Good Business:
A Market Analysis of Energy Efficiency Policy

Working Paper

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EXECUTIVE SUMMARY

This report analyzes the impact of an energy-efficiency policy package assembled by the major National Labs of the U.S. Department of Energy on the competitiveness of U.S. business. The package includes a charge on the carbon content of fuels, with revenue returned through cuts in other taxes, and a comprehensive package of energy technology promotion measures. We examine the impact of this package on aggregate cost and output price for 498 industries, and find that the program generates net savings for more than 80 percent of U.S. business and improves the aggregate competitive position of the U.S. economy in both import and export markets.

All advanced industrial nations have adopted energy policies to encourage energy efficiency and promote new clean technologies. These policies are motivated by many concerns, including national security, improving the balance of payments through reduced oil imports, cushioning the economy from price shocks from global energy markets, reducing energy costs to promote economic competitiveness and productivity, and reducing a wide range of energy-related environmental impacts.

Three factors have united to bring this issue to the forefront of national concern. The first is the recent instability of global energy markets. Current high oil prices highlight our continuing vulnerability to international energy price shocks, while also making clear that the substantial improvements in energy efficiency the U.S. has achieved since the 1970s reduces our exposure to these risks. The second is increasing concern about greenhouse gas emissions from combustion of fossil fuels. As the scientific community deepens its consensus about the risks of climate change, more and more leaders in business and government support action to reduce our emissions of greenhouse gases. Finally, businesses face increasing globalization and international competition. In this context, policies to promote energy efficiency and new clean technologies may be seen as essential to maintaining productivity growth and our competitive position. Alternatively, poorly designed energy policies may be seen as threats to our competitive position.

This paper addresses these concerns about the impact on costs and competitiveness of a national energy efficiency policy. We find that a well-designed national energy efficiency policy, combining voluntary programs, market mechanisms, incentives, federal R&D and selected energy efficiency standards, can reduce costs for more than four-fifths of U.S. business. However, we also find that additional policies are necessary to protect the competitive position of the most energy-intensive industry sectors. These policies become less necessary over time as energy efficiency in those sectors improves.

This report is based on the study *Scenarios for a Clean Energy Future* (CEF) produced by four of the National Laboratories of the U.S. Department of Energy. The CEF report is the product of an enormous, multi-year effort to develop a consensus national energy strategy based on sound science and consistent economic assumptions. It is the first time the National Labs have put forward such a strategy together with a package of concrete implementation policies. As such, it is likely to be a reference point for much of the future debate on this issue.

Although the CEF report estimates the costs as well as the benefits of a national energy policy, it does not attempt to determine the impact of that policy on the cost structure of U.S. businesses. This study attempts to answer that question through an economic analysis based on the results of the CEF report. In particular, we analyze the impact of the CEF advanced scenario using a 498-

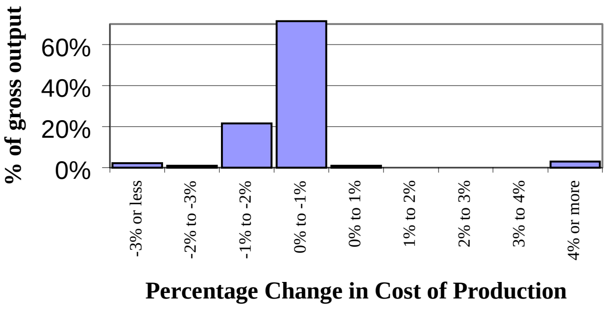
industry input-output (IO) model. This is the first time that the impacts of a comprehensive energy efficiency technology package have been analyzed at this level of sectoral detail.

Costs analyzed include the cost of tradable carbon permits (or carbon taxes, which are economically equivalent), energy-saving equipment, program administration, and the Federal R&D and commercialization programs. Benefits analyzed include the value of energy saved and the return of the revenue from the carbon charge. (Nearly all nations that have adopted carbon charges have used the revenue to cut labor (payroll) taxes, and we assume the U.S. would do the same). We do not attempt to estimate the environmental or health value of reduced emissions from the program. Nor do we attempt to value the economic benefits of reduced exposure to world energy markets, or the balance of payments benefits from reduced oil imports, national security benefits, etc.

The effect of the CEF program is to reduce the aggregate energy bill by $16 billion in 2010 and $122 billion in 2020, despite the higher energy prices caused by the carbon charge. It also provides revenue for a $72 billion cut in labor taxes. These savings are offset by program costs, investment costs and deadweight losses amounting in aggregate to $44 billion in 2010 and $83 billion in 2020. The net effect is a saving of $48 billion in 2010 and $108 billion in 2020.

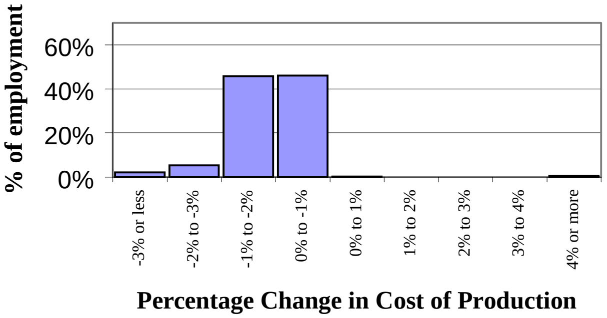
Based on the 498-industry IO analysis, we find that the impact of the CEF advanced scenario energy policy package on the cost of production is positive for 84 percent of U.S. industry in 2010 and 96 percent in 2020. (Share of business is measured as a percentage of gross industry output.) Figure 1 shows the distribution of net impacts on output prices. For example, the tallest bar shows that 71 percent of business would receive net savings amounting to between zero and one percent of their total cost of production, including shipping and retail margins (consumer prices).

Figure 1. Changes in Price for Industrial Output for the CEF Advanced Scenario (2020)



Net cost reductions under the CEF advanced scenario are disproportionately concentrated in employment-intensive industries. As a result, the fraction of business receiving net benefits from the CEF policy package is even greater when measured by employment than when measured by output. Under the CEF Advanced Scenario, 96 percent of all U.S. industry as measured by employment would receive a net price cut in 2010, rising to 99 percent in 2020. See figure 2.

Figure 2. Changes in Price of Industrial Output, CEF Advanced Scenario (by employment, 2020)



As these two figures show, a substantial majority of business would see lower total costs as a result of adopting a stronger national energy policy. However, they also show that a small percentage of business would see non-trivial net cost increases under the advanced scenario program. These businesses include fossil fuels themselves, electricity, and a handful of energy-intensive bulk raw materials such as aluminum and some chemicals. For these industries, special measures are required to prevent competitive losses. The problem is largest in the period around 2010, when the carbon charge has been phased in but the industries have not yet had time to fully adopt the range of new efficiency technologies.

We find that border adjustments (rebating the tax or permit costs on exports, and imposing comparable taxes or permit purchase requirements on imports) would solve the competitiveness problem for the energy-intensive industries of greatest concern. Many existing excise taxes have such adjustments. Border adjustments on taxes are legal under GATT/WTO rules, provided they are no greater than the equivalent charge on domestic industry. (Border adjustments on tradable permits are more likely to raise GATT issues than border adjustments on equivalent energy taxes.) Such border adjustments are administratively feasible provided that they are limited to the most heavily-impacted industries.

We find the CEF policy package together with border adjustments on fossil fuels and electricity would improve the position of U.S. goods with respect to both exports and imports by about 0.1 percent in 2010 and half a percent in 2020. Further, border adjustments on an additional 19 industries (amounting to only 3.5 percent of exports and 2.3 percent of imports) would eliminate negative competitive effects for all industries that would have a net price increase of four percent or more from the energy charge, before energy efficiency improvements.

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I. INTRODUCTION

Why do nations adopt energy policies? All advanced industrial nations have adopted energy policies to encourage energy efficiency and promote new clean technologies. These policies are motivated by many concerns, including national security, improving the balance of payments through reduced oil imports, cushioning the economy from price shocks from global energy markets, reducing energy costs to promote economic competitiveness and productivity, and reducing a wide range of energy-related environmental impacts.

Three factors have united to bring this issue to the forefront of national concern. The first is the recent instability of global energy markets. Current high oil prices highlight our continuing vulnerability to international energy price shocks. On the other hand, total energy consumption is only about half of what it was in the 1970s when measured as a fraction of GDP. As a result, the comparable energy price shocks have more limited inflationary and macroeconomic effects. This highlights one of the benefits of energy efficiency and renewable energy policies: They insulate the economy from the recessionary effect of fluctuations in energy markets.

The second is increasing concern about greenhouse gas emissions from combustion of fossil fuels. Since the finding of the Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 1996a) that human action is having a “discernable impact on the global climate system,” a series of new discoveries and improved modeling techniques have increased our confidence in the projections of climate change.[1] In response, increasing numbers of business leaders are recognizing that important steps to reduce the levels of greenhouse gas emissions are justified. These range from the statement by Ford Board Chairman William Clay Ford, Jr., that our generation would see the replacement of the internal combustion engine with fuel cells[2] to public commitments to voluntarily reduce greenhouse gas emissions from major companies like Intel, British Petroleum Amoco, Boeing, DuPont, Georgia Pacific and Alcan Aluminum.

Finally, businesses face increasing globalization and international competitiveness. As a percentage of U.S. GDP, trade is up by 20 percent over the last decade, while the trade deficit has more than doubled. In this context, policies to promote energy efficiency and new clean technologies may be seen as essential to maintaining productivity growth and our competitive position. Numerous case studies by Michael Porter of the Harvard Business School (Porter 1995) and others (see, e.g., Romm 1994; Business Council for Sustainable Development 1992) have suggested that energy efficiency and pollution prevention can result in significant cost savings and overall productivity improvements. Alternatively, poorly designed energy policies may be seen as wasteful or as threats to our competitive position.

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[1] Probably the most compelling of these findings is the continued run of record-braking global mean temperatures over recent years, with seven of the hottest years of this century in the last decade, and the Nineties as the hottest decade in the last millennium. These land temperature readings have now been corroborated by ocean surface temperature readings, and by measurements of declining ice coverage at both poles. In addition, many of the most serious objections to the IPCC projections have lost their credibility. For instance, claims that the climate models could not duplicate historical patterns of observed temperature change were overturned when cooling effects of sulfate aerosols were included in the model. Similarly, arguments that satellite measurements do not show the same warming trends as surface measurements lost credibility when the National Academy of Sciences found that the surface temperature observations are consistent with the readings from radiosonde balloons and orbital satellites once the satellite readings were corrected to account for orbital decay. (National Research Council 2000). It is now generally believed that the IPCC Second Assessment Report underestimated likely global warming and that the Third Assessment, due out in 2001, will increase those projections substantially.

[2] The Independent, 6 Oct. 2000 (United Kingdom). Also at http://www.independent.co.uk/news/UK/Environment/2000-10/ford061000.shtml

This paper addresses these concerns about the impact on costs and competitiveness of a national energy efficiency policy. We focus our attention on the policy package contained in the study *Scenarios for a Clean Energy Future* (CEF) (Interlaboratory Working Group 2000) produced by four of the National Laboratories of the U.S. Department of Energy.[3] The CEF report is the product of an enormous, multi-year effort to develop a consensus national energy strategy based on sound science and consistent economic assumptions. It is the first time the National Labs have put forward such a strategy together with a package of concrete implementation policies. As such, it is likely to be a reference point for much of the future debate on this issue.

The CEF report is an update and expansion of an earlier study, *Scenarios for Carbon Reduction* (Interlaboratory Working Group 1997), usually referred to as the "five labs" report.[4] The CEF report advances the five labs report in two particularly crucial ways. First, the five labs report was basically a study of technological and economic feasibility. It did not put forward a set of policies to implement its technological scenarios. The CEF report, on the other hand, is a study of a particular policy package consisting of over fifty individual policies, including voluntary programs, market mechanisms, incentives, federal R&D and selected energy efficiency standards. (The CEF package is summarized in Table 3.1 below.) Second, the five labs report included only very limited analysis of the interactions between the policies or feedbacks from the policies to energy prices. The CEF report, on the other hand, is built around an integrated assessment of the policy package using the National Energy Modeling System (NEMS) model of the Energy Information Administration. This is the Department of Energy's primary model for forecasting energy demand and price. Thus, the CEF report is one of the very few studies to include both explicit detailed technological projections and economic and price feedback effects from those technological changes.

As shown in Table 1.1 below, the CEF policy package is estimated to produce aggregate net saving of $48 billion in 2010, rising to $108 billion in 2020.

Table 1.1 Aggregate Economic Impact of the CEF Advanced Scenario

Billions of 1997 dollars per year

Investment costs	**2010**	**2020**
• Annualized implementation and administration costs	-8.8	-12.9
• R & D Costs	-2.8	-2.8
• Annualized incremental technology investment	-29.6	-65.9
Total investment cost	-41.2	-81.6
Net energy bill savings		
• Gross energy bill savings	91.7	191.1
• Carbon fees (permits or taxes)	-72.9	-67.4
• Deadweight loss (consumer and producer surplus)	2.5	1.8
Total net energy bill savings	16.4	121.9
Revenue return/Labor tax cut	72.9	67.4
Total aggregate saving	48.1	107.7

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[3] Oak Ridge National Laboratory, Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, and Argonne National Laboratory.

[4] The five labs are the four involved in the CEF report (Interagency Working Group 2000) together with Pacific Northwest National Laboratory.

Although the aggregate effect of the CEF policy package is positive, this says little about the distribution of the benefits and burdens of the policy across industries. The consumption of energy across industries is highly skewed. Moreover, the cost of achieving energy savings is not evenly distributed across industries or between industries and households. This study is an effort to examine the distribution of the benefits and burdens of the CEF scenario by industry classification at a highly disaggregated (498 industry) level.

Earlier work by this author has established that a high level of disaggregation is necessary to properly capture sectoral effects of energy or carbon charges. (Hoerner 2000, 1998). Carbon and energy intensity vary within most energy-intensive two-digit SIC industries by a factor of ten or more. Since the CEF Advanced Scenario includes a carbon permit charge of $50 per ton of carbon, it is critical to examine industrial distribution of burdens and benefits at a level adequate to capture the variability of this charge.

This study uses a 498-industry input-output (IO) model of the U.S. economy to capture the effects of the CEF policy package. Thus, it has the level of sectoral detail required to do a serious distributional analysis on industrial energy impacts. By relying on CEF forecasts of energy savings, prices, investment requirements, program costs and deadweight efficiency losses, we overcome the primary weakness of IO modeling, its relatively static character. Because our results are built on the CEF report, both technological change and price effects are modeled explicitly and consistently.

In the next section we briefly review the literature on energy efficiency policies, both technological and market-based. Section 3 describes our methodology in greater detail. Section 4 describes two types of results: 4.1 summarizes the overall distribution of burdens and benefits of the CEF scenario across industries and the impact of those changes on product prices, and 4.2 uses the price impacts of 4.1 to look at the potential impact of those price changes on the competitive position of U.S. industry in both foreign and domestic markets.

II. REVIEW OF LITERATURE

2.1 MACROECONOMIC IMPACTS

Estimates of the impact on the economy of stabilizing emissions at 1990 levels vary widely, generally in the range between losses of 2 percent of GDP to net gains of one percent of GDP, ignoring the value of environmental impacts. These estimates vary depending on the baseline, model type, economic assumptions, policy package, and other factors.[5] However, when the

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[5] Broadly speaking, there are two approaches to determining the costs of achieving energy efficiency or emissions reduction goals, each with their own strengths and weaknesses: the economic approach and the engineering approach. The economic approach either assumes that firms and individuals optimize their decisions given prices, preferences and technological constraints (computable general equilibrium models) or assumes that historical relationships between macroeconomic aggregates will continue to hold (macroeconomic models). However, economic models generally have very simple and unrealistic models of technological change and improvement (Wilson and Swisher 1993). The rate at which energy efficiency technology improves does not vary with any policy variable in any of the major multi-sectoral economic models that have been used for economic forecasts of climate policy.

The engineering approach, on the other hand, focuses on technological change at the industry and product level. Typically this involves both some sort of forecasting of known technologies in varying phases of research, development and commercialization. Engineering studies can assess the potential for emerging technologies, but often fail to properly capture adjustment and turnover costs that prevent the economy from instantly moving to the technical revenue from energy or pollution charges is used to cut other taxes, the economic cost is greatly reduced and the net economic effect may become a benefit. This has been shown both theoretically (Goulder 1995; Parry & Bento 2000; Parry, Robertson & Goulder 1999; Mabey & Nixon 1997) and based on surveys of economic modeling studies (Repetto & Austin 1997; Mabey et al 1997; Shackelton et al. 1996; Zhang and Folmer 1998; Hoerner and Bosquet 2000). These surveys have suggested that a net benefit is more likely when the economic impact of the environmental benefit is included in the analysis. Finally, the literature is essentially unanimous in concluding that the cost of achieving energy-efficiency improvements or greenhouse gas emissions reductions are reduced – and may switch to a net benefit – if new technologies are introduced more rapidly (Edmonds et al. 2000).

Neither the CEF analysis nor this report estimates the impact of the CEF policy package on GDP. The CEF focuses on economic analysis of costs and cost savings, and this report applies that analysis to an industrial distribution of benefits and burdens. However, the policy package analyzed in the CEF report includes several of the features that the literature tends to associate with GDP impacts, and these are small or positive. In particular, the CEF combines a relatively modest carbon charge of $50 per ton with revenue recycled to cut other distorting taxes. In addition, it includes an extensive technology promotion package. The CEF included only policies that passed a cost/benefit filter, and the CEF package as a whole is estimated to produce energy savings amounting to more than twice the program and investment costs, as shown in table 3.1 above. The level of cost-effective energy efficiency gains projected by the CEF are roughly in the middle of the range of projections by recent studies of comprehensive energy efficiency options (OTA 1991; NAS 1992; Lovins and Lovins 1997; Interlaboratory Working Group 1997; Tellus 1998; Bernow, et al. 1999; EIA 1998; EIA 1999).

2.2 COMPETITIVE IMPACTS

Although the economic effects of the CEF package appear likely to be positive, the overall economic effect of a policy says little about its competitive impact. An economic or environmental policy could be good for the economy as a whole and still have a negative impact on particular firms or sectors. If those sectors are heavily traded, a policy that benefits the economy as a whole could nonetheless harm particular industries or our national trade position.

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optimum. In addition, engineering studies usually focus on the costs and benefits within a narrow economic sector, with only very limited interaction with the rest of the economy.

A comprehensive review of economic modeling results for the U.S. by the Intergovernmental Panel on Climate Change found that emissions could be stabilized at 1990 levels at a cost ranging from one to two percent of GDP (IPCC 1996). This result was based on achieving reductions through a carbon tax or tradable emissions permit system, with a "lump sum" return of the revenue. This means that the revenue was not used to cut other distortionary taxes or to reduce the national debt. More recent studies have generally found similar results. See, e.g., Zhang and Folmer (1998).

In contrast, engineering models typically find that over a one to two decade time span reductions of emissions on the order of 20 to 30 percent can be achieved at a net saving or for approximately zero net cost, with larger savings possible over longer time horizons (IPCC 1996). More recent engineering studies of the U.S. economy have generally continued/supported this view.

There are also a handful of hybrid models where engineering and economic components are integrated, such as the Markal-Macro model and the Argonne National Laboratory's Amiga model. These have generally yielded results that are more similar to engineering models, i.e., showing emissions reductions which are achievable at a net benefit (Laitner 1997; Hanson and Laitner 2000). An early study is the linking of MENSA (Australian regionalized version of MARKAL) and an input-output study in James, et al. 1986. Another good example of linking a simplified bottom-up model is the HERMES-MIDAS model (Capros, et al. 1990).

Previous research on the effects of environmental regulation on competitiveness has generally found that those effects are small. A comprehensive survey of over 100 economic studies of the competitive effects of environmental regulation found that "…studies attempting to measure the effects of environmental regulation on net exports, overall trade flows, and plant location decisions have produced estimates that are either small, statistically insignificant, or not robust to tests of model specification"(Jaffee 1995). In part this is because environmental costs are usually modest relative to an industry's total cost structure. Environmental control costs rarely exceed three percent of an industry's total costs. Consistent with this result, survey research has also suggested that environmental regulation tends to be a relatively minor factor in firms' locational decisions. See also Bommer (1996) and the review by Adams (1997).

However, there is reason to think that the climate issue may be different from previous regulatory efforts in terms of its competitive impact. Some economic models have suggested that stabilization of greenhouse gas emissions through market mechanisms, such as taxes, would require a carbon charge of $100 per ton of carbon or more. Such charges would more than double the price of coal, and substantially increase the price of other fossil fuels and of certain energy-intensive manufactured goods. Careful attention to the potential competitive impacts of these price changes is required.

In order to correctly analyze the competitive impact of a national energy efficiency or greenhouse gas reduction policy there are at least two other factors that also require careful attention to a range of other factors. First, there needs to be a realistic policy package. Much of the economic modeling to date has involved the use of a single instrument, usually a carbon tax or tradeable permit fee. On the other hand, all of the nine nations that actually have adopted carbon charges have included a range of related policies. In every case these have included policies to cut other taxes, protect the competitiveness of energy-intensive industries, and promote energy efficiency and clean technologies (Hoerner and Bosquet 2000). Attempts to assess the competitive impact of national energy or climate policies have concluded that including these related policies in the analysis is critical because they can offset some or all of the competitive burden of a carbon charge or fee (OECD 1997; IMF 2000, Eakins and Speck 1997).

Finally, work by Hoerner (1998, 2000) has demonstrated the critical importance of a high degree of sectoral disaggregation in assessing competitive effects. Within two-digit SIC industries, such as Primary Metals, Pulp and Paper, or Chemicals, carbon and energy intensity typically varies by a factor of more then 10 between the most energy-intensive four-digit sectors and the majority of production within the sector. Use of aggregated data will underestimate the impact of fuel price changes on the most energy-intensive sectors while over-estimating the fraction of industry potentially at risk. For purposes of assessing the competitive burden on individual industries, the errors caused by the use of a high level of aggregation are unacceptably large.

2.3 THE INPUT-OUTPUT APPROACH

Input-output (IO) analysis uses a consistent national income accounting framework to trace the direct and indirect price and quantity impacts of specified changes in manufacturing inputs (including value-added inputs like labor compensation and profits) or final demand categories through the economy. Taken alone, it is not suitable for estimating microeconomic or macroeconomic behavioral responses to price changes – these must be estimated using other approaches. However, once those impacts have been estimated using other techniques, IO analysis provides the best available framework for following them through the economy, particularly if a high degree of sectoral disaggregation is required.[6].

The extension of IO analysis to represent interactions between the economy and the environment was developed in the late 1960s and later by Leontief (1970, 1973, 1976), Leontief and Ford (1972), and many others. A good survey of the early work is in James et al. (1978). Applications of IO analysis to energy content multiplied in the 1970s and early ‘80s (see, for example, Forsund 1985). Recently, a number of scholars have used IO approaches to examine various questions relating to greenhouse gas emissions, typically focusing primarily or exclusively on carbon dioxide. These include distributional analysis by industry (Goulder 1992); efforts to decompose economy-wide carbon intensity changes into within-industry and between-industry effects (Weir 1998; Rose and Chen 1991; Proops et al. 1993); distribution of tax burden by income class (Casler and Rafiqui 1993); and computation of direct and indirect greenhouse gas requirements for a given vector of final demand (Lenzen 1998).

In IO analysis, it is a common convention to apply the law of one price—that in a unified market for a uniform good, only one price for that good can prevail. This assumption simplifies the analysis considerably. However, in the energy area this simplifying assumption imposes a considerable cost. As discussed in appendix A, the fuel prices vary across industries by a factor of two to four, depending on the fuel. There has been some previous work using hybrid IO approaches in mixed energy and dollar units (see, e.g., Bullard and Herendeen 1975; Dossani and Preziosi 1980) but recent efforts to use IO analysis to estimate the carbon content or carbon tax burden of final demand (or the carbon tax burden on that demand) (Goulder 1992; Bernow et al. 1997a, 1997b) have generally used the “one price” model.

III. THE MODEL

3.1 INTRODUCTION

In our previous work (Hoerner, 2000), we used an input-output model in order to capture the effects on industrial prices (at the 498-industry level) of a labor tax cut funded by a carbon charge (tax or permit fee). That study, however, did not incorporate any consumer or producer response to the policies modeled. Given the fixed technology coefficients employed by the input-output approach, this was best seen as a model of the immediate or short-term impacts of tax reform.

The present study builds upon this previous work in several important ways. We use results from the CEF study to project the technological and demand responses of consumers and producers respectively to a policy package that includes both a carbon charge and a package of technology-promotion initiatives. This enables us to estimate the intermediate- and long-term effects of the policy package on the distribution of energy savings, investment costs and energy prices at a detailed industry level.

The CEF report uses the National Energy Modeling System (NEMS) as an integrating analytical framework to analyze the interactions among the different sectors and policies. NEMS simulates the behavior of U.S. energy markets. It achieves a supply/demand balance in nine end-use demand regions by solving for the prices of each energy product that will balance the quantities producers are willing to supply with the quantities consumers wish to consume. The model

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[6] As a result, many large macroeconomic models contain imbedded IO models in order to capture a finer level of sectoral detail. See, e.g., the LIFT, MUDAN, or DUNA models by Inforum at the University of Maryland (Almon 1993; Almon and Mahmood 1997) or the DRI model (DRI 1992).

reflects market economics, industry structure, and many energy policies and regulations that influence market behavior. The impacts of standards and fiscal policies are generally assessed directly within NEMS, while the impacts of policies such as voluntary agreements, enhanced R&D, and technical assistance have been translated into inputs for NEMS. The integration step of CEF-NEMS allows the estimated effects of changes in energy use in each sector to be taken into account in the energy use patterns of the other sectors.

3.2 POLICY PACKAGE MODELED

3.2.1 Overview

For our purposes, the CEF policy package can be regarded as having five components:

- Government program and administration costs;
- Private investment costs for improved energy efficiency and fuel switching (including to renewables);
- Improvements in energy efficiency;
- An energy charge (tax or permit) equal to $50/ton of carbon;
- A labor tax cut,[7] to return the revenues from the energy charge;

The carbon charge is a broad-based tax or permitting fee on air pollution, levied on the carbon content of fossil fuels at $50 per ton of carbon. A carbon tax places the highest burden on coal, followed by oil, with a lower burden on natural gas. Solar, wind, sustainable harvested biomass, and other renewable energy sources are exempt. A carbon tax is a reasonably good proxy for a general air pollution tax (Muller 1996), although some efforts to capture all the air pollution–related damages from different fuels have suggested that an even higher relative burden on coal is appropriate (Viscusi et al. 1992).

3.2.2 Policy Scenarios

The CEF study develops, among others, Business-as-Usual (BAU) and Advanced scenarios.[8] The BAU scenario assumes a continuation of current energy policies and a steady, but modest, pace of technological progress. In contrast, the Advanced scenario is defined by increasing levels of public commitment to solving the nation's energy-related challenges and a strong political and public resolve that enables policies to be implemented that may be politically infeasible today. This scenario is delimited by a set of public policies and programs – some of these apply economy-wide while others are specific to an individual sector (buildings, industry, transportation, and electric generators). The public policies and programs are assessed for impacts to 2020.

Numerous policies are examined, including fiscal incentives, voluntary programs, regulations, and research and development. Most of the policies were selected on the basis of their potential to improve energy efficiency and reduce carbon emissions. Others were designed specifically to improve air quality (e.g., reducing SO_2 emissions in the electric sector by 50%) or for economic efficiency (e.g., restructuring of the electricity industry).

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[7] The CEF study itself assumes that the revenues from the carbon charge will be returned, but does not specify the form of the return. We assume that this return would take the form of a cut in labor (payroll) taxes, as it has in almost all of the other nine nations that have adopted a carbon charge (Hoerner and Bosquet 2000).

[8] CEF employed the EIA's reference case from the *Annual Energy Outlook 1999* (EIA, 1998) as the starting point for the CEF Business-As-Usual (BAU) forecast. Thus, the EIA's reference case assumptions on fossil fuel supplies, world oil prices, energy transport, end-use service demands, and macro-economic growth underlie the three CEF scenarios. To capture the policies of the Advanced scenario, CEF-NEMS inputs associated with process economics, stock turnover rates, consumer discount rates, and fuel prices are changed from the BAU scenario (and therefore from the EIA's Reference case). The translation of these policies to the inputs required by CEF-NEMS was conducted through off-line analysis, reference to past studies, expert judgment, and outside review.

Table 3.1 Major Policies in the CEF Advanced Scenario*

Buildings	• Efficiency standards for equipment • Labeling and deployment programs
Industry	• Voluntary programs • Agreements with individual industries and trade associations
Transportation	• Fuel economy agreements with auto manufacturers (similar to CAFE) • "Pay-at-the-pump" auto insurance
Electric Generation	• Renewable energy portfolio standards and production tax credits • Electric industry restructuring
Cross-Sector Policies	• Doubled federal R&D • Domestic carbon market mechanism (auctioned permit or tax, $50/ton of carbon)

*The scenarios are defined by approximately 50 policies. The 10 in this table are the most important ones in the Advanced scenario. Each policy is specified in terms of magnitude and timing. For instance, "Efficiency standards for equipment" comprise 16 new equipment standards introduced in various years with specific levels of minimum efficiencies. These voluntary agreements, because they are met in the Advanced scenario, would have the same effect as a CAFE standard of the same level. For details see the CEF report.

The policies in the Advanced Scenario identified as most important by the CEF are summarized in Table 3.1. A key policy mechanism for the Advanced Scenario for all of the sectors is a domestic carbon permit fee (or a carbon tax, which is economically equivalent) of $50/tC (in $1997). This fee or tax is referred to as a carbon charge (CC) throughout this paper. The second key policy mechanism in the Advanced Scenario for all of the sectors is the doubling of federal government appropriations for cost-shared research, development, and demonstration (RD&D) in efficient and clean-energy technologies. Since these resources are spent in public/private RD&D partnerships, they are matched by private-sector funds, resulting in an assumed increase of $1.4 billion per year by approximately 2005 (half as federal appropriations and half as private-sector cost share) and continuing through 2020. Fuel efficiency standards, especially on autos, are also important.

3.2.3 Revenue Recycling

The revenue raised by the proposed carbon charge is assumed to be recycled back to the economy by cutting existing distortionary taxes. We chose labor tax reduction as a basis of our revenue recycling.[9] The motivation for a labor tax cut is threefold. First, like the capital tax cut, it both returns the revenue from the pollution and energy tax to the economy and cuts a tax that produces economic distortion. Second, the tax cut distributes the benefits across households similarly to the burden of the pollution and energy tax increase. The particular form of payroll tax reduction modeled here provides a proportionally greater benefit to lower-income taxpayers relative to an across-the-board payroll tax cut. This is a desirable policy feature because, as measured against annual income, energy taxes are slightly more regressive than payroll taxes, especially at the lower end of the income spectrum (Chernick and Reschovsky 1997; Metcalf 1994). Finally, many

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[9] There are many possible ways to cut taxes on labor income. These include across-the-board cuts in one or more of the payroll taxes, certain forms of income tax reduction, any of several tax subsidies to human capital investment, and increases in income tax credits against labor income such as the Earned Income Tax Credit. The labor tax cut we modeled takes the form of a "zero bracket" in the payroll tax, i.e., a tax exemption on a portion of wages earned. This is intended to represents a family of tax reductions on labor income or human capital investment that would have qualitatively similar economic and distributional consequences, rather than as a policy recommendation.
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actual environmental tax reform proposals around the world have used pollution tax revenues to cut labor taxes (Hoerner and Bosquet 2000).

3.3 DATA SOURCES

The primary sources for calculating carbon emissions in the base year for our 498 sectors were EIA carbon emissions for main sectors (EIA 1997) and dollar purchases of energy by type (coal, petroleum, natural gas and electricity) from the 1996 input-output tables assembled by the BEA (Planting 2000). We have used various supplemental sources, such as Manufacturing Energy Consumption Survey, MECS (EIA, 1997) in the industrial sector, Transportation Energy Databook (ORNL 1998) and Residential Transportation Energy Consumption Survey, RTECS (EIA 1993) in the transportation sector, Electric Power Annual (EIA, 1998) for fuel consumption by utilities and non-utilities. The future carbon emissions were based on the projections in the CEF study.

We have adjusted our carbon emissions estimates for the proportion of non-fuel energy use in the industrial sector (based on data in the MECS). As a result, our carbon emissions are not actual carbon emissions, but rather taxable equivalent carbon emissions. Multiplying our emissions vector by a carbon charge rate yields an estimate of the actual tax or permit fee burden for each industry. We have used the employment projection from the BLS (BLS 1999) to determine the size of payroll tax reduction. See appendix A for a more detailed discussion of methodology.

3.4 DEMAND RESPONSE AND TECHNOLOGICAL CHANGE

IO models distribute the results of demand and technology changes using a consistent accounting framework that allows explicit, closed-form estimation of second-, third- and nth-order effects. It requires changes in final demand and technology (input requirement sets) as inputs. We utilized information from the CEF study to generate changes in energy intensity for the sectors and fuels. These fuel intensities are changes in the Btu's required per physical unit of output in each sector in the CEF study. For example, in the air transportation sector we take the ratio in Btu's per seat-mile in 1997 and Btu's per seat-mile in 2020 (after the carbon charge and other policy measures have been in place for over 20 years). Tables 3.2 and 3.3 report the fuel intensity changes we derived from the CEF study.

Table 3.2 Advanced scenario change in energy intensity by 2010
(Btu/$ in 2010)/(Btu/$ in 1997); constant prices

	Petroleum	Natural Gas	Coal	Electricity
Energy Intensive Manufacturing				
- Iron and Steel	0.26	0.54	0.68	0.61
- Paper	0.52	0.42	0.24	0.61
- Cement	0.77	1.16	0.58	0.70
- Other Energy-Intensive Manufacturing	0.79	0.81	0.39	0.65
Non-Energy-Intensive Manufacturing	0.90	0.84	0.64	0.80
Commercial Sector	0.46	0.83	0.76	0.79
Transportation				
- Road Transportation	0.87	1	n/a	2
- Air Transportation	0.85	n/a	n/a	2
- Rail Transportation	0.82	n/a	n/a	0.72
- Marine Transportation	1.05	n/a	n/a	1.71
- Pipelines	n/a	1.04	n/a	n/a
Electricity Generation	0.63	0.61	0.99	1

The changes in fuel intensities reflect both the changes in available technology, as well as substitution among energy sources towards less carbon intensive ones. The magnitude of adjustment implied by the CEF study varies substantially across the different sectors, ranging from more than 50 percent decreases in the energy intensive sectors, to much smaller cuts in the commercial sector. The derivation of these fuel intensities is described in some detail in appendix B. We change the IO tables in our model to reflect above reported adjustments in fuel intensities. This process is described in appendix B as well.

Table 3.3 Advanced Scenario Change in Energy Intensity by 2020
(Btu/$ in 2020)/(Btu/$ in 1997); constant prices

	Petroleum	Natural Gas	Coal	Electricity
Energy Intensive Manufacturing				
- Iron and Steel	0.11	0.41	0.57	0.46
- Paper	0.38	0.42	0.18	0.44
- Cement	0.49	0.97	0.44	0.52
- Other Energy-Intensive Manufacturing	0.60	0.73	0.32	0.46
Non-Energy-Intensive Manufacturing	0.78	0.71	0.54	0.66
Commercial Sector	0.38	0.69	0.63	0.62
Transportation				
- Road Transportation	0.70	1	n/a	2
- Air Transportation	0.78	n/a	n/a	2
- Rail Transportation	0.72	n/a	n/a	0.72
- Marine Transportation	1.20	n/a	n/a	1.56
- Pipelines	n/a	1.14	n/a	n/a
Electricity Generation	0.81	0.56	0.99	1

3.5 DIRECT EMISSIONS AND PRICE CHANGE ESTIMATION

Using the estimates of changes in energy-intensity described above, we derive estimates of fossil fuel purchases that each sector will make in 2010 and 2020, in both dollar and physical terms (see appendix A for details). These in turn are converted to into metric tons of carbon using fuel- and sector-specific carbon coefficients.

Throughout the paper, we refer to such obtained carbon emissions as *direct emissions*, i.e., emissions that are actually emitted during the production process of a particular commodity and will be chargeable under the carbon charge in the CEF policy proposal. We exclude fossil fuel purchases for non-fuel use (such as petrochemical feedstocks, etc.) that would not be taxed. On the other hand, we include carbon emissions associated with purchased electricity as a part of each sector direct emissions vector. (See appendix A for details.)

We use the vector of direct (taxable) emissions to derive our estimates of carbon charge burden for each sector. The total revenue of the carbon tax is then distributed back to each sector through a cut in payroll taxes based on actual and projected employment as estimated by the BLS (BLS 1999)[10]. The difference between the carbon charge burden and the payroll tax decrease is the change in net tax burden of each sector.

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[10] There are fewer sectors in the BLS classification than in our model. We use the value of output to split the BLS employment number among our more disaggregated sectors.

Additionally, we identify two other major benefits and costs to each industry, which we included in our net tax vector. In the advanced scenario, each industry is induced by the policy package to invest in research and development, as well as in modernizing its capital stock. We view the investment costs that are additional to those that would occur without the policy package as direct costs incurred by the industries. On the other hand, the additional investment costs have the benefit of lowering the energy intensity of production and hence we include the energy bill savings over the BAU scenario as a benefit to each industry. Finally, the CEF study quantified the costs of running the package of policies and we include these as costs to the industries concerned.[11] We have distributed these costs and benefits based on the amount of energy saved by each industry. This methodology is consistent with the CEF study, which calculated the level of incremental investment in an industry based on the amount of energy saved.

Table 3.4 Additional Investment and Program Costs and Energy Bill Savings

$Billion 1997

	Additional Investment		**Program Costs**		**Energy Bill Savings**	
Sector	2010	2020	2010	2020	2010	2020
Industrial	6.9	11.8	2.3	3.9	18.4	29.8
Commercial	2.7	5.8	0.8	1.6	13.8	19.4
Transportation	5.5	13.9	0.6	1.6	25.0	56.5
Electric Utilities	na	na	2.8	0.0	na	na

Note: The transportation sector in the above table excludes residential transportation. The investment costs and energy bill savings in electric utilities are reflected in the price of electricity.

Appendix C describes the technical details of the price model used to determine the price decreases implied by the vector of net tax burdens. The price changes are percentage increases in costs due to the net tax, provided that the net tax burden and all subsequent cost increases are passed on to customers in the form of higher prices.

In order to account for the entire revenue from the carbon tax correctly, we also adjusted household income to account for the share of the carbon charge paid by households. We treat the tax paid by households as a reduction in household income in that year. However, the household sector faces the same costs and benefits as the industrial sector. In particular, it is induced by the policy package to make additional investments and, as a result, save on energy bills in the future. At the same time, we assumed that the program costs that were not already assigned to a particular industry would be financed through taxes on the household sector. The sum of these considerations was a 0.05% increase in overall real income in 2010 and 0.22% decrease in 2020.

IV. RESULTS

4.1 DISTRIBUTION OF PRICE CHANGES

By an order of magnitude, the most important price increases arising from the CEF package are those on fossil fuels themselves, and on electricity. The carbon charge modeled in this study would increase the prices of the different fossil fuels in proportion to their carbon content. Table 4.1 lists the prices of major fossil fuels and the burden resulting from a charge (tax or permit fee) of $50 per metric ton of carbon.

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[11] If administrative costs are paid out of general tax revenues rather than carbon charge revenues, this method will overstate the burden on energy-intensive industries and understate the burden on non-energy-intensive industries.

Table 4.1 Prices and Carbon Charge (CC) Burden for Major Fuels, 1997 values

Fuel	Price	CC Burden	CC as % of price
Petroleum ($ per gallon)			
- motor gasoline	1.21	0.12	10.0 %
- diesel fuel	1.07	0.14	13.0 %
- heating oil	0.42	0.16	40.0 %
- kerosene	0.83	0.13	16.1 %
Natural Gas ($ per 1000 cubic feet)	4.75	0.74	15.7 %
Electricity (cents per kWh)	6.88	0.82	11.9 %
Coal ($ per metric ton)			
- residential use	60.76	31.58	52.0 %
- commercial use	36.94	31.58	85.5 %
- industrial use	38.35	31.30	81.6 %
- electric utilities	28.77	29.17	101.4 %

Source: prices are national averages from State Price and Expenditure Data Report 1997 (EIA 2000), except kerosene which is a weighted average of residential, commercial and industrial use with nominal expenditures as weights; carbon charge burden was calculated based on carbon content coefficient reported in GHG (EIA, 1998) and the heat content reported in State Energy Data Report 1997 (EIA, 2000); electricity was based on generation from and carbon emissions by electric generators from the CEF study (Interlaboratory Working Group 2000).

The above price increases are those based on the carbon charge paid directly on the carbon content of the fossil fuels. In addition, there are indirect costs and savings that affect the price of fossil fuels. These include:

- The benefit of improved energy efficiency in producing fuels, partially offset by the investment and program costs needed to achieve those benefits;
- The benefit of labor tax cuts; and
- Changes in materials prices as a result of energy, investment, and tax changes in supplying industries.

Because fossil fuel production is itself an energy-intensive process, the total price increase tends to be somewhat higher then those given above. Table 4.2 shows price changes relative to 1997 price levels reflecting both the direct and indirect effects of carbon taxation, as well as the effect of the CEF advanced scenario policy package.

Table 4.2 Total Fossil Fuel Price Increases

Including the effects of carbon charge with labor tax rebate, additional investment costs and energy bill savings

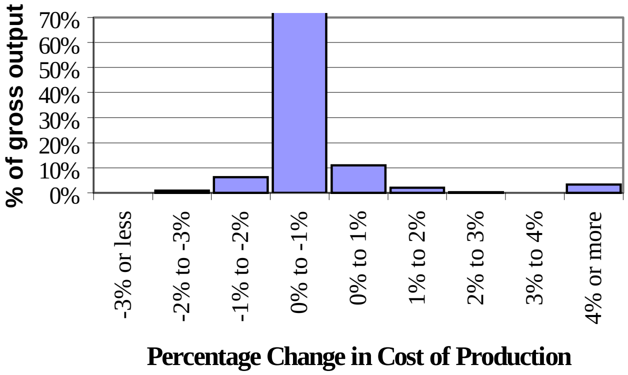
Fuel	1997 + CC	2010	2020
Coal	119.19%	117.12%	114.87%
Petroleum	22.51%	21.01%	20.03%
Natural Gas	16.18%	15.30%	14.48%
Electricity	12.50%	11.95%	11.38%

Compared with the price increases of the fossil fuels, all other commodities' price changes are smaller by an order of magnitude. Moreover, the largest of these increases drops substantially over time as efficiency policies are phased in. For example, the largest non-fuel price increase – 14.84% in the Primary Aluminum industry in 2010 -- drops to 3.34% in 2020 as a result of technological improvements induced by the CEF policy package. The other most energy intensive industries exhibit a similar pattern: price change in Cement industry drops from 9.94% to 0.32%, Aluminum rolling & drawing from 6.29% to 0.74%, Industrial chemicals from 3.84% to 0.08% and Aluminum castings from 3.65% to 0.05%.

The rest of the energy intensive industries have large enough energy savings to completely offset the carbon charge. As a result, the costs of production in these industries decrease in the CEF advanced scenario relative to a BAU scenario. The results for industries with the largest price impacts in 1997 are in table D.1 in appendix D. (The first column represents the hypothetical price changes if the carbon charge and labor tax cut were applied to industries at their 1997 levels of energy and labor use.)

An input-output model that takes no account of consumer and producer response would produce the results that we label ‘1997 + CC’. The reaction of the agents to the policy package modeled flattens out the extremes of the distribution. As a result, the price increases in the industries with the highest carbon charge burden decline substantially over time, as energy efficiency improves. As the most energy-intensive industries lower their carbon consumption, the carbon charge revenue declines as well. This means lower tax breaks for the industries that benefit from the CEF policy package. In addition, over time the energy bill savings from efficiency improvements come increasingly to dominate the distribution of the cost changes.

Figure 3. Changes in Price for Industrial Output for the CEF Advanced Scenario (2010)



As a result, virtually all of the economy would see net decreases in their total cost of production as a consequence of the CEF Advanced Scenario package. The impact on the cost of production is positive for 84 percent of U.S. industry in 2010 and 96 percent in 2020. Share of business is measured as a percentage of gross industry output. Figure 1 shows the distribution of net impacts on output prices in 2020. For example, the tallest bar shows that 71 percent of business would receive net savings amounting to between zero and one percent of their total cost of production, including shipping and retail margins (consumer prices). Figure 3 shows the same information for 2010, and Table 4.3 presents the same information in tabular form.

Figure 1. Changes in Price for Industrial Output for the CEF Advanced Scenario (2020)

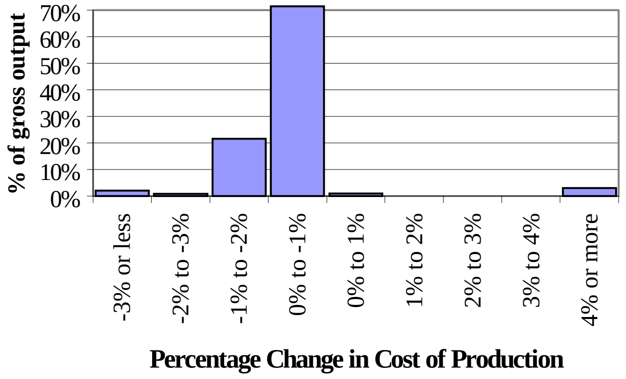
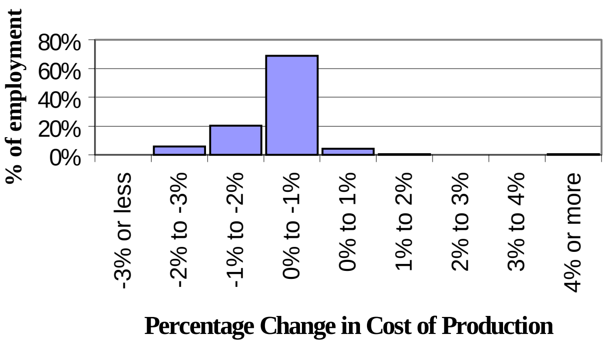


Table 4.3 Distribution of Price Changes (weighted by value of output)

Price change	1997 + CC (hypothetical)	2010	2020
+4% and more	4.30%	3.20%	3.02%
+3 to +4%	0.94%	0.00%	0.00%
+2 to +3%	4.00%	0.18%	0.00%
+1 to +2%	8.62%	1.96%	0.00%
0 to +1%	30.47%	10.95%	0.99%
-1 to 0%	45.60%	76.48%	71.46%
-2 to –1%	5.09%	6.26%	21.59%
-3 to -2%	0.47%	0.98%	0.89%
-3% and less	0.51%	0.00%	2.05%

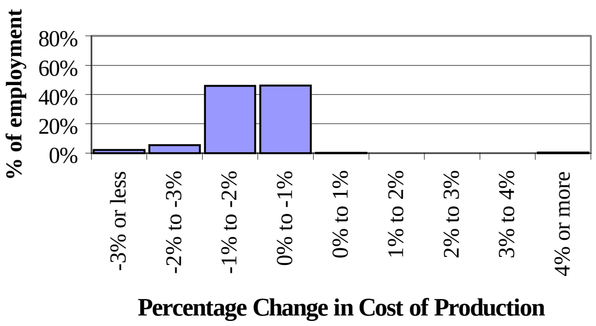
Net cost reductions under the CEF advanced scenario are disproportionately concentrated in employment-intensive industries. As a result, the fraction of business receiving net benefits from the CEF policy package is even greater when measured by employment than when measured by output. Under the CEF Advanced Scenario, 96 percent of all U.S. industry as measured by employment would receive a net price cut in 2010, rising to 99 percent in 2020. See figures 2 and 4.

Figure 4. Changes in Price of Industrial Output, CEF Advanced Scenario (by employment, 2010)



4.2 COMPETITIVENESS EFFECTS

Figure 2. Changes in Price of Industrial Output, CEF Advanced Scenario (by employment, 2020)



The implementation of the CEF Advanced Scenario would have a variety of impacts on the international competitiveness of U.S. industries, both in the domestic and foreign markets. The burden of the energy charge and the cost of additional investments in energy-efficiency technology would increase the cost of U.S. production relative to foreign producers. On the other hand, the labor tax cut and energy savings would reduce the cost of production. The impact of the policy package on the relative price of U.S. and foreign production for a particular industry depends on the net of these effects as a percentage of total value of shipments. For the economy as a whole, the impact on the relative price of domestic and foreign production also depends on the extent to which the price impacts occur in highly competitive or untraded sectors.

Whatever the effect on the economy as a whole, it seems clear that a carbon charge could not fail to have a negative impact on certain sectors, most notably the fossil fuels themselves. If, for example, we adopted a charge on domestically produced oil without imposing the same charge on imported oil, it would have a devastating effect on U.S. oil producers.

If we think of the carbon charge as a tax on carbon consumption, the normal response to competitiveness concerns would be a border tax adjustment (BTA). A border tax adjustment would impose the U.S. carbon charge on carbon-intensive imports and would rebate the charge previously paid by U.S. producers on pollution-intensive exports. BTAs are a normal feature of consumption taxes and are allowed under GATT/WTO rules, provided that they are no greater than the domestic tax. (Demeret and Stewardson 1994; Hoerner and Muller 1996) U.S federal taxes with border adjustments include taxes on motor fuels, alcoholic beverages, toxic chemicals, and many others. Most European nations collect much of their national tax revenue from value-added taxes, virtually all of which have BTAs.

Because we believe that border adjustments must be limited to the hardest-hit industries to be administratively feasible, we examine various cut-off levels for BTA eligibility for pollution-intensive firms. Tables 4.4 and 4.5 show the competitiveness effects for different thresholds and policy scenarios. Note that the numbers labeled "1997 + CC" in this and subsequent table represent a hypothetical case, where the carbon charge and labor tax cut are implemented with industries' 1997 labor and energy values. These figures are offered for comparison purposes, to allow the reader to better judge the impact of the energy-efficiency improvement.

The index of competitiveness shown in these tables are changes in industry prices caused by the CEF policies, with the weights being the value of exports or imports, respectively. In calculating the index we assumed that the level of carbon charge (direct and indirect) in 1997 decides which industries would receive the BTA but that the amount of the adjustment depends on the current level of CC. The carbon charge is measured as a percentage of the value of industry shipments for each industry. The table below shows the impact of BTAs, varying with the cutoff used to determine which industries will get adjustments.

Table 4.4 US Export Price Increase, CEF Advanced Scenario

Carbon Charge with labor tax rebate

BTA for :	1997 + CC (hypothetical)	2010	2020
None	1.63%	0.99%	0.55%
Fossil fuels only	0.52%	-0.12%	-0.55%
With CC>5%	0.46%	-0.18%	-0.61%
With CC>4%	0.32%	-0.27%	-0.68%
With CC>3%	0.19%	-0.36%	-0.75%
With CC>2%	-0.01%	-0.51%	-0.87%
With CC>1%	-0.65%	-0.95%	-1.22%
All industries	-0.92%	-1.15%	-1.37%

The above table shows that, with no border adjustments, under the CEF Advanced Scenario the aggregate price of U.S. exports would increase by one percent in 2010, declining to half a percent in 2020. However, this is an unrealistic scenario. Any plausible carbon charge would be rebated on exports of fuels from the U.S. As the next line shows, this is sufficient to result in a small net reduction in the aggregate price of U.S. exports under the advanced scenario. If BTAs are provided to additional energy-intensive sectors, this would result in further decreases in the average cost of U.S. exports.

Table 4.5 Price Decrease of U.S. Goods Relative to Imports
Carbon Charge (CC) with labor tax rebate

BTA for:	1997 + CC (hypothetical)	2010	2020
None	-1.28%	-0.69%	-0.27%
Fossil fuels only	-0.47%	0.12%	0.54%
With CC>5%	-0.42%	0.17%	0.58%
With CC>4%	-0.36%	0.20%	0.61%
With CC>3%	-0.25%	0.28%	0.67%
With CC>2%	-0.10%	0.39%	0.75%
With CC>1%	0.59%	0.87%	1.13%
All industries	0.87%	1.07%	1.29%

Table 4.5 shows a similar result with respect to the domestic market. With no border adjustments, the average price of U.S. production relative to imports increases. This would probably result in an increasing market share for imports. However, BTAs on fossil fuels suffice to switch the sign to a net decrease. Providing adjustments to additional industries further increases this net improvement.

The difficulty of implementing and overseeing BTAs depends directly on the number of industries benefiting from the BTAs and the volume of trade these would affect. As table 4.6 below shows, only a small share of imports and exports would require border adjustments in order to offset competitive burdens on the most heavily affected industries. The actual industries that would receive such BTAs at each price impact level can be seen in Appendix D.

Table 4.6 Proportion of Industries with Carbon Charge (CC) BTAs

	Number of Industries	% of total exports	% of total imports
Fossil fuels only	4	1.26%	3.58%
With CC>5%	17	2.38%	4.66%
With CC>4%	23	4.71%	5.83%
With CC>3%	38	8.36%	9.01%
With CC>2%	94	16.80%	12.29%
With CC>1%	279	63.75%	64.38%
All industries	498	100.00%	100.00%

Administering BTAs consists of collecting revenue from imports to the U.S. and subsidizing exports from the U.S. This activity will be a source of net revenue. The main reason for this is that the U.S. is net importer fossil fuels and these imports will be taxed. Table 4.7 below shows hypothetical revenue from BTAs. As in the tables above, we use the 1997carbon charge thresholds and current year CC burdens in calculating the revenue. In the absence of better predictions, we assumed that the trade balance of each industry stays at the same level as in 1997. As a result, our BTA revenue estimates are correct for 1997 but only indicative for later years.

Table 4.7 Revenue from BTAs
Million 1997$

BTA for:	1997 + CC (hypothetical)	2010	2020
Fossil fuels only	22.8	22.8	22.8
With CC>5%	26.1	24.8	23.9
With CC>4%	21.5	21.3	21.1
With CC>3%	26.2	24.5	23.5
With CC>2%	29.7	26.8	25.5
With CC>1%	72.5	57.3	49.3
All industries	89.4	69.2	58.5

Taken together, these results suggest that BTAs for the most energy-intensive industries are administratively feasible and economically desirable.

V. CONCLUSION

Driven by concerns ranging from protecting national security to preventing global climate change, industrial nations around the world are adopting aggressive energy-efficiency policies, usually consisting of a mixture of carbon or energy charges, cuts in other taxes, and policies to promote energy efficiency technologies. In the U.S., however, there has been serious concern that such a policy could have a negative effect on the costs and competitiveness of U.S. business. These legitimate concerns have caused the U.S. to adopt a “go slow” approach to solving these problems.

This study finds that a properly designed energy-efficiency policy, including a market incentive to reduce fossil fuel consumption together with cuts in other taxes, would be beneficial to a substantial majority of U.S. business, whether measured by value of shipments or by employment. These net benefits are modest for most individual businesses but are very large in aggregate, and increase over the twenty-year forecast horizon. Excluding fossil fuel industries themselves, by the end of that period only the aluminum, cement, and certain industrial chemicals industries have net price increases as a result of the CEF policy package, and only aluminum has a negative impact greater than one half of one percent. The rest of the business sector either breaks even or is a net winner.

The main factor behind the ability of energy intensive industries to decrease their carbon charge liability is technological progress. The CEF package includes a variety of measures to accelerate the process of research, development, and commercialization of new energy efficiency technologies. This study shows that resulting improvement in productivity, when correctly distributed through the economy, is sufficient to offset the burden of the carbon charge for a substantial majority of industries in 2010 and for virtually every non-fuel industry in 2020.

In the period between the present and 2020, however, a small number of energy-intensive primary materials industries would suffer modest net increases in costs that could harm their competitive position in international markets. Our analysis of the competitiveness effects of the CEF package confirms that a reasonably defined border tax adjustment that is both consistent with WTO rules and is administratively feasible would entirely eliminate any erosion of US competitiveness. In fact, the CEF policy package together with border tax adjustments on a few industries would lead to a decline in production costs of the U.S. relative to the rest of the world.

In closing, it is worth observing that these results are based entirely on domestic policies and produce net domestic economic benefits. American businesses need not wait for other nations, developed or developing, to adopt similar standards in order to reap these rewards. These results suggest that the business community would benefit if it could persuade the U.S. to replace its current foot-dragging approach to energy-efficiency and climate policy with a more proactive global leadership role.

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APPENDICIES

A. TAX BURDEN DERIVATION

In general, the burden of the carbon charge is the sum of the direct burden and the indirect burden. For industries other than electricity, the direct burden of the reference tax is equal to the carbon content of the fossil fuels combusted by that industry, multiplied by the tax rate. For the electric utility industry, the direct burden of the tax is the sum of the carbon content of the fossil fuels combusted by the electric utility industry multiplied by the tax rate.

Table A.1 Electricity Generation and Carbon Emissions

	1997	2010 BAU	2010 Adv.	2020 BAU	2020 Adv.
Fossil fuel electricity generation (TWh)	2212	2962	2326	3485	2241
Electric sector carbon emissions (MmtC)	532	645	460	709	382
Carbon content of electricity (Mmtc/TWh)	0.17	0.22	0.20	0.20	0.17

A.1 Overview

As discussed in section 2.2.2, it is conventional in input-output analysis to use the law of one price to impute physical units of a manufacturing input from the dollar purchases. The constant price for each commodity is equal to the total purchases of that commodity in dollars divided by the total purchases in physical units (such as barrels or tons). Once this ratio has been calculated for each energy commodity in the IO classification, one can assume that the price each sector pays for the particular energy commodity is uniform across all the 498 classifications. One can then use the IO data on each sector's purchases to determine the amount of carbon or energy purchased by that sector, according to the equation:

$F_i = E_i * p$

where F_i is the consumption of a specified fuel in physical units by IO classification i, E_i is the classification's expenditure on that fuel, and p is the classification-independent price for that fuel.

The assumption of the law of one price is firmly rejected by the data in the sector for which we have the best available data, manufacturing. A review of the prices paid for various fuel types by manufacturing industries reveals a large variation in energy prices. Using data from the 1994 Manufacturing Energy Consumption Survey (MECS) of the Energy Information Administration (EIA), we found that the price paid per physical unit of fuel varied between the least and most energy-intensive industries by a factor of two to four, depending on the fuel, with the most energy-intensive industries paying the lowest price.

In response, a three-stage imputation strategy was used to estimate the consumption of fuels and electricity by the IO classifications in the commercial and industrial sectors (transportation will be discussed separately below). First, for each fuel, the price of that fuel was econometrically estimated for each industry. Second, the expenditure recorded in the IO table for a fuel was divided by the estimated price to yield the preliminary estimate of consumption of that fuel type by that industry.

Because carbon and energy taxes have generally included exemptions for nonfuel use, we adjusted the fuel consumption estimates to exclude such use.[12] We utilized data from MECS on nonfuel use for the most important sectors. We assumed that the proportion of nonfuel use to total energy use will remain constant and subtracted that share from taxable carbon emissions for these sectors.

Finally, for each of the sectors (commercial, industrial, and transportation) we summed the consumption of each major fuel type and then forced the sum to equal sectoral control totals by applying a uniform percentage adjustment across the fuel-sector category. The control totals were the electricity or fuel totals for that sector from the EIA's greenhouse gas emissions report (EIA, 1998) and the projections from the CEF report (Interlaboratory Working Group 2000), adjusted as described in section A.3.

A.2 Estimation of Industry-Specific Fuel and Electricity Prices

Using data from the MECS, Table A1, we tested a wide range of functional relationships between energy intensity and price using OLS regression. The following nonlinear functional relationship between the energy price to each sector and its ratio of energy expenditures to the value added generally yielded the best results:

$$p_i = \alpha + \beta \ln (E_i / VA_i)$$

where p_i is the price for a particular fuel type that sector i pays in dollars per physical unit and VA_i is the total value added of that sector. (Note that a full system of such equations would also require fuel-type subscripts on p_i, α, β, and E_i). Based on the estimates of the above relationship for each type of energy, the consumption of each fuel type by each sector can be calculated by:

$$F_i = E_i * [\alpha + \beta \ln (E_i / VA_i)],$$

where E_i and VA_i are available for all 498 industries in the IO table. This imputation procedure was carried out for each fossil fuel type and for electricity.[13]

A.3 Sectoral Controls

After estimating the consumption of each of the 498 industrial classifications for each fuel type using the imputation procedure outlined in section A.2 (except for the transportation sector, which used a different procedure described below), the sectoral totals for each fuel type and for electricity were forced to sum to control totals for that fuel and sector. Forcing was accomplished by multiplying the fuel use for each industry classification in the sector by the ratio of the control total to the sectoral total. The control totals were the totals for that fuel/sector category from the Energy Information Administration's Greenhouse Gas Inventory (EIA 1998), with the following adjustments.

Industrial—Emissions from fuel consumption by nonutility power producers (NPP) have been moved from the industrial sector into the electricity sector.[14] The NPP category includes

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[12] For industries that (according to the 1994 MECS) used more than 5 percent of any fuel type for feedstock uses, the 1995 fuel use was reduced by the percentage of feedstock fuel use in the 1994 MECS (EIA, 1997). We use the EIA's greenhouse gas report methodology (EIA, 1998) and consider tax-exempt nonfuel use of energy to be only the part of the nonfuel energy from which its carbon content is sequestered. For example, the (nonfuel) use of natural gas to make nitrogenous fertilizers is nonsequestering, since during the production process the natural gas reacts with nitrogen, leaving the carbon dioxide literally "up in the air." The rates of sequestration were taken from table A2 of the report.

[13] Econometric results for the fuel equations are available from the authors.

companies producing only electricity, and also co-generators that produce both electricity and some other form of energy that is used in a production process. Therefore, the fuel consumption in the industrial sector was adjusted to exclude the part of fuel consumption attributable to production of electricity.[15] This is equivalent to assuming that co-generators produce electricity as a secondary product. In other words, we assume that if this electricity were not generated (and sold off-site), the utility sector would have to cover the demand for electricity, using a mix of fuels similar to its current average mix.

Commercial—No adjustments were made to the commercial sector emission totals. However, the sector was expanded to include IO transportation categories that provide only services connected with transportation and do not include actual transportation.[16]

Transportation—Residential transportation emissions were subtracted from the transportation sector emissions, based on data from the EIA's Residential Transportation Energy Consumption Survey (RTECS).[17] The transportation sector constitutes only seven IO industrial categories, and the transportation emissions were divided among the transportation sector IO classifications[18] using fuel consumption estimates from the Oak Ridge National Laboratory (ORNL, 1998, table 2.9), rather than the imputation formula described in the imputation section (A.3).

Electricity—Emissions of nonutility power producers, which were subtracted from the manufacturing sector, were added to the electric utility sector[19] (for estimation method, see the discussion for the industrial sector above).[20] For electricity, like fossil fuels, tax increases are distributed across purchasing industrial categories based on purchases measured in physical units (kWh) rather than measured in dollars.

B. ADJUSTMENTS TO THE IO TABLES

B.1 Derivation of Fuel Intensities Changes

This section describes how we arrived at our estimated changes in energy requirements per unit of output. In the manufacturing sector we used energy consumption projections together with the growth rate of real output of the manufacturing sector that was used in deriving the CEF results. The energy intensity change (reported in tables 3.2 and 3.3) was then calculated as:

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[14] Fuel consumption and electricity delivery data for NPP were taken from Electric Power Annual 1997, volume II, table 53 (EIA 1998).

[15] From the Electric Power Annual, part I, the fuel efficiency of electric utilities for each of the four fuel categories (coal, petroleum, natural gas, and other gases) was calculated. Given these efficiencies, fuel use was calculated based on the reported electric generation for all NPPs, both co-generators and independent power producers. These fuel uses were converted to carbon using carbon coefficients from the SEDS utility sector (EIA 1997), and this figure was then subtracted from the emissions of the industrial sector and added to the electricity sector. For co-generators, this methodology is equivalent to treating the process energy produced as a byproduct of electric generation.

[16] In particular, these are BEA categories 650302, 650400, 650500, 650600, 650701, and 650702.

[17] Residential transportation usage is reported in the RTECS with a three-year periodicity. The most recent years available for our analysis are 1991 and 1994. Consequently, SEDS transportation fuel use data for 1991 and 1994 were used together with the RTECS to construct residential transportation share in the total transportation energy use. The analysis did not reveal any significant time variation and, thus, the SEDS 1995 transportation energy usage along with the 1994 residential share ratio allowed us to construct an estimate of 1995 residential transportation energy usage in the SEDS categories in Btu units. Carbon content coefficients were used to calculate the resulting carbon dioxide emissions that were then subtracted from the transportation sector emissions reported in EIA 1998.

[18] The transportation sector was redefined to include IO categories 650100, 650200, 650301, 650400, 650500, 650600, and 680201.

[19] Electricity sector includes IO-code categories 680100, 780200, and 790200. However, in the commodity classification, only category 680100 has non-zero entries.

[20] The emissions associated with electricity production were calculated based on fuel consumption only; the onsite consumption of electricity was handled alongside other nonfuel requirements for electricity production (maintenance, equipment amortization, etc.) through total requirement matrix.

$(E_{2020}/Y_{2020}) / (E_{1997}/Y_{1997}) = (E_{2020}/E_{1997}) / (Y_{1997}/Y_{2020}) = (E_{2020}/E_{1997}) * (1+g_y)^{23}$

where E is energy consumption of particular fuel in Btu's, Y is the sector's output in constant prices and g is the assumed growth rate of Y; subscripts refer to time.

The same data was available for the commercial sector and, hence we have used the same formula. However, in the transportation sector, we were able to use efficiency data directly. The CEF reports projected efficiency improvements for the fleet of autos, light and freight trucks as well as improvements in Btu's per seat mile in the air transportation sector, and Btu's per ton-mile in the rail transportation and Btu per ton mile in the water transportation sector.

B.2 Adjustment to Use and Make Matrices

Our goal was to obtain an estimate of how much carbon each sector consumes, after technological change has taken place and final demand has changed (both the total and its composition).

Let us illustrate the situation on a simplified example: suppose that the only change that occurred was that the steel industry requires 10% less coal per unit of its product (e.g., 10% less Btu's per ton of steel). Let's trace the changes that this fact implies in the IO tables. Start with the base year (e.g., 1996) current dollar flow matrices – use, make, value added and final demand. We will continue working in the base year prices – this will enable us to use our (nonlinear) fuel price imputation formula. If the final demand stayed the same, the steel industry would need to buy 10% less of the product coal (reduce the corresponding cell in the use matrix by 10%). Therefore, there will be $\underline{x}$% less of the product coal needed in the economy (remember we express this in constant prices), where $\underline{x}$ is 10 times the share of steel industry purchases of the product coal in the total sales of the product coal. Hence we need to scale down the production of the product coal by $\underline{x}$% - that is, decrease each element of the corresponding column in the make matrix by $\underline{x}$%. As a result, output of every industry that produces coal decreases by a certain percentage. If there is only one industry making coal and coal is the only product it makes, its output would go down by exactly $\underline{x}$%. If there are more industries producing coal or if the coal industry produces products other than coal (i.e., there are off diagonal entries in the make matrix), then the output of several industries might be decreased by a percentage lower than $\underline{x}$. That requires us to decrease the purchases these industries make by a corresponding proportion, i.e., scale the columns of the use matrix, leading to changes to its columns. Therefore, we need to scale down the rows of the make matrix and so on. It is relatively easy to show that this process converges; note that the procedure is similar to well-known RAS balancing.

In the adjustment process, we change the elements of the value-added row but we do not change the elements of the final demand (we assumed it to be fixed). By looking at the purchases of coal in the 'new' use matrix, obtained by the above procedure, and dividing them by our imputed coal prices, we obtain the coal (in Btu's) that each sector needs to buy in 2010 (or 2020), had the final demand been the same as in 1996.

B.3 Adjustment for Changes in the Final Demand

However, the final demand has changed and we need to take that into account. Therefore, we need to obtain coefficient matrices out of our adjusted flow use and make matrices. Thus, we divide (element by element) the columns of the use matrix and the rows of the make matrix by our old vector of final demand. This produces coefficient matrices that record inter-industry purchases required per unit of their output.

The linear technology assumption means that, when final demand changes, we can just multiply (element by element) the rows of the use and the columns of the make matrices and obtain the flow matrices that are required for our new vector of final demand.

From the CEF study, we know what is the amount of coal (in Btu's or tons of carbon) each sub-sector purchases *after* both technology and final demand changed in 2020. Hence we just take our coal vector for the old final demand and force its sub-sectoral totals to equal the CEF numbers. This means that we assume that the numbers in the CEF study reflect forecasts of the changes in the composition and level of the final demand as well as the changes in technology.

The procedure described above yields an estimate of fuel consumption (in Btu's) for each fuel and industry. These are easily translated, via the carbon coefficients, to a vector of direct carbon emissions by industry in 2010 and 2020.

C. EMBODIED CARBON AND PRICE CHANGE CALCULATIONS

The focus of this section is to briefly describe the methodology of obtaining the carbon embodied in products and the price changes resulting from carbon taxation. When estimating these, we essentially rely on Leontief price model, see, e.g., Miller and Blair (1985), pages 351-357. Here we want to briefly restate this model in intuitive terms.

Let's first turn to the carbon embodied in the 498 commodities as defined by the BEA classification system. We start with a vector of *direct emissions*, i.e., emissions that are actually emitted during the production process in a particular industry. Our goal is then to obtain a vector of *total emissions* that are embodied in each commodity through both direct emission (emitted during the production process), as well as the emission associated with inputs that are used in the production of each commodity.

Abstract for a while from the commodity and industry distinction and denote the total emissions embodied in commodity *i* by T_i, the direct emissions by D_i,[21] the input of commodity *j* into the production of commodity *i* by $f_{j,i}$ (measured in current dollars), and the total current-dollar economy-wide output of commodity j by Q_j. Assuming that the total carbon emissions embodied in a commodity are proportionally assigned to its uses as intermediate input and in final demand according to the dollar values of the intermediate inputs and final demand, we can write the total embodied emissions in a commodity *j* as:

$$(1) \qquad T_i = T_1 * (f_{1,i} / Q_1) + T_2 * (f_{2,i} / Q_2) + ... + T_{498} * (f_{498,i} / Q_{498}) + D_i$$

where 498 is the number of commodities in the BEA classification. Equation (2) states the above assertion that the total emissions embodied in each commodity consist of the total emissions embodied in the inputs that were used in producing the commodity and the direct carbon emitted during the production process. The system of these equations for all the commodities can be written conveniently in matrix notation as:

$$(2) \qquad T = B' T + D$$

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[21] The total and direct emissions are in MtC units; they are economy-wide emissions associated with the current production levels of each commodity. They are not emissions per unit of a commodity.

where matrix B has elements $b_{i,j} = f_{i,j} / Q_j$; T and D are the vectors of total and direct emissions; and Q is the vector of commodity outputs. Notice that the matrix B is similar to the regular commodity-by-commodity coefficient input-output matrix A with elements $a_{i,j} = f_{i,j} / Q_{I,}$ but B has the rows rather than the columns of the flow input-output matrix divided by total commodity outputs.

Solving the above equation gives us the formula we have used in determining the total emissions:

(3) $T = (I – B') * D$

where I is an identity matrix. How does this relate to the Leontief price model? We can multiply equation (1) by per unit carbon tax and divide by Q_i to translate the total emissions T_i into changes of the price of commodity *i* (ΔP_i)[22]. The direct emissions D_i are then translated into the share of the carbon tax in the value of commodity *i*, which is the change in the value added share due to the carbon tax (ΔK_i). Hence, equation (3) would become:

(4) $\Delta P = (I – A') * \Delta K$

and this is exactly the Leontief price model, as in for example equation 9-93 in Miller and Blair (1985).

In the following we will derive the Leontief price model, paying more attention to the role of different parts of value added.

Intuitively the Leontief price model can be described as follows. Let's assume that a part of value added changes due to, for example, the carbon tax. Let's further assume that the cost increases are fully passed through to the customers, i.e., any cost increase is reflected on a one-to-one basis in the increased price of each commodity. Then the final price increase for commodity *i* consists of the weighted average of the final price increases of the inputs used in production of that commodity plus the direct change in the proportion of the value added. The weights are the (dollar) share of each input in the total (dollar) value of commodity *i*. That is:

(5) $\Delta P_i = \Delta P_1 * (f_{1,i} / Q_i) + \Delta P_2 * (f_{2,i} / Q_i) + ... + \Delta P_{498} * (f_{498,i} / Q_i) + \Delta K_i$

or in matrix notation:

(6) $\Delta P = A' \Delta P + \Delta K$

yielding the Leontief price equation as in (4).

The same analysis that was done above for changes in the value added can be done to its levels; more precisely to the proportion of the value added instead of changes in that proportion. This than gives us equations for deriving the share of labor and capital payments, as well as the carbon tax or payroll tax reduction, in the dollar value of each commodity.

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[22] Assuming the cost increases due to the carbon tax are fully passed through to the consumers, i.e., any cost increase is reflected on a one-to-one basis in the increased price of each commodity.

D. DETAILED TABLES OF RESULTS

Table D.1 Industries Most Adversely Affected by Carbon Charge with Labor Tax Rebate

	Employment	Value of Output	Cost Change		
Industry	**(% of total)**	**(% of total)**	**1997**	**2010**	**2020**
Primary aluminum	0.01%	0.04%	14.84%	11.26%	3.34%
Cement, hydraulic	0.01%	0.04%	9.94%	2.95%	0.32%
Lime	0.00%	0.01%	6.92%	1.78%	-0.02%
Natural gas transportation	0.01%	0.06%	6.85%	0.47%	-6.64%
Aluminum rolling and drawing	0.04%	0.14%	6.29%	4.13%	0.74%
Iron and miscellaneous metal ores	0.00%	0.02%	5.46%	1.89%	-0.08%
Asphalt paving mixtures and blocks	0.01%	0.04%	5.09%	1.04%	-0.17%
Blast furnaces and steel mills	0.09%	0.40%	4.98%	1.36%	-0.50%
Lubricating oils and greases	0.01%	0.04%	4.73%	1.09%	-0.20%
Malt	0.00%	0.01%	4.66%	1.40%	-0.25%
Water transportation	0.14%	0.26%	4.54%	-0.51%	-0.81%
Metal cans	0.02%	0.09%	4.49%	2.34%	-0.03%
Animal and marine fats and oils	0.00%	0.02%	4.49%	1.30%	-0.24%
Sugar	0.02%	0.05%	4.37%	0.87%	-0.65%
Glass containers	0.02%	0.03%	4.23%	1.92%	0.00%
Industrial chemicals	0.16%	0.76%	3.84%	1.83%	0.08%
Asphalt felts and coatings	0.01%	0.03%	3.72%	0.74%	-0.37%
Aluminum castings	0.05%	0.06%	3.65%	2.09%	0.05%
Carbon black	0.00%	0.01%	3.55%	0.77%	-0.33%
Brick and structural clay tile	0.01%	0.01%	3.47%	0.73%	-0.49%
Wet corn milling	0.01%	0.07%	3.46%	1.14%	-0.16%
Electrometallurgical products	0.00%	0.01%	3.41%	1.64%	-0.25%
Structural clay products	0.00%	0.00%	3.38%	0.66%	-0.61%
Cottonseed oil mills	0.00%	0.01%	3.11%	1.25%	-0.19%
Gum and wood chemicals	0.00%	0.01%	2.98%	1.40%	-0.12%
Fertilizers	0.02%	0.07%	2.97%	0.54%	-1.05%
Glass and glass products	0.08%	0.13%	2.90%	1.24%	-0.16%
Cellulosic manmade fibers	0.00%	0.01%	2.85%	0.72%	-0.45%
Paper and paperboard mills	0.12%	0.44%	2.82%	1.08%	-0.62%
Clay, ceramic, refractory minerals	0.01%	0.01%	2.78%	0.58%	-0.35%
Copper ore	0.01%	0.03%	2.68%	0.88%	-0.33%
Trucking, courier services, except air	1.34%	1.46%	2.66%	-0.35%	-5.32%
Chemical and fertilizer minerals	0.01%	0.03%	2.56%	0.61%	-0.36%
Products of petroleum and coal	0.00%	0.01%	2.53%	0.89%	-0.21%
Gypsum products	0.02%	0.03%	2.50%	0.46%	-0.73%
Air transportation	1.03%	0.87%	2.45%	-0.46%	-1.98%
Metal shipping barrels, drums, kegs	0.00%	0.01%	2.45%	0.63%	-0.49%
Ready-mixed concrete	0.08%	0.12%	2.39%	0.36%	-0.84%
Local and highway passenger transp.	0.48%	0.21%	2.38%	-0.65%	-5.93%
Synthetic rubber	0.01%	0.04%	2.28%	0.71%	-0.36%
Pulp mills	0.01%	0.04%	2.26%	0.78%	-0.66%

Table D.2 Industries Most Benefited by Carbon Charge with Labor Tax Rebate

Industry	Employment (% of total)	Value of Output (% of total)	Cost Change 1997	2010	2020
Personnel supply services	3.25%	0.52%	-3.08%	-2.35%	-2.15%
Amusements	1.04%	0.32%	-2.38%	-3.40%	-4.35%
Services to buildings	0.97%	0.26%	-1.64%	-1.44%	-1.51%
Agricultural and forestry services	1.02%	0.27%	-1.46%	-1.45%	-1.64%
Social services and membership org.	5.03%	1.50%	-1.41%	-1.43%	-1.57%
Eating and drinking places	7.80%	2.08%	-1.29%	-1.46%	-1.70%
Photofinishing and photography	0.33%	0.13%	-1.06%	-1.05%	-1.19%
Educational Services	1.82%	0.75%	-1.02%	-1.07%	-1.24%
Other business services	1.95%	0.84%	-0.95%	-0.97%	-1.15%
Detective and protective services	0.33%	0.14%	-0.93%	-0.89%	-1.01%
Personal & repair services	1.67%	0.76%	-0.77%	-1.01%	-1.23%
Arrangement of passenger transportation	0.22%	0.12%	-0.76%	-0.87%	-1.06%
Automotive repair and services	2.08%	0.92%	-0.73%	-0.95%	-1.18%
Computer and data processing services	2.86%	1.71%	-0.72%	-0.81%	-1.01%
Freight forwarders and transport. services	0.20%	0.12%	-0.70%	-0.87%	-1.12%
Management and PR services	1.31%	0.81%	-0.69%	-0.79%	-1.01%
Accounting, auditing and bookkeeping	0.82%	0.59%	-0.62%	-0.70%	-0.90%
Miscellaneous repair shops	0.40%	0.21%	-0.61%	-0.80%	-1.03%
Health Services	9.28%	5.10%	-0.53%	-0.78%	-1.03%
Misc. equipment rental and leasing	0.37%	0.24%	-0.52%	-0.70%	-0.91%
Credit agencies other than banks	0.83%	0.77%	-0.50%	-0.61%	-0.83%
Retail trade, except eating and drinking	10.96%	5.72%	-0.48%	-0.80%	-1.06%
Insurance carriers	1.22%	1.64%	-0.48%	-0.60%	-0.83%
Engineering, architectural, etc. services	0.82%	0.78%	-0.47%	-0.64%	-0.86%
Insurance agents, brokers, and services	0.67%	0.60%	-0.43%	-0.60%	-0.85%
Forestry products	0.04%	0.06%	-0.40%	-0.66%	-0.98%
R&D and testing services	0.36%	0.28%	-0.39%	-0.60%	-0.86%
Radio and TV broadcasting	0.15%	0.29%	-0.35%	-0.57%	-0.82%
Legal services	1.01%	0.98%	-0.33%	-0.48%	-0.70%
Advertising	0.26%	0.23%	-0.23%	-0.50%	-0.86%
Security and commodity brokers	0.75%	1.23%	-0.19%	-0.40%	-0.63%
U.S. Postal Service	0.62%	0.42%	-0.12%	-0.62%	-1.02%
Banking	1.44%	2.43%	-0.11%	-0.38%	-0.67%
General government industry	4.91%	6.56%	-0.08%	-0.23%	-0.44%
Logging	0.09%	0.16%	-0.07%	-0.44%	-0.77%
Communication services	1.09%	2.21%	-0.07%	-0.34%	-0.62%
Wholesale trade	4.93%	5.90%	-0.05%	-0.41%	-0.73%
Costume jewelry	0.01%	0.01%	-0.04%	-0.45%	-0.82%
Other new construction	1.10%	1.22%	-0.04%	-0.47%	-0.90%
Miscellaneous publishing	0.08%	0.09%	-0.02%	-0.34%	-0.71%
New office, industrial and commercial buildings construction	0.85%	0.94%	-0.01%	-0.44%	-0.88%

Note: the above tables omit the Government Passenger Transportation industry; the results for this industry are distorted by the subsidies it receives and hence are not reported.