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BURDENS AND BENEFITS OF ENVIRONMENTAL TAX REFORM:
An Analysis of Distribution by Industry

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1. INTRODUCTION AND SUMMARY

Over the last three decades, the United States has made considerable progress in reducing many varieties of air and water pollution, and some major environmental problems such as atmospheric lead have been virtually eliminated (CEQ 1995, CEQ 1996). However, the rate of improvement has declined considerably, and emissions from hard-to-control distributed and mobile sources constitute an increasing portion of total emissions. In addition, one major class of emissions—greenhouse gases—has continued to rise, and is now almost 50 percent higher than it was thirty years ago.

At the same time, both the economy and environmental policy operate under more rigid constraints than in the past. International competition is increasingly fierce,[1] and there are limited resources available for environmental enforcement and little enthusiasm among policymakers, business, or the public for aggressive new schemes of environmental regulation.

In response to these constraints, a consensus is emerging among economists, environmentalists, and business leaders that new tools will be necessary to solve the new breed of environmental problems—policies designed to achieve both environmental and economic goals. The hallmarks of these new and creative approaches are flexibility in technology, the use of market incentives to stimulate innovation and least-cost approaches to pollution reduction, and the elimination of barriers to cleaner ways of doing business. In the best cases, these new approaches can lead to economic benefits from lower cost of pollution reduction and more efficient production methods. There is broad agreement in the economics profession that, where they are administratively feasible,[2] market-based approaches to environmental

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[1] To take one basic measure, between the mid-1980s and the mid-1990s, U.S. total international trade (imports plus exports) as a fraction of GDP has increased by nearly 40 percent.

[2] In the early days of environmental regulation, pollution control technology standards, rather than emission standards, were the primary instrument. This approach was justified because the emissions monitoring technology was primitive, expensive, and unreliable. As emissions monitoring technology improves, market-based instruments become relatively less costly and more advantageous. However, there remain many areas of environmental policy in which traditional regulatory approaches still have lower costs for monitoring, enforcement, and administration.

problems, such as pollution taxes and tradable emissions permits, are the lowest-cost way to achieve our environmental goals (OECD 1989, 1996).

The prototype of this new breed of policies is the market-based approach to environmental problems. In the United States, this approach is best exemplified by the highly successful programs to phase out the use of ozone-depleting chemicals and to reduce emissions of sulfur dioxide. In both cases, a market incentive[3] was linked to a variety of programs to develop new, less polluting ways of doing business. In each case, the cost of achieving the environmental goal was below Environmental Protection Agency projections by a factor of two or more. It is clear that the market-based approach used in these two cases was essential to our success in reaching these environmental goals under budget and ahead of schedule (Joskow et al. 1998; Stavins 1998; Hoerner 1996).

In this paper we explore the implications of an environmental tax reform for the competitive position of U.S. industry. Environmental tax reform (ETR) is a decrease in a tax on income from work or investment, financed by an increase in a tax on pollution emissions or consumption of natural resources. The ETR proposals we model are revenue-neutral: they neither increase nor decrease the overall tax burden and size of the government. ETR proposals are motivated by the simultaneous desire to reduce the tax burden on work and investment and to improve our environmental performance. By shifting a portion of the tax burden off of valuable economic activities and onto pollution, the ETR provides an incentive for continued progress in achieving environmental quality while minimizing the negative impact on the economy as a whole.

Broad-based pollution taxes based on consumption of fossil fuels and other energy sources have now been adopted by seven nations.[4] The trend toward adoption of such taxes is clearly accelerating, as two of the worlds ten largest economies, Germany and Italy, have implemented ETR proposals in 1999; a third, Great Britain, has announced its intent to do so in 2000; and for the first time the French Ministries of the Economy, Industry, and the Environment have joined in support of such a measure.

This study uses a 498-industry input-output model to analyze the industrial distribution of a broad-based pollution and energy tax (PET), described in section 3.1 below, with the revenue recycled to reduce other taxes. Two offsetting tax cuts are considered: a cut in payroll taxes, and a general reduction in taxes paid by firms on

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[3] The ozone-depleting chemicals tax and a tradable sulfur dioxide emissions permit system, respectively.

[4] Denmark, Finland, Germany, Italy, the Netherlands, Norway, and Sweden. See Hoerner and Bosquet 2000 for summaries of these environmental tax reforms.

all income from capital (including interest, dividends, and retained earnings). Our purpose in this paper is to measure the relative distribution of burdens and benefits of an environmental tax reform across industries. We make no claim to assess whether the aggregate effect on the macroeconomy will be positive or negative, as the input-output methodology we employ is not suited to answering these questions. Given the fixed technology coefficients employed by the input-output approach, this is probably best seen as a model of the immediate or short-term impacts of tax reform.

The impact of an environmental tax reform on economic aggregates such as employment and GDP are controversial. Economic modeling results vary considerably based on the model structure and exact policy being modeled. Dozens of studies of the impact of 20 to 50 percent reductions in fossil fuel use (and related emissions) have been done for the United States, some using "top down" economic tools such as macroeconomic and computable general equilibrium models, and some using "bottom up" engineering models (which project optimum energy technology choices on a technology-by-technology basis) or hybrid economic/engineering models. When macroeconomic and general equilibrium models are used to project the impact of such reductions on a stand-alone basis, projected impacts on the order of 1 to 3 percent loss of GDP are common (IPCC 1996; Energy Modeling Forum 1993). However, when the revenue from the environmental tax is returned by reducing other distorting taxes, employment impacts are generally found to be small but positive (Majocchi 1996; Hoerner and Bosquet 2000), while GDP impact estimates have a mean which is negative but near zero (Hoerner and Bosquet 2000; Repetto and Austin 1997; Shackleton et al. 1992). Engineering and hybrid models rarely incorporate reduction of other taxes, but nonetheless generally find small increases in GDP from 20 to 50 percent emission reductions (IPCC 1996; Brown et al. 1998). Again, this report is agnostic on these questions. We assume macroeconomic impacts of ETR will be modest and of uncertain direction and instead focus on distributional issues.

Following the incidence assumptions used by the U.S. Department of the Treasury and Congress's Joint Committee on Taxation, we assume the pollution and energy tax is fully passed forward to purchasers and consumers in the form of higher product prices. Each tax reduction is analyzed under two different assumptions concerning tax incidence. The first assumption is that the full benefit of the tax reduction is passed forward to purchasers and consumers in the form of lower product prices, just as the pollution and energy tax increase is passed forward. We refer to this assumption as "consumer incidence." Under the second assumption, the tax cut is passed back to factor suppliers (workers for the labor tax, capital owners for the capital tax). We refer to this assumption as "input incidence" or as labor or capital incidence.

Our overall conclusion is that the burden of an environmental tax reform is concentrated in a few industries, while a substantial majority of industries would receive net tax reductions. This pattern holds true regardless of whether labor or capital taxes are cut; whether the incidence of the tax is assumed to fall on consumers or on input factors; and whether one measures the aggregate share of industry by value of output or by number of workers. See table 1 below, which shows the percentage of net "winner" industries under alternative assumptions for tax cut, incidence, and measure of aggregate industry size. Depending on the choice of revenue recycling option and incidence assumption, 73 to 80 percent of industry (measured by value of output) and 78 to 92 percent of industry (measured by employment) would receive net tax cuts under an environmental tax reform. It should be observed that although the substantial majority of production and employment are in firms that would receive a net tax cut, the percentage reduction in the price of "winner" firms are on average smaller than the percentage price increases for the adversely affected firms. These results are presented in greater detail in section 5 below.

TABLE 1: **INDUSTRIES THAT RECEIVE NET TAX REDUCTIONS FROM ETR**

Measured by:	**Labor**		**Capital**	
	Consumer Incidence	Worker Incidence	Consumer Incidence	Capital Incidence
Percent of Value	74.8	79.5	74.5	73.2
Percent of Employment	78.3	92.3	78.1	89.6

Environmental tax reform would cause significant tax increases and potential competitive burdens for a small but important sector of the economy. Table 2 shows the percentage of industry (measured by value of output) that would have price increases of 3 percent or more under the different tax cut and incidence assumptions from ETR. Depending on the tax cut chosen and the incidence assumption, 1 to 4 percent of aggregate production by value would see price increases of 3 percent or more. The hardest-hit industries other than fossil fuels and electricity (lime, electrometalurgical products, primary aluminum, cement, and iron ore) would see price increases of 10 to 14 percent under these tax proposals. These increases are sufficient to affect the international competitiveness of these industries unless policies to offset the competitive burden are adopted. (For instance, the international variation in price for bulk raw aluminum is generally only 2 to 3 percent.) The last row of table 2 shows the percentage of workers employed in such industries under each tax cut and incidence assumption. Depending on the tax cut chosen and the incidence assumption, the percentage of workers in heavily impacted industries varies from less than 1.1 to 3.5 percent. A list of the 35 industries with the highest net tax increases from the ETR proposals we examine is in table A2 in the appendix (section 9.2).

TABLE 2: **INDUSTRIES WITH NET LOSSES OF 3 PERCENT OR MORE FROM ETR**

Measured by:	**Labor**		**Capital**	
	Consumer Incidence	Worker Incidence	Consumer Incidence	Capital Incidence
Percent of Value	5.3	7.3	4.7	7.1
Percent of Employment	1.5	3.5	1.1	2.7

Finally, turning to the potential impact of environmental tax reform on international competitiveness, we have examined the distribution of price increases and decreases from ETR on traded goods. In an effort to determine the aggregate impact of a tax reform on traded goods, we have done two things. First, we have constructed two indexes of aggregate price change. The first weights price changes by export volume and is intended to capture the impact of ETR on the global competitiveness of U.S. products. The second weights price changes by total trade (exports plus imports) and is intended to capture the impact of ETR on the U.S. balance of trade.[5]

Second, we have used these two indexes to examine the impact of a policy designed to offset international competitive burdens: border tax adjustments (BTAs). A border tax adjustment would impose the U.S. pollution and energy tax on pollution-intensive imports and would rebate the tax previously paid by U.S. producers on pollution-intensive exports. BTAs are a normal part of taxes on national consumption and are not considered a form of protectionism. They are allowed under the General Agreement on Tariffs and Trade (Demaret and Stewardson 1994; Hoerner and Muller 1996). American taxes with BTAs include taxes on motor fuels, alcoholic beverages,

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[5] Under the total trade weighting on net price increases, the sign of the change in trade is what would be expected based on a partial equilibrium analysis, and the magnitude of the impact on the trade balance is proportional to the size of the price change times the volume of trade. The index does not adjust for industry-specific price elasticities.

ozone-depleting chemicals, and many others. Value-added taxes (VATs) common in Europe also 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.[6]

We conclude that even without BTAs, the overall impact of ETR on the U.S. competitive position is modest and may be positive. Under the assumption that tax cuts are passed through to consumers, ETR with either capital or labor tax cuts result in net improvement in U.S. competitiveness. This improvement becomes even greater with the addition of BTAs. If the tax cuts are assumed to be passed back to workers or capital owners, without BTAs there is a modest increase in the price of exports of approximately 0.4 percent. The bulk of this negative impact is eliminated by BTAs on goods from the 30 industries (3.7 percent of U.S. industries by value of output) with a pollution and energy tax (PET) greater than 4 percent of the value of production. If BTAs are also extended to the 15 industries with PET burdens between 3 and 4 percent (an additional 2.9 percent of U.S. production by value), the net impact on our competitive position becomes positive.

We find that the impact of ETR on the balance of trade is slightly positive under the assumption of consumer incidence, and negative under the assumption that the incidence of the tax cuts are on factor suppliers. If BTAs are applied to the 22 industries with the largest price impacts (7 energy industries and 15 energy-intensive manufacturing or mining industries), then ETR improves the U.S. trade position, regardless of the choice of tax cut and incidence assumption. A more detailed description of the competitiveness and trade analysis can be found in section 6.

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[6] Our baseline scenario assumes that BTAs would be applied only to fossil fuels and electricity. The alternate scenarios extend BTAs to other pollution-intensive goods.

2. A BRIEF REVIEW OF THE LITERATURE

2.1 INTRODUCTION

The literature assessing the economic impact of energy-based environmental tax reform is vast. Much of it is reviewed by the Intergovernmental Panel on Climate Change (IPCC 1996), and some more recent European studies are reviewed in Hoerner and Bosquet 2000. In this section we focus on efforts to assess the impact of such reforms on an industry-by-industry basis in the United States. A number of authors have estimated the impact of a broad environmental tax reform on industry sectors. We make no attempt to do a comprehensive review of such literature, but rather describe a few representative studies in an effort to highlight key results and limitations of previous work.

2.2 APPROACHES TO MODELING

2.2.1 Computable General Equilibrium (CGE) Models

In approaching the long-term distribution of burdens and benefits of an environmental tax reform, the flagship modeling approach of the economics profession is the computable general equilibrium (CGE) model. CGE models specify technical possibilities for industries and tastes for consumers using either a calibration or an econometric approach. The models then determine the evolution of the prices and quantities of products produced, and sometimes the evolution of stocks such as the capital supply, within the modeling framework.

Jorgenson and Wilcoxen (1993) have used an intertemporal CGE model of the United States to examine the costs of carbon taxes under three specifications for revenue recycling. Their simulations showed that a tax of $50 per ton of carbon, similar in magnitude to the tax examined here, would yield results ranging from a 1.7 percent GDP loss to a 1.1 percent gain, depending on the choice of the offsetting tax reduction.

There have been numerous other national and international studies of the effects of carbon taxes using the CGE approach. For a good review see, for example, IPCC 1996 or Zhang and Folmer 1998. Most of the CGE models focus on long-term macroeconomic effects of carbon taxes and do not investigate the difference in impact of the tax on detailed sectors of the economy. This is due to the prohibitive computational and data requirements necessary for a detailed analysis.

Because CGE models are built on solid theoretical microeconomic foundations, many authors consider the CGE approach to be superior to other modeling strategies. CGE models vary enormously in sectoral detail, the type of behavior modeled, coefficients that determine the responsiveness of the model to various price and policy variables, and in many other ways. The data demands in order to appropriately calibrate or empirically estimate multisectoral CGE models are very substantial. As a result, the key parameters often lack empirical validation because they are calibrated rather than econometrically estimated (Borges 1986).

A second caution is that, precisely because of their sophistication, CGE models can give a spurious impression of forecasting precision. As we pointed out previously, many of the central behavioral coefficients needed to do forecasting are calibrated. The calibration procedure often borrows a variety of elasticities from other studies, and the values of elasticities that are eventually chosen are difficult to defend. For example, estimates of the elasticity of household capital supply with respect to the returns to saving vary from zero to more than one. Sometimes even the sign of the key parameters is disputed. For example, Gibbons (1984, 1985) and Santini (1992) conclude that capital and energy are long-term substitutes, while several papers in Berndt and Field 1981 suggest that they are complements.

In addition, if a model fails to include the behavioral adjustments that are actually most important in a specific decisionmaking context, the presence of a complex and sophisticated behavioral structure may serve more to mask the model's shortcomings than to improve the precision of forecasting. Suppose, for example, that in the long run firms respond to permanent energy price increases primarily by increasing their stock of energy-efficiency technology. If a CGE model does not assume that investments in energy-efficiency technology respond rationally to price—and none of the major multisectoral CGE models do—then the results from that model would not capture key features of the economy's adjustment process.

However, it should be emphasized that the failure to include key behavioral adjustments is not an inherent failing of CGE models, and indeed those models may offer the best hope of capturing such effects. But it is clear that at the current state of the art, many behavioral responses critical to long-run environmental policy have not yet been incorporated into the leading models in the field.

2.2.2 Input-Output Models

There is a long history of using input-output (IO) analysis (sometimes called interindustry analysis) to analyze the impact of energy and environmental policy on industries. IO analysis, first developed by Professor Wassily Leontief (1936, 1976), is actually one of the first forms of general equilibrium analysis that allowed explicit solution of a multisectoral model to be computed. It is appropriate to regard Leontief IO analysis as a form of CGE model in which the behavioral assumptions have been simplified to allow results to be more easily calculated. In the words of Dale Jorgenson:

> The usefulness of the "fixed-coefficients" assumption that underlies input-output analysis is hardly subject to dispute. By linearizing technology and preferences, it is possible to solve at one stroke the two fundamental problems that arise in the practical implementation of general equilibrium models. First, the resulting general equilibrium model can be solved as a system of linear equations with constant coefficients. Second, the unknown parameters describing technology and preferences can be estimated from a single data point. (1984)

As noted earlier, the computational and data demands of CGE models usually limit them to a fairly small number of sectors and fairly simple interactions between those sectors. Where interindustry material flows are important or a high degree of sectoral disaggregation is necessary, the IO analysis often remains the best tool available.

It should be understood, however, that IO analysis is not suitable for assessing the impact of an environmental tax reform on macroeconomic aggregates. IO analysis generally treats these quantities as fixed, although it can be quite helpful in tracing the effect of exogenously determined changes through the economy.[7] In the context of the current study, one should recognize that a very substantial modeling effort in both the United States and Europe has reached no consensus on whether tax reforms of the sort modeled here will increase or decrease employment or GDP. For a tax reform of the magnitude we examine, the aggregate impact on GDP is at most one or two percentage points. However, whether the impact is positive or negative depends on the structure and assumptions of the model, the way the tax revenue is returned to the economy, the presence of ancillary policies to encourage energy efficiency, and many

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[7] 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).

other factors.[8] In this paper, we take no position on whether the tax reform packages we model would induce a small increase or a small decrease in overall economic activity. Our focus is rather on the distribution of the benefits and burdens of reform across firms and on the implications of that distribution for policymaking.

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).

The most important limitation of IO analysis is that the fixed technological coefficients imply that all manufacturing inputs must be used in a fixed ratio to output. For instance, the amount of electricity required per unit of output is fixed by the technical coefficients and does not respond to price. Thus IO analysis is more appropriate for short-term than for long-term forecasting. When IO analysis is used to estimate the effect of a tax on an input to manufacturing (such as an energy tax or a labor tax), the result tends to overstate negative impacts of an increase (or underestimate positive effects from a cut), as firms are assumed not to adjust their behavior to reduce (increase) use of the taxed factor.

In the context of energy taxation, 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, as discussed in section 4.3.2 below, 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, for example, Bullard and Herendeen 1975; Dossani and Preziosi 1980) but recent efforts to use IO analysis to

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[8] See, for example, Shackleton et al. 1992, comparing various environmental tax reform options for the U.S. economy using five major models; IPCC 1996, for a comprehensive international survey of hundreds of modeling efforts using both economic and engineering models; Repetto and Austin 1997 for a meta-analysis studying the sensitivity of economic outcomes to various modeling assumptions.

estimate the carbon content or carbon tax burden on final demand (Goulder 1992; Bernow et al. 1997a, 1997b) have generally used the “one price” model.

2.2.3 Simple Passthrough Models

The U.S. system of collecting economic statistics collects better data on the manufacturing sector than on most other sectors of the economy. The Annual Survey of Manufactures (ASM) provides data on dollar value of electricity and nonelectric energy purchases, and also electricity purchases in kilowatt-hours. The triennial Manufacturing Energy Consumption Survey (MECS) provides consumption of fuels for more than six fuel types[9] and electricity for all twenty of the two-digit Standard Industrial Classification (SIC) manufacturing industries and the forty most energy-intensive four-digit industries. In addition the ASM and Census of Manufactures provide data on investment, value added, value of shipments, and many other variables of interest a very fine level of disaggregation. Taking advantage of this wealth of data, a number of scholars have focused on the impact of market mechanisms on the manufacturing sector (for example, Ross et al. 1993).

In a previous work, Hoerner (1997) studied the impact of an environmental tax reform on the competitiveness of manufacturing industries. This study estimated the potential competitive burden of a carbon/energy tax on all the MECS industries and examined a range of possible policies to offset those burdens. The most important conclusion of that study was that the high level of disaggregation allowed by the MECS was of critical importance to assessing potential industrial impacts and crafting policies to offset them. It was quite common for four-digit SIC industries within a single two-digit SIC industry to differ in energy or carbon intensity by a factor of ten or more. This recognition is a major factor motivating the current study.

However, the Hoerner study had three important limitations. First, the analysis was relatively static, making no allowance for energy conservation and other economic responses to the tax reform studied. Second, the study covered only the manufacturing sector. And finally, the study considered only the direct impact of the tax reform on the industries studied. There was no effort to examine the indirect effects on, for example, the steel industry due to the tax on mining operations.

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[9] Coal, coke, and breeze; residual fuel oil; distillate fuel oil; LPG; natural gas; and other. Some subsidiary detail is given for the “other” category, which includes blast furnace gasses, wood wastes, and a variety of other industry-specific fuel sources.

2.2.4 Bottom-Up and Hybrid Modeling

The so-called bottom-up models refer to those that typically incorporate a detailed representation of technologies for energy supply and use. As a result, they are often referred to as engineering models. These models are used to identify the cost and energy-saving potentials of particular energy-efficiency technologies on a technology-by-technology and industry-by-industry basis. However, the adjustment costs associated with implementing the technologies are not always fully captured by the modeling framework, and linkages between economic decisions and between economic sectors may be weak. By contrast, the top-down models such as CGE and macroeconomic models concentrate on the economic linkages between sectors, but most have very primitive modeling of the process of technological change and productivity improvement (Wilson and Swisher 1993).

Given the relative strengths and weaknesses of bottom-up and top-down approaches, rather than competing, they can serve to complement each other. Because of the difficulties in linking models originating from two different disciplines, only a few studies have attempted such hybrid approach. An early study is the linking of MENSA (Australian regionalized version of MARKAL) and an input-output study MERG in James et al. 1986. Another good example of linking a simplified bottom-up model is the HERMES-MIDAS model (Capros et al. 1990).

While the hybrid approach is able to shed more light on the technological aspect of the carbon emissions, it has some drawbacks. In order to obtain consistent linking results, the hybrid approach needs to remove all the inconsistencies between the two models, which is time-consuming, cumbersome and often necessitates use of simplified versions. Nevertheless, the integration of top-down and bottom-up models remains a promising approach for further work.

2.3 LIMITATIONS OF PREVIOUS STUDIES

Except for IO models, simple passthrough models, and a few large commercial macroeconomic models with imbedded IO models, previous studies of environmental tax reform have generally been limited to fewer than thirty-five economic sectors. As discussed above, this level of detail virtually necessitates that carbon, energy, or pollution intensity per dollar of output will vary within economic sectors by a factor of ten or more. For purposes of assessing the competitive burden on individual industries, these errors, necessitated by the use of a high level of aggregation, are unacceptably large.

Similarly, studies that assume that fuels and electricity sell to all industries at a uniform price will underestimate tax burdens on energy-intensive industries, relative to low-pollution industries, by a factor of two to four. For purposes of assessing the distribution of burden of an ETR, these errors are unacceptably large, even when compared to the substantial interindustry variation in fuel purchases in dollars.

Finally, many studies of the impact of pollution or energy taxes on the economy have either failed to return the revenue to households or have done so in lump-sum fashion, rather than by reducing distorting taxation. This approach highlights the economic burden of pollution and energy taxation without allowing for potential alleviation by revenue recycling.

The current study achieves a high level of disaggregation (498 sectors) and so captures major intersectoral differences. Fuels and electricity are measured in physical units and no uniform price assumption is imposed. It captures the distributional effects of both the pollution and energy tax and the offsetting tax decreases. The entire economy is studied. Direct tax burdens are estimated based on the use of the taxed factor, and indirect burdens are estimated using the IO methodology.

However, the current study does not capture behavioral changes caused by the tax increases and decreases, nor does it attempt to measure the increases or decreases in economic distortion caused by ETR. It is the view of the author that for tax changes of the modest level studied here, these effects are small relative to the distributional effects.

3. DESCRIPTION OF TWO MODEL ETR PROPOSALS

This paper will analyze two versions of environmental tax reform. These two simplified proposals should be regarded as illustrative of major tendencies in the tax reform debate. They do not represent the richer and more nuanced proposals that generally emerge from the complex balancing of interests and needs by the legislative process. Both start with a broad-based tax on pollution and energy. The first returns the revenue from that tax by means of a reduction in the tax on labor; the second, with a reduction of tax on capital. Both proposals are revenue-neutral; that is, all revenue raised through the pollution and energy tax is returned through reductions in other taxes. The next three subsections will describe the tax changes we have modeled: the pollution and energy tax, the labor tax cut, and the capital tax cut.

3.1 THE POLLUTION AND ENERGY TAX

The tax we will analyze, which we will refer to as the "pollution and energy tax" or PET, is a hybrid tax on fossil fuels and on other energy sources that present serious environmental concerns. The PET is a broad-based tax on air pollution in the form of a general tax on the carbon content of fossil fuels of $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, sustainably 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).

In addition, we impose an equalizing charge on electricity generated from nuclear and large-head hydropower, equal to the average rate on fossil-generated electricity. The reason for this equalizing charge is threefold. First, the mix of fuels used to generate electricity is quite different from state to state, and a tax on fossil energy alone would raise substantial issues of interstate equity. Second, most broad-based pollution and energy tax proposals that have been enacted or introduced as legislation in the industrialized countries have in fact included such charges, perhaps because of regional equity concerns (see, for example, Muller 1996; Hoerner and Bosquet 2000). Finally, although hydropower and nuclear energy do not produce air pollution, they are associated with their own environmental risks, which are difficult to compare with the risks of burning fossil fuels. Most advocates of pollution taxes do not wish to provide an incentive to shift from fossil generation to the construction of new nuclear or hydroelectric plants. We therefore include an equalizing charge to level the playing field between fossil and nonfossil conventional generating technologies.

3.2 THE LABOR TAX REDUCTION

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. For purposes of this paper, we assume that the labor tax cut takes the form of a "zero bracket" in the payroll tax, that is, that the taxpayer will pay no payroll taxes on wages earned up to the zero bracket amount. The reader should not take this particular form of labor tax cut too seriously. Rather, it represents a family of alternative tax reductions on labor income or human capital investment that would have qualitatively similar economic and distributional consequences.

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 actual ETR proposals around the world have used pollution tax revenues to cut labor taxes (Hoerner and Bosquet 2000).

3.3 THE CAPITAL TAX REDUCTION

The capital tax reduction modeled here is a general proportional reduction in taxation on all forms of return to ownership, regardless of firm organization. This includes profits, whether retained or distributed; interest payments; rents; royalties; and the like.

Like the labor tax cut, the capital tax cut is intended to return the PET revenue to the economy by cutting distorting taxes. Some economists believe that the tax on capital is more distorting than the tax on wages. It has also been suggested that a cut in the tax on returns to investment would stimulate increased savings, and that this in turn would lead to increased economic growth. However, as discussed in section 2.2.1, the magnitude of this savings effect remains controversial.

4. METHODOLOGY

4.1 INTRODUCTION

The basic approach of this paper is to estimate the pollution and energy tax increase and the labor and capital tax decrease on an industry-by-industry basis for all of the 498 industrial categories contained in the BEA's 1992 benchmark IO table (Lawson 1997a, 36–85; 1997b, 22–47). The IO table is updated to 1995 using data from the smaller (185-category) IO tables prepared annually by the Department of Labor. The updated IO table is then used to estimate the indirect burden of the tax changes on each of the 498 industries. The total tax burden is taken as the sum of the direct and indirect burden.

The total tax burden estimates are divided by the value of production for each industrial category to yield estimates of the percentage change in each category's output price. For estimates done under the assumption that the incidence of the tax cut is on inputs (that is, paid by workers or investors), the change in output prices is compared to the change in incomes to estimate the real price change for each industrial category.

These price changes are then used to assess the distribution of an ETR across industries. For purposes of this analysis, the size of affected industrial categories is measured two different ways: by value of output and by employment.

Finally, the price changes are used to construct an index of the impact of these ETR on U.S. competitiveness and an index of the impact on the balance of trade. These indexes are used to assess the desirability of using border tax adjustments to offset the competitive burden of the ETR on pollution-intensive industries.

The remainder of this section provides more detail of how these analyses were performed.

4.2 DATA SOURCES AND UPDATING

This study relies primarily on three types of data: benchmark and annual input-output tables, industrial energy consumption data, and employment data. These data sources are described below.

4.2.1 Input-Output Tables and Updating

Every five years, the Bureau of Economic Analysis (BEA) of the U.S. Department of Commerce publishes baseline input-output tables (Lawson 1997a, 36–85; 1997b, 22–47). The baseline tables disaggregate the U.S. economy into 498 industries and are available in two versions with slightly different industry classification systems, the Standard Industrial Classification (SIC) system and the input-output (IO) classification system. The SIC versions of the tables were used. IO tables are generally published about five years later than the date of the economic census to which they correspond. These censuses take place in years ending with a "2" or a "7."

The choice of 1992 as a base year is unfortunate for a number of reasons. It is old enough that nontrivial changes in energy and carbon intensity have taken place in the major economic sectors. In addition, 1992 was a recession year. Although the energy-output ratio (measured in physical units) is not terribly sensitive to cyclical effects, the labor-output ratio in a recession year tends to be higher than normal (because firms are hesitant to lay off skilled workers in response to temporary downturns), while the capital-output ratio is lower than normal as profits tend to fall faster than output in a downturn.

In response to these concerns, we updated the BEA baseline IO table using the annual IO tables published by the Department of Labor (BLS 1997). The Bureau of Labor Statistics (BLS) publishes tables disaggregated at the 185-industry level. We assigned each industry in the 1992 baseline IO table to a category of the 1995 BLS table using unpublished tables of correspondences from the BLS. Each total output for an industry or commodity in the baseline IO table was then multiplied by the ratio between the corresponding industry or commodity total in the 1995 BLS table over the corresponding industry or commodity total in the 1992 BLS table. The full 1992 baseline IO table was then updated using the standard RAS balancing method. The same approach was used for the capital and labor value-added totals, based on unpublished value-added subtotals used to produced the published BLS value-added total.

4.2.2 Energy and Carbon Consumption Data

This paper draws primarily on three sources of energy data: energy purchases by industry in the input-output tables, measured in dollars; the official U.S carbon emission estimates by sector and fuel type published by the Energy Information Administration (EIA) of the U.S. Department of Energy; and energy purchases by manufacturing industries, in physical units, drawn from the Manufacturing Energy Consumption Survey (MECS) of the EIA. The input-output data are discussed in the previous section.

The Energy Policy Act of 1992 required the Energy Information Administration (EIA) of the U.S. Department of Energy to prepare a report of aggregate U.S. carbon dioxide and other greenhouse gas emissions over the 1987–90 period, with annual updates thereafter. The 1997 annual report includes corrected annual greenhouse gas emissions in five broad sectors—residential, commercial, industrial, transportation, and electric utilities—from 1980 through 1997 (EIA 1998a). For each sector, there are separate estimates for the consumption of each major fuel or energy type in physical units. These estimates are derived from the EIA's State Energy Data System (EIA 1997b), which in turn is based on annual surveys of fuel and energy dealers. The EIA's annual emission reports form the basis for the official U.S. reports on greenhouse emissions to the Conference of Parties of the Framework Convention on Climate Change. We used the greenhouse gas report (EIA 1998a) fuel estimates by sector, adjusted as described in section 4.3.2.3, and also the carbon coefficients by fuel type from the same source.

The industrial sector includes manufacturing, mining, agriculture, and construction, Standard Industrial Classifications (SICs) 1–39. Fuels used to generate electricity by nonutility power producers (NPPs)—consisting of co-generators, which produce electricity as a byproduct of other manufacturing activities, and independent power producers (IPPs)—are reported as consumed in the industrial sector. The transportation sector includes both residential and business transportation. Fossil fuels used by the residential transportation sector are separately reported by the EIA's Residential Transportation Energy Consumption Survey (RTECS) (EIA 1996).

Data on fuel use by manufacturing industries were taken from the EIA's Manufacturing Energy Consumption Survey (MECS) (EIA 1997a). The MECS is based on a survey of manufacturing establishments and is drawn from the same sample as the BEA's Annual Survey of Manufactures. It reports fuel and electricity consumption at the two-digit SIC level for the entire manufacturing sector and at the four-digit level for the forty most energy-intensive four-digit manufacturing industries. The MECS distinguishes fuel from nonfuel (feedstock) uses of fossil fuels in manufacturing and reports both.

In addition to these major sources of energy data, a variety of sector-specific data were used for such purposes as distinguishing residential motor fuels from commercial motor fuels and estimating electricity production and fuel use by co-generators and independent power producers. Most of this data were from various EIA sectoral publications. These sources will be described as needed in the section on sectoral fuel controls below (section 4.3.2.3).

4.2.3 Employment and Capital Data

Employment data for 1995 were available for the 185 industries in the 1995 BLS IO tables (BLS 1997). We then divided the number of employees in these BLS industries among the BEA sectors using as weights their wage compensation component of the value added from the 1992 baseline IO table.

Total capital earnings for each industry were taken from the value-added row of the 1992 BEA baseline IO table, updated to 1995 by the procedure described in section 4.2.1.

4.3 ESTIMATION OF INDUSTRIAL POLLUTION AND ENERGY TAX BURDENS

4.3.1 The Pollution and Energy Tax Burden: Direct and Indirect

Recall that the pollution and energy tax modeled here has two parts: a tax on the carbon content of fossil fuels, and a tax on nuclear and hydroelectric power equivalent to the average charge on fossil electricity. In general, the burden of the PET 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 fossil fuels combusted by electric utility industry multiplied by the tax rate, plus a per kilowatt-hour charge on nuclear and large-head hydro power equal to the average per-kilowatt-hour charge for fossil electricity.

4.3.2 Imputation of Energy and Carbon Consumption in Physical Units

4.3.2.1 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 is 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.[10] 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, adjusted as described in section 4.3.2.3.

[10] 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 1997a). We use the EIA's greenhouse gas report methodology (EIA 1998a) 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.

4.3.2.2 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.[11]

4.3.2.3 Sectoral Controls | After estimating the consumption of each of the 498 industrial classifications for each fuel type using the imputation procedure outlined in section 4.3.2 (except for the transportation section, 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 EIA greenhouse gas report (EIA 1998a), 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.[12] The NPP category includes 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.[13] This is equivalent to assuming that

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[11] Econometric results for the fuel equations are available from the author.

[12] Fuel consumption and electricity delivery data for NPP were taken from Electric Power Annual 1995, volume II, table 53 (EIA 1996).

[13] 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

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 control totals. However, the sector was expanded to include IO transportation categories that provide only services connected with transportation and do not include actual transportation.[14]
- **Transportation**—Residential transportation emissions were subtracted from the transportation sector emissions, based on data from the EIA's Residential Transportation Energy Consumption Survey (RTECS).[15] The transportation sector constitutes only seven IO industrial categories and the transportation emissions were divided among the transportation sector IO classifications[16] using fuel consumption estimates from the Oak Ridge National Laboratory (Davis 1997, table 2.9), rather than the imputation formula described in the imputation section (4.3.2).
- **Electricity**—Emissions of nonutility power producers, which were subtracted from the manufacturing sector, were added to the electric utility sector[17] (for estimation method, see the discussion for the industrial sector above).[18] 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.

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electric generation for all NNPs, both co-generators and independent power producers. These fuel uses were converted to carbon using carbon coefficients from the SEDS utility sector (EIA 1997a), 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.

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

[15] 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. The GHG carbon content coefficients were used to calculate the resulting carbon dioxide emissions that were then subtracted from the transportation sector emissions reported in the GHG.

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

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

[18] 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.

4.3.3 Estimating the Indirect Burden of the Pollution and Energy Tax

Once the direct burden of the PET on each industrial classification is calculated, this is treated as an increase in indirect business taxes. The indirect burden of these taxes is calculated using an IO approach, under the assumption of a Leontief production technology (fixed relative factor input requirements) and constant returns to scale. Each industry has a direct tax burden based on the fuels and electricity it consumes. It also pays first-order indirect taxes on the fuels and electricity used to produce its inputs (fuel used to produce fertilizer consumed by the farming industry, steel consumed by the auto industry, and so on). These inputs—fertilizer and steel in the examples above—were in turn produced with equipment and chemical feedstocks that required fuels and energy to produce, resulting in third-order tax burden. Using IO matrix algebra techniques, it is possible to explicitly sum the infinite series of indirect tax burdens to a unique total burden. For a more detailed discussion of how this is done, see appendix section 9.1.

4.4 ESTIMATION OF DIRECT LABOR AND CAPITAL TAX CUTS BY INDUSTRY

The direct labor tax cuts for each industry are equal to the total labor tax cut (which in turn is equal to the revenue from the PET) times the labor share of that industry. The labor share is the percentage of the total national labor force employed by that industry. Employment for each of the 498 industries was determined as specified in section 4.2.3 above.

The direct capital tax cuts for each industry are equal to the total capital tax cut times the capital share of that industry. The capital share is the percentage of the total national payments to capital that accrue to that industry. Payments to capital for each of the 498 industries was determined as specified in section 4.2.3 above.

4.5 TAX INCIDENCE

Sections 4.3 and 4.4 explain how the direct burden of the pollution and energy tax increase and the labor and capital tax cuts are calculated. However, the final impact on each industry depends on assumptions about tax incidence—the way the tax flows through the economy.

For the pollution and energy tax, we assume that the tax burden is entirely passed through to consumers in the form of increased product prices. This is the most common assumption in the academic literature and is approximately the approach used by the U.S. Treasury’s Office of Tax Analysis and by the Joint Committee on

Taxation of the U.S. Congress.[19] The tax on a product includes both the tax on the fuels and energy directly used by that IO industry category, and also the fuels and energy used to produce the other materials that are inputs to the manufacturing process. For instance, the fuel used to produce automobiles includes the fuel used to make the steel used in cars. This can be extended back to the tax on fuel used to produce iron ore used to make steel, and so on. The IO methodology allows one to calculate all the indirect effects, however distant. See appendix 9.10 for a more detailed description of the working of the IO methodology.

For both the capital and the labor tax reductions, we analyze the impact of the tax reform on product prices using two different incidence assumptions, which we will call consumer incidence and input incidence. Consumer incidence is based on the assumption that industries are competitive and that taxes are part of the industry's cost of production. Under this assumption, the full benefit of the tax reduction will be passed forward to reduce product prices in a manner precisely analogous to the way that the pollution and energy tax increases product prices.

Input incidence is based on the assumption that taxes on inputs to production such as labor and capital are born by workers or investors, respectively. Under this assumption, tax cuts result in higher income for the persons receiving the cut instead of lower prices for goods. This increment to income is assumed to be spent in proportion to current aggregate national spending patterns.[20] A uniform increase in income coupled with an equal uniform increase in prices is effectively a wash—it has no economic effect.[21] The real (inflation-adjusted) change in the price of each good is therefore the percentage change in the price of the good less the percentage increase in income.

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[19] For purposes of distributional analysis by income class, the OTA and JCT assume that all energy taxes paid by industry are passed through to final consumers. However, they generally assume that such taxes cause a uniform increase in product prices, rather than doing an industry-by-industry analysis as we do here. The aggregate result for consumers is the same under our approach as theirs. It should be observed that, were we analyzing distribution by income class rather than by industry category, our approach would be more accurate than that of the OTA and JCT because the relative share of energy-, capital-, and labor-intensive goods in consumption is not constant across income classes. See, e.g., Bullard and Herendeen 1975; Casler and Rafiqui 1993.

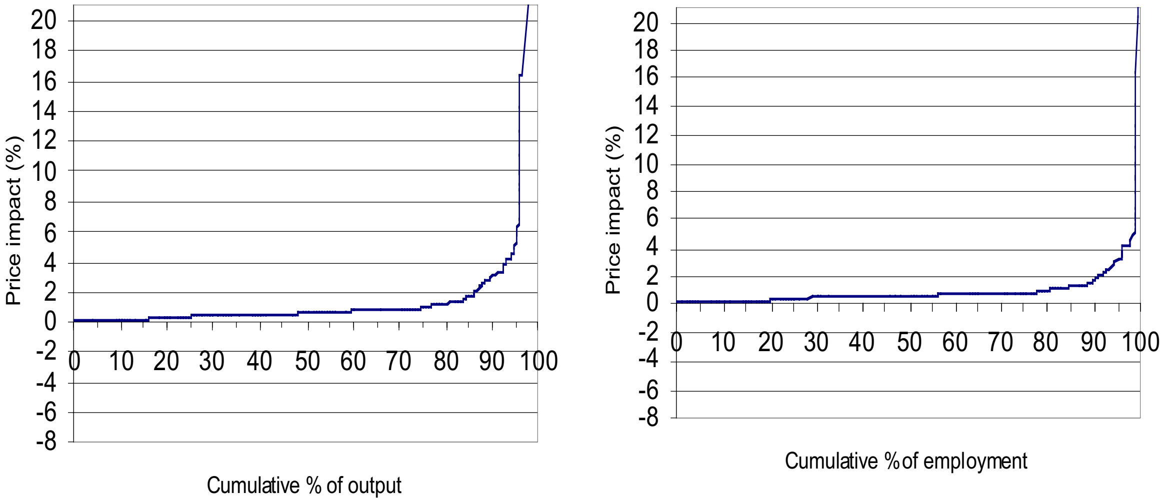
[20] In this study we have made no effort to adjust the distribution of this spending for different consumption patterns between recipients of capital and labor income.

[21] Except for possible macroeconomic effects from money illusion or sticky prices.

5. THE EFFECT OF ENVIRONMENTAL TAX REFORM ON INDUSTRY

The distribution of direct and indirect PET burden by industry as a percentage of output value is shown in chart 1, below. Given our assumption that the PET is passed through to the final consumer, these percentages can be interpreted as percentage changes in the price of the industries' products, and this is the interpretation we will follow henceforth. The left-hand graph shows the industrial distribution of price impacts from the PET against the cumulative output of industries measured by value of production. So, for example, the graph crosses the 2 percent price increase line at about 87 percent of cumulative output. This means that 87 percent of the value of national production is produced by industries that would pay a PET equal to 2 percent or less of their total costs. The right hand graph is similar except that the fraction of industry is measured by employment. Here the graph crosses the 2 percent price change line at about 92 percent. This means that 92 percent of workers are in industries that would pay a PET of 2 percent or less of their total costs.

CHART 1: **EFFECTS OF A POLLUTION AND ENERGY TAX (PET) ALONE**

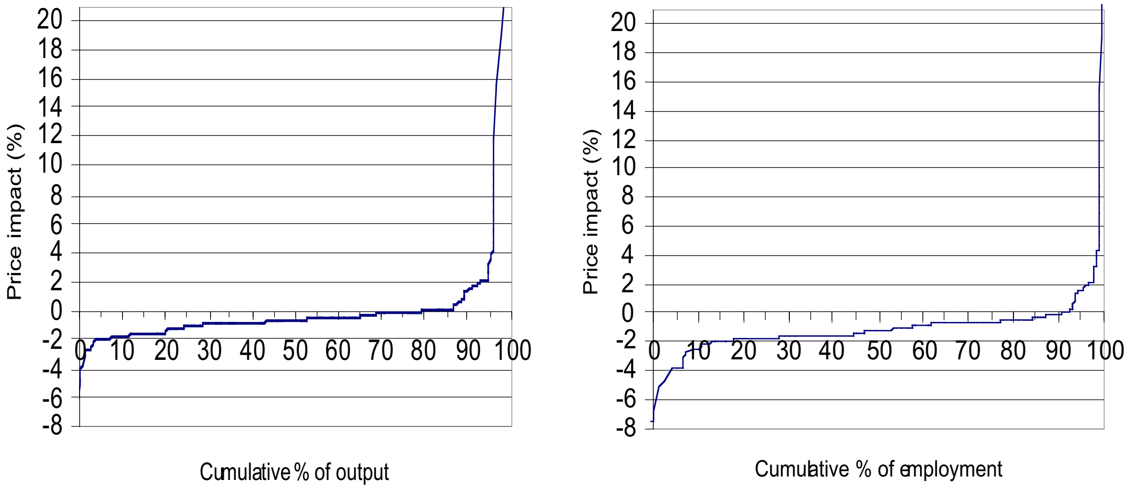


Note: Industries above the price cutoff are coal, oil, gas, and natural gas. See table A2 in appendix for the price import on these industries.

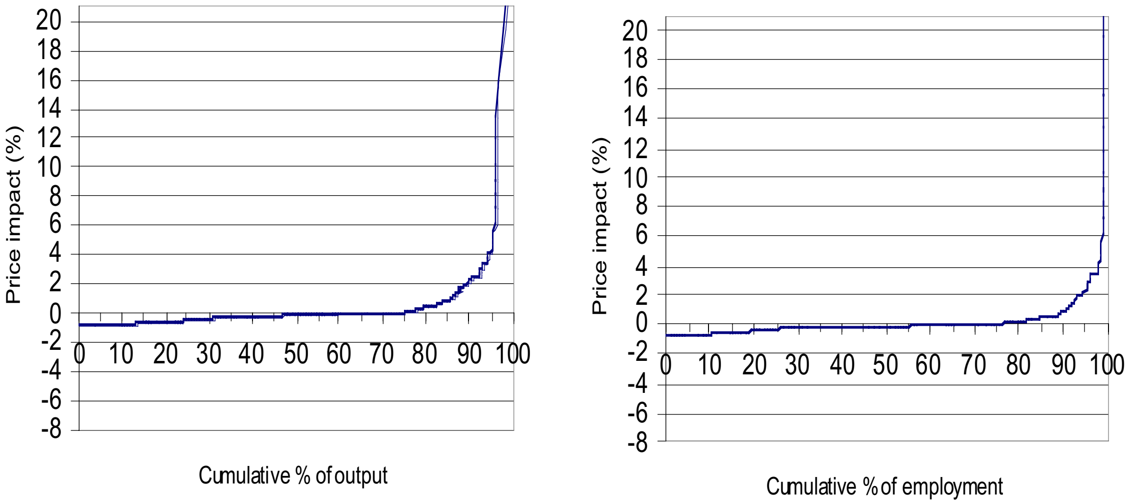
Industries above the price cutoff on the right of each graph are the fossil fuel industries: coal, oil, and gas. The industries with burdens of between 14 and 21 percent are all electric utilities, both public and investor-owned.

CHART 2: **EFFECTS OF ETR WITH A LABOR TAX CUT**

Consumer Incidence for Tax Cut



Worker Incidence for Tax Cut



Note: Industries above the price cutoff are coal, oil, gas, and natural gas. See table A2 in appendix for the price import on these industries.

The distribution of benefits and burdens under a labor-oriented environmental tax reform are shown in chart 2. The upper section in chart 2 shows the distribution under the assumption that the labor tax cut will be passed on to consumers through reductions in product prices, while the lower section shows the distribution under the assumption that the labor tax cut will be passed back to workers in the form of higher incomes.

The general pattern of the results shown by chart 2 was described in the introduction. A substantial majority of all industries receive a net tax cut under any of the tax reforms. However, the most-benefited industries receive a tax cut that is smaller in percentage terms than the tax increase that the most-burdened industries receive. A list of the most-burdened industries and the percent change in price for each can be found in table A2 in the appendix (section 9.2). Lists of the industries receiving the largest net benefits from the labor tax reduction under the labor and consumer incidence assumptions can be found in the appendix, tables A3 and A4, respectively (section 9.2).

Under both incidence assumptions, the percentage of net winners is larger when measured by industry employment than when measured by industry value. For the breakeven points (the percentage above which the ETR is a net burden and below which the ETR is a net benefit) see table 1 in the introduction.

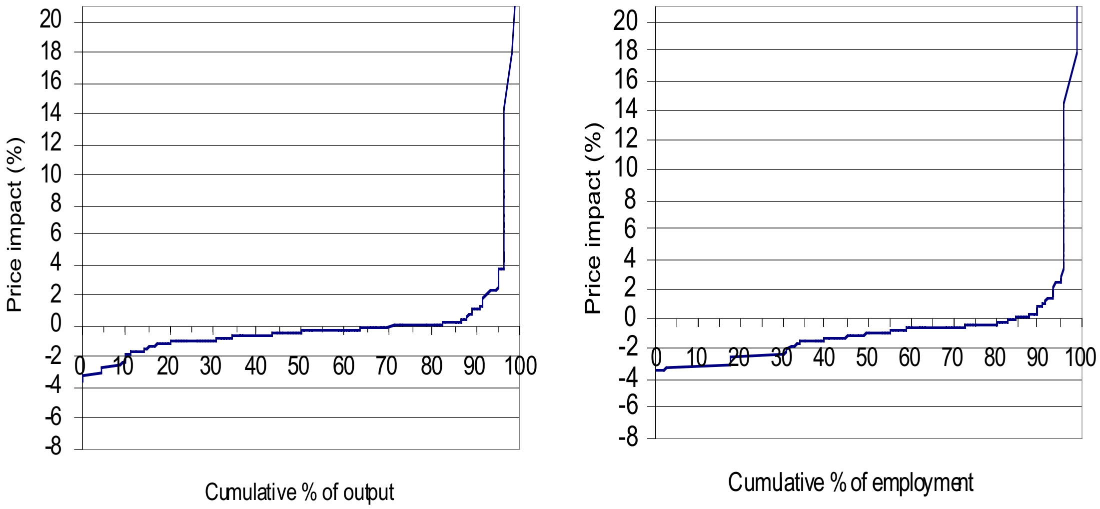
Chart 3 shows the overall distribution of benefits and burdens for a capital-oriented environmental tax reform. Again, the results for consumer incidence are shown in the upper section and the results for capital incidence are shown in the lower section.

Qualitatively, overall distribution of the capital-oriented ETR results are quite similar to the distribution for a labor-oriented ETR. Because energy-intensive industries tend to be capital-intensive as well, there are slightly fewer net winners under a capital-oriented shift, while industries with net burdens tend to have burdens which are slightly smaller. But these effects are modest.

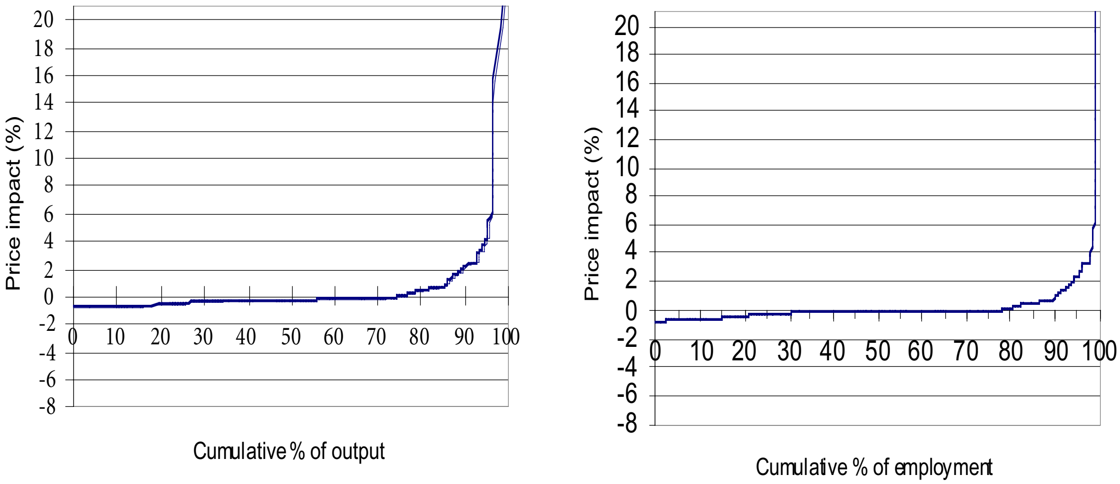
However, it should also be observed that, under the consumer incidence assumption, the similarity in the overall distribution of burdens and benefits can hide significant difference in the precise distribution of benefits to firms. This can be seen by comparing the list of industrial classifications receiving the largest net benefits under a labor tax cut (table A4 in the appendix) with the list of industrial classifications receiving the largest net benefits under a capital tax cut (table A5). Note that this is less true under the assumption of incidence on inputs. When the tax reduction is passed back to suppliers of capital or labor inputs and then spent, the resulting distribution of price changes across industrial classifications is virtually identical for the two tax cuts. In part, this is an artifact of our failure to differentiate

CHART 3: **EFFECTS OF ETR WITH A CAPITAL TAX CUT**

Consumer Incidence for Tax Cut



Capital Incidence for Tax Cut



Note: Industries above the price cutoff are coal, oil, gas, and natural gas. See table A2 in appendix for the price import on these industries.

the consumption patterns of the recipients of capital and labor income. However, it remains the case that under an input incidence assumption the difference between labor and capital tax cuts lies primarily in a different distribution of benefits across individuals. The distribution of impacts on industrial output prices are similar for the two taxes.

6. TRADE AND COMPETITIVENESS IMPLICATIONS OF THESE ETR

In order to better assess the aggregate impact of these environmental tax reforms on U.S. trade and competitiveness, we have studied the impact of such reform on the price of traded goods. We have constructed two indexes of the impact of these ETR on the aggregate price of traded goods: the price of traded goods weighted by export volume of each good, and the price of traded goods weighted by the total trade of each good (exports plus imports). In both cases the price change is expressed as a ratio to prices without the environmental tax reform. The former measure is intended to capture the aggregate impact of these ETR on the competitive position of U.S. exports in world markets, while the latter is intended to indicate the impact of these ETR on the U.S. balance of trade. We therefore refer to them as the competitiveness index and the balance of trade index, respectively.

The last row of table 3 shows the competitiveness index for each of the tax reform scenarios under each of the incidence assumptions. For all the ETR proposals, the impact on trade is small—less than 0.5 percent. For both labor and capital tax cuts, the ETR results in a slight overall improvement in competitiveness under the assumption that incidence is on the consumer and a slight worsening of competitive position under the assumption that incidence is on input factor suppliers.

Essentially all existing U.S. federal and state taxes on the consumption of fossil fuels and electricity, such as motor fuel taxes or consumer electricity excise taxes, have border tax adjustments (BTAs). BTAs impose the U.S. or state tax on fuels or electricity that are imported into the United States, and, when fuels are exported, provide a rebate of fuel taxes previously paid on those fuels. BTAs are a nearly universal feature of fuel consumption taxes around the world. Examples of other taxes with BTAs include sales taxes, taxes on alcoholic beverages, the ozone-depleting chemicals tax, value-added taxes common in Europe, and many more. BTAs are a common feature of consumption taxes of every sort and are not considered to be tariffs or a form of protectionism. They are explicitly allowed by the General Agreement on Tariffs and Trade (GATT) (as amended by the Uruguay Round Amendments, which created the World Trade Organization [WTO]),[22] provided that

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[22] Final Act Embodying Uruguay Round of Multilateral Trade Negotiations, Marrakech 15 April 1995, entered into force 1 January 1995.

the tax imposed on imports is no greater than the domestic tax[23] and the rebate of tax on export is no greater than the tax previously paid.[24]

TABLE 3: PRICE CHANGE FOR TRADED GOODS: COMPETITIVENESS INDEX (Export Weights)

BTAs for industries with price increase greater than:	Border Adjusted Industries		PET only (percent)	Labor Tax Cut		Capital Tax Cut	
	Number of industries	Proportion of Total Output (percent)		Worker incidence (percent)	Consumer incidence (percent)	Capital incidence (percent)	Consumer incidence (percent)
2%	89	13.14	0.51	-0.29	-1.21	-0.25	-0.83
3%	45	8.72	0.76	-0.04	-0.63	0.00	-0.59
4%	30	5.87	0.88	0.08	-0.50	0.12	-0.46
5%	22	3.43	0.97	0.17	-0.42	0.20	-0.38
Fossil fuel only	7	2.89	1.19	0.39	-0.19	0.43	-0.15

This paper assumes that there will be BTAs on fuels and energy themselves. We also explore BTAs on the pollution and energy tax paid by industries producing pollution- and energy-intensive goods. BTAs improve the competitiveness of U.S. exports by removing the U.S. tax paid on exported products. They also reduce the competitive advantage of pollution-intensive foreign products in U.S. markets by ensuring that they pay the same taxes that U.S. producers do. The benefits of the tax cuts are not eliminated by BTAs because there are no BTAs on labor and capital taxes. (There are currently no BTAs on U.S. payroll and income taxes, and BTAs on these taxes are illegal under GATT).

The administrative burden of placing BTAs on all products would be very high. We assume that they are applied only to products with price increases greater than some threshold level. For instance, we might apply them only when the PET is 3

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[23] GATT Art. III:2. "The products of the territory of any contracting party imported into the territory of any other contracting party shall not be subject, directly or indirectly, to internal taxes or other internal charges of any kind in excess of those applied, directly or indirectly, to like domestic products. Moreover, no contracting party shall apply internal taxes.... to imported or domestic products in a manner contrary to the principles set forth in paragraph 1." The referenced language in Art. III:1 provides that internal taxes "should not be applied to imported or domestic products so as to afford protection to domestic production."

[24] Ad Article XVI, provides that certain BTAs on exports are not subsidies. It states: "The exemption of an exported product from duties or taxes born by the like product when destined for domestic consumption, or the remission of such duties or taxes in amounts not in excess of those which have accrued, shall not be deemed a subsidy."

percent or more of the output price.[25] Table 3 shows the impact of BTAs on the competitiveness of U.S. exports for various threshold levels of application. We find that BTAs on the 45 industries (38 industries other than fuels and electricity) with price impacts of 3 percent or more (representing 9 percent of the value of U.S. production and less than 4 percent of U.S. employment) would suffice to ensure that the net impact of the ETR on competitiveness is positive, regardless of the choice of tax cut or incidence assumption. For some combinations of tax cut and incidence assumption, the same effect can be achieved with BTAs on a smaller number of industries.

The last row of table 4 shows the balance of trade index for each of the tax reform scenarios under each of the incidence assumptions. The impact of the ETR on balance of trade is ambiguous and depends on the incidence assumption. It is small but favorable if incidence is assumed to be on input factors, and larger but unfavorable if incidence is assumed to be on consumers. A labor-oriented ETR has a slightly more positive effect on trade than a capital-oriented ETR.

TABLE 4: **PRICE CHANGE FOR TRADED GOODS: BALANCE OF TRADE INDEX (Total Trade Weights)**

BTAs for industries with price increase greater than:	Border Adjusted Industries		PET only (percent)	Labor Tax Cut		Capital Tax Cut	
	Number of industries	Proportion of Total Output (percent)		Worker incidence (percent)	Consumer incidence (percent)	Capital incidence (percent)	Consumer incidence (percent)
2%	89	13.14	-1.62	-2.42	-3.26	-2.38	-3.00
3%	45	8.72	-1.21	-2.02	-2.85	-1.98	-2.59
4%	30	5.87	-1.02	-1.82	-2.66	-1.78	-2.40
5%	22	3.43	-0.87	-1.67	-2.51	-1.63	-2.25
Fossil fuel only	7	2.89	2.67	1.86	-0.40	1.90	-0.14

Border adjustments of even a few industries suffice to ensure that the overall effect of ETR on the balance of trade is favorable. Border adjustments on 22 industries (15 nonenergy industries)—accounting for only 3.5 percent of U.S. production—suffices to ensure a positive overall trade impact regardless of the choice of tax cut and incidence assumption.

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25. A similar threshold approach was used in the version of the BTU tax bill that passed the U.S. House of Representatives.

7. CONCLUSION

Environmental tax reform—reducing taxes on productive work and investment by shifting the tax burden onto things we wish to discourage, such as pollution—is an emerging trend around the world. Support for such an approach has stalled in the United States, largely because of business concerns that such a tax reform could hurt U.S. competitiveness and cost jobs. This paper suggests that a substantial majority of U.S. industry—73 to 80 percent by value, employing 78 to 92 percent of U.S. workers—would be net beneficiaries if the revenue from a pollution and energy tax were used to cut either labor taxes, capital taxes, or a combination of the two.

However, it is also clear from these results that certain industries could be harmed by such a reform. Fossil fuel industries would see large price increases that would ultimately lead to significant reductions in sales. In addition, a small but important group of energy-intensive of industries, mostly in mining and the production of bulk metals, chemicals, and ceramics, would also suffer substantial price increases. These industries could be significantly harmed unless special policies were adopted to meet their concerns.

We examine one approach to addressing the concerns of pollution- and energy-intensive industries: border tax adjustments. We find that border tax adjustments on roughly 20 to 40 of the 498 industries in our model would be sufficient to ensure that both the overall competitiveness of U.S. industry in world markets and the balance of trade would be improved by an environmental tax reform. This conclusion holds true regardless of whether labor or capital taxes are lowered and regardless of the choice of incidence assumption.

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9. APPENDIX

9.1 INPUT-OUTPUT METHODOLOGY

Consider a simple economy consisting of a manufacturing sector, a commercial sector, a transportation sector, and an energy sector. Each sector purchases manufactured goods, commercial goods, and energy, denominated in dollars. In addition, each sector purchases labor, pays a return to invested capital (stocks, bonds, loans, partnership shares, and so on), and pays taxes. The sum of these purchases and payments equal the total revenue expenditures of the firm. Suppose, for example, that the industrial sector, in order to produce its output in 1995, had to purchase $1,552 billion worth of industrial products, $607 billion worth of commercial services, $92 billion worth of transportation services, and $78 billion worth of energy. These interindustry purchases may be regarded as purchases of materials. In addition, the industrial sector has to pay wages, profits, and other payments to capital (including corporate income tax) and indirect business taxes. The latter purchases are collectively referred to as "value added," because they represent the increment to value above the cost of materials. The various payments for requirements of the industrial sector are arranged in the first column of table A1, and the similar requirements of the commercial, transportation, and energy sectors are arranged in the second, third, and fourth column. The numbers in table A1 are chosen to roughly approximate the U.S. economy in 1995.

Now let us ask, not what the industrial sector buys, but rather what it sells. Once again, it sells a certain amount of product to itself, as steel mills sell to auto makers, and so on. Obviously, industry sector sales to itself are the same, $1,552 billion, as the industry sector purchases from itself mentioned above. But it also sells products to other industries, to households, to the government, and to other countries (exports). Sometimes exports are less than imports, and net exports are negative. The sum of all the sales to households, government, and exports are called "final demand." Interindustry sales plus final demand equal the total output from an industry, measured in dollar terms. With the addition of the final demand columns, table A1 becomes a schematic of the entire U.S. economy, representing all the major market flows.[26]

TABLE A1: **A SCHEMATIC INPUT-OUTPUT REPRESENTATION OF THE U.S. ECONOMY, 1995 ($ billion)**

	Industrial Requirements	Commercial Requirements	Transportation Requirements	Energy Requirements	Private Purchases	Government Purchases	Net Exports	Total FD	Total Sector Sales
Industrial Sales	1,552	438	23	20	1,914	388	-235	2,067	4,100
Commercial Sales	607	1,681	95	52	3,546	699	140	4,383	6,818
Transportation Sales	92	76	72	14	108	25	48	181	435
Energy Sales	78	88	26	137	123	30	-47	107	435
Total Sector Purchases	2,329	2,283	216	223					
Value Added	1,772	4,536	220	213				6740	
Total Expenditure	4,100	6,818	435	435					

By an accounting identity, the sales of an industry are equal to its purchases. This is because profits in a given year are defined as revenues (all sales) less costs (all purchases except for profits). Thus, for any given industry, the column sum equal the row sum, as can be seen in the table above. As a result, the aggregate of the sales of all industries equals the aggregate of the purchases of all industries. Finally, consider that the sum of all the interindustry transactions (the numbers in bold in the table). This sum can be called either interindustry sales or interindustry purchases and was equal to $5,051 billion in 1995. Note that total final demand equals total the sum of sector sales minus interindustry sales. Similarly, total value added equals the sum of sector purchases minus interindustry purchases. But because aggregate interindustry sales

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[26] Note that valuable services that do not flow through the market, such as the value of home production and the services provided by nature, are not included in this table.

equal aggregate interindustry purchases, this implies that total value added equals total final demand. Or to put it another way, total payments (to capital, labor, and government [taxes]) are equal to total purchases (by workers, capital owners, and government) plus net imports. This aggregate quantity, $6740 billion, shown in the lower right-hand corner of the table, is the gross domestic product (GDP).

The sum of emissions associated with each IO category's consumption of electricity, coal, natural gas, and petroleum products (adjusted for nonfuel use) can be referred to as "direct" taxable emissions associated with that sector's production. However, this approach does not take into account the effect of tax on emissions that are already embodied in other inputs to production. For example, agriculture production requires not only energy inputs (diesel for farm equipment and the like) but also fertilizers. In turn, the production of fertilizers requires large energy inputs and hence emissions.

Think of a product as being manufactured from inputs that consist of the products of other industries, labor services, capital services, and so on—the elements of the columns in table A1 above. Suppose that the amount of each of these inputs that is required to produce a unit of output is fixed. These per-unit unit requirements can be easily calculated by dividing each column through by the total level of output. Call the resulting technical coefficients a_{ij}, where i is the producing industry (the row in the table above) and j is the industry supplying the necessary input to production (the column in the table above). The total output of industry j, which we will call X_j, consists of two parts: the output that goes to consumers, government, or net export (the final demand for industry j, which we shall call Y_j) and the output that goes to industries as inputs to production. Therefore,

$$X_1 = Y_1 + (a_{11}X_1 + a_{12}X_2 + \ldots + a_{1n}X_n)$$

$$X_2 = Y_2 + (a_{21}X_1 + a_{22}X_2 + \ldots + a_{2n}X_n)$$

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$$X_n = Y_n + (a_{n1}X_1 + a_{n2}X_2 + \ldots + a_{nn}X_n)$$

or equivalently,

$$X_1 - (a_{11}X_1 + a_{12}X_2 + \ldots + a_{1n}X_n) = Y_1$$

$$X_2 - (a_{21}X_1 + a_{22}X_2 + \ldots + a_{2n}X_n) = Y_2$$

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$$X_n - (a_{n1}X_1 + a_{n2}X_2 + \ldots + a_{nn}X_n) = Y_n$$

If we let A be a matrix of the technology coefficients, and X and Y be column vectors of the X_js and the Y_js respectively, and I be the identity matrix (the n x n matrix with ones on the diagonal and zeros elsewhere) then the last system of equations can be compactly expressed as:

$$(I-A)X = Y$$

It is then possible to calculate the total output of all commodities X required to produce any specified final demand vector Y by:

$$X = (I-A)^{-1}Y$$

The matrix $(I-A)^{-1}$ is referred to as the Leontief inverse or as the total requirements matrix (T). The latter designation is inspired by the fact that each element of the matrix is the total amount of input i that is required, directly *or indirectly,* to produce a unit of output j.

The calculation of direct and indirect requirements can also be illustrated by a more intuitive approach. Following Proops et al. (1993), we note that in order to satisfy a final demand vector Y, the economy has to produce not just the vector of final goods but also the intermediate goods used in producing these final goods. The first-round indirect requirement is the production necessary to allow the production of the final demand vector Y. This is simply AY. The second-round indirect requirement is the production necessary to allow the production of the first-round indirect requirement vector AY. This is $A(AY)=A^2Y$. By similar reasoning the third-round requirement is $A(A^2Y)= A^3Y$.

Therefore, the total output of the economy needed to satisfy a final demand vector Y is:

$$X=Y+AY+ A^2Y+ A^3Y+ A^4Y+ A^5Y+ \dots\ .$$

Using the identity matrix I, we can rewrite this expression as:

$$X=(I+ A+ A^2+ A^3+ A^4+ A^5+ \dots\ )Y$$

However, the two matrices $(I-A)^{-1}$ and $(I+ A+ A^2+ A^3+ A^4+ A^5+ \dots\ )$ are equal to each other[27] and our previous result holds.

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[27] The equivalence of these two matrices is just a straightforward extension of the scalar geometric series sum; recall that for a scalar b, satisfying $-1<b<1$, we can write $1/(1-b)=1+b+b^2+b^3+ \dots$ Similarly, there is a condition on the matrix A that has to hold. The precise condition is known as the Hawkins-Simon condition and is summarized in Hawkins and Simon 1949. However, as long as the technological matrix is derived from an input-output table that actually describes the operations of a "realistic" economy, then this condition is almost certain to be satisfied.

In the discussion above, we assumed each industry makes a single commodity. In using actual data, the construction of the total requirements matrix is somewhat more complicated because firms make products that fall in several industrial categories. Thus, it is necessary to start with separate tables consisting of the commodities each firm makes (the "make" table) and commodity inputs required by industry (the "use" table), which are compiled by the BEA. Construction of the total requirements matrix T from these tables is straightforward.[28]

The total requirements matrix has, in each row, the amounts of each industry output that are required per unit of that commodity output. Post-multiplying the total requirement matrix by the final demand vector gives a vector of the actual amounts of industrial outputs. The vector of the direct emissions can be interpreted as the demand for actual emissions vector. Hence, post-multiplying the total requirements matrix by this vector gives the vector of emissions that were necessary in the production processes that resulted in such direct emissions vector. In other words, it is the vector of total emissions that were necessary in producing the different commodities (that can be referred to as the total emissions vector). Dividing each element by the amount of that commodity produced results in a figure that gives the total emissions necessary per unit of final demand. If there is a carbon tax imposed (in per unit of carbon dioxide) and such tax is passed onto the consumers in the form of price increases, the exact amount of costs increase (for production of each commodity) is the overall carbon emissions per unit of final demand multiplied by the tax (in per unit of emissions units). Hence, the price increase vector is the total emissions vector normalized by the total output vector and multiplied by the carbon tax.

This approach is based on the standard IO formula for calculating price increases (Leontief price model) due to changes in indirect taxation (see for example Miller and Blair 1985, 351–354).

Various previous authors have observed that energy inputs do not have a uniform price across industries, and that consistent energy accounting requires appropriate accounting for energy losses in the energy transformation sectors. One solution to these problems is to work with IO matrices in hybrid units, with the energy

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[28] The industry by commodity total requirements matrix was constructed from the updated IO tables as follows:

$$T = V(Q^{-1})\,[\,I - U(X^{-1})\,V(Q^{-1})\,]^{-1}$$

where T is the total requirement matrix, V and U are the make and use matrices respectively, Q is a matrix with total outputs of each commodity on the main diagonal and zeros elsewhere and finally X is a matrix with total outputs of each industry on the main diagonal and zeros elsewhere. For derivation, see for example Miller and Blair (1985, 166–168). This formula incorporates the assumption that the total output of a commodity is provided by industries in fixed proportions; so-called industry-based technology assumption.

production and transformation sectors being measured in physical energy units and the rest of the economy measured in dollar units. This approach incorporates a consistent system of energy accounting based on the laws of thermodynamics within the energy sector and can avoid the errors caused by assuming energy prices are constant across industries (provided data on industrial energy consumption in physical units is available). The same methodology can be used to do IO analysis in hybrid carbon-dollar units. See, for example, Lenzen 1998 for an analysis of the Australian economy comparing a monetary to a hybrid approach. These hybrid approaches provide a considerable improvement in accuracy in assessing the energy and carbon content of products.

In this paper we employed a slightly different but essentially equivalent methodology. As described in section 4.3.2 above, we imputed fossil fuel consumption by industries in physical units, transformed those fuel units into carbon measures using the EIA carbon coefficients, and then multiplied this by the tax rate to yield the industry's tax in dollars. This tax is then treated as an indirect business tax and passed through to output prices using the standard IO approach for such taxes. In the electricity sector, taxable content (carbon, nuclear, and hydropower) is summed for the entire electrical sector. The purchase of electricity in physical units (kWh) is imputed to industries and the total tax to the electric sector is allocated to industries on a per kWh basis.

9.2 DETAILED TABLES OF RESULTS

Table A2 shows the total tax burden as a percentage of value of shipments for the 35 industries for which the pollution and energy tax is the highest (measured as a percentage of value of shipments). Tables A3 through A5 show, respectively,

the industries most benefiting under a labor-oriented environmental tax reform with labor incidence of the tax cut, the industries most benefiting under a labor-oriented environmental tax reform with consumer incidence of the tax cut, and the industries most benefiting under a capital-oriented environmental tax reform with consumer incidence of the tax cut. The distribution of industrial burdens under the capital tax/capital incidence case is similar to distribution for the labor tax/labor incidence case and is available from the author on request, as are results for other industries.

TABLE A2: **INDUSTRIES WITH HIGHEST PET BURDENS (percent)**

			Price Changes			
Industry Description	**Value of Shipments ($ million)**	**Employment (thousands)**	**Pollution and Energy Tax (%)**	**Labor ETR Passed Back (%)**	**Labor ETR Passed Forward (%)**	**Capital ETR Passed Forward (%)**
Coal	23,150	103.95	124.99	124.19	123.04	121.46
Natural gas distribution	51,107	135.61	32.95	32.15	26.70	26.38
Petroleum refining	144,638	104.50	24.47	23.67	23.43	23.49
Electric services (utilities)	184,738	496.30	20.30	19.50	18.98	17.81
State and local govt. electric utilities	23,070	86.20	16.40	15.59	15.31	14.31
Federal electric utilities	6,540	28.00	16.35	15.55	15.26	14.25
Lime	1,109	8.24	14.14	13.34	11.81	12.20
Electrometallurgical products, except steel	1,533	6.60	13.21	12.41	9.14	10.83
Primary aluminum	7,745	17.20	11.95	11.14	10.13	10.67
Cement, hydraulic	5,153	17.90	11.77	10.96	10.00	8.83
Iron, ferroalloy and miscellaneous metal ores	2,083	16.0	9.87	9.07	5.52	6.79
Products of petroleum and coal, n.e.c.	785	2.18	8.99	8.18	7.50	7.27
Carbon black	705	3.16	8.77	7.97	6.75	6.54
Chemical and fertilizer minerals	3,422	19.09	7.90	7.10	5.26	4.23
Asphalt paving mixtures and blocks	4,498	13.14	7.87	7.07	6.68	6.22
Crude petroleum and natural gas	72,715	161.90	6.84	6.03	4.03	1.32
Secondary nonferrous metals	8,097	5.96	6.42	5.62	4.18	4.82
Natural gas transportation	12,605	52.49	6.22	5.42	4.22	2.84

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TABLE A2—*CONTINUED*

			Price Changes			
Industry Description	**Value of Shipments ($ million)**	**Employment (thousands)**	**Pollution and Energy Tax (%)**	**Labor ETR Passed Back (%)**	**Labor ETR Passed Forward (%)**	**Capital ETR Passed Forward (%)**
Carbon and graphite products	1,666	10.90	6.22	5.42	4.35	4.68
Lubricating oils and greases	5,299	13.05	6.06	5.25	4.54	4.55
Clay, ceramic, and refractory minerals	1,790	9.27	5.89	5.08	3.90	3.44
Maintenance, petroleum, and natural gas wells	1,440	39.46	5.86	5.05	1.03	0.64
Nonmetallic mineral services and misc.	1,044	7.44	5.65	4.85	3.03	2.70
Minerals, ground or treated	2,067	19.38	5.13	4.33	2.63	2.61
Cold-rolled steel sheet, strip, and bars	7,086	4.75	5.10	4.30	3.13	3.76
Blast furnaces and steel mills	54,275	217.45	5.06	4.26	3.10	3.72
Steel pipe and tubes	6,610	4.91	4.89	4.09	2.95	3.55
Local transit and highway passenger transport	15,080	469.10	4.80	4.00	1.92	3.32
Asphalt felts and coatings	4,130	12.33	4.58	3.77	2.85	2.50
Water transportation	38,525	185.90	4.52	3.72	3.58	3.66
Brick and structural clay tile	1,231	11.41	4.47	3.67	2.42	2.46
Copper ore	3,538	19.64	4.29	3.49	1.41	1.79
Structural clay products, n.e.c.	146	1.49	4.17	3.37	1.95	2.08
Trucking and courier services, except air	183,006	1724.45	4.12	3.32	1.99	2.40
Clay refractories	996	7.90	4.08	3.28	2.02	2.35

TABLE A3: **MOST-BENEFITED INDUSTRIES LABOR ETR, LABOR INCIDENCE**

Industry Description	Value of Shipments ($ million)	Employment (thousands)	Price Changes Pollution and Energy Tax (percent)	Price Changes Labor ETR, Labor Incidence (percent)
Owner-occupied dwellings	526,982	0.00	0.00	-0.80
General govt. industry	700,323	1823.00	0.00	-0.80
Household industry	11,172	939.00	0.00	-0.80
Cigars	310	0.30	0.09	-0.71
Chewing and smoking tobacco and snuff	1,512	1.47	0.04	-0.76
House slippers	260	4.29	0.27	-0.53
Leather gloves and mittens	116	0.64	0.64	-0.16
Dolls and stuffed toys	306	3.31	0.27	-0.53
Access structures for solid mineral development	909	1.45	0.09	-0.71
Personal leather goods, n.e.c.	373	2.81	0.24	-0.56
Women's handbags and purses	402	2.49	0.24	-0.56
New residential 2 to 4 unit structures, nonfarm	3,309	19.48	0.03	-0.77
Knitting mills, n.e.c.	252	1.55	0.42	-0.38
Fine earthenware table and kitchenware	52	0.56	2.19	1.39
New farm residential construction	1,853	12.27	0.08	-0.72
Asbestos products	88	1.05	1.68	0.88
Calculating and accounting machines	1,669	5.00	0.11	-0.69
Scales and balances, except laboratory	918	3.54	0.24	-0.56
Small arms ammunition	945	7.81	0.27	-0.53
Special product sawmills, n.e.c.	198	2.70	1.32	0.52

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TABLE A3—*CONTINUED*

Industry Description	Value of Shipments ($ million)	Employment (thousands)	Price Changes Pollution and Energy Tax (percent)	Price Changes Labor ETR, Labor Incidence (percent)
Rolling mill machinery and equipment	792	4.50	0.36	-0.44
Schiffli machine embroideries	397	5.56	0.78	-0.02
Jewelers' materials and lapidary work	961	26.97	0.36	-0.44
Knit underwear and nightwear mills	1,032	5.31	0.35	-0.45
Measuring and dispensing pumps	1,118	2.99	0.33	-0.47
Wood television and radio cabinets	397	14.97	0.92	0.12
Tanks and tank components	2,797	18.26	0.14	-0.66
Automatic vending machines	1,028	4.49	0.37	-0.43
Ordnance and accessories, n.e.c.	1,095	12.54	0.37	-0.43
Leather goods, n.e.c.	502	4.41	0.82	0.02
Manufactured ice	389	2.10	1.09	0.29
Boot and shoe cut stock and findings	294	14.46	1.46	0.66
Commercial laundry equipment	731	3.16	0.60	-0.20
New residential apartments construction	11,027	63.35	0.04	-0.76
Rubber and plastics footwear	1,050	2.44	0.44	-0.36
Small arms	1,133	11.69	0.42	-0.38
Costume jewelry	1,717	9.56	0.28	-0.52
Travel trailers and campers	2,518	12.31	0.20	-0.60
Household furniture, n.e.c.	537	12.98	0.95	0.15

TABLE A4: **MOST-BENEFITED INDUSTRIES LABOR ETR, CONSUMER INCIDENCE**

			Price Changes	
Industry Description	**Value of Shipments ($ million)**	**Employment (thousands)**	**Pollution and Energy Tax (percent)**	**Labor ETR, Consumer Incidence (percent)**
Boot and shoe cut stock and findings	294	14.46	1.46	-6.80
Child day care services	18,902	1,077.60	0.09	-5.14
Agricultural, forestry, and fishery services	9,856	504.81	2.14	-4.96
Landscape and horticultural services	12,310	578.52	0.73	-4.88
Personnel supply services	66,022	2,502.50	0.54	-4.06
Services to dwellings and other buildings	30,022	1,075.20	0.73	-3.96
Beauty and barber shops	19,660	802.10	0.45	-3.89
Residential care	17,463	656.60	0.35	-3.11
Business, professional membership organizations	16,724	512.55	1.12	-3.06
Professional sports clubs and promoters	4,962	83.13	0.80	-2.95
Job training and related services	9,621	304.10	0.34	-2.89
Other business services	91,055	1,707.32	0.71	-2.74
Typesetting	1,730	20.71	1.19	-2.71
Wood television and radio cabinets	397	14.97	0.92	-2.69
Research, development, and testing services	35,692	995.68	0.51	-2.66
Other federal govt. enterprises	8,780	127.60	0.75	-2.65
Platemaking and related services	3,438	38.69	1.37	-2.52
Private libraries and educational services, n.e.c.	12,726	367.13	0.29	-2.51
Detective and protective services	15,381	296.71	0.66	-2.43

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TABLE A4—*CONTINUED*

			Price Changes	
Industry Description	**Value of Shipments ($ million)**	**Employment (thousands)**	**Pollution and Energy Tax (percent)**	**Labor ETR, Consumer Incidence (percent)**
Veterinary services	6,500	133.76	0.46	-2.40
Bowling centers	2,626	88.20	1.91	-2.33
Vitreous china table and kitchenware	363	4.38	2.25	-2.31
Credit agencies other than banks	31,653	701.20	2.02	-2.23
Social services, n.e.c.	32,373	847.40	0.20	-2.23
Insurance agents, brokers, and services	62,400	854.50	0.21	-2.13
U.S. Postal Service	55,711	843.40	0.56	-2.12
Commercial fishing	4,277	36.71	1.34	-2.11
Special product sawmills, n.e.c.	198	2.70	1.32	-2.08
Leather tanning and finishing	2,544	36.47	1.27	-2.07
Accounting, auditing, bookkeeping, n.e.c.	74,585	935.00	0.63	-2.05
Colleges, universities, and professional schools	58,021	1,253.94	0.22	-2.05
Elementary and secondary schools	19,095	458.13	0.25	-2.03
Other repair and maintenance construction	135,760	2,582.93	1.22	-1.99
Industrial patterns	737	16.03	1.34	-1.90
Nursing and personal care facilities	64,194	1,696.40	0.49	-1.90

TABLE A5: **MOST-BENEFITED INDUSTRIES CAPITAL ETR, CONSUMER INCIDENCE**

Industry Description	Value of Shipments ($ million)	Employment (thousands)	Price Changes: Pollution and Energy Tax (percent)	Price Changes: Capital ETR, Consumer Incidence (percent)
Royalties	66,362	0.00	1.45	-3.61
Landscape and horticultural services	12,310	578.52	0.73	-3.51
Greenhouse and nursery products	11,175	137.44	1.14	-3.32
Professional sports clubs and promoters	4,962	0.00	0.80	-2.68
Real estate agents, managers, operators, lessors	544,973	83.13	0.69	-2.48
Maintenance and repair of residential structures	63,961	1,744.80	0.46	-2.46
Grass seeds	606	1,040.14	1.65	-2.34
Agricultural, forestry, and fishery services	9,856	8.37	2.14	-2.19
Tobacco	3,659	504.81	1.09	-2.17
Detective and protective services	15,381	46.37	0.66	-2.04
Other business services	91,055	296.71	0.71	-1.99
Photographic equipment and supplies	20,886	1,707.32	0.61	-1.97
Services to dwellings and other buildings	30,022	86.10	0.73	-1.92
Vegetables	13,743	1,075.20	0.54	-1.92
Book printing	5,839	116.03	0.71	-1.87
Typesetting	1,730	53.13	1.19	-1.85
Tobacco manufacturing	39,193	34.73	0.04	-1.83
Greeting cards	4,442	20.71	0.29	-1.72
Miscellaneous publishing	11,711	1.47	0.68	-1.70

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TABLE A5—*CONTINUED*

Industry Description	Value of Shipments ($ million)	Employment (thousands)	Price Changes Pollution and Energy Tax (percent)	Price Changes Capital ETR, Consumer Incidence (percent)
Legal services	120,942	29.10	0.57	-1.64
Tree nuts	1,818	92.20	1.09	-1.64
Telephone, telegraph communications, and services	221,182	5.60	0.43	-1.61
Photofinishing labs and commercial photography	18,569	1,158.40	0.49	-1.59
Newspapers	38,043	20.13	0.75	-1.58
Electric services (utilities)	184,049	1,163.68	0.94	-1.54
Periodicals	24,281	228.87	0.54	-1.54
Platemaking and related services	3,438	0.30	1.37	-1.51
Bookbinding and related work	1,585	465.80	0.66	-1.47
Motion picture services and theaters	57,780	496.30	0.37	-1.46
Blankbooks, looseleaf binders, and devices	4,371	142.20	0.69	-1.45
Flavoring extracts and flavoring syrups, n.e.c.	7,449	38.69	0.51	-1.44
Electrical repair shops	11,941	20.72	0.86	-1.43
Automobile parking and car washes	9,258	368.60	0.37	-1.41
Stationery, tablets, and related products	1,574	54.08	0.61	-1.40
Drugs	78,312	38.53	0.35	-1.38