Chapter 3. The Benefits and Costs of the Clean Air Act: 1970 to 1990

3.1 Introduction

The Clean Air Act of 1970 and its subsequent amendments through 1990 were designed to improve air quality and reduce the adverse consequences of air pollution. As a result, this legislation imposed costs on producers and consumers as economic activities were brought into compliance with statutory requirements. However, the legislation also produced 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. This chapter examines the consequences of these costs and benefits for overall economic performance and welfare. We use IGEM 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 without the economic benefits that result from improvements in environmental quality, adversely affect economic performance. Ultimately, real consumption and income are one percent lower due to this legislation. These effects reflect the policy's impact on capital formation and on productivity at the industry level. To achieve compliance with the environmental regulations, a portion of each new dollar of invested capital 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 the operation and maintenance of both new and existing capital. This reduces productivity at the industry level.

The benefits arising from the Clean Air Act, analyzed without cost considerations, enhance economic performance. Real consumption and income ultimately are almost three percent higher with the legislation. The policy has a favorable impact by reducing pollution-related illnesses, increasing intellectual acuity due to a decline in lead poisoning, and eliminating pre-mature deaths associated with air pollution. These changes directly affect the availability of labor for production and the welfare of consumers as purchasers of goods and services. Clean air legislation generates enhanced economic activity through its impact on both demand and supply of goods and services.

By combining the costs and benefits of pollution control, the Clean Air Act provides 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, the consequences of avoided deaths and work-loss days soon compensate for the long-run costs 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 cumulate to sizeable amounts. From a welfare perspective, computed as present value of equivalent variations in consumer expenditure, there are cumulative net gains of $(1990) 26.2 trillion. The benefits of the clear air legislation far outweighs 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 Clean Air Act 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.

3.2 Relationship to previous work

Jorgenson and Wilcoxen (1990, 1993) analyzed the impact of environmental regulations on U.S. economic growth. They utilized detailed data on costs of compliance imposed on individual industries by these regulations. They first simulated U.S. economic growth with the existing regulations in order to provide a base case for comparison with growth under alternative environmental policies. These policies correspond to different costs of pollution control for individual industries and generate different time paths for U.S. economic growth. Removing environmental regulations produces an alternative growth path called the alternative case.

Jorgenson and Wilcoxen decomposed the overall effects of environmental regulations into components associated with pollution abatement in industry and controls on motor vehicle emissions. They measure the impact of the regulations by eliminating each type of control separately and then eliminating both. They compare growth in the base case with growth in each of these alternative cases. The growth path with pollution controls differs from the base case at the initial equilibrium, at steady state growth, and on the transition path that traces out the U.S. economy's adjustment to the alternative environmental policy.

In this chapter we examine 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 air 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. Perhaps less visible and immediate, its enactment also gave rise 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, we reported on our detailed analysis of the economic costs associated with compliance to the 1970 Act and the 1977 Amendments (Jorgenson, et. al., 1993). Using IGEM, we determined that this legislation adversely affected economic performance. Real consumption and income ultimately would have been one percent higher. 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 of goods and services. 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. 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 in this chapter extends this earlier work. In particular, we use IGEM to evaluate the estimated benefit stream arising from the 1970 and 1977 legislation. We perform a net benefit analysis incorporating the costs assessed by Jorgenson, et al., (1993). As before, the costs and benefits of the Clear Air Act were analyzed independently. These were quantified in a manner that allows their introduction into the IGEM framework, so as to isolate and measure the policy's direct and indirect consequences. 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 economic consequences of compliance with this legislation.

The remainder of this chapter is organized as follows. Sections 3.3 analyzes the costs and Section 3.4 the benefits of the Clean Air Act. These sections describe how the costs and benefits are introduced into IGEM. Sections 3.5, 3.6 and 3.7 present the simulation results. Section 3.5 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 of foregone consumption. Section 3.6 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 3.7 reports on the industry details as reflected in the prices paid by producers and consumers and changes in the composition of domestic output.

3.3 The costs of compliance

The CAA compliance costs included in this analysis include 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, since 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. See also Appendix H.

Annual CAA compliance costs average almost $15.0 billion over the period 1973-1990. Capital and net operating expenditures for stationary sources 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.

All compliance costs for non-mobile sources are 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 costs. In order to achieve comparability with earlier analytical efforts, these data were not considered in this assessment. Second, the cost data represent all air pollution abatement expenditures, including those that would have occurred in the absence of the CAA. Similarly, the benefit estimates employ a baseline without any changes in air quality due to the CAA. Industry incurred expenses for air pollution control prior to 1970 and, presumably, would have continued to do so without the Act, yielding corresponding benefits. Unfortunately, there is no basis for isolating either the benefits or the costs attributable to the Clean Air Act.

The operating and maintenance costs included in our analysis average over four tenths of one percent of total domestic product during the period 1973-1990. However, these costs 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. We 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.

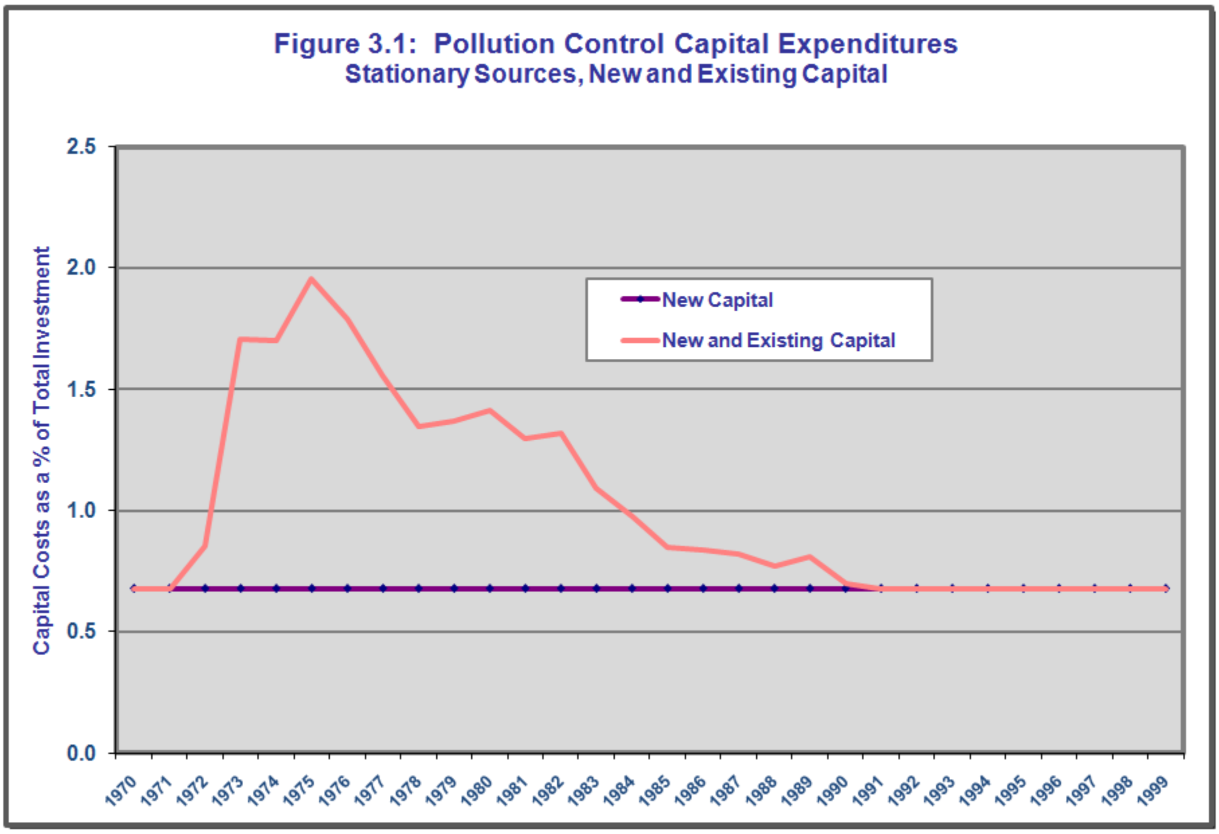
The permanent effect was introduced into IGEM as a reduction in the price of investment goods. This follows from the fact that under the CAA purchasers of capital goods had to buy a certain amount of pollution abatement capital for each unit of new productive capital, thereby increasing the price of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

The capital costs of pollution control expenditures 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



The operation and maintenance of air pollution control devices increases the input requirements per unit of output for each affected sector. The first step in eliminating the operating portion of the CAA compliance costs was to compute the share of these costs in the total for each industry. For the manufacturing sectors, these costs were net of any recovered costs associated with the operation of pollution control equipment. We simulated removal of these costs by reducing the unit costs by these proportions. The net additional resources required to operate and maintain pollution control equipment were released by reducing each of the input demands for a given amount of output 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 as 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.

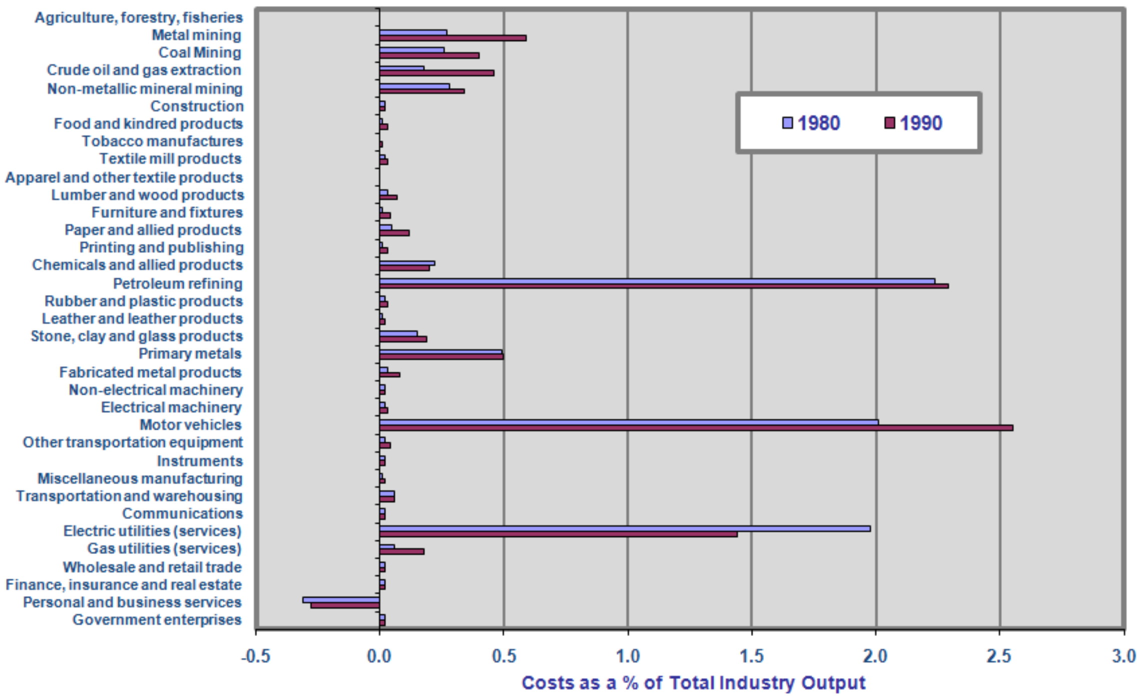
Table 3.3:
Pollution Control Expenditures
as a Percent of the Value of Industry Output

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	1.98	1.44
31	Gas utilities	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



3.4 The benefits from compliance

The Clean Air Act produced improvements in the general health and welfare of the population through reductions in lead concentrations and emissions of 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 premature 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. Reduced intellectual acuity 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 our benefit measures. 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; the results appear in Appendix H. These extrapolations were necessary because 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.

The relative contributions of lead and non-lead pollutants in the mix of overall benefits are of considerable interest. 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 IGEM requires the actuarial adjustments shown in Table 3.4 below. Since individuals die and retire, there comes a point in time in which an avoided death or activity day lost no longer appears in the 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 comprises fourteen hours per day devoted to work and leisure for each member of the working-age population, ages 14 to 74. This is expressed in dollars, reflecting the prevailing after-tax compensation received per unit of labor services provided to employers.

The avoided deaths in any given year represent EPA's 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 difference being that persons over 75 were not considered part of the labor force and, hence, were not considered avoided-death benefits. Retirement at 75 is consistent with IGEM's time endowment, based on 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 3.4:
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 loss in intellectual acuity. 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 intellectual acuity 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 3.3 and 3.4 below. Figure 3.3 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 3.3 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. The 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 had risen to almost one 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.

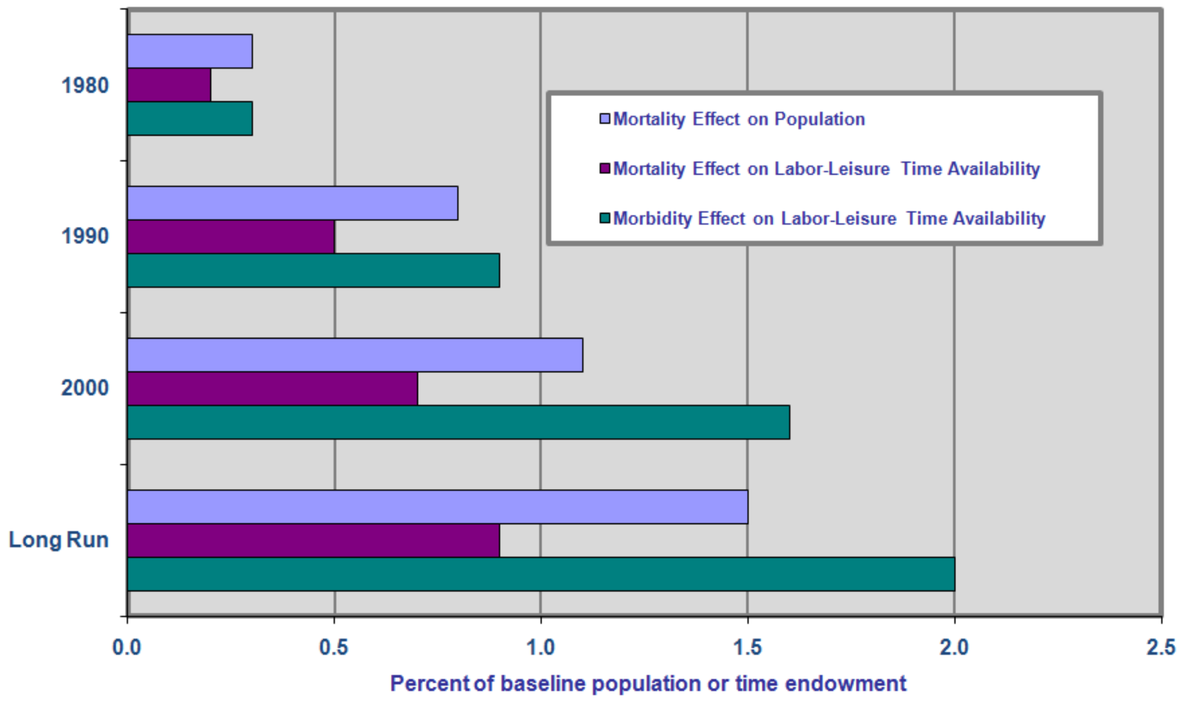


Figure 3.3: Mortality and Morbidity Effects
Counterfactual Scenario: No Adoption of the Clean Air Act

The expenditure effects portrayed in Figure 3.4 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.

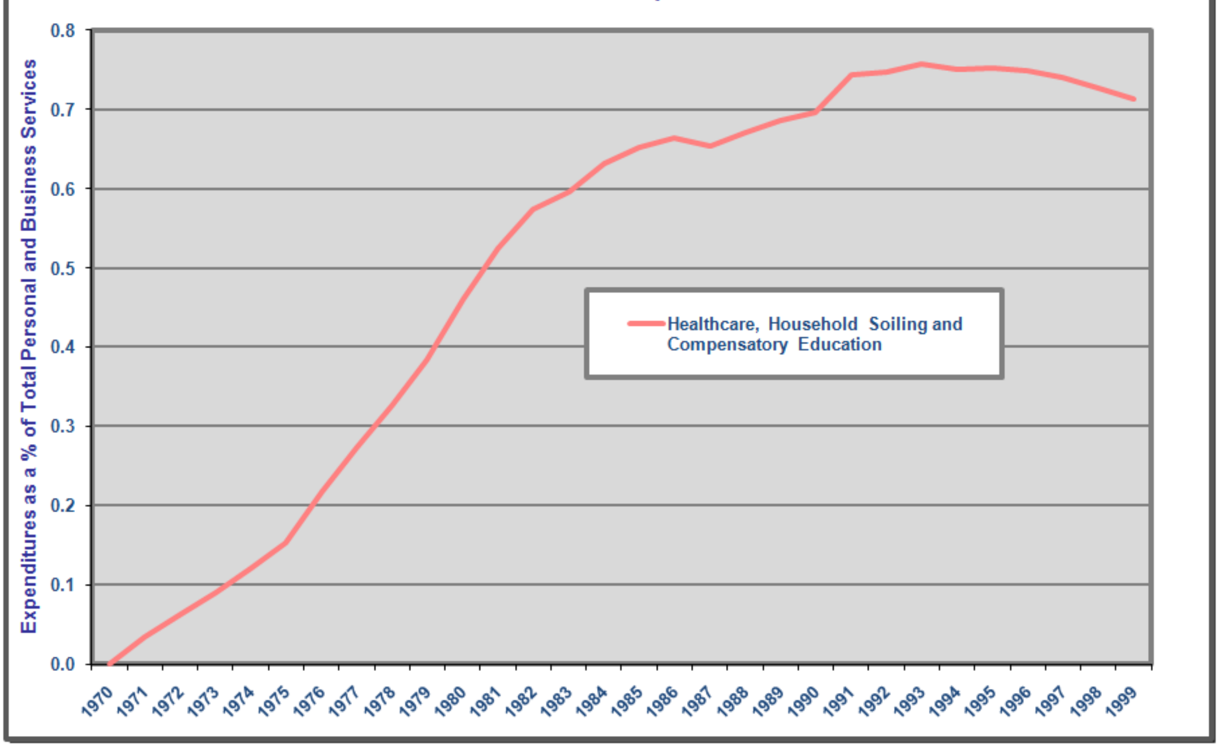
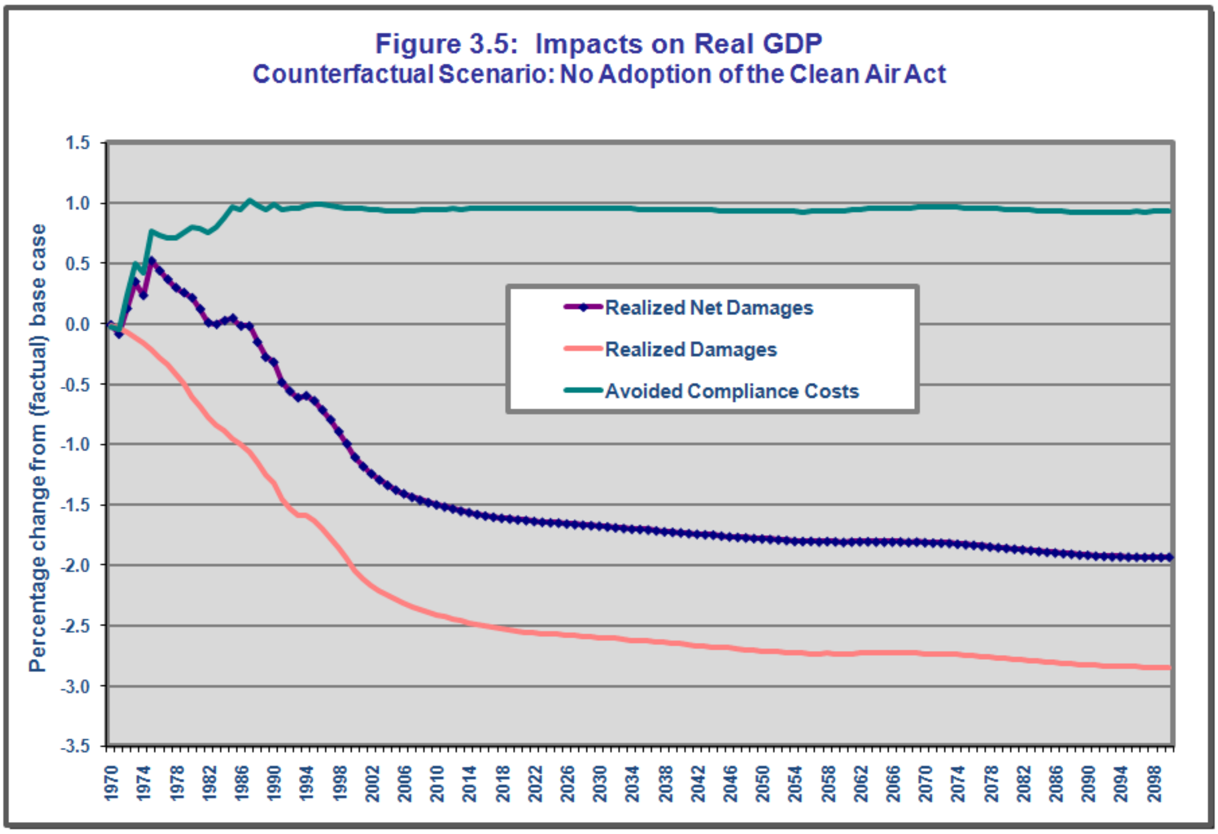


Figure 3.4: Additional Household Expenditures
Counterfactual Scenario: No Adoption of the Clean Air Act

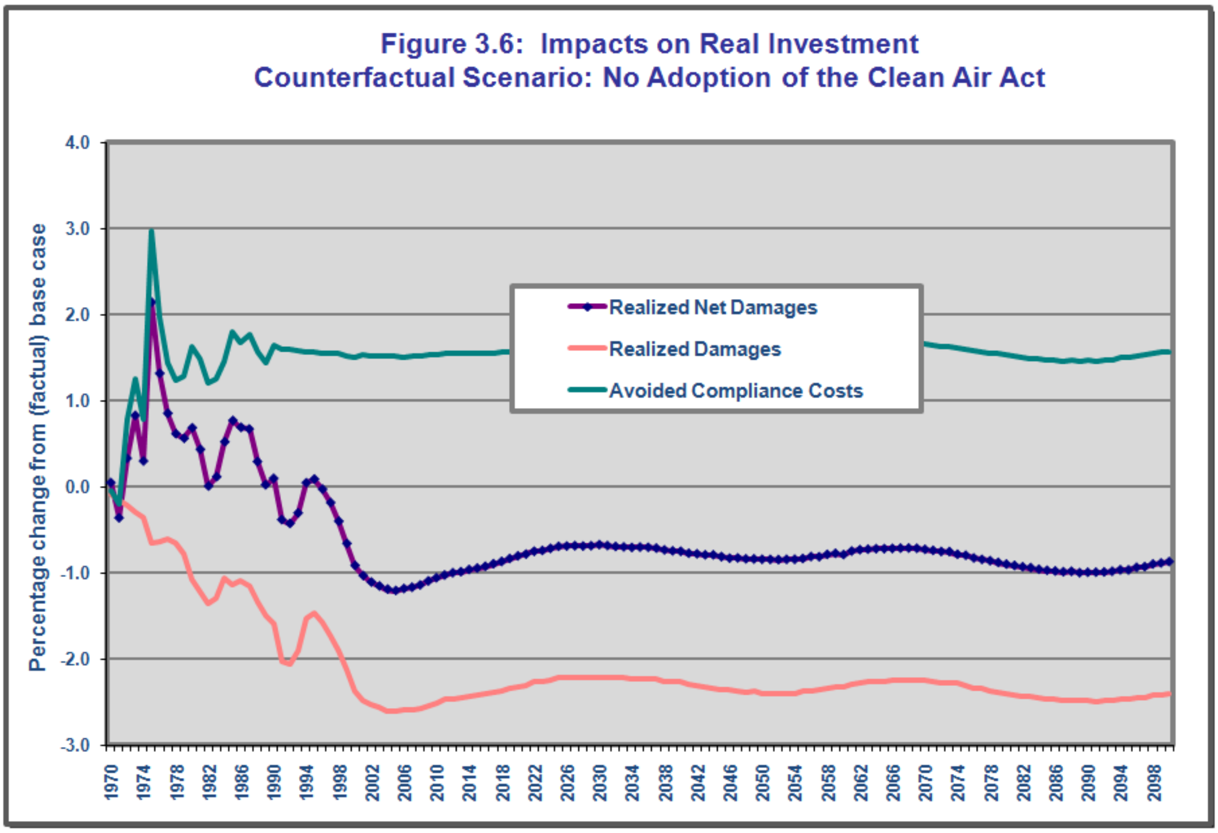
3.5 Economic performance and welfare

3.5.1 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 3.5 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. If the economy were 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. If these were 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.



The macroeconomic adjustments to CAA compliance are somewhat more intricate than the benefit adjustments. The principal impacts of compliance are to reduce investment and capital accumulation. These reductions and the economic restructuring associated with them are shown in Figures 3.6 and 3.7. 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 bringing 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. Less rapid accumulation of capital implies a higher rental price for capital services and a lower demand. The increased rental prices also raise the prices of goods and services and the overall price level.



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 fall. Ultimately, real income (Figure 3.5) and consumption (Figure 3.8) fall by one percent while real investment (Figure 3.6) and the capital stock (Figure 3.7) decrease by one and one half percent.

Figure 3.7: Impacts on Capital Stock
Counterfactual Scenario: No Adoption of the Clean Air Act

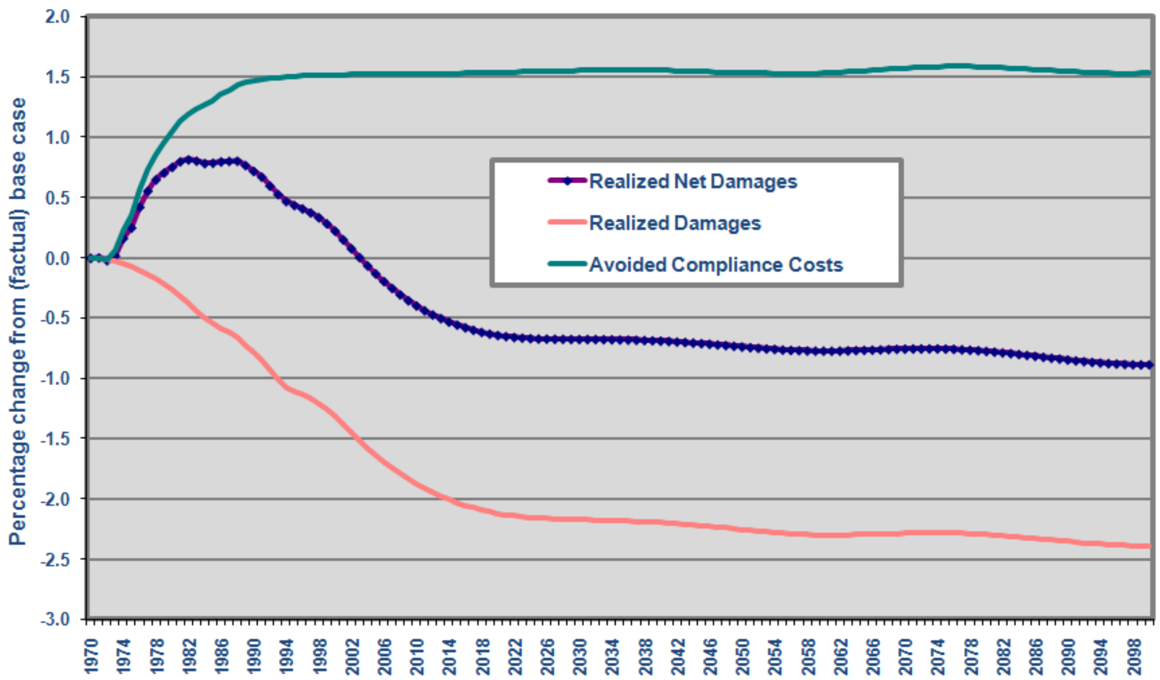
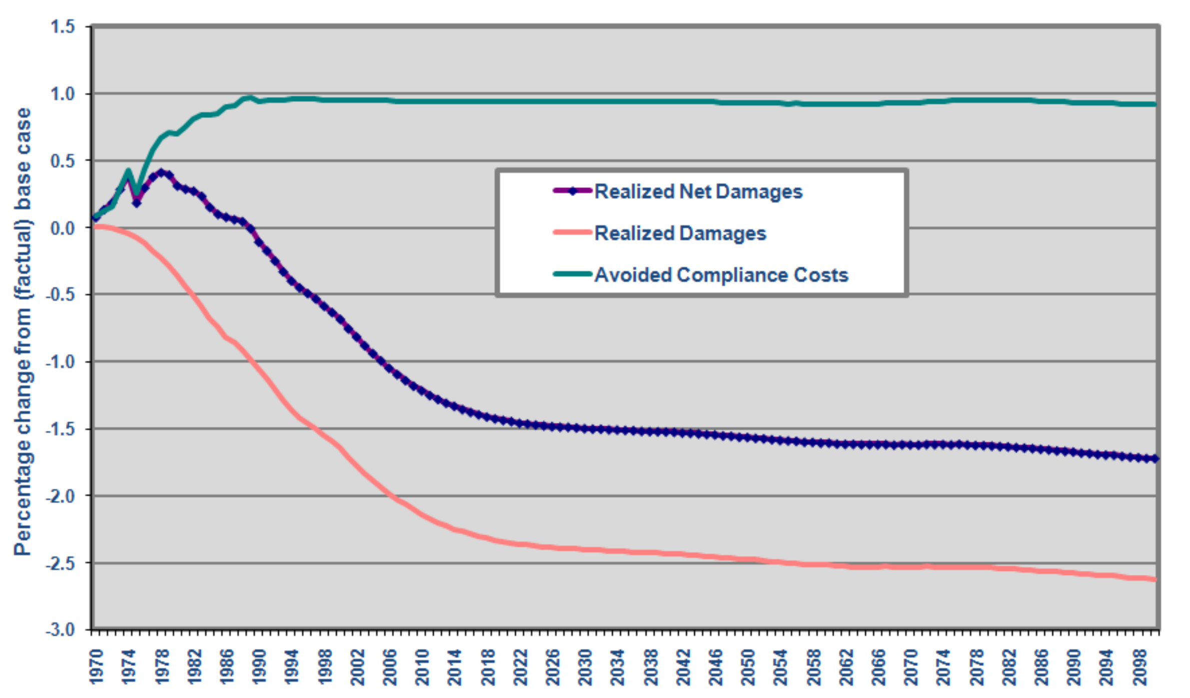


Figure 3.8: Impacts on Real Consumption
Counterfactual Scenario: No Adoption of the Clean Air Act



Compliance costs of the CAA reduce future real earnings through effects on prices. This leads to a decrease in real consumption in all periods, as shown in Figure 3.8, and decreases in household saving and the demand for leisure shown in Figure 3.9. Households increase their offer of labor services, as shown in Figure 3.10, since 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.

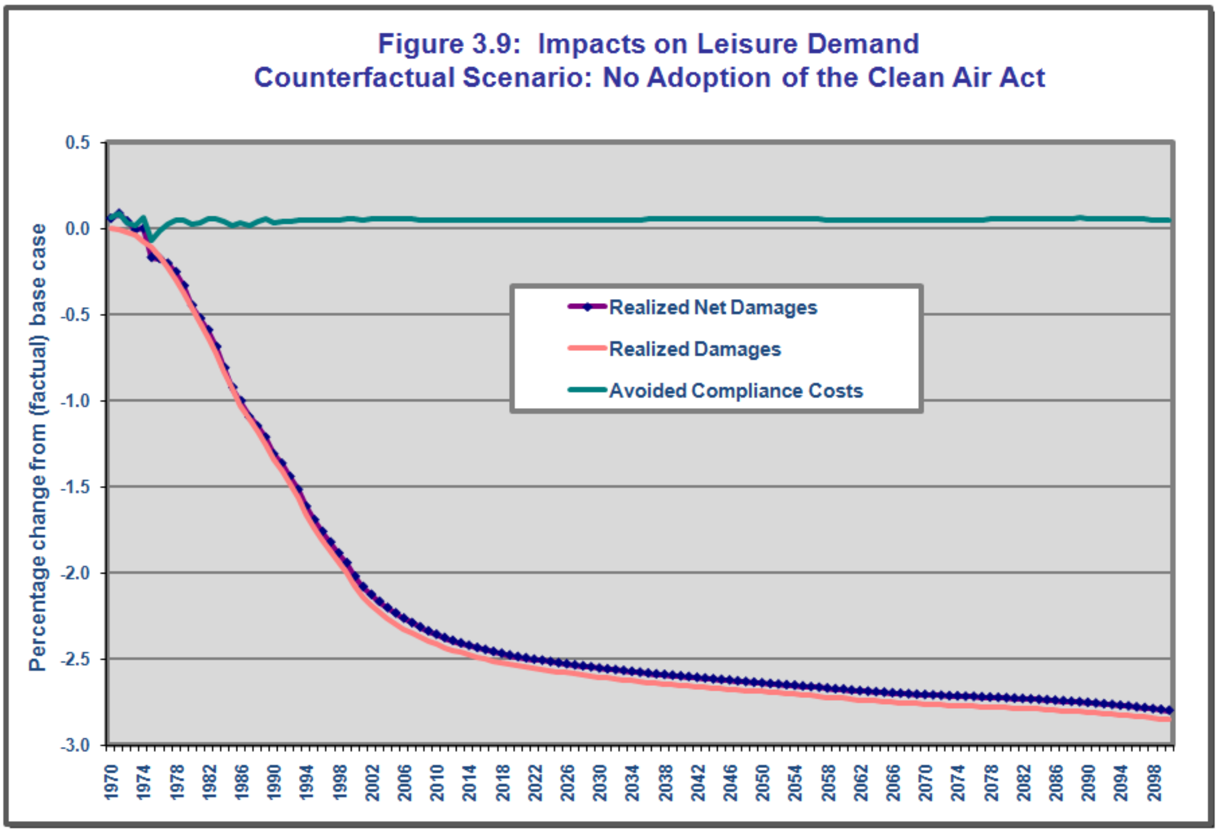
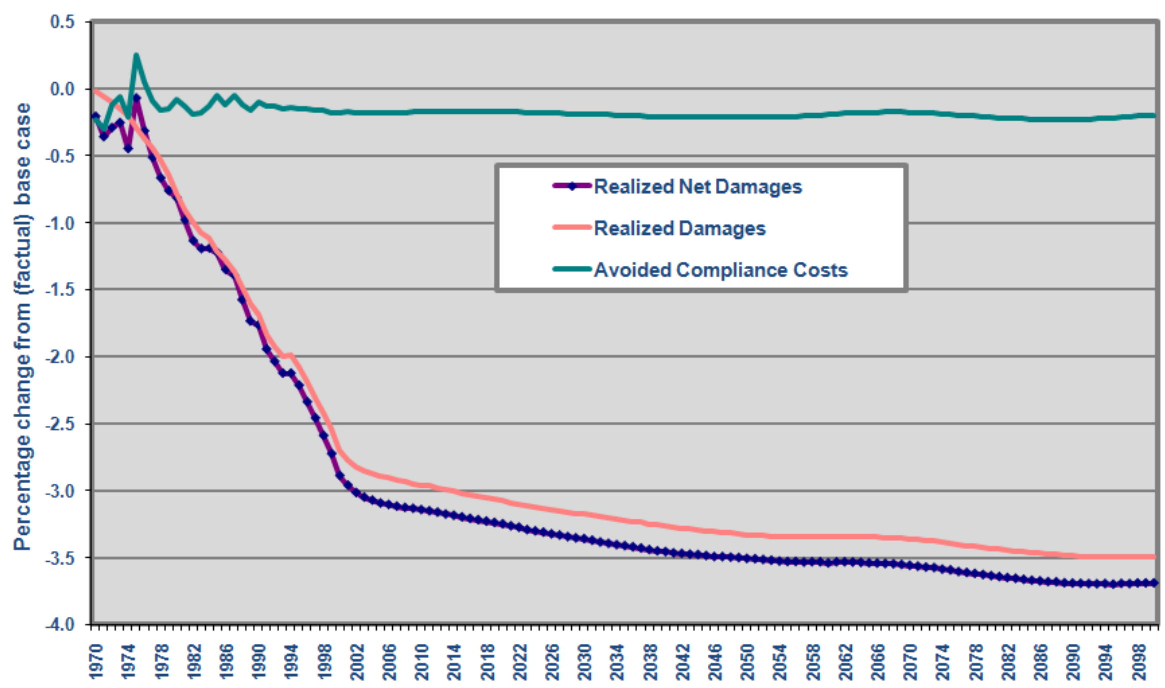


Figure 3.9: Impacts on Leisure Demand
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
Realized Net Damages
Realized Damages
Avoided Compliance Costs
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098

Figure 3.10: Impacts on Labor Demand & Supply
Counterfactual Scenario: No Adoption of the Clean Air Act



Real government spending falls as a consequence of higher commodity prices and the adjustments that hold spending in line with changes in tax revenues and maintain the 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.

Productivity effects generate 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 productivity. Relative price changes alter the structure of final demand, both within and across spending categories, and change the output composition of the economy. Since productivity differs among industries, this compositional change affects overall productivity. The output effect on overall productivity also appears in the input-to-output relation between the intermediate use of goods and services and final demand.

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 3.9 and 3.10, 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 greater with increases approximately equal to the proportionate increases in people and time.

More people and greater labor time favor labor supply and consumption proportionally more than saving and investment. 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.

3.5.2 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 3.5 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 3.5:
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.

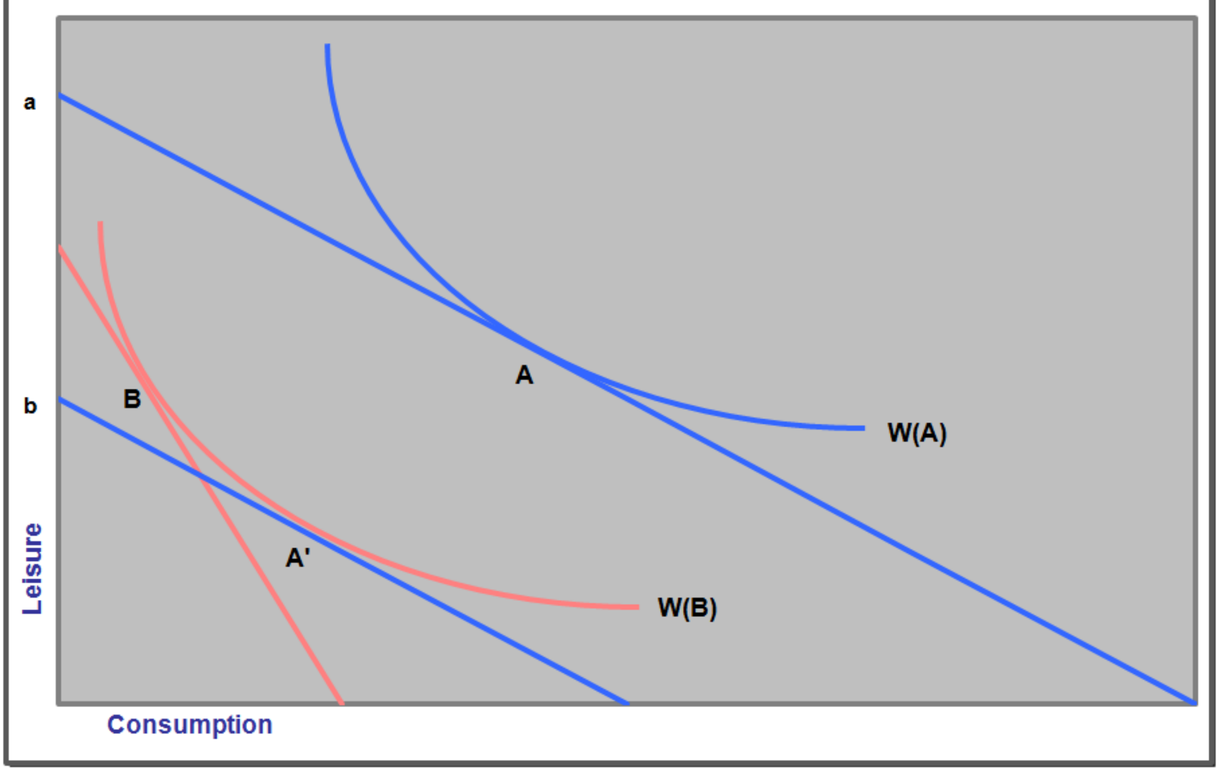
Valuations of a statistical life-year (VSLY) saved are easily determined from the lifetime value by computing annuities under various discount rates and time horizons. The $(1990) 21.1 trillion mortality benefit results from applying an annuity value of about $138,500 to the change in the discounted present value population or, equivalently, from applying the value of $(1990) 4.8 million to the discounted present value of the change in additions to the population. An annuity value is used because benefits from avoided deaths appear in multiple periods until these same deaths would have occurred naturally.

IGEM offers a purely market view of economic welfare. Within IGEM indirect utility functions are recovered from the systems of household demand functions involving goods and services, as shown by Jorgenson and Slesnick (1987, 2008). These can be inverted to give the level of expenditure necessary to achieve a given level of welfare at a prevailing set of prices. This is the equivalent variation in household expenditure. This perspective is limited in that it does not consider welfare valuations beyond those reflected in market prices and transactions, for example, 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). They estimate 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 its scale is national.

Figure 3.11 illustrates the market implications of a policy change for social welfare for a static two-good world involving aggregate consumption and leisure. In IGEM the actual welfare calculations are present values of equivalent variations determined from the time paths of interest rates and the prices for goods, services and leisure. Figure 3.11 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 total expenditure, 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 equivalent variation or the measure of society’s willingness to pay.

Figure 3.11 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. 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 3.5. 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 of 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)

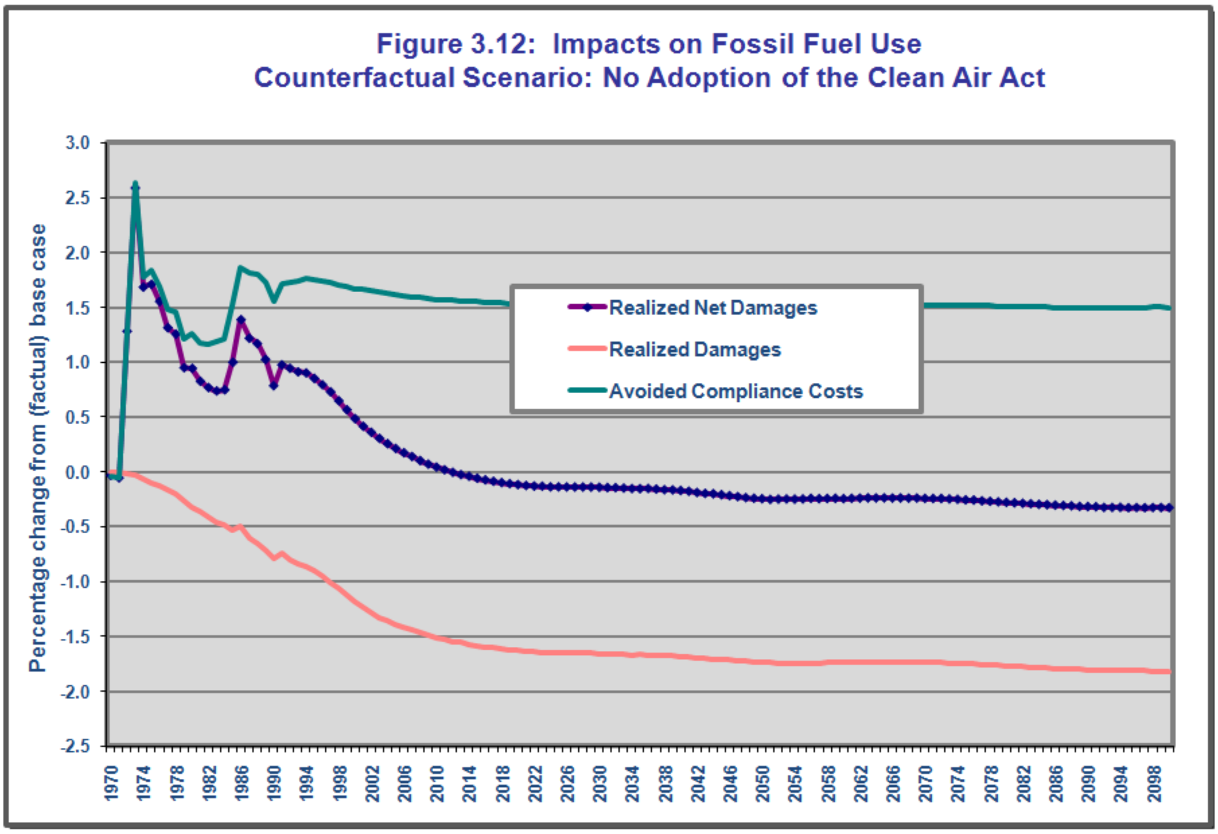
700,000. This is toward the low end of EPA's range of data and analyses which is not surprising since it is based solely on market considerations.

If the CAA benefits comprise only the market valuations from IGEM, a total market-based benefit of $(1990) 9.8 trillion would more than compensate for 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 comprehensible 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. These results reflect the magnitudes of the avoided premature deaths and adverse health consequences attributed to the CAA. As described in Section 3.4, 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.

3.6 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 3.12 and 3.13 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.



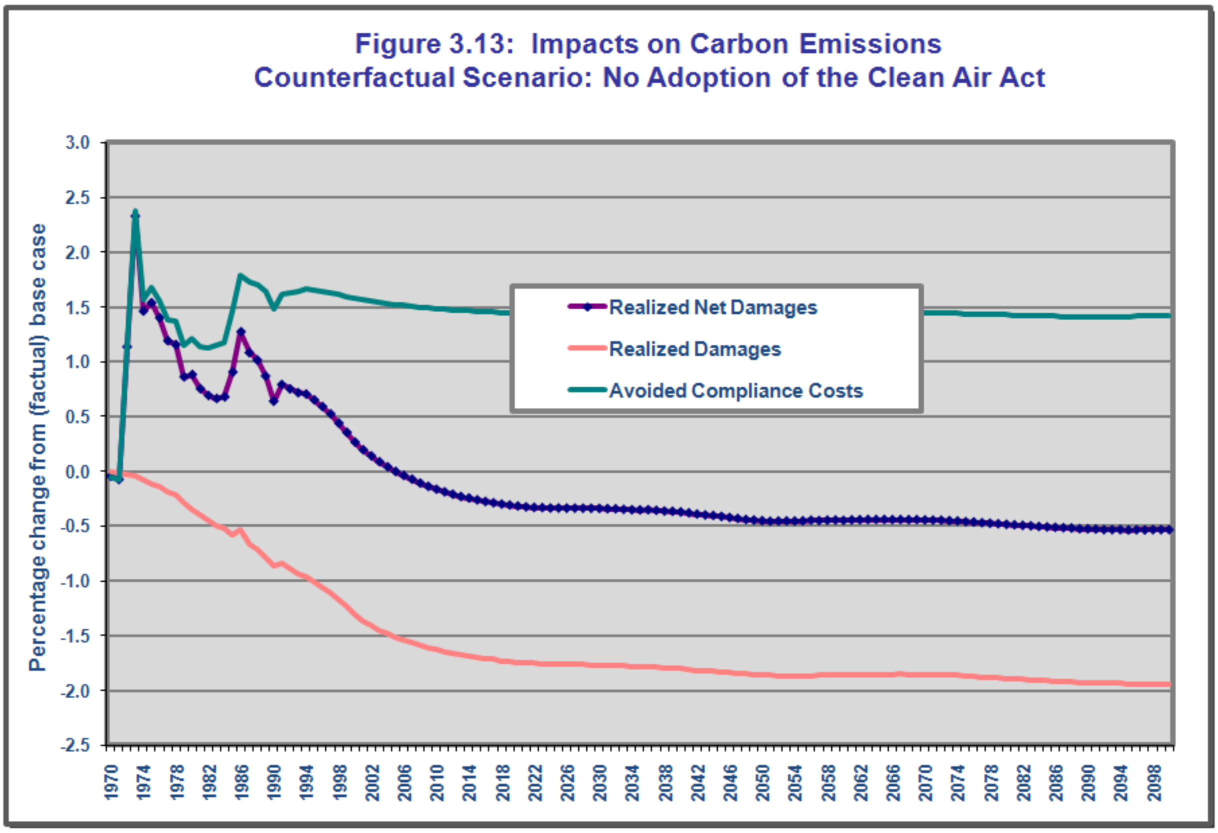


Figure 3.13: Impacts on Carbon Emissions
Counterfactual Scenario: No Adoption of the Clean Air Act

Figures 3.14 and 3.15 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 3.16, the emissions-intensity of fossil fuel use increases under the act. As will be discussed in Section 3.7, this arises because of the reduced petroleum-intensity and increased coal-intensity of the nation's energy-consuming capital stock.

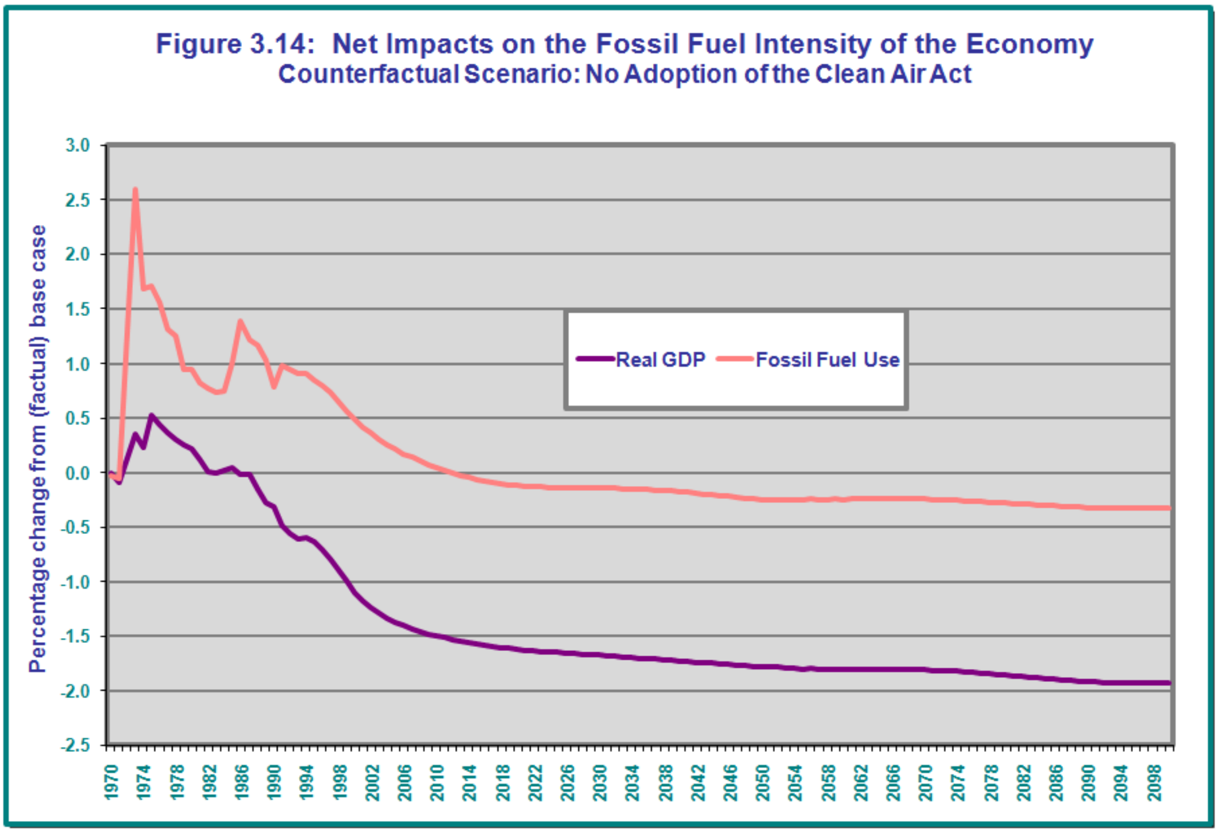


Figure 3.14: Net Impacts on the Fossil Fuel Intensity of the Economy
Counterfactual Scenario: No Adoption of the Clean Air Act
Real GDP
Fossil Fuel Use
Percentage change from (factual) base case
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098

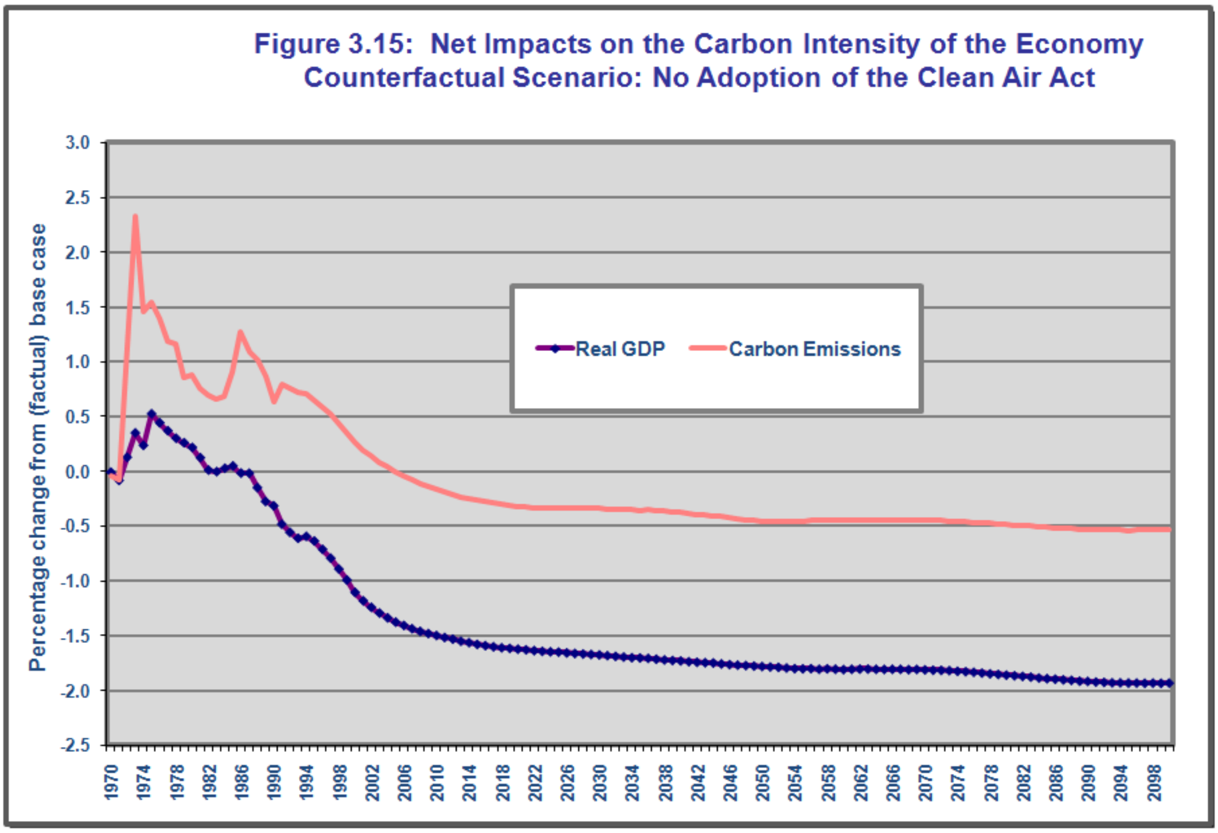
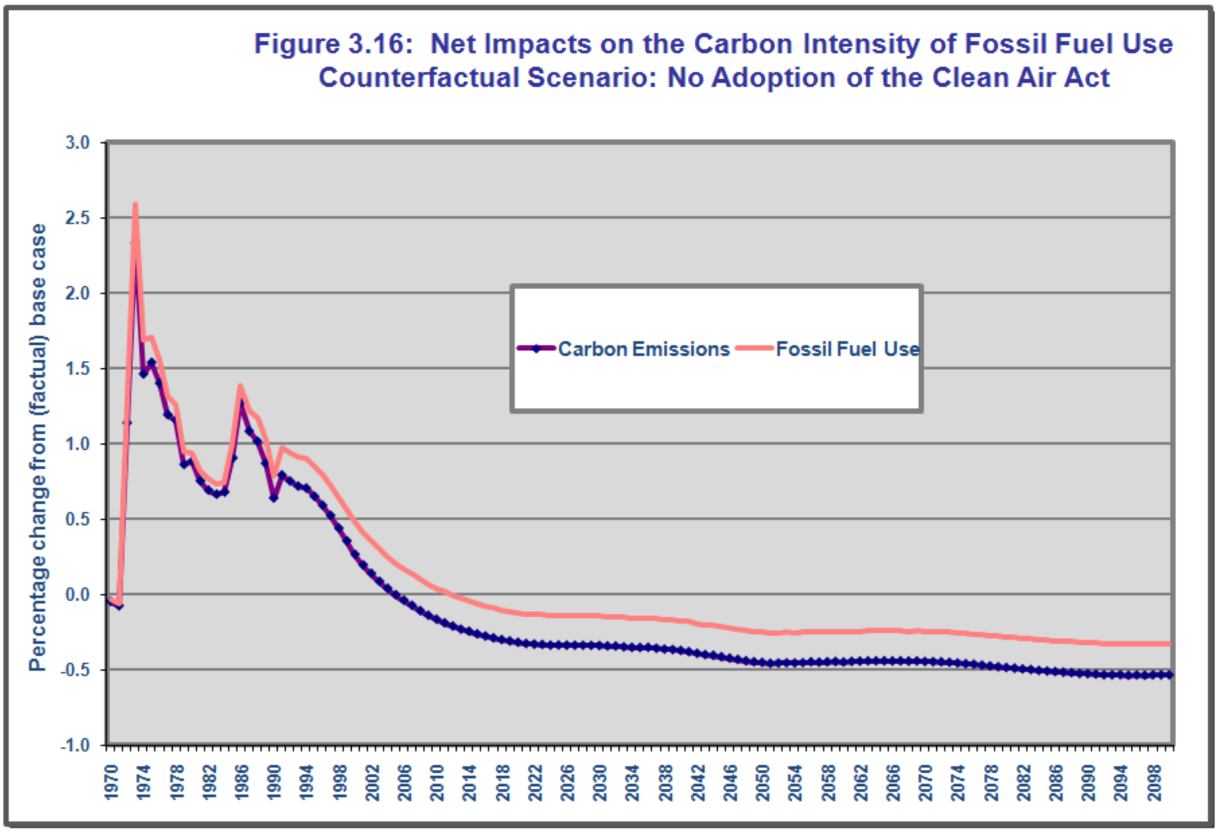


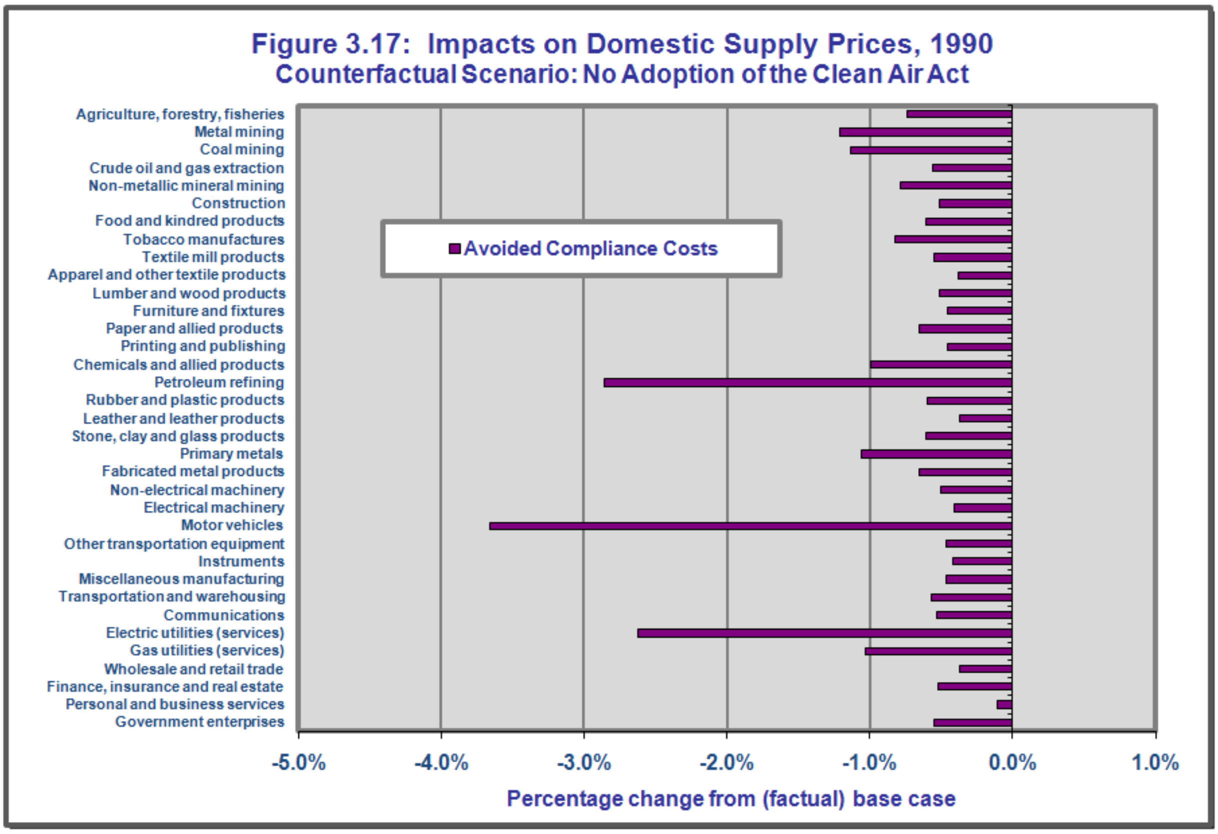
Figure 3.15: Net Impacts on the Carbon Intensity of the Economy
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
Real GDP
Carbon Emissions
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
2014
2018
2022
2026
2030
2034
2038
2042
2046
2050
2054
2058
2062
2066
2070
2074
2078
2082
2086
2090
2094
2098

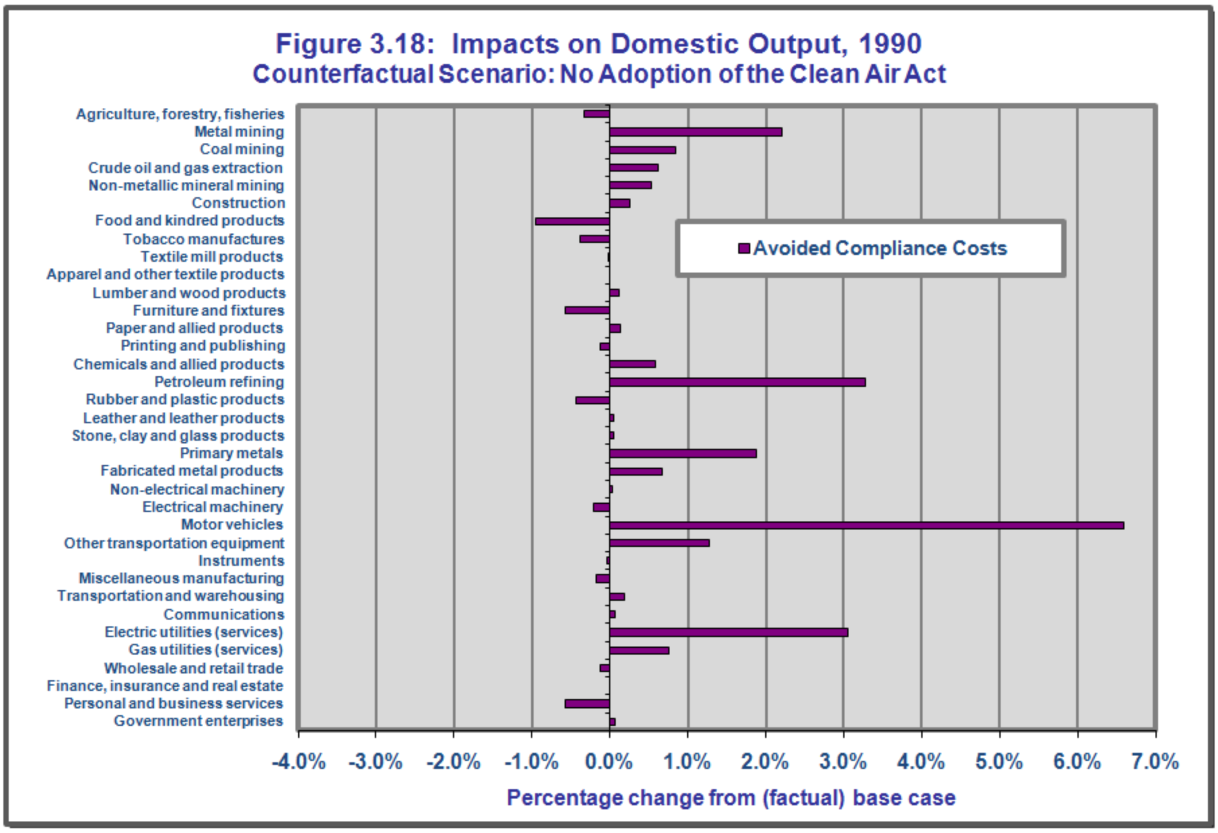


3.7 The structure of economic activity

The Clean Air Act has its biggest direct impacts on the petroleum refining, motor vehicle and electric utility sectors, as shown in Tables 3.1 and 3.3. 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 3.17. This shows industry supply prices for 1990 as compliance costs were counter-factually eliminated. Figure 3.18 shows the output consequences of cost-side adjustments. Clearly, the CAA costs affect the composition of domestic supply.

Relative price changes follow from the CAA cost impacts and, in turn, alter the input patterns within each producing sector; we can compare Figures 3.2 and 3.17. 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 3.17. 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 3.4). 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 expand with the 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, as shown in Figures 3.19 and 3.20. 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.

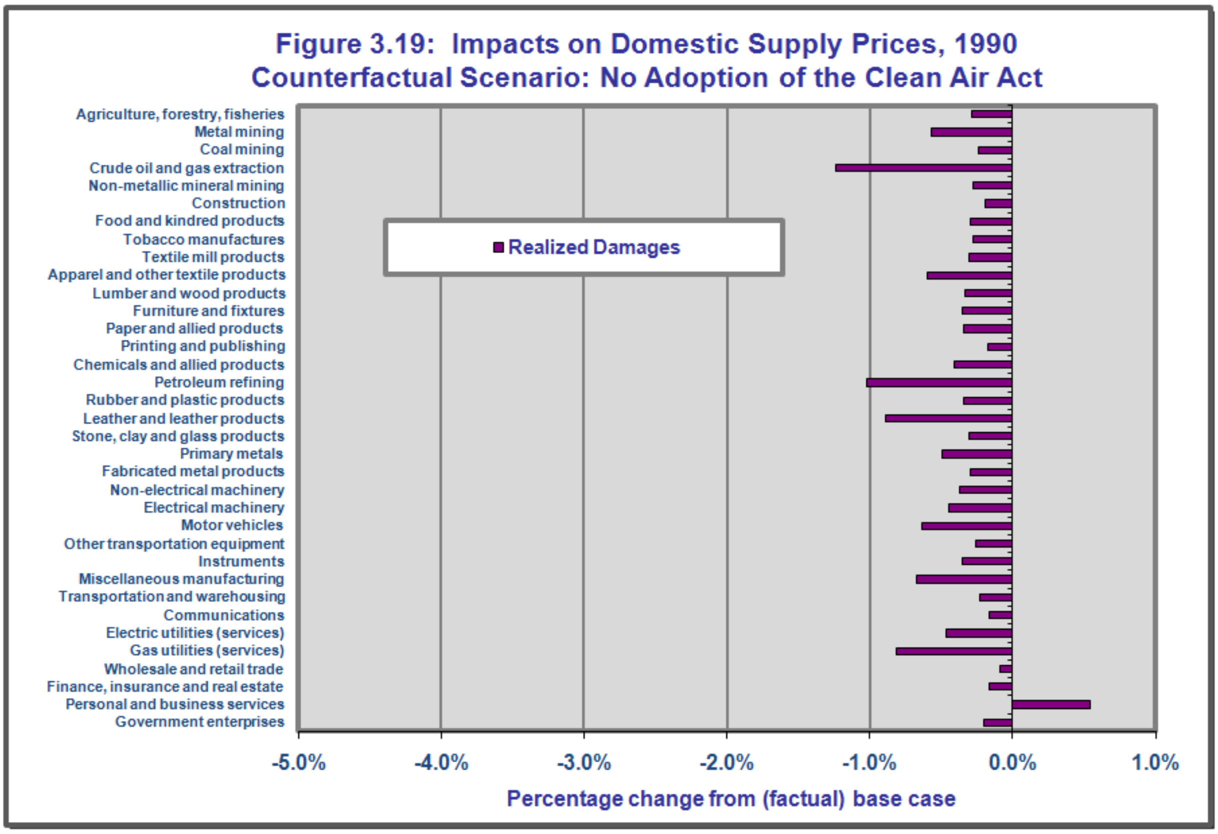
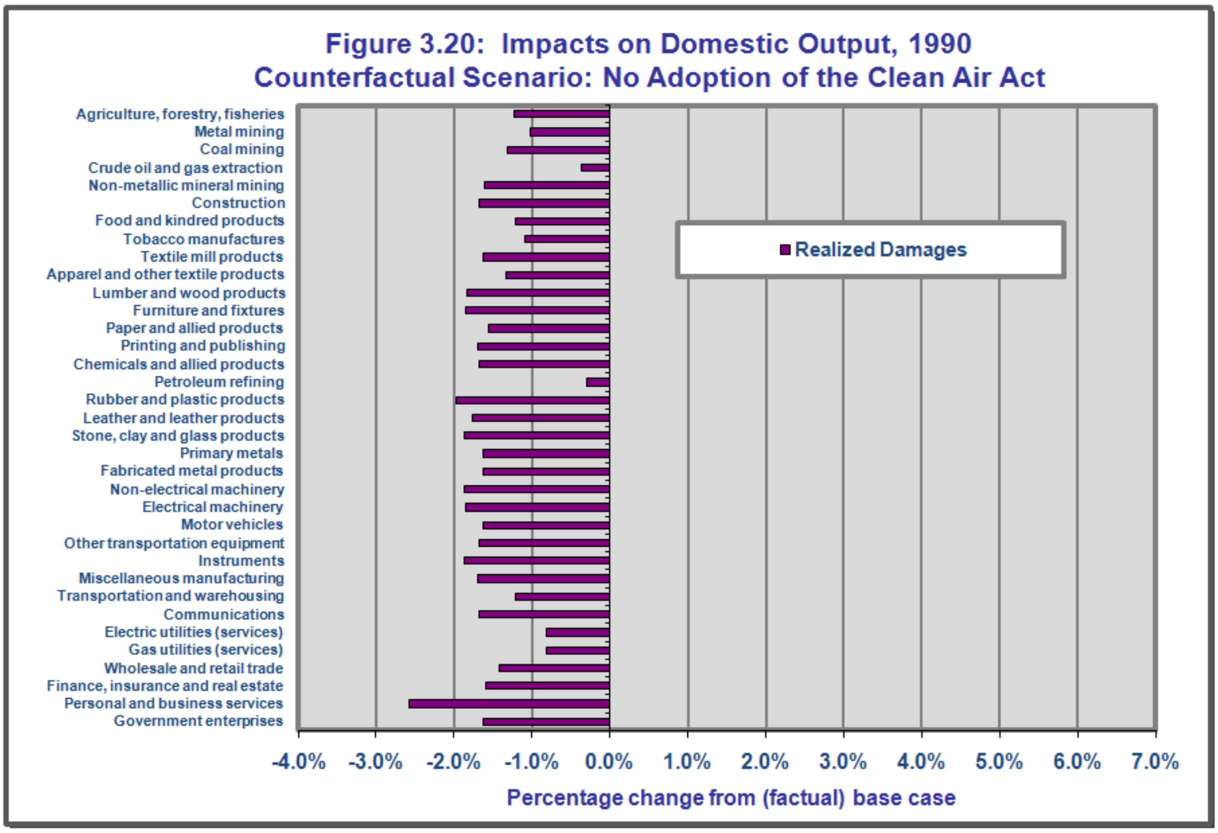


Figure 3.19: Impacts on Domestic Supply Prices, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act
Agriculture, forestry, fisheries
Metal mining
Coal mining
Crude oil and gas extraction
Non-metallic mineral mining
Construction
Food and kindred products
Tobacco manufactures
Textile mill products
Apparel and other textile products
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



Combining the benefits and costs of the Clean Air Act as in Figures 3.21 through 3.24 makes the mix of industrial winners and losers all the more visible. Figures 3.21 and 3.22 show the dynamic impacts on selected industries from the combined effects of CAA costs and benefits while Figures 3.23 and 3.24 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.

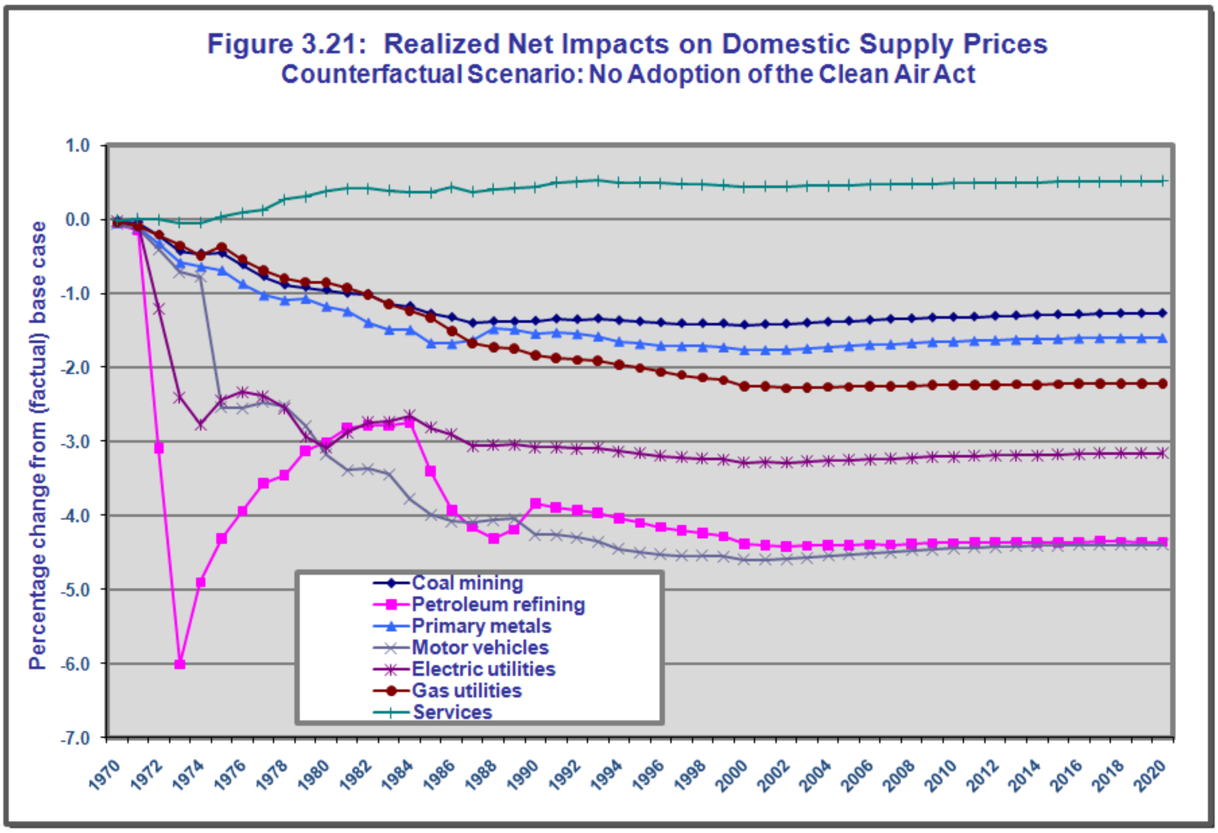


Figure 3.21: Realized Net Impacts on Domestic Supply Prices
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
Coal mining
Petroleum refining
Primary metals
Motor vehicles
Electric utilities
Gas utilities
Services
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

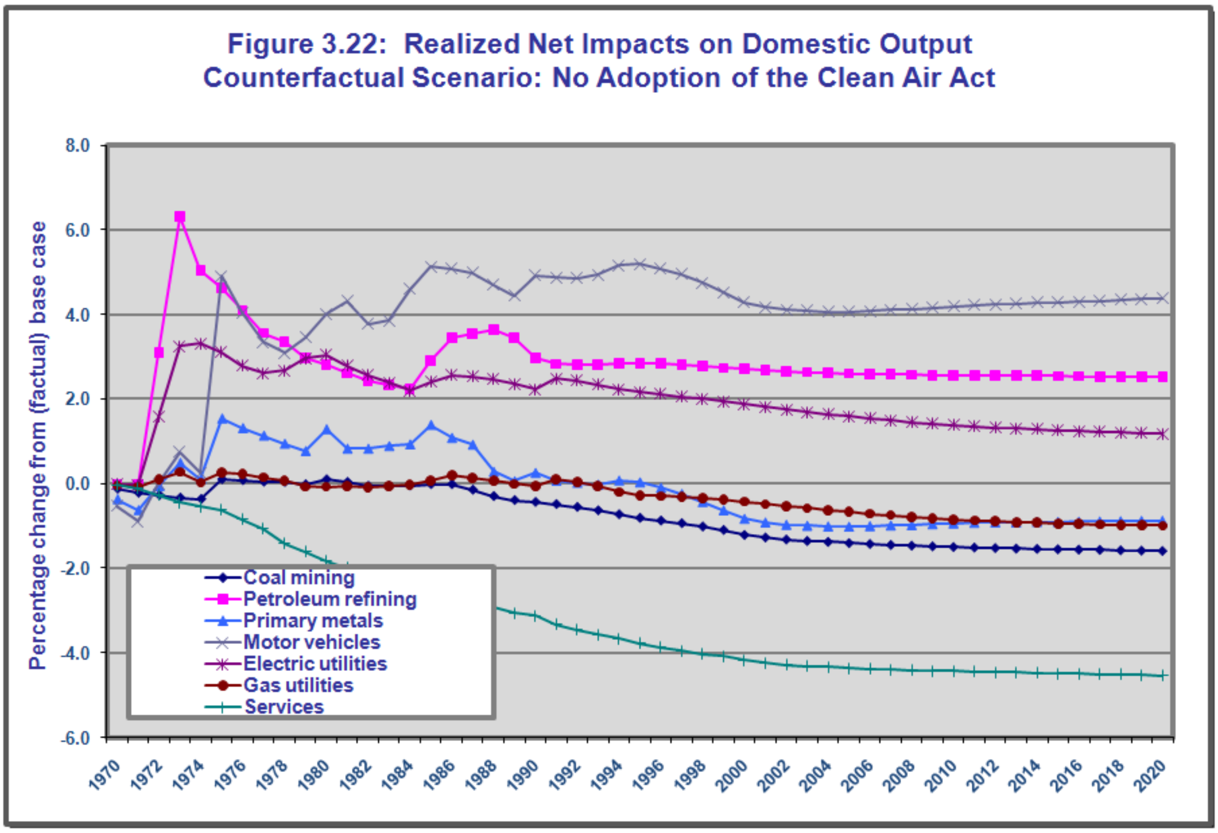


Figure 3.22: Realized Net Impacts on Domestic Output
Counterfactual Scenario: No Adoption of the Clean Air Act
Percentage change from (factual) base case
8.0
6.0
4.0
2.0
0.0
-2.0
-4.0
-6.0
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Coal mining
Petroleum refining
Primary metals
Motor vehicles
Electric utilities
Gas utilities
Services

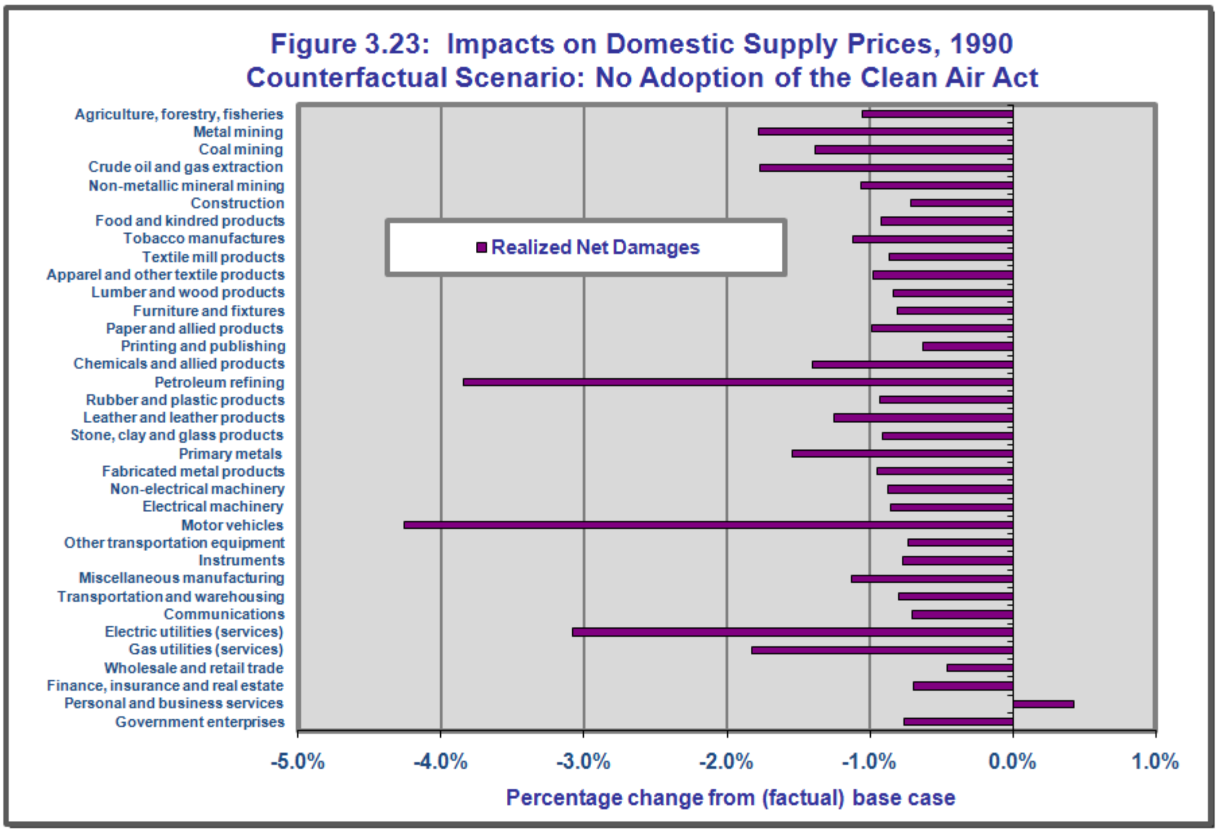


Figure 3.23: Impacts on Domestic Supply Prices, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act
Agriculture, forestry, fisheries
Metal mining
Coal mining
Crude oil and gas extraction
Non-metallic mineral mining
Construction
Food and kindred products
Tobacco manufactures
Textile mill products
Apparel and other textile products
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

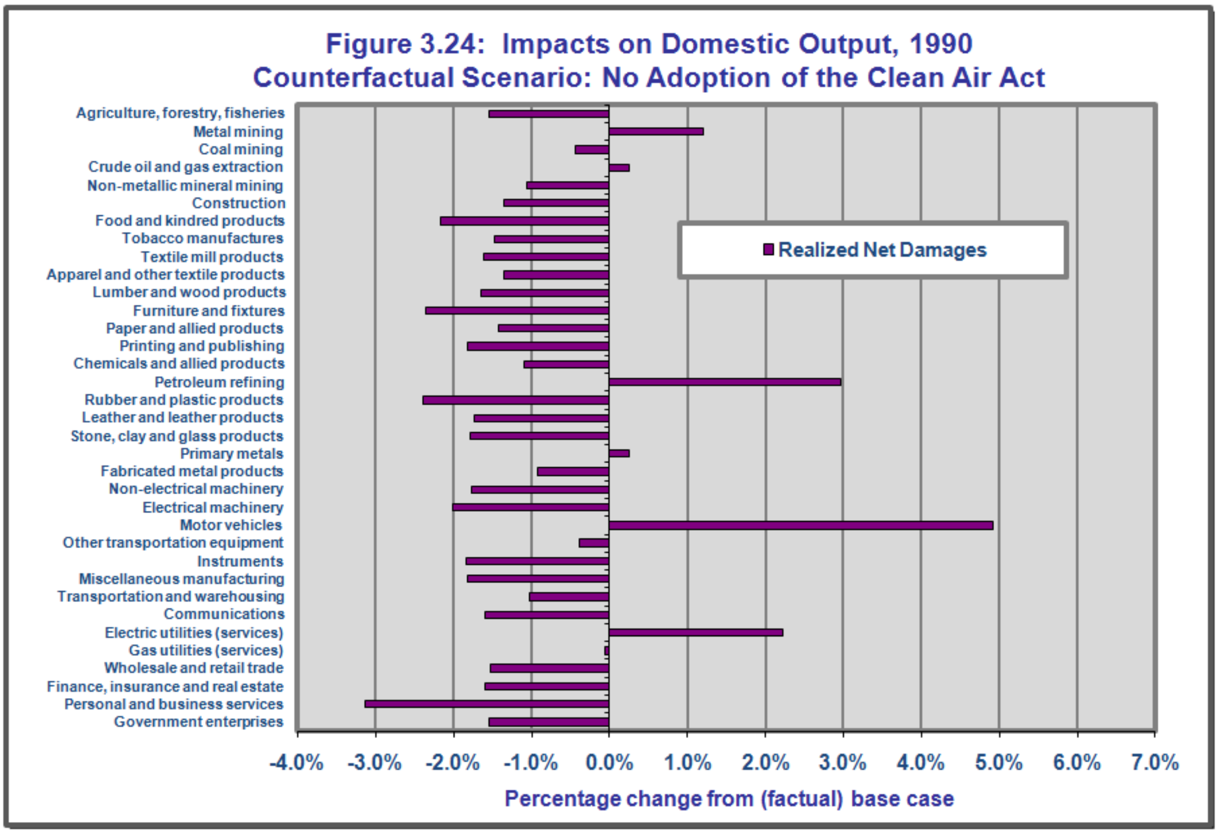


Figure 3.24: Impacts on Domestic Output, 1990
Counterfactual Scenario: No Adoption of the Clean Air Act
Agriculture, forestry, fisheries
Metal mining
Coal mining
Crude oil and gas extraction
Non-metallic mineral mining
Construction
Food and kindred products
Tobacco manufactures
Textile mill products
Apparel and other textile products
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
-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