3	920.2	1,660.4	137,814
2018	688.0	28.9	0.0	13.0	1.2	15.4	972.2	1,718.7	142,648
2019	693.7	29.2	0.0	13.1	1.2	15.5	1,024.7	1,777.4	147,522
2020	699.5	29.4	0.0	13.2	1.2	15.7	1,077.7	1,836.6	152,436
2021	705.2	29.6	0.0	13.3	1.2	15.8	1,131.1	1,896.3	157,389
2022	711.0	29.9	0.0	13.4	1.2	15.9	1,185.0	1,956.4	162,382
2023	716.8	30.1	0.0	13.5	1.2	16.0	1,239.4	2,017.0	167,414
2024	722.6	30.3	0.0	13.6	1.2	16.2	1,294.2	2,078.1	172,486
2025	728.4	30.6	0.0	13.7	1.2	16.3	1,349.5	2,139.7	177,598
2026	734.3	30.8	0.0	13.8	1.2	16.4	1,405.3	2,201.8	182,750
2027	740.1	31.0	0.0	13.9	1.2	16.5	1,461.5	2,264.4	187,942
2028	746.0	31.3	0.0	14.0	1.3	16.7	1,518.2	2,327.4	193,175
2029	751.9	31.5	0.0	14.1	1.3	16.8	1,575.3	2,390.9	198,448
2030	757.9	31.8	0.0	14.2	1.3	16.9	1,632.9	2,455.0	203,763
2031	763.8	32.0	0.0	14.3	1.3	17.1	1,691.0	2,519.5	209,119
2032	769.8	32.2	0.0	14.5	1.3	17.2	1,749.5	2,584.5	214,516
2033	775.9	32.5	0.0	14.6	1.3	17.3	1,808.5	2,650.0	219,954
2034	781.9	32.7	0.0	14.7	1.3	17.5	1,868.0	2,716.1	225,433
2035	787.9	33.0	0.0	14.8	1.3	17.6	1,928.0	2,782.6	230,952
2036	794.0	33.2	0.0	14.9	1.3	17.7	1,988.4	2,849.5	236,512
2037	800.0	33.4	0.0	15.0	1.3	17.9	2,048.4	2,916.1	242,035
2038	806.1	33.7	0.0	15.1	1.4	18.0	2,108.0	2,982.2	247,520
2039	812.2	33.9	0.0	15.2	1.4	18.1	2,167.0	3,047.8	252,969
2040	818.3	34.1	0.0	15.3	1.4	18.3	2,225.7	3,113.0	258,380
2041	824.4	34.4	0.0	15.4	1.4	18.4	2,283.9	3,177.8	263,755
2042	830.5	34.6	0.0	15.5	1.4	18.5	2,338.9	3,239.4	268,870
2043	836.6	34.8	0.0	15.6	1.4	18.6	2,390.8	3,297.9	273,724
2044	842.7	35.1	0.0	15.7	1.4	18.8	2,439.5	3,353.2	278,317
2045	848.8	35.3	0.0	15.8	1.4	18.9	2,485.2	3,405.4	282,650
2046	854.9	35.6	0.0	15.9	1.4	19.0	2,527.7	3,454.5	286,724
2047	861.0	35.8	0.0	16.0	1.4	19.2	2,567.4	3,500.9	290,573
2048	867.1	36.0	0.0	16.2	1.4	19.3	2,604.5	3,544.6	294,198
2049	873.2	36.3	0.0	16.3	1.5	19.4	2,638.9	3,585.5	297,600
2050	879.3	36.5	0.0	16.4	1.5	19.6	2,670.6	3,623.8	300,777
2051	885.4	36.8	0.0	16.5	1.5	19.7	2,699.6	3,659.4	303,731
2052	891.6	37.0	0.0	16.6	1.5	19.8	2,727.4	3,693.9	306,590
2053	897.7	37.3	0.0	16.7	1.5	20.0	2,754.1	3,727.2	309,354
2054	903.8	37.5	0.0	16.8	1.5	20.1	2,779.6	3,759.3	312,024
2055	910.0	37.8	0.0	16.9	1.5	20.2	2,803.9	3,790.4	314,600
2056	916.2	38.0	0.0	17.0	1.5	20.4	2,827.1	3,820.3	317,083
2057	922.4	38.3	0.0	17.2	1.5	20.5	2,850.3	3,850.2	319,567
2058	928.7	38.5	0.0	17.3	1.5	20.6	2,873.4	3,880.1	322,050

AVOIDED WORK LOSS DAYS (millions of worker-days)

	NON-Pb			Pb				TOTAL	
	chronic bronchitis	direct WLD	worker product-ivity	hyper-tension	congestive heart disease	stroke	IQ-related prod. loss		@83/day ($millions)
2059	935.0	38.8	0.0	17.4	1.6	20.8	2,896.5	3,910.1	324,534
2060	941.3	39.1	0.0	17.5	1.6	20.9	2,919.6	3,940.0	327,024
2061	947.7	39.3	0.0	17.6	1.6	21.1	2,942.7	3,970.1	329,520
2062	954.2	39.6	0.0	17.8	1.6	21.2	2,965.9	4,000.3	332,024
2063	960.7	39.9	0.0	17.9	1.6	21.4	2,989.1	4,030.5	334,534
2064	967.2	40.2	0.0	18.0	1.6	21.5	3,012.3	4,060.8	337,050
2065	973.9	40.5	0.0	18.1	1.6	21.6	3,035.5	4,091.3	339,574
2066	980.6	40.8	0.0	18.3	1.6	21.8	3,058.7	4,121.8	342,107
2067	987.3	41.0	0.0	18.4	1.6	22.0	3,082.0	4,152.4	344,648
2068	994.1	41.3	0.0	18.5	1.7	22.1	3,105.3	4,183.1	347,199
2069	1,001.0	41.6	0.0	18.7	1.7	22.3	3,128.7	4,214.0	349,759
2070	1,008.0	41.9	0.0	18.8	1.7	22.4	3,152.1	4,244.9	352,329
2071	1,015.0	42.2	0.0	18.9	1.7	22.6	3,175.6	4,276.0	354,911
2072	1,022.1	42.5	0.0	19.1	1.7	22.7	3,199.1	4,307.3	357,505
2073	1,029.3	42.8	0.0	19.2	1.7	22.9	3,222.7	4,338.7	360,111
2074	1,036.5	43.2	0.0	19.4	1.7	23.1	3,246.4	4,370.2	362,729
2075	1,043.9	43.5	0.0	19.5	1.7	23.2	3,270.2	4,401.9	365,361
2076	1,051.2	43.8	0.0	19.6	1.8	23.4	3,294.0	4,433.8	368,006
2077	1,058.7	44.1	0.0	19.8	1.8	23.6	3,318.0	4,465.8	370,665
2078	1,066.2	44.4	0.0	19.9	1.8	23.7	3,342.0	4,498.1	373,338
2079	1,073.8	44.7	0.0	20.1	1.8	23.9	3,366.2	4,530.4	376,025
2080	1,081.4	45.0	0.0	20.2	1.8	24.1	3,390.4	4,562.9	378,725
2081	1,089.1	45.3	0.0	20.3	1.8	24.2	3,414.8	4,595.7	381,439
2082	1,096.9	45.7	0.0	20.5	1.8	24.4	3,439.2	4,628.5	384,167
2083	1,104.7	46.0	0.0	20.6	1.8	24.6	3,463.8	4,661.6	386,910
2084	1,112.6	46.3	0.0	20.8	1.9	24.8	3,488.5	4,694.8	389,667
2085	1,120.5	46.6	0.0	20.9	1.9	24.9	3,513.4	4,728.2	392,439
2086	1,128.4	47.0	0.0	21.1	1.9	25.1	3,538.3	4,761.8	395,227
2087	1,136.4	47.3	0.0	21.2	1.9	25.3	3,563.4	4,795.5	398,030
2088	1,144.5	47.6	0.0	21.3	1.9	25.5	3,588.7	4,829.5	400,848
2089	1,152.5	47.9	0.0	21.5	1.9	25.7	3,614.1	4,863.6	403,682
2090	1,160.7	48.3	0.0	21.6	1.9	25.8	3,639.6	4,898.0	406,531
2091	1,168.8	48.6	0.0	21.8	2.0	26.0	3,665.3	4,932.5	409,396
2092	1,177.0	48.9	0.0	21.9	2.0	26.2	3,691.1	4,967.2	412,276
2093	1,185.3	49.3	0.0	22.1	2.0	26.4	3,717.1	5,002.1	415,172
2094	1,193.5	49.6	0.0	22.2	2.0	26.6	3,743.2	5,037.1	418,083
2095	1,201.9	49.9	0.0	22.4	2.0	26.7	3,769.5	5,072.4	421,010
2096	1,210.2	50.3	0.0	22.5	2.0	26.9	3,795.9	5,107.9	423,952
2097	1,218.6	50.6	0.0	22.7	2.0	27.1	3,822.5	5,143.5	426,910
2098	1,227.0	51.0	0.0	22.9	2.0	27.3	3,849.2	5,179.3	429,885
2099	1,235.5	51.3	0.0	23.0	2.1	27.5	3,876.1	5,215.4	432,876
2100	1,243.9	51.6	0.0	23.2	2.1	27.7	3,903.1	5,251.6	435,885

POPULATION PROJECTIONS: from Census Bureau copy of file:

(NP-T1) Annual Projections of the Total Resident Population as of July 1:
Middle, Lowest, Highest, and Zero International Migration Series,
1999 to 2100.

Source: (1) Population Estimates Program, Population Division,
U.S. Census Bureau, Washington, D.C. 20233
(2) Population Projections Program, Population Division,
U.S. Census Bureau, Washington, D.C. 20233
Contact: Statistical Information Staff, Population Division,
U.S. Census Bureau, (301)457-2422 by telephone,
POP@CENSUS.GOV by e-mail (please include telephone number).

Internet Release Date: January 13, 2000
Revised Date: February 14, 2000

(Numbers in thousands. Consistent with the 1990 estimates base.)

Year	Projected Population Middle Series	Lowest Series	Highest Series	Zero International Migration Series
Estimates (1)				
1990	249,439	-	-	-
1991	252,127	-	-	-
1992	254,995	-	-	-
1993	257,746	-	-	-
1994	260,289	-	-	-
1995	262,765	-	-	-
1996	265,190	-	-	-
1997	267,744	-	-	-
1998	270,299	-	-	-
Projections (2)				
1999	272,820	272,695	272,957	272,323
2000	275,306	274,853	275,816	273,818
2001	277,803	276,879	278,869	275,279
2002	280,306	278,801	282,087	276,709
2003	282,798	280,624	285,422	278,112
2004	285,266	282,352	288,841	279,493
2005	287,716	284,000	292,339	280,859
2006	290,153	285,581	295,911	282,219
2007	292,583	287,106	299,557	283,579
2008	295,009	288,583	303,274	284,945

2009	297,436	290,018	307,060	286,322
2010	299,862	291,413	310,910	287,710
2011	302,300	292,778	314,846	289,108
2012	304,764	294,120	318,893	290,514
2013	307,250	295,436	323,044	291,924
2014	309,753	296,723	327,293	293,334
2015	312,268	297,977	331,636	294,741
2016	314,793	299,197	336,069	296,144
2017	317,325	300,379	340,589	297,539
2018	319,860	301,521	345,192	298,921
2019	322,395	302,617	349,877	300,288
2020	324,927	303,664	354,642	301,636
2021	327,468	304,667	359,515	302,958
2022	330,028	305,628	364,524	304,251
2023	332,607	306,545	369,671	305,511
2024	335,202	307,412	374,960	306,735
2025	337,815	308,229	380,397	307,923
2026	340,441	308,999	385,971	309,070
2027	343,078	309,727	391,672	310,172
2028	345,727	310,413	397,507	311,230
2029	348,391	311,056	403,483	312,246
2030	351,070	311,656	409,604	313,219
2031	353,749	312,204	415,839	314,153
2032	356,411	312,692	422,154	315,049
2033	359,059	313,124	428,554	315,910
2034	361,695	313,499	435,041	316,737
2035	364,319	313,819	441,618	317,534
2036	366,934	314,086	448,287	318,304
2037	369,544	314,303	455,053	319,049
2038	372,148	314,472	461,917	319,773
2039	374,750	314,594	468,882	320,478
2040	377,350	314,673	475,949	321,167
2041	379,951	314,710	483,122	321,843
2042	382,555	314,707	490,401	322,506
2043	385,163	314,667	497,790	323,160
2044	387,776	314,591	505,290	323,807
2045	390,398	314,484	512,904	324,449
2046	393,029	314,346	520,633	325,087
2047	395,671	314,181	528,480	325,723
2048	398,326	313,990	536,447	326,359
2049	400,998	313,778	544,539	326,998
2050	403,687	313,546	552,757	327,641
2051	406,396	313,296	561,106	328,291
2052	409,127	313,030	569,589	328,949
2053	411,884	312,752	578,211	329,617
2054	414,667	312,461	586,975	330,297
2055	417,478	312,160	595,885	330,991
2056	420,318	311,850	604,943	331,700
2057	423,191	311,532	614,157	332,427

2058	426,097	311,206	623,527	333,172
2059	429,037	310,873	633,058	333,937
2060	432,011	310,533	642,752	334,724
2061	435,021	310,187	652,615	335,533
2062	438,067	309,833	662,648	336,365
2063	441,149	309,471	672,853	337,220
2064	444,265	309,098	683,233	338,098
2065	447,416	308,716	693,790	338,999
2066	450,600	308,321	704,524	339,922
2067	453,815	307,913	715,438	340,866
2068	457,061	307,488	726,530	341,830
2069	460,337	307,048	737,804	342,814
2070	463,639	306,589	749,257	343,815
2071	466,968	306,109	760,892	344,833
2072	470,319	305,608	772,707	345,865
2073	473,694	305,086	784,704	346,909
2074	477,090	304,540	796,883	347,966
2075	480,504	303,970	809,243	349,032
2076	483,937	303,375	821,785	350,107
2077	487,387	302,756	834,510	351,189
2078	490,853	302,111	847,420	352,278
2079	494,334	301,442	860,514	353,372
2080	497,830	300,747	873,794	354,471
2081	501,341	300,029	887,263	355,574
2082	504,866	299,286	900,922	356,681
2083	508,406	298,521	914,773	357,792
2084	511,959	297,732	928,818	358,907
2085	515,529	296,923	943,062	360,026
2086	519,113	296,093	957,506	361,149
2087	522,712	295,244	972,153	362,277
2088	526,327	294,375	987,006	363,409
2089	529,958	293,488	1,002,069	364,546
2090	533,605	292,584	1,017,344	365,689
2091	537,269	291,664	1,032,834	366,838
2092	540,948	290,727	1,048,542	367,992
2093	544,645	289,775	1,064,472	369,153
2094	548,357	288,808	1,080,626	370,319
2095	552,086	287,826	1,097,007	371,492
2096	555,830	286,830	1,113,615	372,672
2097	559,590	285,820	1,130,457	373,857
2098	563,365	284,796	1,147,532	375,048
2099	567,153	283,758	1,164,842	376,243
2100	570,954	282,706	1,182,390	377,444

Note: For a description of the methodology and assumptions see the corresponding menu item, "Methodology and Assumptions for the Population Projections of the United States: 1999 to 2100, Working Paper #38."

Appendix D

Compliance Costs: Sources, Methods and Data

D.1 Compliance Cost Sources

CAPITAL EXPENDITURES

U.S. Environmental Protection Agency. *Environmental Investments: The Cost of a Clean Environment.* November 1990

U.S. Department of Commerce, Bureau of Economic Analysis. *Survey of Current Business.* Selected Issues

Historical data, 1973-89. EPA estimates, 1990.

OPERATING & MAINTENANCE EXPENDITURES

U.S. Environmental Protection Agency. *Environmental Investments: The Cost of a Clean Environment.* November 1990

U.S. Department of Commerce, Bureau of Economic Analysis. *Survey of Current Business.* Selected Issues

U.S. Department of Commerce, Bureau of the Census. *Current Industrial Reports: Pollution Abatement Costs and Expenditures, 19__.*

Historical data for non-farm business aggregates

- 1973-1984 Complete
- 1985-1986, Revised data allocated on the basis of historical 1985-1986 shares
- 1987-1989, Revised data allocated on the basis of historical 1986 shares
- 1990 EPA estimates allocated on the basis of 1986 shares

Historical data for sectors within manufacturing

- 1973-1986, 1988 Complete
- 1987 Survey not taken or published. Numbers determined on the basis of historical shares within total manufacturing
- 1989-90 totals allocated on the basis of 1988 shares

RECOVERED COSTS

U.S. Department of Commerce, Bureau of the Census. *Current Industrial Reports: Pollution Abatement Costs and Expenditures, 19__.*

Historical data for manufacturing

1979-1986, 1988 Complete

1987 Survey not taken or published. Numbers for 1973-78 and 1987 determined on the basis of historical shares of total recovered costs

1989-90 totals and allocation based on 1988 shares

MOBILE SOURCES

U.S. Environmental Protection Agency. *Environmental Investments: The Cost of a Clean Environment.* November 1990 and Revisions.

U.S. Department of Commerce, Bureau of Economic Analysis. *Survey of Current Business.* Selected Issues

U.S. Department of Labor, Bureau of Labor Statistics. *Producer Price Indexes.* Selected Supplements

Historical data, 1973-1989. EPA estimates, 1990.

OTHER SOURCES

U.S. Department of Commerce, Bureau of Economic Analysis. *The National Income and Product Accounts of the United States.* Selected Releases

U.S. Department of Labor, Bureau of Labor Statistics. *Time Series on Input-Output Industries.* Selected Releases

Historical data, BEA, 1973-90, and BLS, 1973-89.

D.2 Compliance Cost Estimation Methods

Operating & Maintenance Expenditures: Manufacturing

Missing values in the Census data at the two-digit level were estimated, generally by linear interpolation. Depreciation expenses were removed from the annual O&M expenditures using the 1979 value share (the only year available). The resulting O&M outlays were aggregated across sectors to yield an industry total by year. Value shares then were computed from the sectoral data and the industry totals. The result was a matrix of sectoral shares of total O&M outlays for manufacturing in each year, 1973-1988. Share values for 1988 were used for 1989 and 1990. These share values were applied to the BEA (EPA) O&M totals for all manufacturing to yield the compliance costs reported below.

Recovered Costs: Manufacturing

Missing values in the Census data at the two-digit level were determined in one of two ways. Where data were present, the average share of air recovered costs in total recovered costs was applied to total recovered costs. This provided data for those situations in which total recovered costs were available but air recovered costs were not. The remaining missing values were estimated, generally by linear interpolation. These results then were aggregated to yield air recovered costs for total manufacturing by year. In many instances, these are very close to BEA's figures for all air-related recovered costs, manufacturing and non-manufacturing alike.

Operating & Maintenance Expenditures: Non-manufacturing

BEA capital expenditures on air pollution control equipment for non-manufacturing aggregates were allocated to sub-aggregates on the basis of BLS industry output shares. These capital expenditures were accumulated over time within each non-manufacturing sub-aggregate and aggregate capital by year was determined. Capital value shares by year for the sub-aggregates then were computed and applied to the BEA (EPA) O&M expenditures for the non-manufacturing aggregates to yield the compliance costs below.

In all cost categories, data for the years 1971 and 1972 were determined by linear interpolation between 1970, assumed to be zero, and 1973, the first full year of available information.

The compliance costs used in this analysis are reported fully in the pages that follow.

	O&M Expenditures, $Mn				
Industry	Metal mining	Coal mining	Crude & natural gas	Non-metallic mining	Construction
Year					
1973	5.83	8.14	27.93	6.51	42.11
1974	6.87	11.91	36.84	7.41	43.06
1975	7.69	15.70	45.22	8.67	50.85
1976	11.27	25.78	71.05	12.85	52.18
1977	15.26	37.39	105.04	18.06	59.28
1978	18.79	46.67	134.05	22.72	65.75
1979	22.99	57.10	168.50	27.46	68.40
1980	26.68	66.52	210.34	31.75	81.30
1981	29.37	73.88	250.14	35.03	92.52
1982	26.35	69.44	248.91	32.15	80.33
1983	29.66	79.73	295.28	36.78	91.21
1984	34.03	93.33	352.50	42.90	104.11
1985	36.37	101.87	390.32	46.76	110.76
1986	36.88	106.02	402.79	48.59	113.96
1987	37.60	110.42	417.47	50.69	115.95
1988	35.82	106.95	400.80	49.40	114.10
1989	37.09	111.96	417.17	52.19	121.20
1990	40.53	123.95	459.21	58.24	135.43

	O&M Expenditures, $Mn				
Industry	Food & products	Tobacco	Textile products	Lumber & products	Furniture & fixtures
Year					
1973	31.82	1.80	4.19	9.65	2.89
1974	37.31	2.67	5.87	11.87	3.53
1975	40.90	3.07	5.90	13.89	3.77
1976	43.96	3.50	5.72	16.13	4.44
1977	44.58	3.35	6.81	12.67	5.65
1978	53.30	3.92	11.91	16.93	4.96
1979	66.20	4.33	11.28	23.27	6.15
1980	63.54	4.51	10.55	24.54	6.74
1981	61.31	5.60	12.08	26.92	6.73
1982	59.22	6.54	9.28	16.14	5.51
1983	74.22	6.90	13.43	19.12	8.17
1984	78.01	9.57	16.22	25.25	9.73
1985	82.61	10.38	19.61	25.85	13.35
1986	100.22	9.27	18.51	39.06	16.89
1987	115.99	9.08	19.69	47.40	18.48
1988	123.72	8.27	19.52	52.42	18.82
1989	130.97	8.76	20.67	55.49	19.92
1990	146.60	9.80	23.13	62.11	22.29

	O&M Expenditures, $Mn				
Industry	Paper & products	Printing & publishing	Chemicals & products	Petroleum refining	Rubber & plastics
Year					
1973	44.43	4.87	148.28	182.90	10.04
1974	57.26	5.20	163.08	212.73	12.13
1975	71.54	6.20	192.20	304.61	16.08
1976	87.07	6.58	235.72	414.65	17.18
1977	93.42	6.20	268.04	539.17	15.40
1978	112.21	6.99	320.55	570.65	13.74
1979	118.49	7.96	369.47	637.57	23.68
1980	140.91	11.93	439.98	827.39	23.93
1981	152.96	13.62	468.49	1022.05	23.59
1982	146.44	15.48	447.04	1071.76	17.24
1983	161.35	26.15	505.12	1085.33	39.74
1984	199.38	35.83	501.32	1193.95	39.78
1985	224.35	46.55	547.29	1160.03	36.69
1986	234.17	54.24	538.18	1143.10	40.93
1987	260.71	61.76	578.71	1148.46	46.85
1988	269.30	65.02	579.64	1076.32	49.53
1989	285.09	68.83	613.63	1139.43	52.44
1990	319.09	77.04	686.81	1275.33	58.69

	O&M Expenditures, $Mn				
Industry	Leather & products	Stone, clay & glass	Primary metals	Fabricated metals	Non-electric machinery
Year					
1973	.70	54.53	224.44	22.37	16.66
1974	.73	68.61	270.54	26.86	19.31
1975	.88	76.67	344.33	25.51	22.69
1976	.80	85.07	457.05	27.46	24.39
1977	.80	99.46	570.19	31.42	26.72
1978	1.03	114.30	647.86	32.92	32.73
1979	.91	124.33	744.07	42.22	37.88
1980	.82	128.91	809.86	38.85	38.85
1981	.71	135.96	907.13	41.14	38.50
1982	.59	99.72	718.05	38.01	37.21
1983	1.11	126.32	727.72	64.40	46.56
1984	1.77	150.53	816.29	50.89	54.76
1985	1.79	153.46	863.99	62.82	61.40
1986	1.75	171.38	802.66	77.42	67.30
1987	1.88	180.10	823.74	95.96	63.64
1988	1.88	176.56	788.98	107.77	55.75
1989	1.99	186.91	835.24	114.08	59.01
1990	2.23	209.20	934.86	127.69	66.05

	O&M Expenditures, $Mn				
Industry	Electrical machinery	Motor vehicles	Other transport equip.	Instruments	Misc. manufacturing
Year					
1973	15.70	23.84	6.19	1.81	4.89
1974	16.58	27.00	8.98	4.16	5.59
1975	20.26	33.38	8.69	5.04	4.39
1976	19.50	36.33	9.11	7.36	5.95
1977	20.27	38.67	9.48	7.66	4.02
1978	22.52	50.98	11.19	6.23	3.08
1979	32.44	59.85	13.60	8.56	4.74
1980	33.61	74.42	15.83	9.77	4.06
1981	38.73	75.73	20.77	11.13	4.86
1982	40.42	67.42	17.62	11.01	7.31
1983	57.02	104.54	22.84	21.45	9.51
1984	54.87	118.88	37.09	20.19	5.71
1985	57.89	120.04	38.69	20.89	7.32
1986	67.07	119.89	43.75	17.58	4.62
1987	70.45	131.32	45.37	18.88	6.51
1988	69.04	133.73	43.90	18.90	7.93
1989	73.08	141.58	46.47	20.00	8.40
1990	81.80	158.46	52.01	22.39	9.40

	O&M Expenditures, $Mn				
Industry	Transportation	Communications	Electric utilities	Gas utilities	Trade
Year					
1973	24.21	8.91	390.00	8.07	40.04
1974	38.78	9.46	649.00	14.54	45.79
1975	48.81	11.47	678.00	16.27	61.90
1976	60.47	11.92	691.00	21.34	78.72
1977	73.82	13.57	839.00	24.61	91.89
1978	82.92	15.03	1016.00	26.53	101.11
1979	93.09	15.60	1488.00	32.10	115.27
1980	107.42	18.61	1928.00	45.57	132.75
1981	132.80	21.36	1986.00	66.40	141.54
1982	123.74	18.65	1979.00	73.12	126.99
1983	140.05	21.38	2008.00	91.34	143.85
1984	162.94	24.47	2049.00	112.02	167.65
1985	176.48	26.08	2138.00	127.06	180.45
1986	184.19	26.97	2137.00	132.06	187.19
1987	190.39	27.50	2227.00	138.47	200.33
1988	179.49	27.23	2214.00	131.41	201.40
1989	183.71	29.07	2346.00	135.37	218.33
1990	198.78	32.67	2609.00	147.37	248.74

	O&M Expenditures, $Mn		
Industry	Finance, insurance & real estate	Other services	Government enterprises
Year			
1973	23.35	33.43	5.47
1974	26.53	39.18	5.65
1975	35.58	53.02	6.82
1976	45.34	68.03	7.05
1977	53.13	79.95	7.99
1978	58.83	88.82	8.78
1979	67.49	102.93	9.09
1980	78.46	120.82	10.77
1981	83.86	129.82	12.27
1982	75.71	117.90	10.70
1983	86.40	135.09	12.23
1984	101.17	158.89	13.99
1985	109.48	172.44	14.93
1986	114.71	181.17	15.47
1987	124.84	197.56	15.79
1988	127.78	202.89	15.73
1989	140.27	224.71	16.92
1990	162.09	261.82	19.17

	Recovered Cost Values, $Mn				
Industry	Food & products	Tobacco	Textile products	Lumber & products	Furniture & fixtures
Year					
1973	13.44	.99	.48	2.63	.45
1974	21.51	1.46	.43	4.43	.96
1975	25.80	1.93	1.14	6.03	1.15
1976	26.25	2.40	1.43	8.84	1.67
1977	21.97	2.87	1.13	5.47	2.18
1978	23.53	2.88	.96	9.25	1.79
1979	39.50	2.90	.80	6.30	2.30
1980	31.80	5.30	1.00	11.50	3.70
1981	40.40	3.57	1.10	6.00	3.30
1982	21.00	1.83	.70	5.75	.70
1983	10.60	.10	2.20	3.00	3.70
1984	19.50	1.13	2.20	6.00	3.50
1985	11.90	2.15	1.70	6.00	1.70
1986	21.47	3.18	1.60	7.30	7.10
1987	31.03	4.21	2.05	9.60	6.75
1988	40.60	5.24	2.50	11.90	6.40
1989	41.15	5.31	2.53	12.06	6.49
1990	46.07	5.94	2.84	13.50	7.26

	Recovered Cost Values, $Mn				
Industry	Paper & products	Printing & publishing	Chemicals & products	Petroleum refining	Rubber & plastics
Year					
1973	26.84	2.02	40.53	31.54	2.42
1974	41.68	2.02	50.97	59.45	10.24
1975	55.15	2.25	68.62	98.05	6.56
1976	67.63	3.92	92.03	130.87	8.30
1977	74.12	2.65	100.66	169.75	4.04
1978	86.31	3.34	112.81	186.41	4.20
1979	83.10	7.40	124.60	200.00	8.90
1980	107.10	6.70	152.20	310.10	6.90
1981	133.40	6.50	181.20	356.00	7.60
1982	112.50	4.10	182.60	335.30	7.00
1983	159.30	6.90	148.80	341.10	4.00
1984	47.70	5.80	158.40	423.30	5.20
1985	52.30	6.90	119.40	406.60	5.90
1986	58.80	8.90	145.00	406.90	6.90
1987	98.85	14.65	180.00	396.30	7.50
1988	138.90	20.40	215.00	385.70	8.10
1989	140.79	20.68	217.92	390.94	8.21
1990	157.60	23.15	243.94	437.62	9.19

	Recovered Cost Values, $Mn				
Industry	Leather & products	Stone, clay & glass	Primary metals	Fabricated metals	Non-electric machinery
Year					
1973	.03	19.28	39.90	3.04	3.64
1974	.03	26.05	59.58	2.74	2.82
1975	.03	32.82	73.83	2.50	3.05
1976	.03	46.67	78.02	2.10	4.08
1977	.03	54.07	97.85	1.17	4.52
1978	.06	58.87	109.78	1.50	3.80
1979	.10	67.50	182.40	5.00	2.30
1980	.10	59.90	137.20	8.00	5.00
1981	.06	68.70	156.00	9.20	6.90
1982	.03	56.00	109.10	3.60	4.00
1983	.01	38.90	74.20	9.10	8.00
1984	.06	36.80	133.60	10.10	2.00
1985	.10	26.10	107.80	4.80	2.50
1986	.10	33.50	139.50	8.10	2.20
1987	.10	59.50	141.65	8.15	2.75
1988	.10	85.50	143.80	8.20	3.30
1989	.10	86.66	145.75	8.31	3.34
1990	.11	97.01	163.16	9.30	3.74

	Recovered Cost Values, $Mn				
Industry	Electrical machinery	Motor vehicles	Other transport equip.	Instruments	Misc. manufacturing
Year					
1973	8.15	1.57	.65	.56	.57
1974	8.94	1.02	.50	.89	.67
1975	6.30	1.16	.26	1.09	.96
1976	15.72	1.31	.20	2.94	1.24
1977	10.44	1.18	.24	1.54	.98
1978	7.05	1.47	.27	1.27	1.29
1979	12.90	.40	.00	2.00	1.80
1980	9.00	.60	.20	2.80	2.40
1981	12.20	.40	.70	1.60	2.20
1982	6.40	.40	.50	4.00	1.35
1983	5.90	.30	1.00	4.60	.50
1984	6.10	2.40	1.30	3.68	.80
1985	5.50	2.20	1.10	2.76	1.00
1986	6.50	5.00	1.10	2.70	1.40
1987	11.60	5.60	1.50	3.82	1.50
1988	16.70	6.20	1.90	4.94	1.60
1989	16.93	6.28	1.93	5.00	1.62
1990	18.95	7.03	2.16	5.60	1.82

	Total Air Pollution Control Outlays, $Mn				
Industry	Nonfarm business	Government enterprise	Air control investment	O&M expenditures	Recovered cost values
Year					
1973	2968	82	3050	1436	199
1974	3328	104	3432	1895	296
1975	3914	102	4016	2240	389
1976	3798	156	3954	2665	496
1977	3811	197	4008	3223	557
1978	3977	205	4182	3724	617
1979	4613	285	4898	4605	750
1980	5051	398	5449	5568	862
1981	5135	451	5586	6123	997
1982	5086	508	5594	5815	857
1983	4155	422	4577	6292	822
1984	4282	416	4698	6837	870
1985	4141	328	4469	7186	768
1986	4090	312	4402	7255	867
1987	4179	277	4456	7599	987
1988	4267	243	4510	7474	1107
1989	4760	235	4995	7916	1122
1990	4169	226	4395	8842	1256

	Mobile Source Emissions Control Costs, $ Mn				
	EPA				
	Investment in Vehicles	Investment in Aircraft	O & M Expenditures	Fuel Price Penalty	Fuel Economy Penalty
Year	(All Vehicle Types)		(All Vehicle Types)	(All Vehicle Types)	(All Vehicle Types)
1973	276		-26	91	1700
1974	242		-98	244	2205
1975	1567	3	-289	358	2213
1976	1953	8	-514	468	2106
1977	2233	15	-738	568	1956
1978	2501	12	-1527	766	1669
1979	2937	4	-1826	1187	1868
1980	2944	5	-2120	1912	1998
1981	3526	8	-2386	2181	1594
1982	3518	33	-2542	2071	1026
1983	4271	60	-2739	1956	628
1984	5670	9	-2651	2012	313
1985	6379	8	-2838	3057	118
1986	6876	10	-3859	2505	-40
1987	6839	12	-4126	2982	-158
1988	7193	13	-4492	3127	-210
1989	7037	16	-4794	3476	-318
1990	7299	13	-5089	3754	-481

	Mobile Source Emissions Control Costs, $ Mn EPA, Light Duty Vehicles Only				
	Inspection-Maintenance	Maintenance Credit	Fuel Price Penalty	Fuel Economy Penalty	Fuel Density Credit
Year					
1973		38	91	1466	3
1974		113	244	1913	14
1975	5	309	345	1928	40
1976	6	536	442	1841	69
1977	24	784	529	1748	106
1978	26	1578	711	1604	242
1979	28	1840	1065	1831	345
1980	31	2125	1696	2048	533
1981	44	2393	1915	1754	650
1982	117	2628	1782	1232	619
1983	147	2845	1641	847	580
1984	483	3152	1653	582	592
1985	553	3399	2630	403	584
1986	834	4754	2117	216	469
1987	913	5086	2513	152	512
1988	952	5464	2590	105	500
1989	993	5780	2910	79	581
1990	1034	6087	3108	58	720

	Other Air Pollution Control Expenditures, $Mn						
	Private R&D expenditures were not included in CAA costs						
	Abatement		Regulation & Monitoring		Research & Development		
Year	Federal	State & Local	Federal	State & Local	Private	Federal	State & Local
1973	47		50	115	451	126	6
1974	56		52	131	492	100	7
1975	88	1	66	139	466	108	8
1976	105	1	69	135	543	131	6
1977	106	1	80	161	654	144	7
1978	90		93	183	789	146	8
1979	103		100	200	924	105	7
1980	95		122	207	869	130	5
1981	85		108	226	852	131	
1982	87		93	230	912	126	2
1983	136	4	88	239	1315	133	6
1984	115	14	101	250	1359	165	4
1985	98	12	103	250	1427	247	3
1986	67	14	106	307	1499	217	4
1987	80	15	110	300	1574	200	2
1988	65	10	120	320	1652	220	1
1989	70	12	130	360	1718	230	2
1990	71	13	133	343	1820	231	2

	Mobile Source Emissions Control Costs, $ Mn			
	BEA			
	Investment in Vehicles	O & M Expenditures	Fuel Price Penalty	Fuel Economy Penalty
Year	(All Vehicle Types)	(All Vehicle Types)	(All Vehicle Types)	(All Vehicle Types)
1973	1013	1104		697
1974	1118	1380	5	1180
1975	2131	1520	97	1344
1976	2802	1420	309	1363
1977	3371	1289	701	1408
1978	3935	1136	1209	1397
1979	4634	931	1636	1792
1980	5563	726	2217	2320
1981	7529	552	2996	2252
1982	7663	409	3518	1876
1983	9526	274	4235	1582
1984	11900	118	4427	1370
1985	13210	165	4995	1133
1986	14368	-331	4522	895
1987	13725	-453	3672	658
1988	16157	-631	3736	420
1989	15340	-271	1972	183
1990	14521	-719	1370	-55

Appendix E

Figures from Text

Full Page Landscape

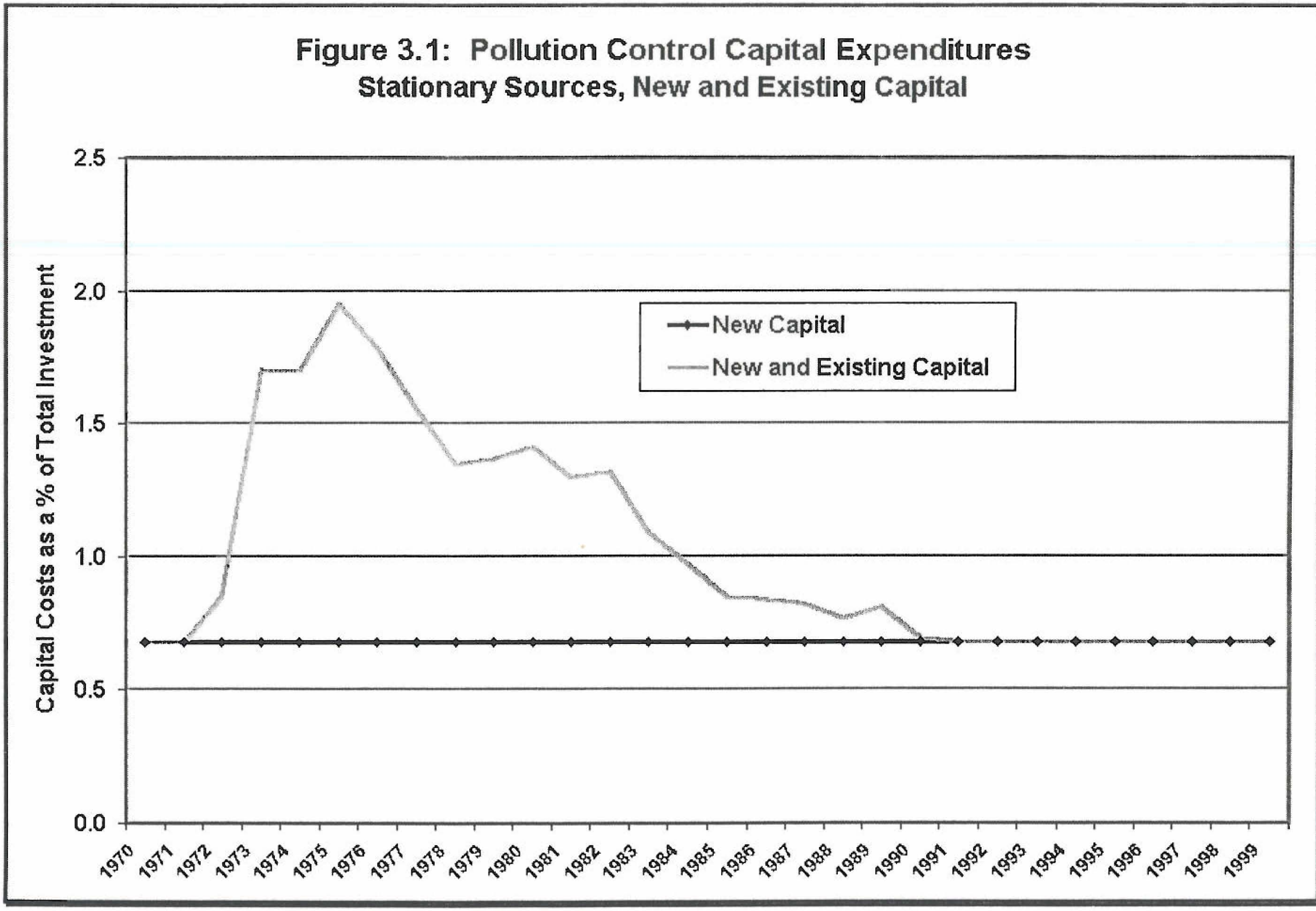


Figure 3.1: Pollution Control Capital Expenditures
Stationary Sources, New and Existing Capital
Capital Costs as a % of Total Investment
2.5
2.0
1.5
1.0
0.5
0.0
New Capital
New and Existing Capital
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999

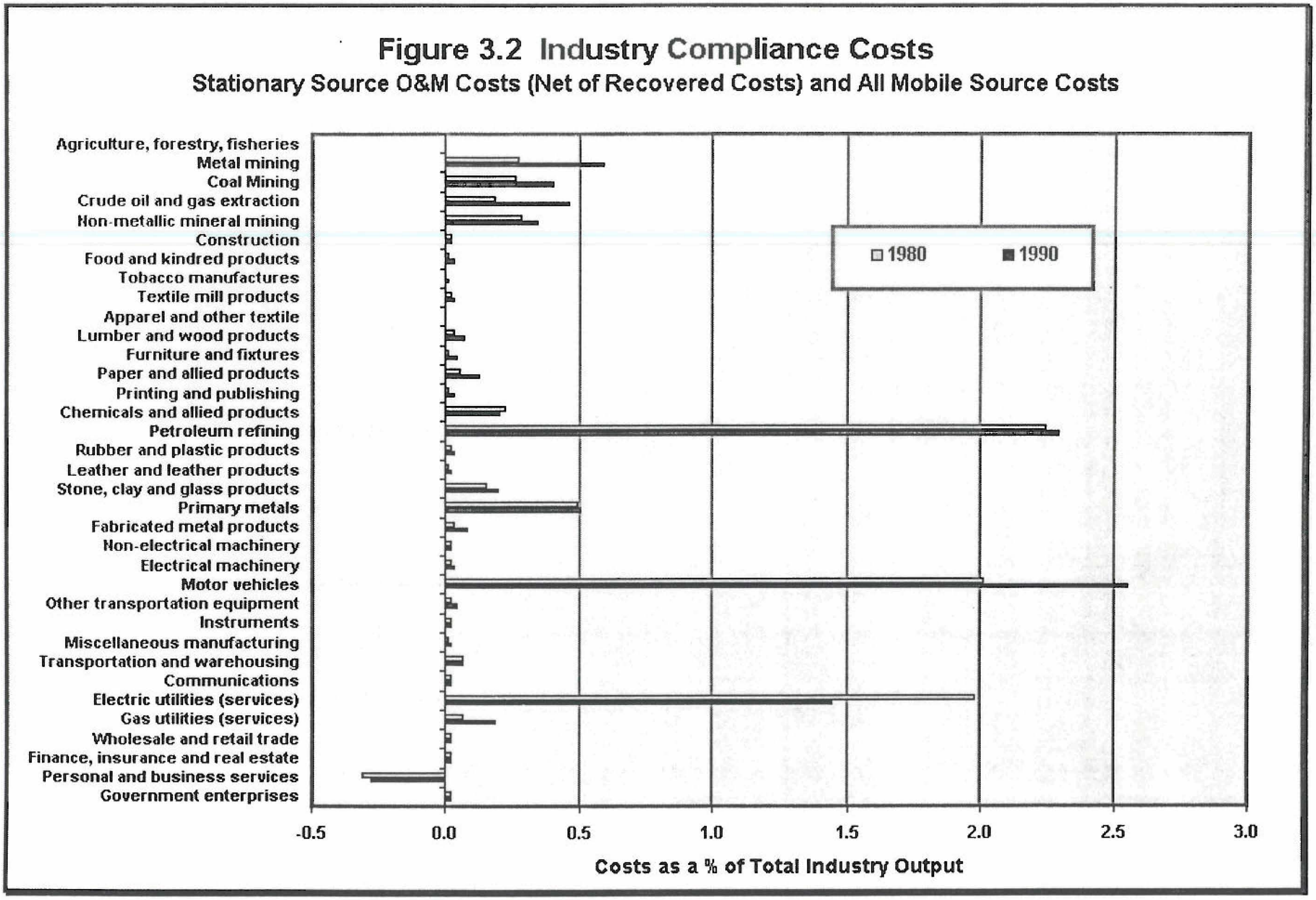


Figure 3.2 Industry Compliance Costs
Stationary Source O&M Costs (Net of Recovered Costs) and All Mobile Source Costs
Agriculture, forestry, fisheries
Metal mining
Coal Mining
Crude oil and gas extraction
Non-metallic mineral mining
Construction
Food and kindred products
Tobacco manufactures
Textile mill products
Apparel and other textile
Lumber and wood products
Furniture and fixtures
Paper and allied products
Printing and publishing
Chemicals and allied products
Petroleum refining
Rubber and plastic products
Leather and leather products
Stone, clay and glass products
Primary metals
Fabricated metal products
Non-electrical machinery
Electrical machinery
Motor vehicles
Other transportation equipment
Instruments
Miscellaneous manufacturing
Transportation and warehousing
Communications
Electric utilities (services)
Gas utilities (services)
Wholesale and retail trade
Finance, insurance and real estate
Personal and business services
Government enterprises
1980
1990
-0.5
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Costs as a % of Total Industry Output

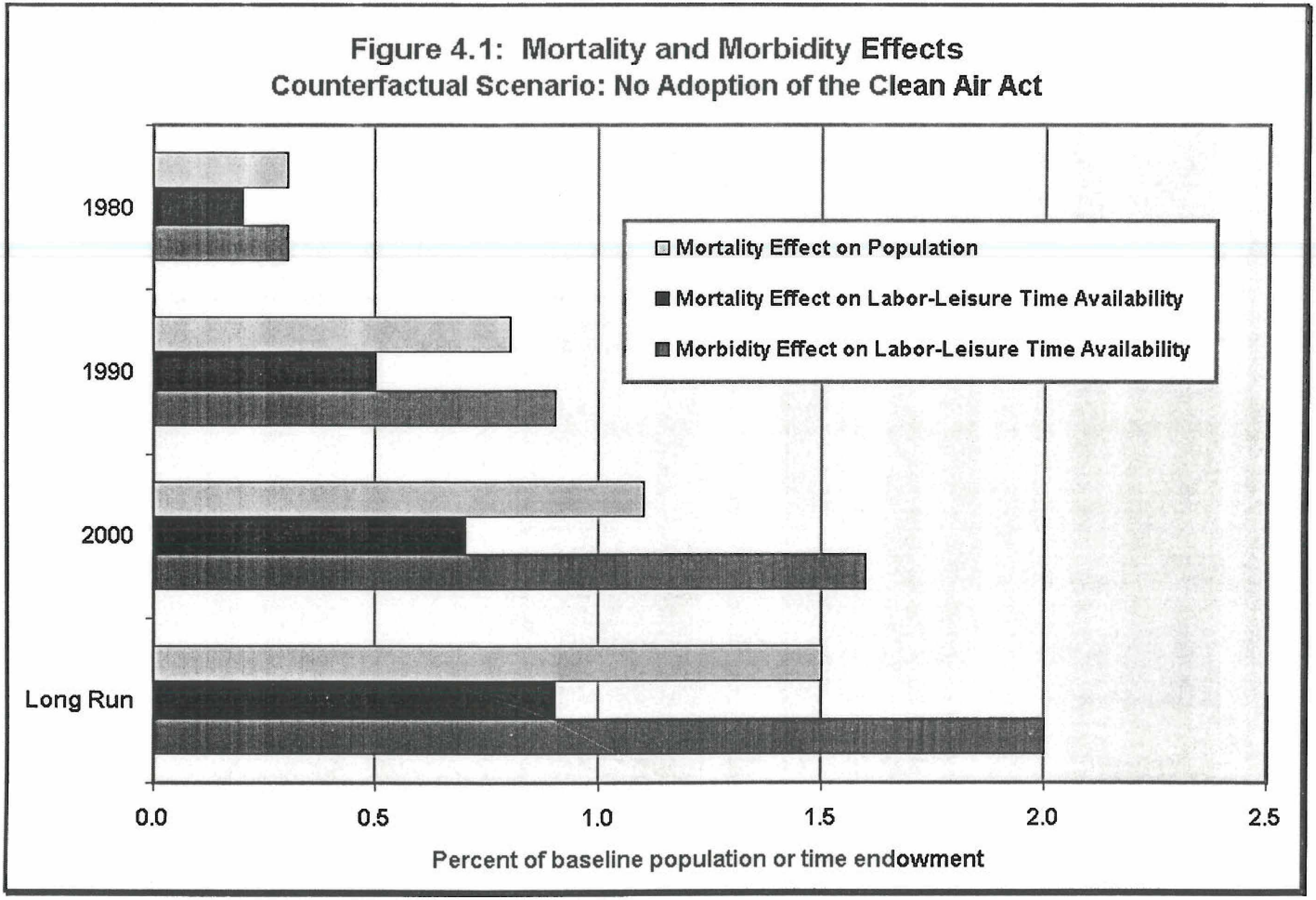


Figure 4.1: Mortality and Morbidity Effects
Counterfactual Scenario: No Adoption of the Clean Air Act
1980
1990
2000
Long Run
Mortality Effect on Population
Mortality Effect on Labor-Leisure Time Availability
Morbidity Effect on Labor-Leisure Time Availability
0.0
0.5
1.0
1.5
2.0
2.5
Percent of baseline population or time endowment

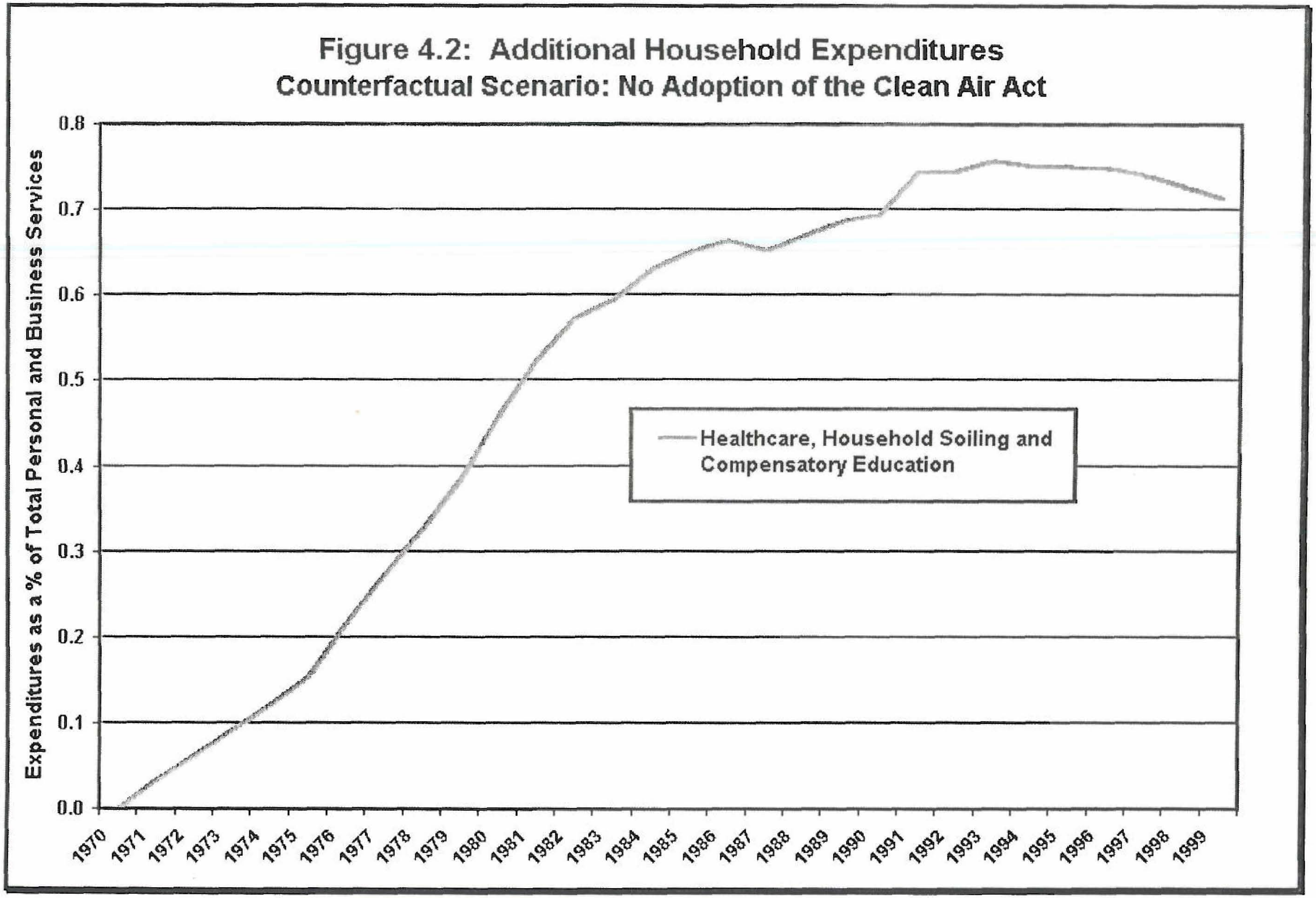


Figure 4.2: Additional Household Expenditures
Counterfactual Scenario: No Adoption of the Clean Air Act
Expenditures as a % of Total Personal and Business Services
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Healthcare, Household Soiling and Compensatory Education
1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999

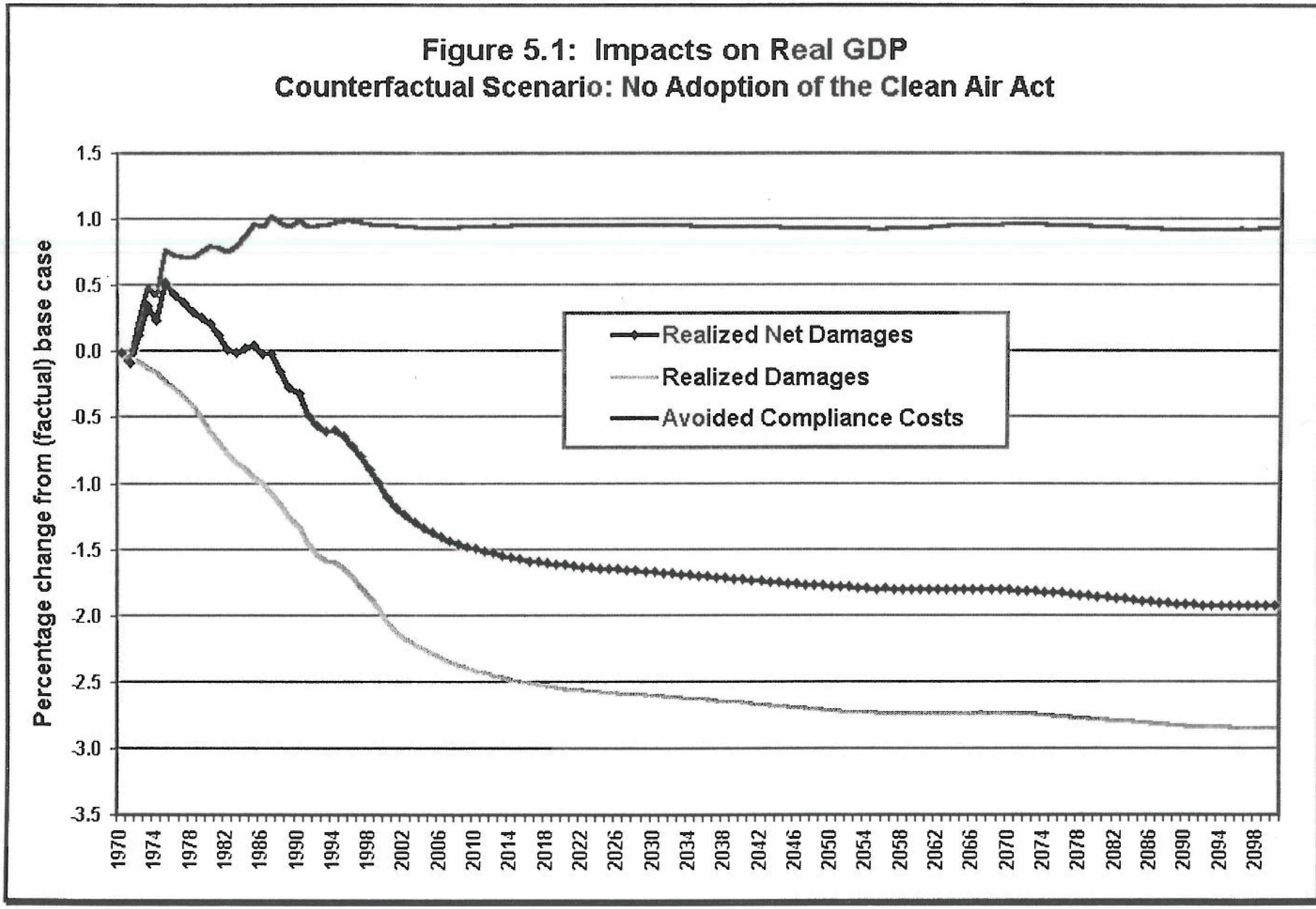


Figure 5.1: Impacts on Real GDP
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
Realized Net Damages
Realized Damages
Avoided Compliance Costs
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098

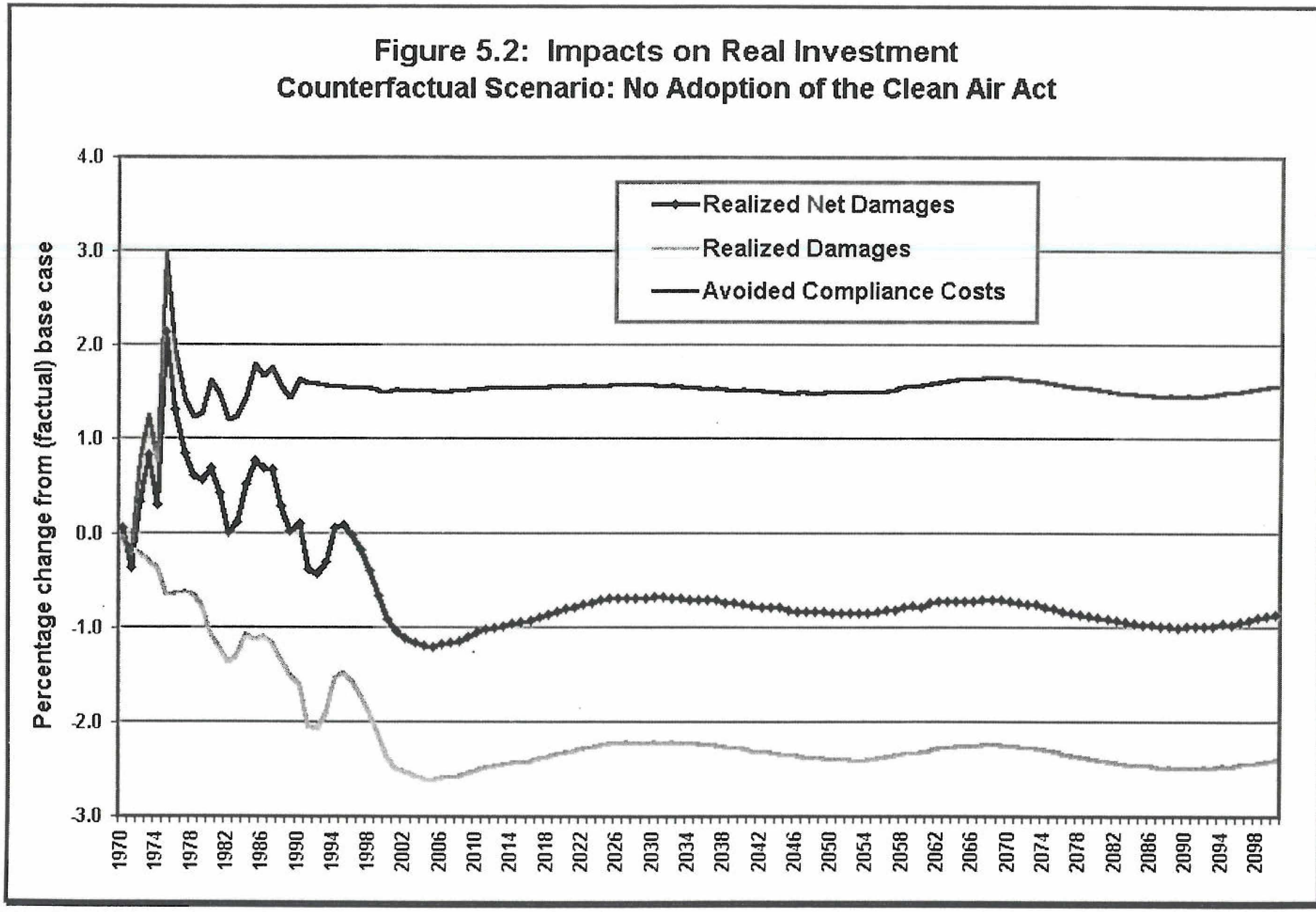


Figure 5.2: Impacts on Real Investment
Counterfactual Scenario: No Adoption of the Clean Air Act
Realized Net Damages
Realized Damages
Avoided Compliance Costs
Percentage change from (factual) base case
4.0
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098

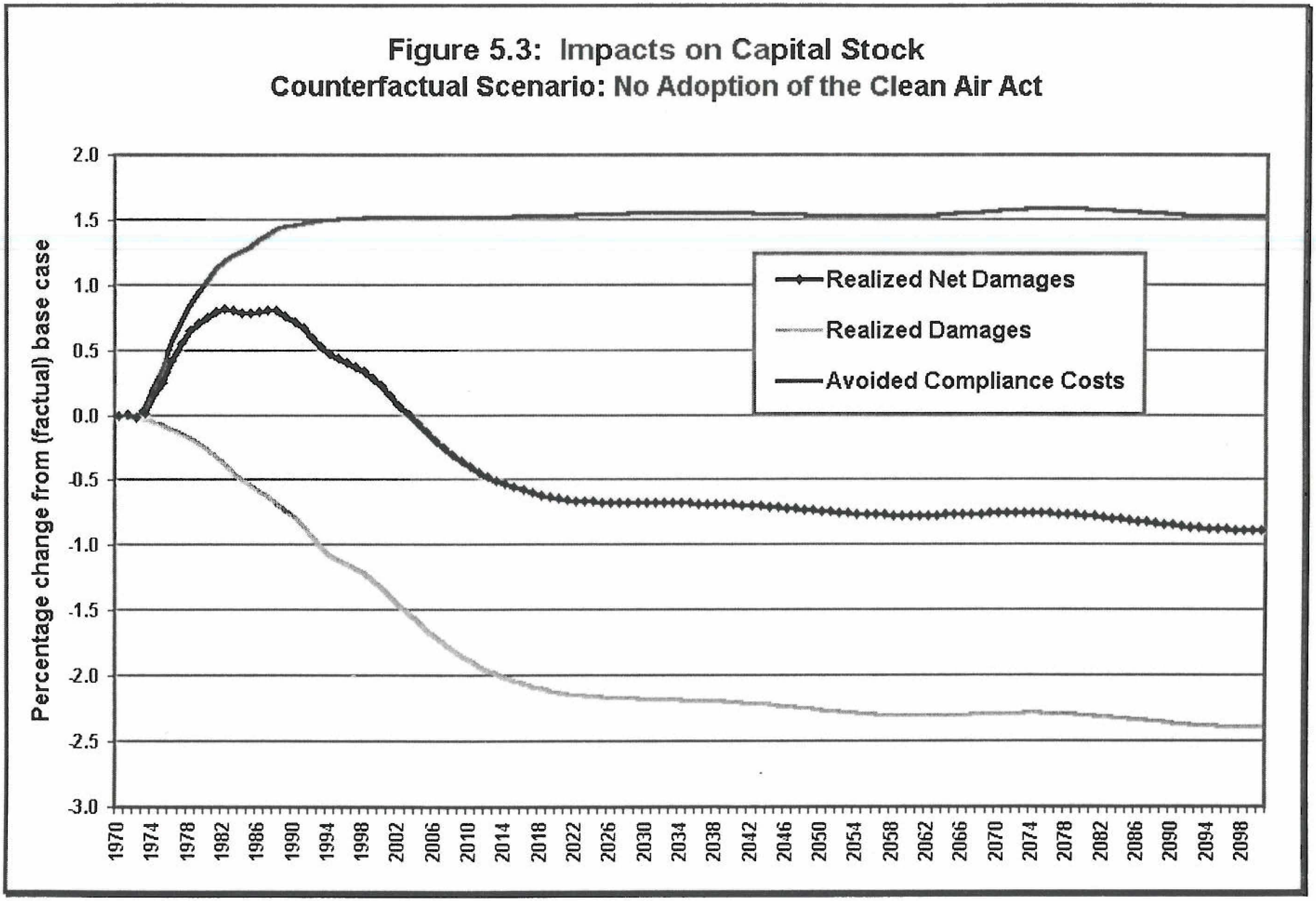


Figure 5.3: Impacts on Capital Stock
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Realized Net Damages
Realized Damages
Avoided Compliance Costs
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098

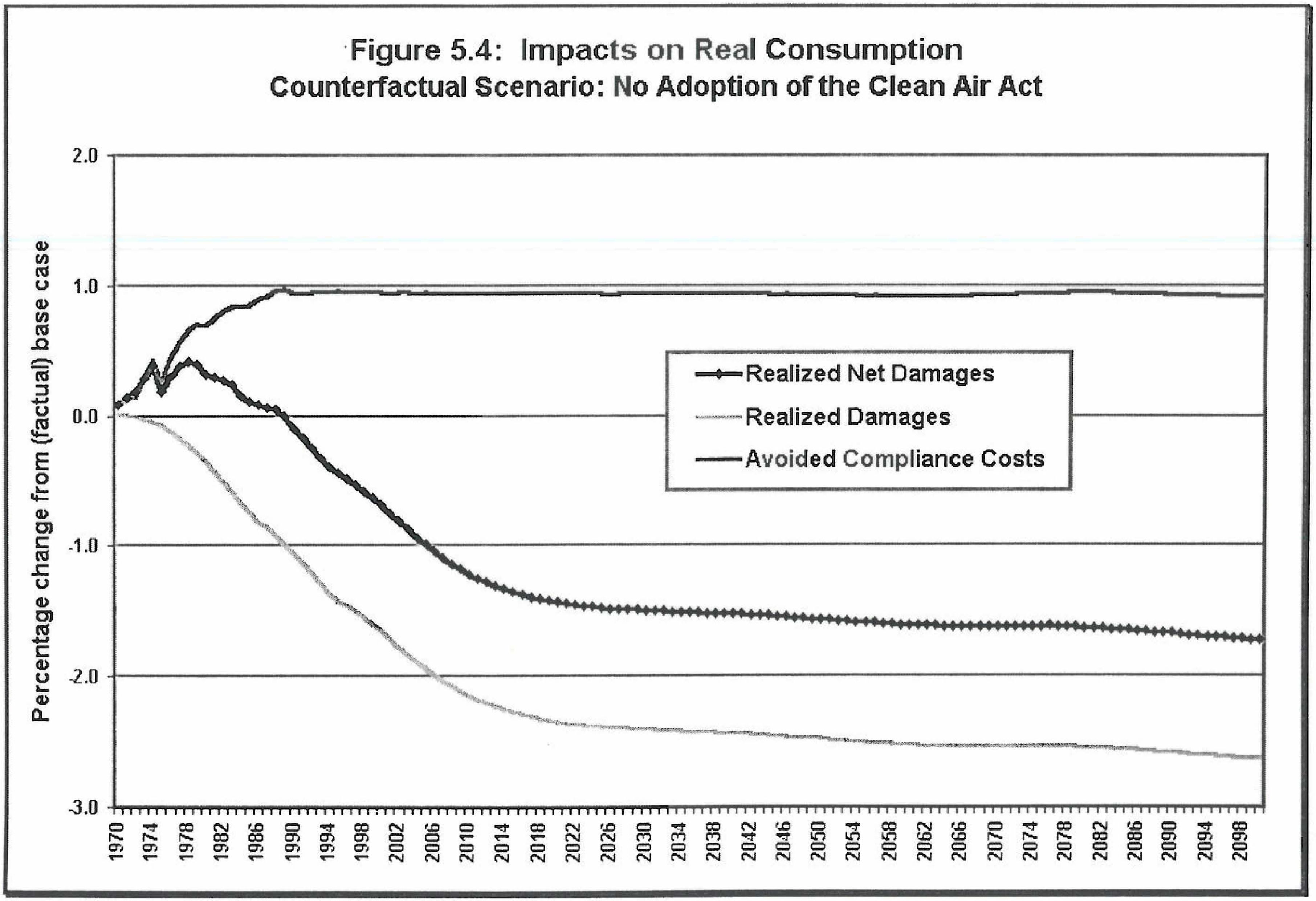


Figure 5.4: Impacts on Real Consumption
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
2.0
1.0
0.0
-1.0
-2.0
-3.0
Realized Net Damages
Realized Damages
Avoided Compliance Costs
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
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2070
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2082
2086
2090
2094
2098

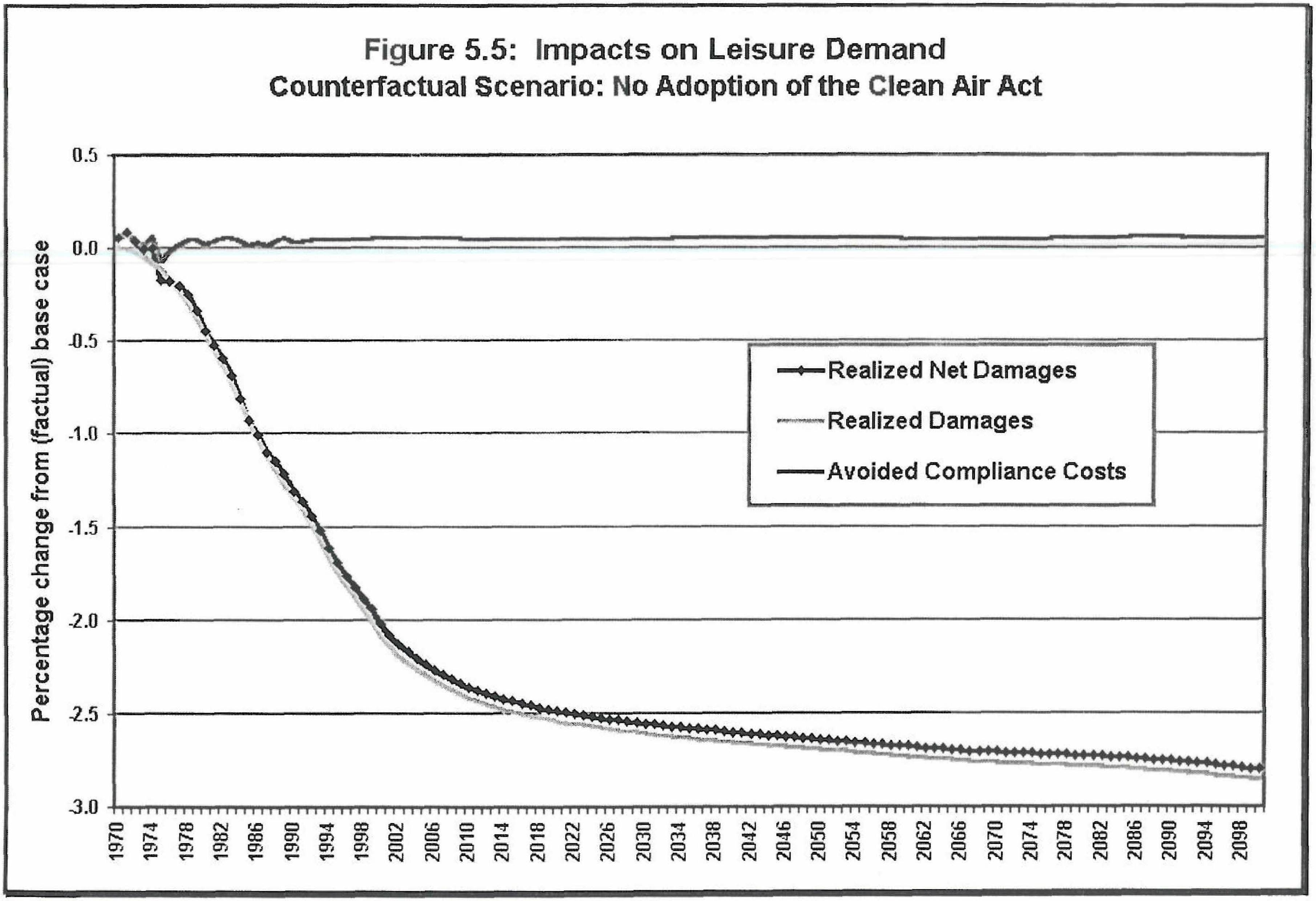
Figure 5.5: Impacts on Leisure Demand
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
Realized Net Damages
Realized Damages
Avoided Compliance Costs
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
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2078
2082
2086
2090
2094
2098

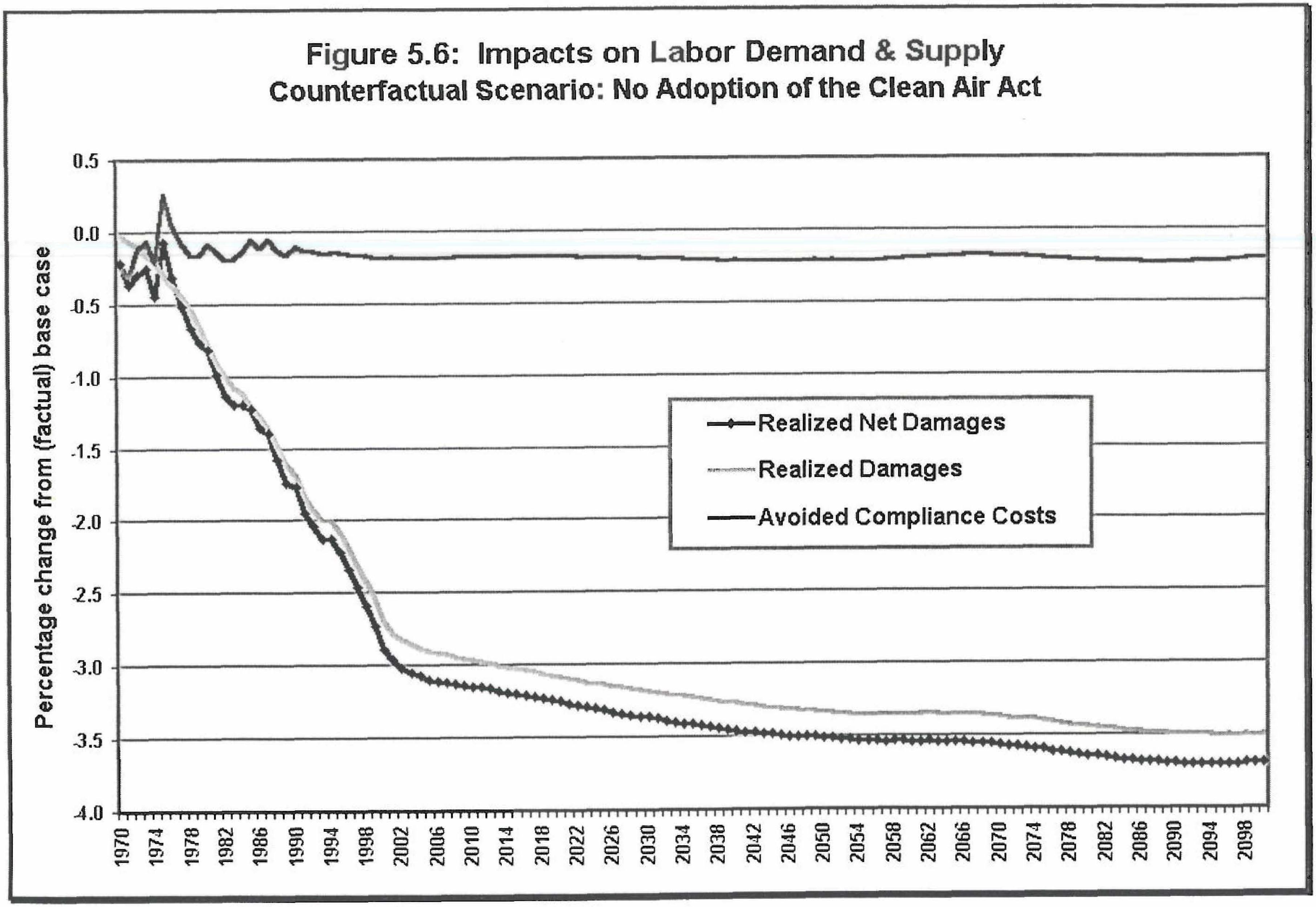

Figure 5.6: Impacts on Labor Demand & Supply
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
Realized Net Damages
Realized Damages
Avoided Compliance Costs
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
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2078
2082
2086
2090
2094
2098

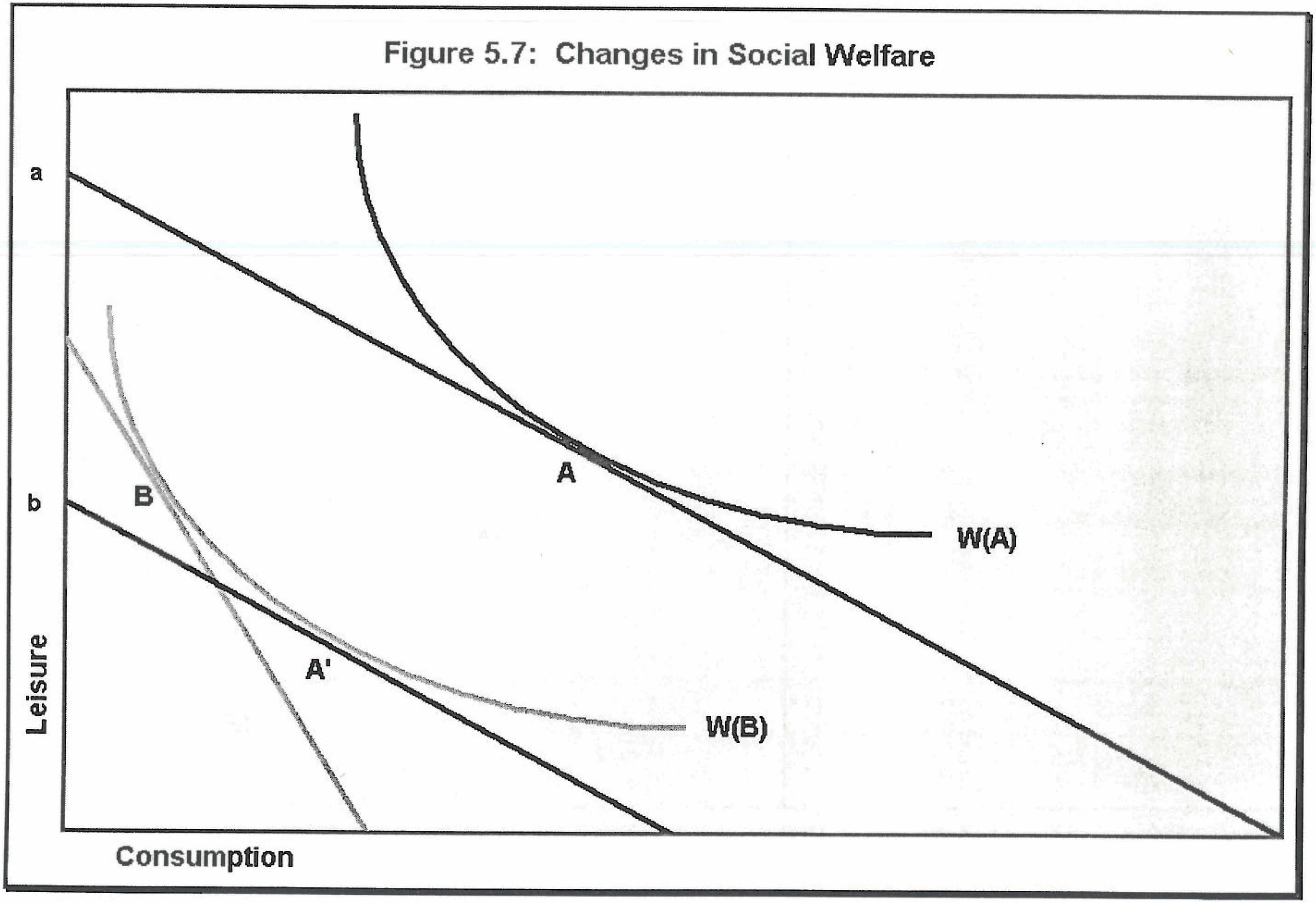
Figure 5.7: Changes in Social Welfare
a
b
A
B
A'
W(A)
W(B)
Leisure
Consumption

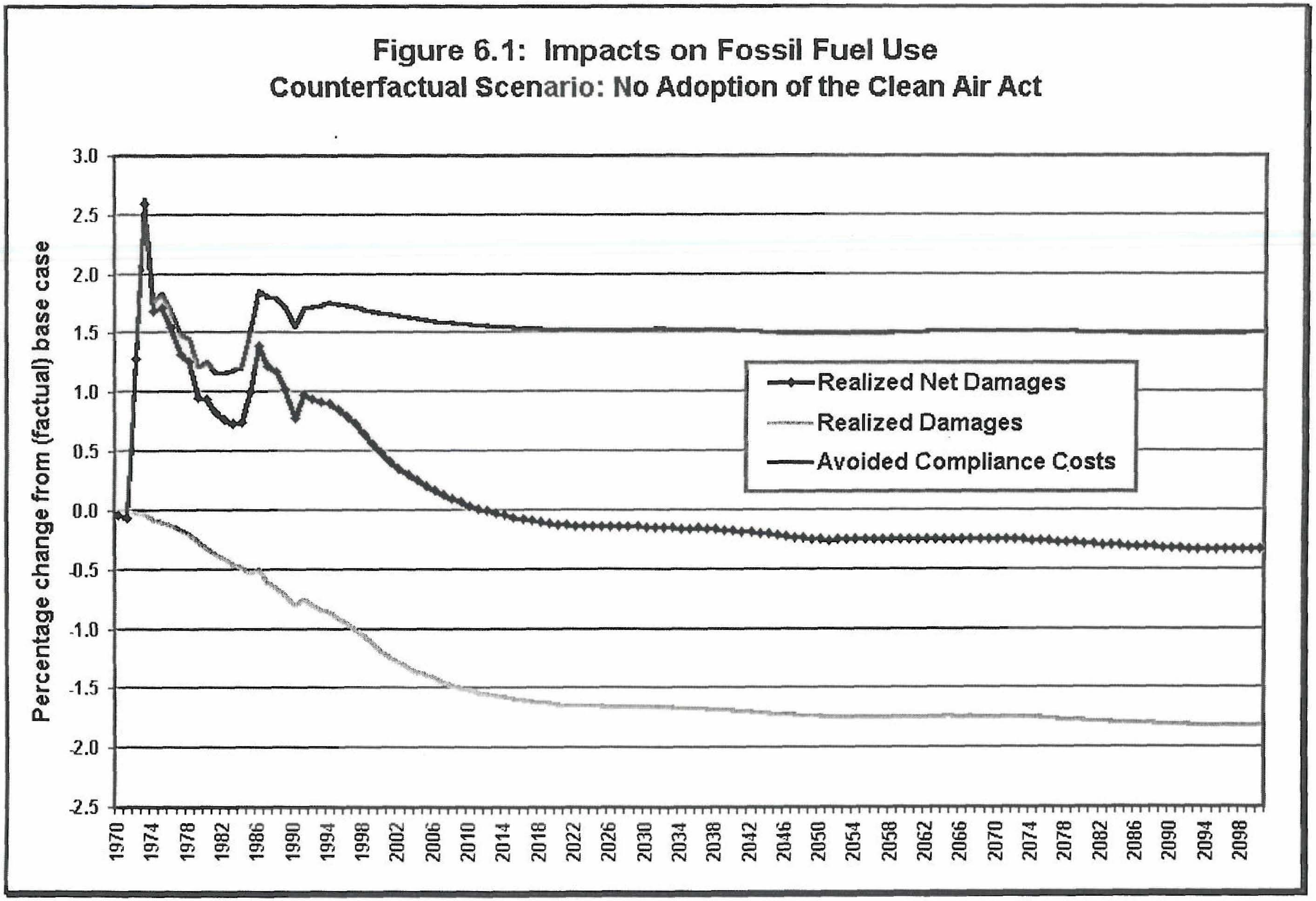
Figure 6.1: Impacts on Fossil Fuel Use
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098
Realized Net Damages
Realized Damages
Avoided Compliance Costs

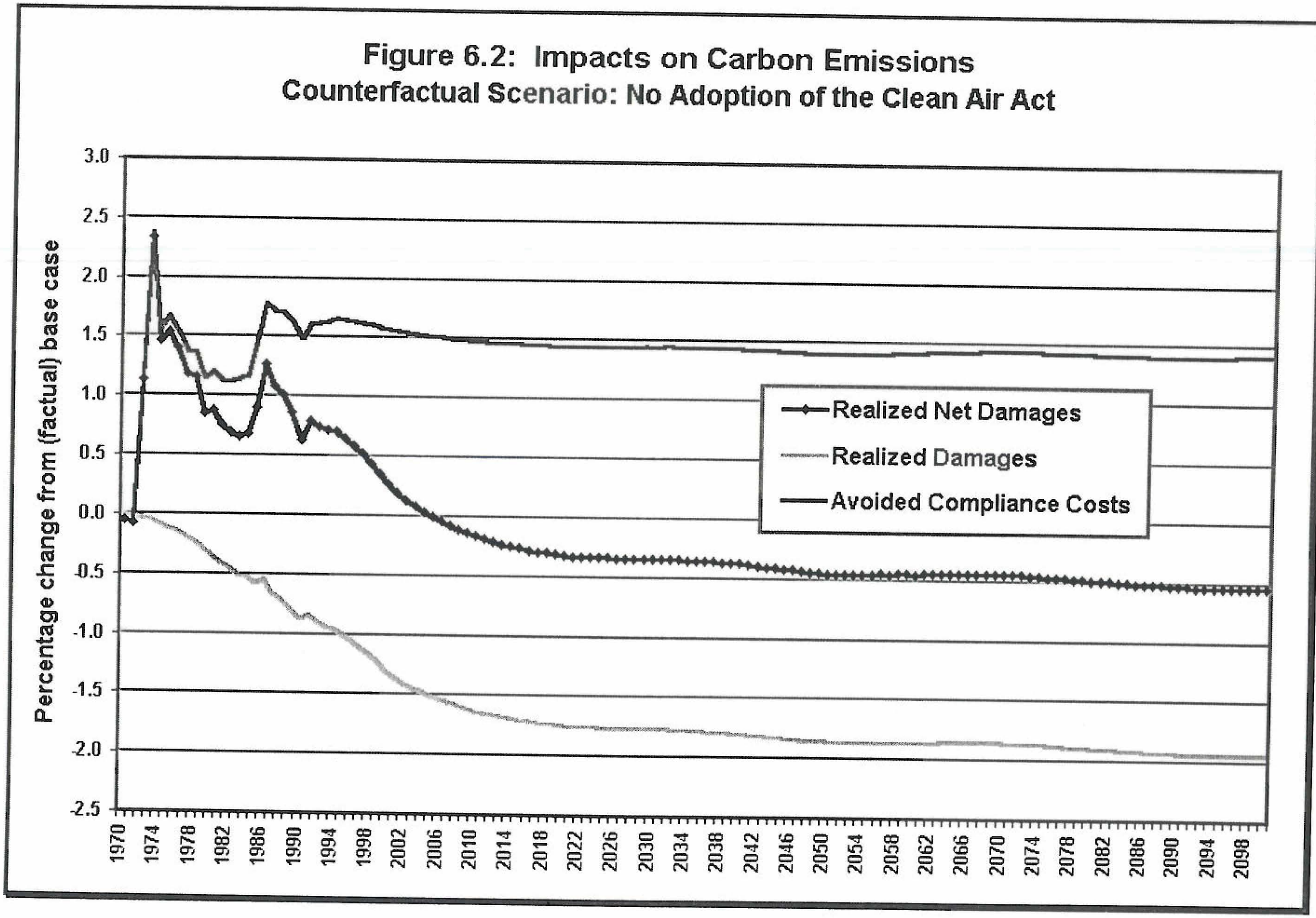
Figure 6.2: Impacts on Carbon Emissions
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098
Realized Net Damages
Realized Damages
Avoided Compliance Costs

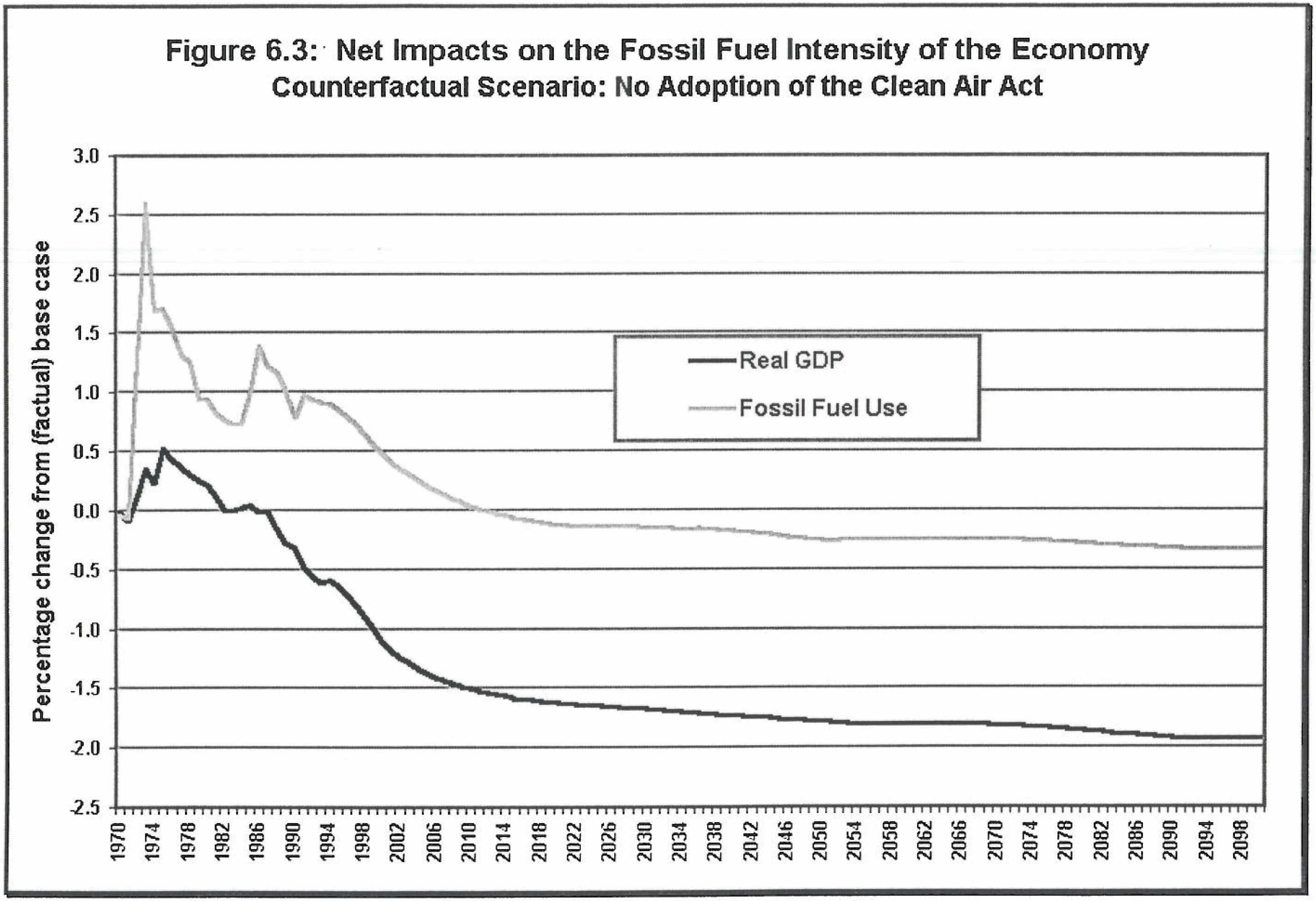
Figure 6.3: Net Impacts on the Fossil Fuel Intensity of the Economy
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
Real GDP
Fossil Fuel Use
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
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2054
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2066
2070
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2082
2086
2090
2094
2098

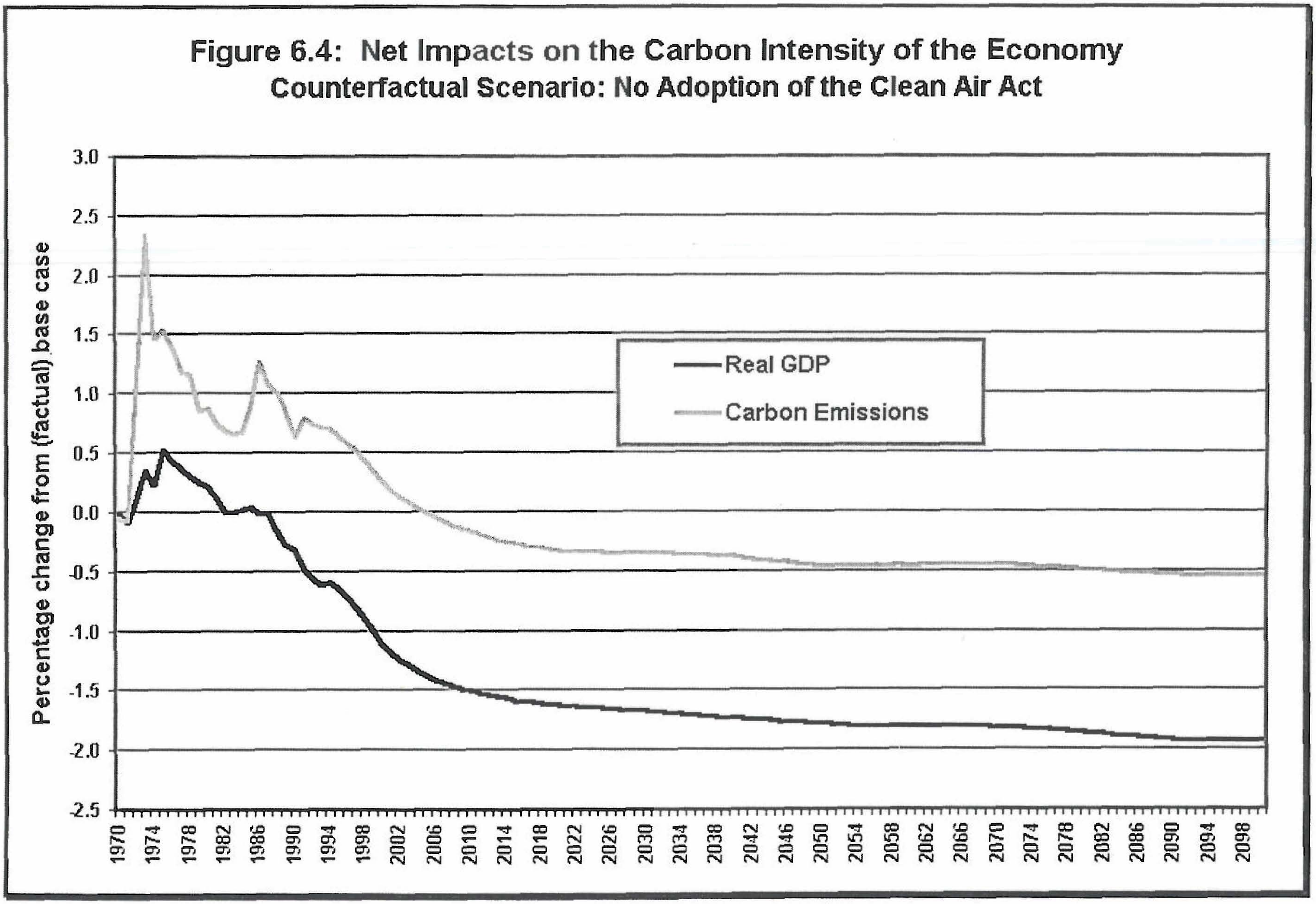
Figure 6.4: Net Impacts on the Carbon Intensity of the Economy
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
Real GDP
Carbon Emissions
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098

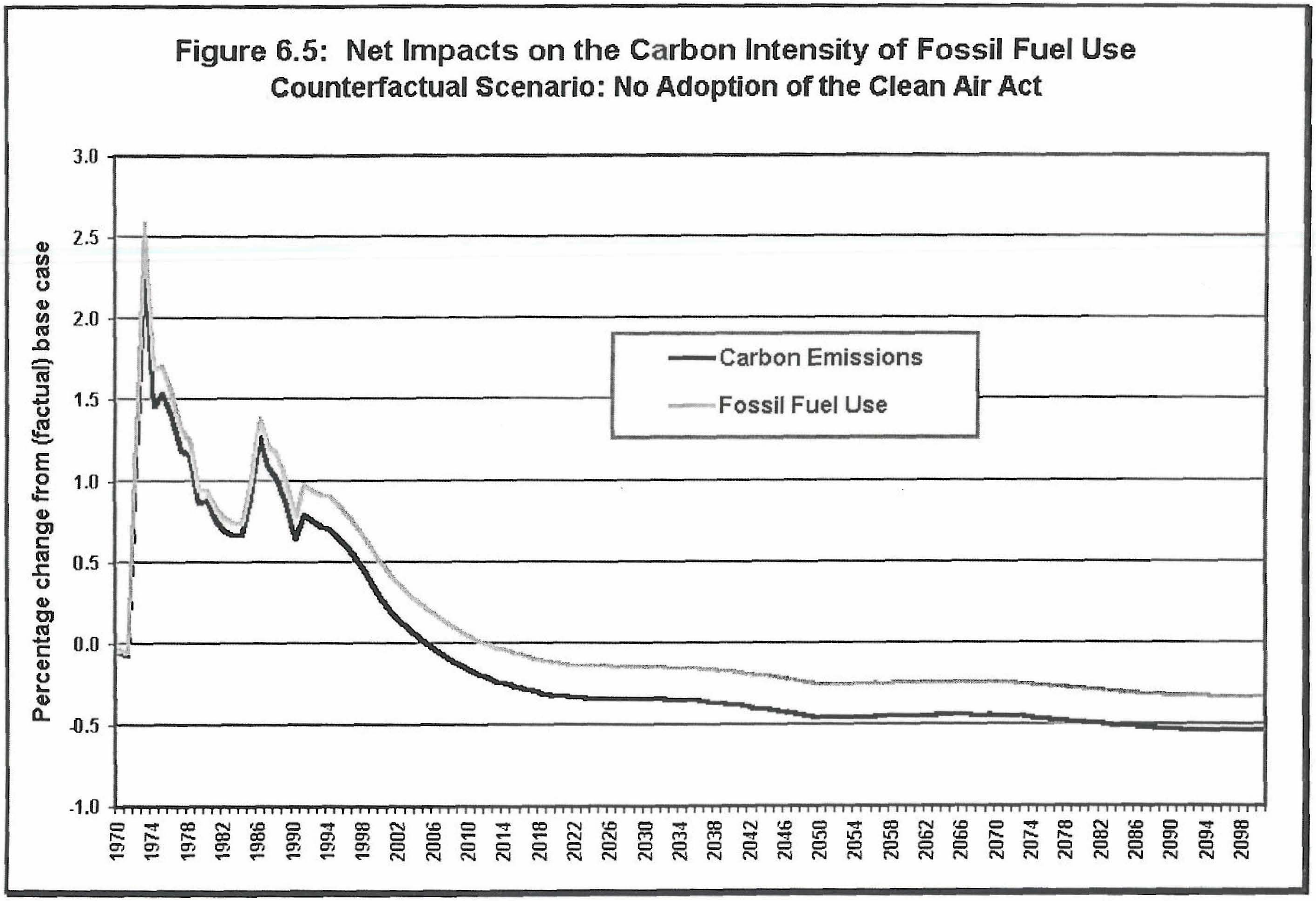
Figure 6.5: Net Impacts on the Carbon Intensity of Fossil Fuel Use
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
Carbon Emissions
Fossil Fuel Use
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
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2082
2086
2090
2094
2098

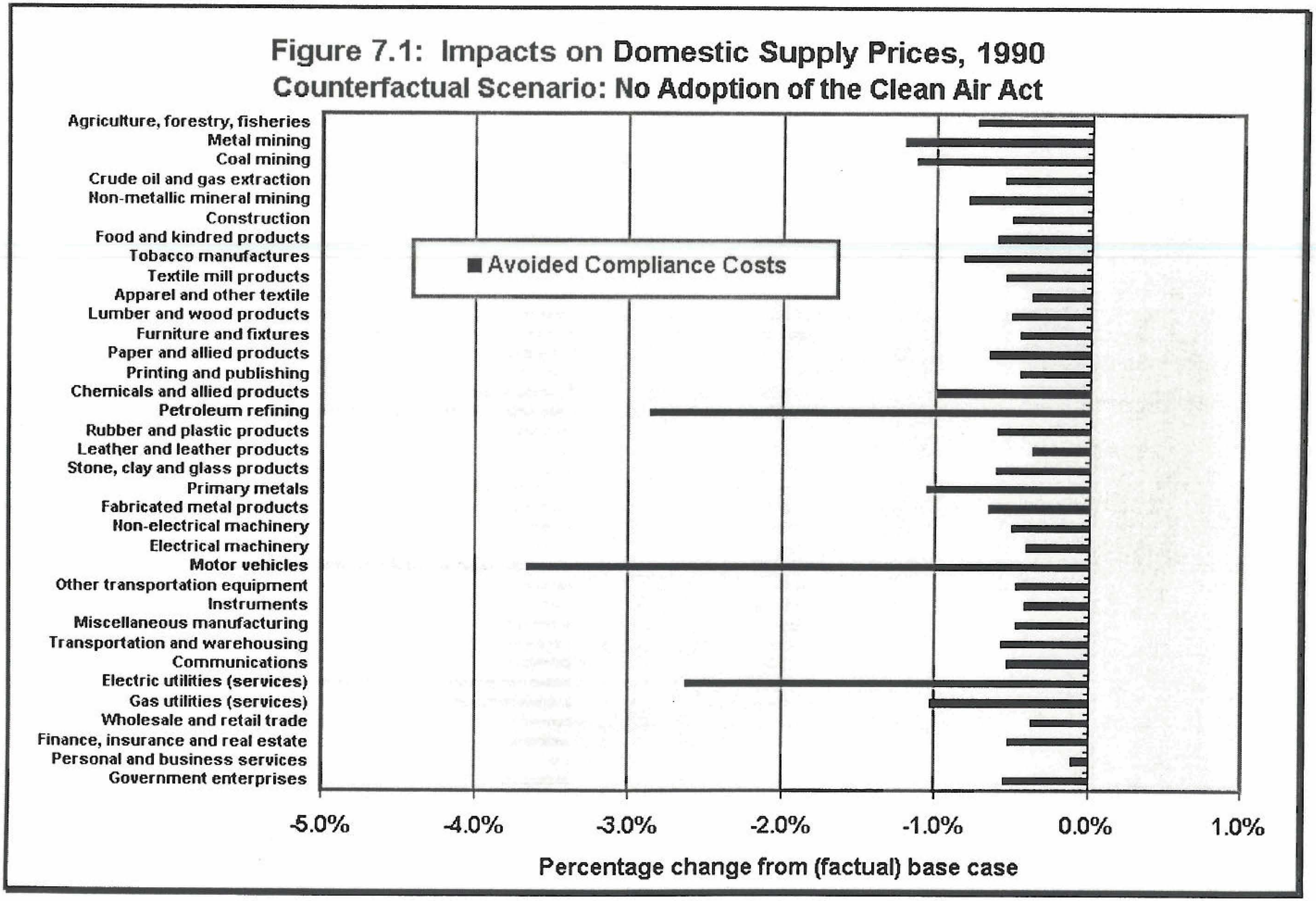
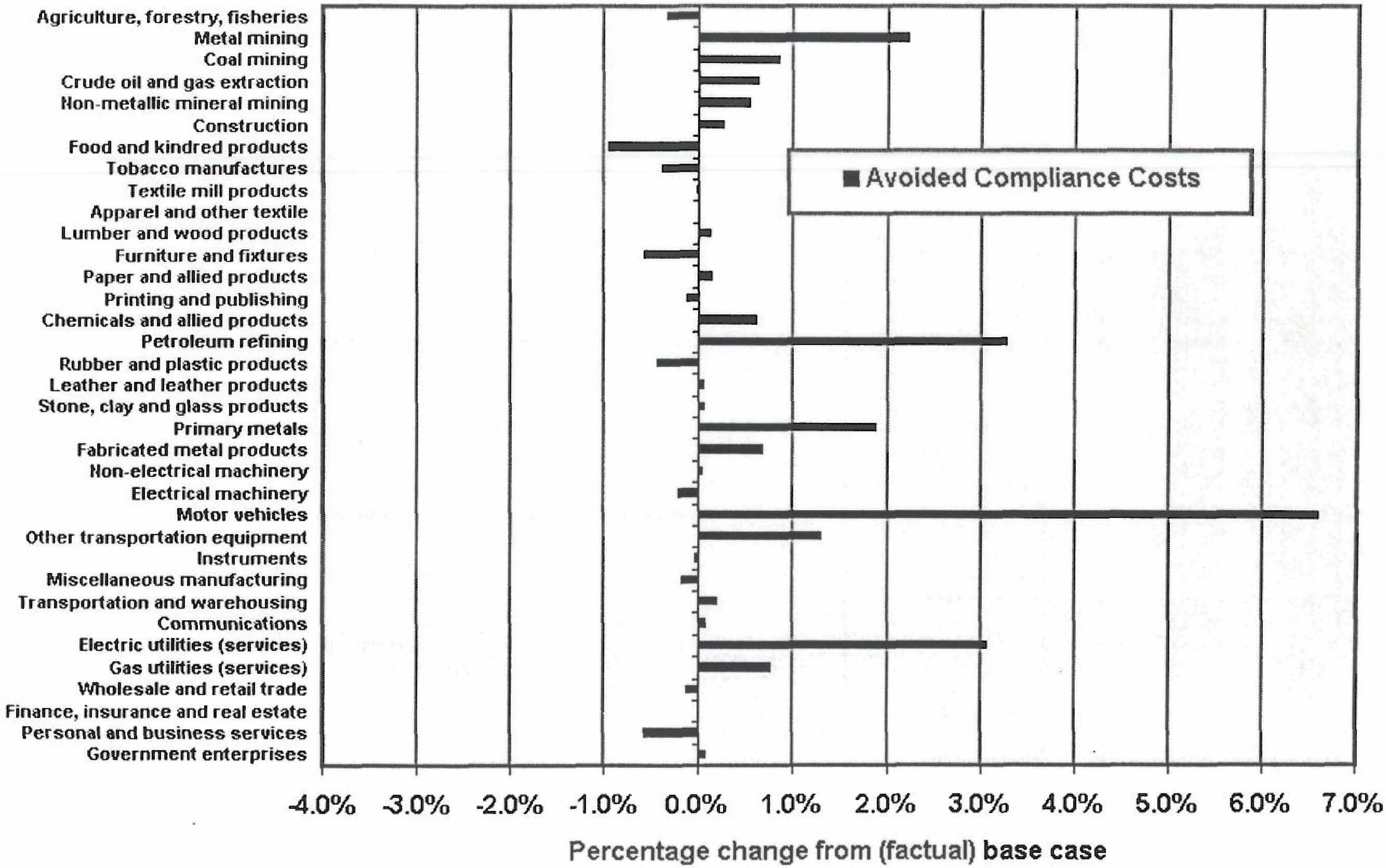


Figure 7.1: Impacts on Domestic Supply Prices, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act
Agriculture, forestry, fisheries
Metal mining
Coal mining
Crude oil and gas extraction
Non-metallic mineral mining
Construction
Food and kindred products
Tobacco manufactures
Textile mill products
Apparel and other textile
Lumber and wood products
Furniture and fixtures
Paper and allied products
Printing and publishing
Chemicals and allied products
Petroleum refining
Rubber and plastic products
Leather and leather products
Stone, clay and glass products
Primary metals
Fabricated metal products
Non-electrical machinery
Electrical machinery
Motor vehicles
Other transportation equipment
Instruments
Miscellaneous manufacturing
Transportation and warehousing
Communications
Electric utilities (services)
Gas utilities (services)
Wholesale and retail trade
Finance, insurance and real estate
Personal and business services
Government enterprises
Avoided Compliance Costs
-5.0%
-4.0%
-3.0%
-2.0%
-1.0%
0.0%
1.0%
Percentage change from (factual) base case

Figure 7.2: Impacts on Domestic Output, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act



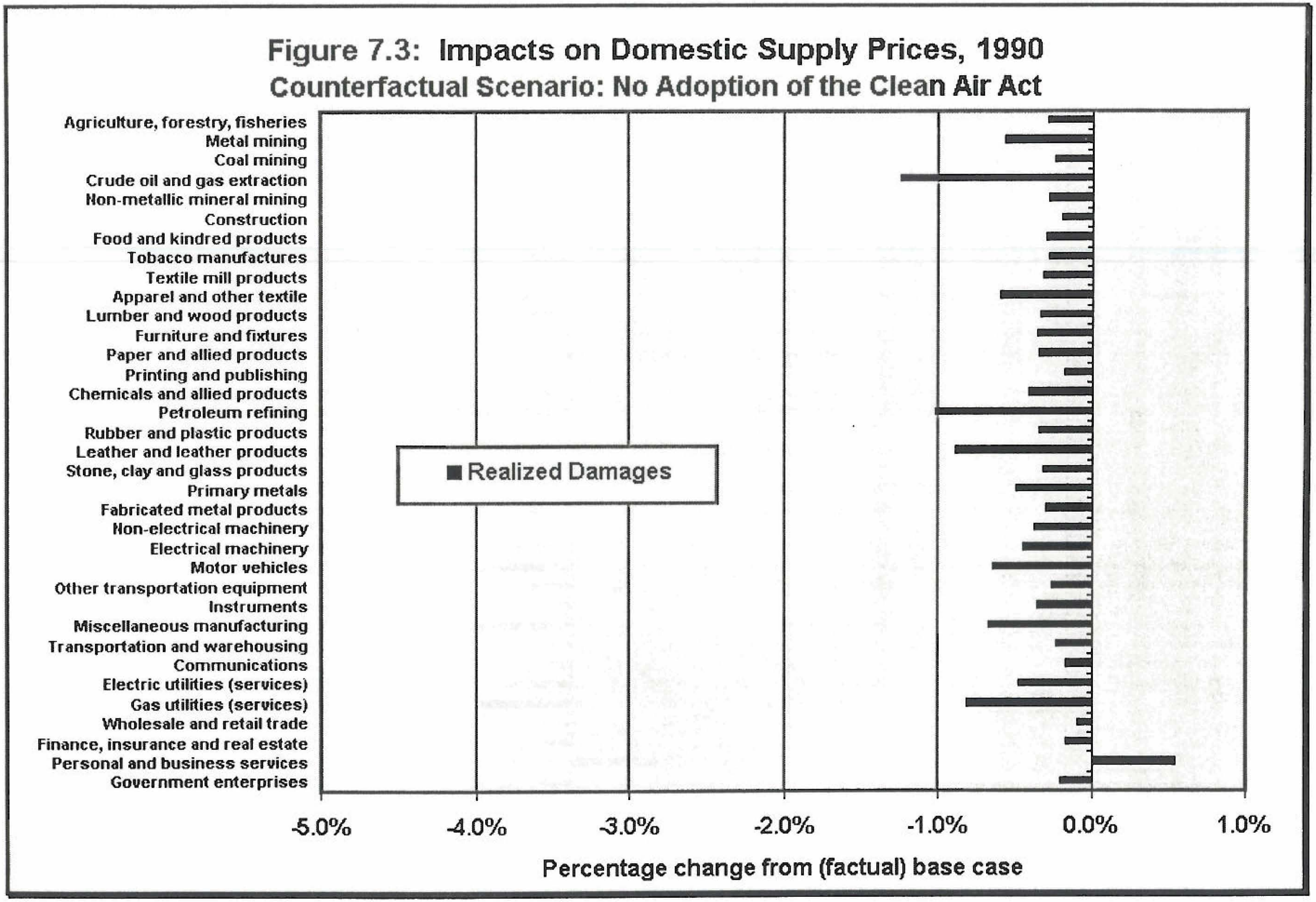


Figure 7.3: Impacts on Domestic Supply Prices, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act
Agriculture, forestry, fisheries
Metal mining
Coal mining
Crude oil and gas extraction
Non-metallic mineral mining
Construction
Food and kindred products
Tobacco manufactures
Textile mill products
Apparel and other textile
Lumber and wood products
Furniture and fixtures
Paper and allied products
Printing and publishing
Chemicals and allied products
Petroleum refining
Rubber and plastic products
Leather and leather products
Stone, clay and glass products
Primary metals
Fabricated metal products
Non-electrical machinery
Electrical machinery
Motor vehicles
Other transportation equipment
Instruments
Miscellaneous manufacturing
Transportation and warehousing
Communications
Electric utilities (services)
Gas utilities (services)
Wholesale and retail trade
Finance, insurance and real estate
Personal and business services
Government enterprises
Realized Damages
-5.0%
-4.0%
-3.0%
-2.0%
-1.0%
0.0%
1.0%
Percentage change from (factual) base case

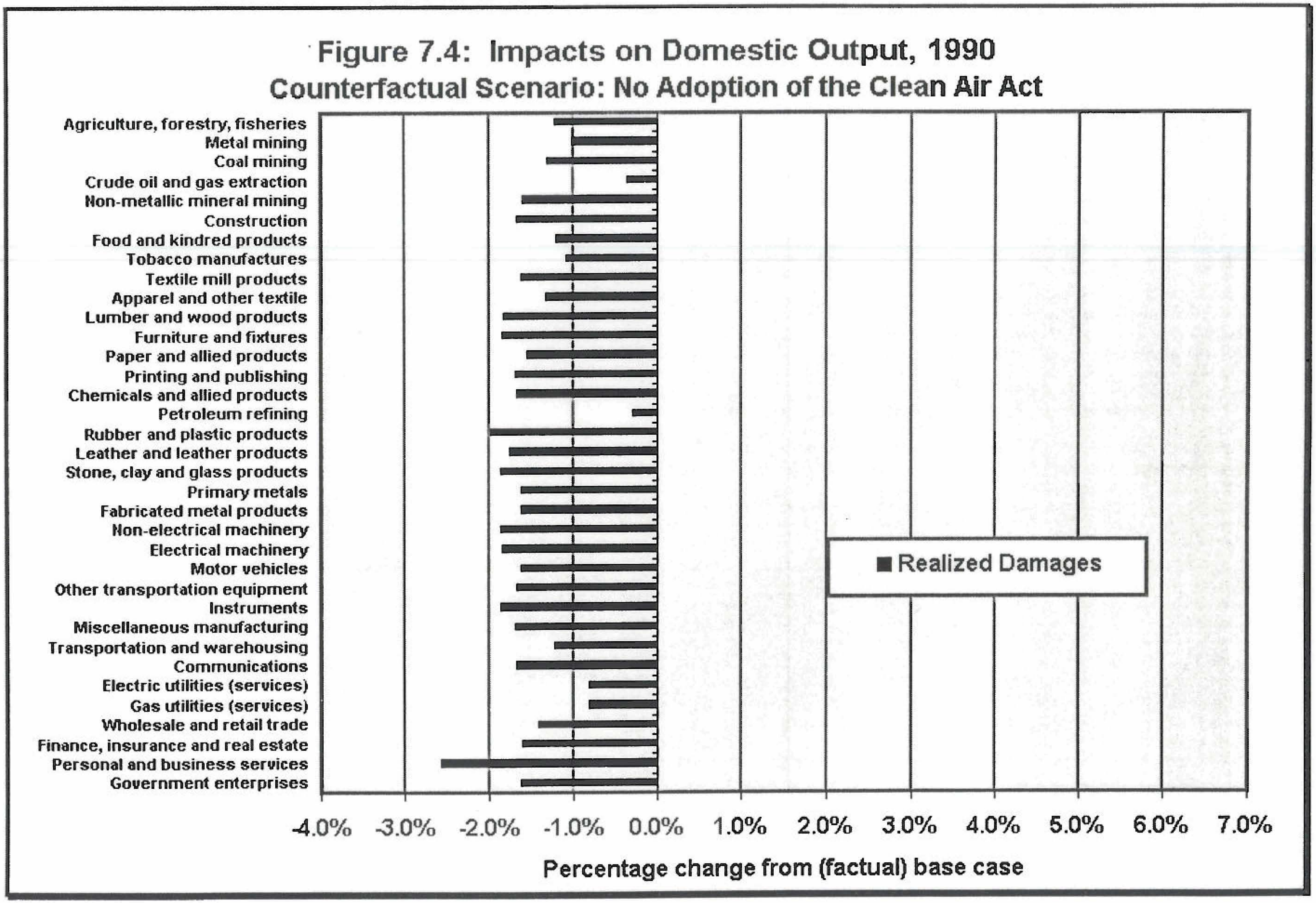


Figure 7.4: Impacts on Domestic Output, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act
Agriculture, forestry, fisheries
Metal mining
Coal mining
Crude oil and gas extraction
Non-metallic mineral mining
Construction
Food and kindred products
Tobacco manufactures
Textile mill products
Apparel and other textile
Lumber and wood products
Furniture and fixtures
Paper and allied products
Printing and publishing
Chemicals and allied products
Petroleum refining
Rubber and plastic products
Leather and leather products
Stone, clay and glass products
Primary metals
Fabricated metal products
Non-electrical machinery
Electrical machinery
Motor vehicles
Other transportation equipment
Instruments
Miscellaneous manufacturing
Transportation and warehousing
Communications
Electric utilities (services)
Gas utilities (services)
Wholesale and retail trade
Finance, insurance and real estate
Personal and business services
Government enterprises
Realized Damages
-4.0%
-3.0%
-2.0%
-1.0%
0.0%
1.0%
2.0%
3.0%
4.0%
5.0%
6.0%
7.0%
Percentage change from (factual) base case

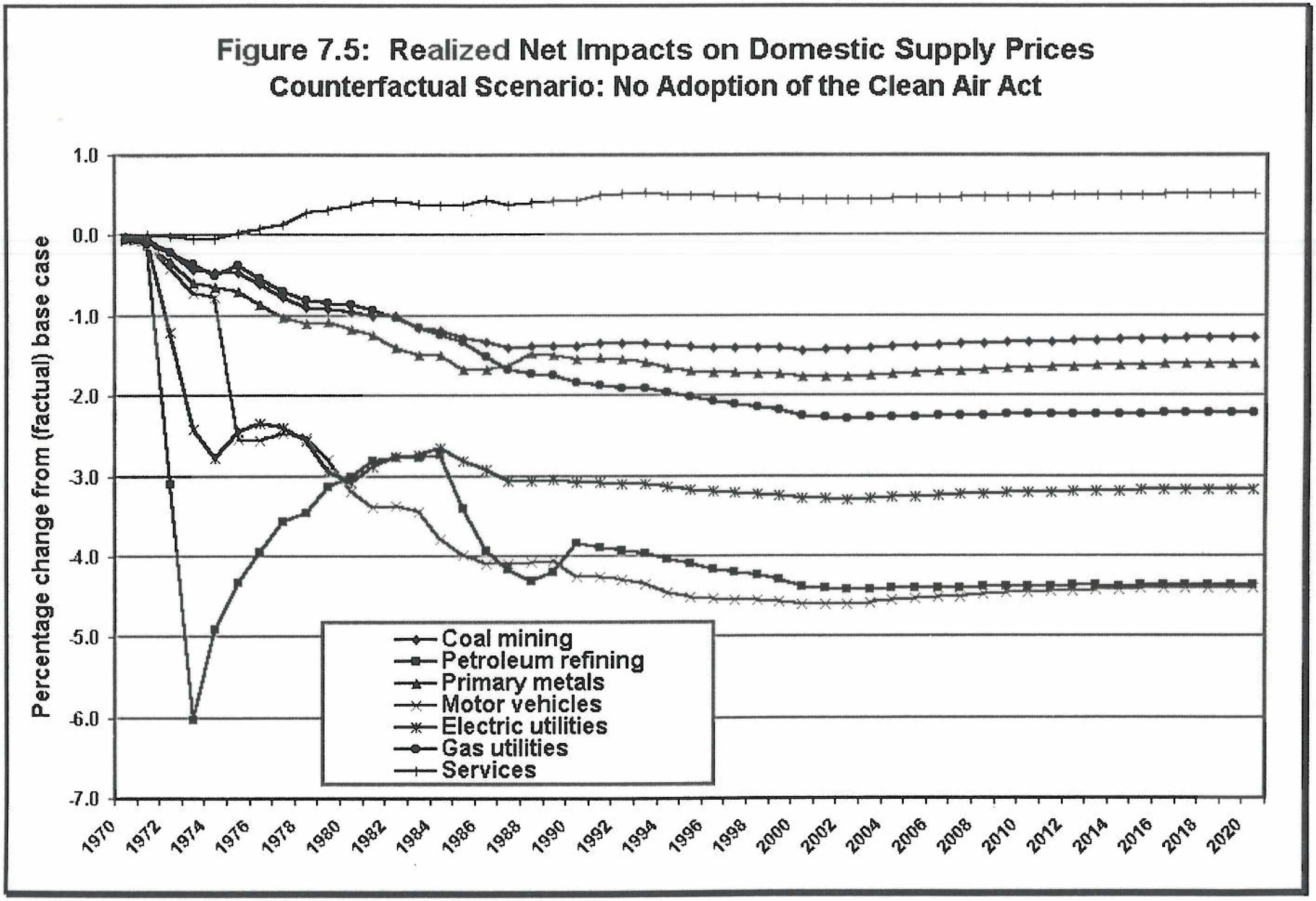


Figure 7.5: Realized Net Impacts on Domestic Supply Prices
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Coal mining
Petroleum refining
Primary metals
Motor vehicles
Electric utilities
Gas utilities
Services

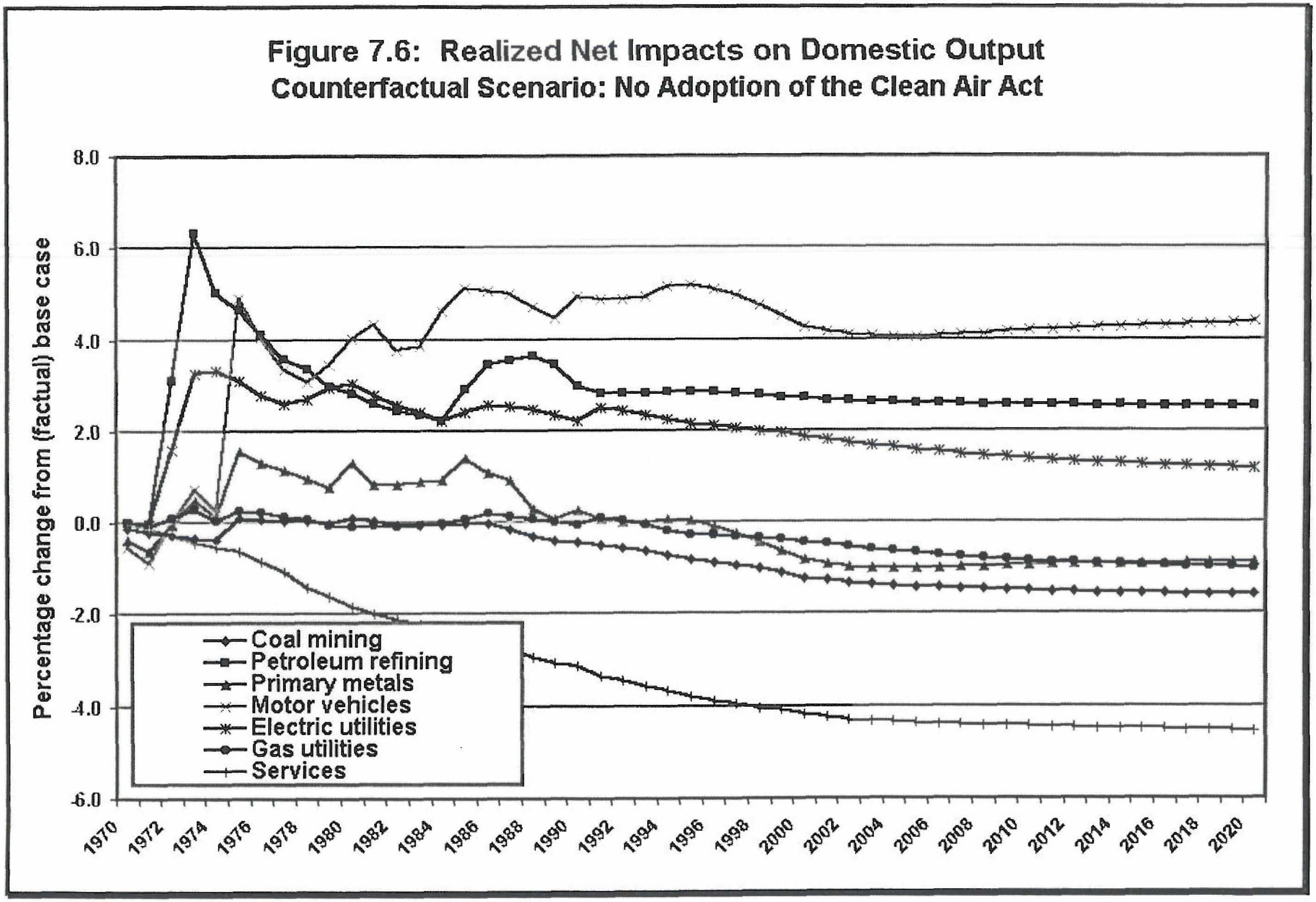


Figure 7.6: Realized Net Impacts on Domestic Output
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
Coal mining
Petroleum refining
Primary metals
Motor vehicles
Electric utilities
Gas utilities
Services
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020

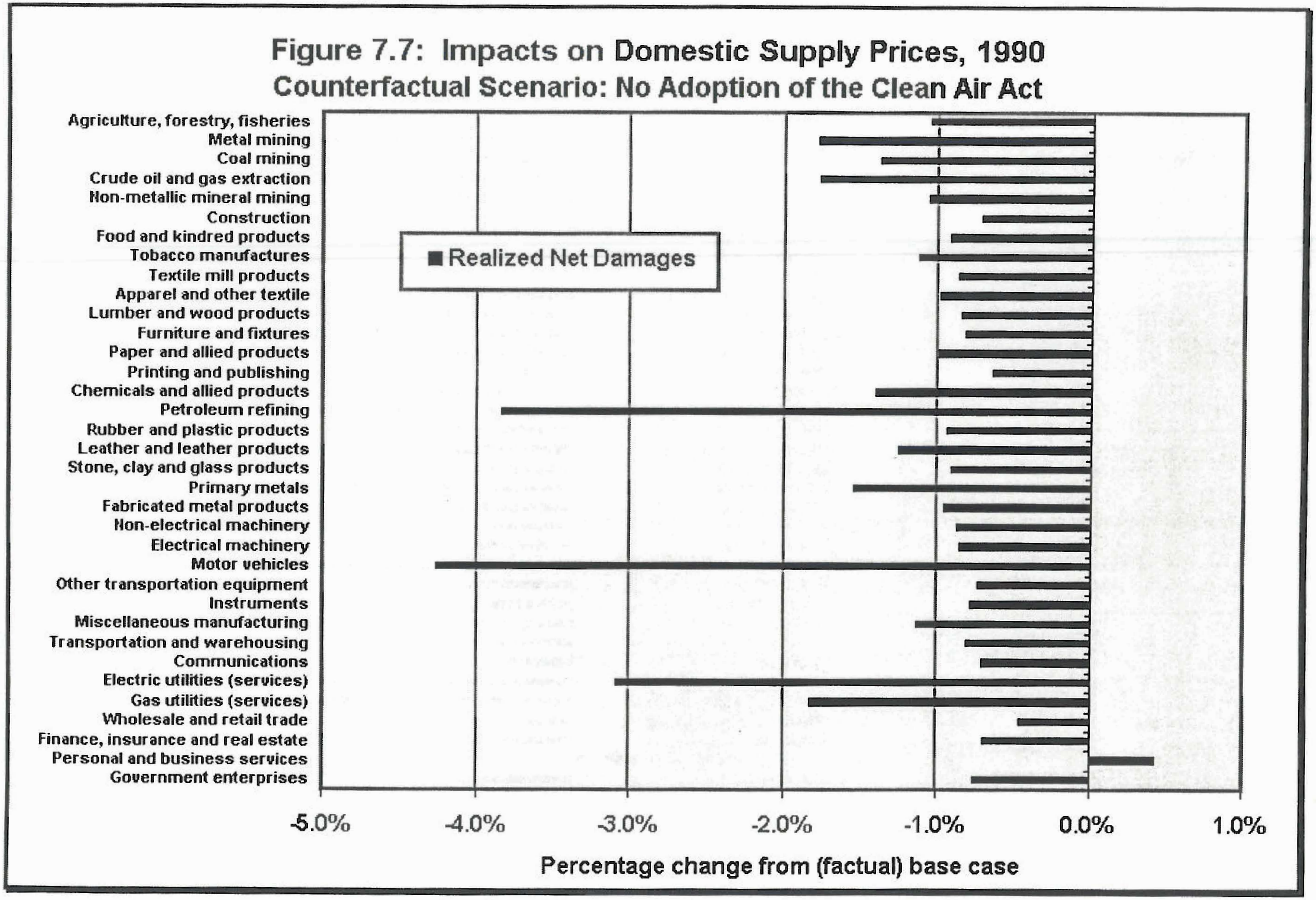


Figure 7.7: Impacts on Domestic Supply Prices, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act
Agriculture, forestry, fisheries
Metal mining
Coal mining
Crude oil and gas extraction
Non-metallic mineral mining
Construction
Food and kindred products
Tobacco manufactures
Textile mill products
Apparel and other textile
Lumber and wood products
Furniture and fixtures
Paper and allied products
Printing and publishing
Chemicals and allied products
Petroleum refining
Rubber and plastic products
Leather and leather products
Stone, clay and glass products
Primary metals
Fabricated metal products
Non-electrical machinery
Electrical machinery
Motor vehicles
Other transportation equipment
Instruments
Miscellaneous manufacturing
Transportation and warehousing
Communications
Electric utilities (services)
Gas utilities (services)
Wholesale and retail trade
Finance, insurance and real estate
Personal and business services
Government enterprises
Realized Net Damages
-5.0%
-4.0%
-3.0%
-2.0%
-1.0%
0.0%
1.0%
Percentage change from (factual) base case

Figure 7.8: Impacts on Domestic Output, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act