1999

A Distributional Analysis of Green Tax Reforms

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Abstract *- I measure the distributional impact of a shift toward greater reliance on environmental taxes (a green tax reform) using both annual and lifetime income measures to rank households. An environmental tax reform can be designed that has a negligible impact on the income distribution when the funds are rebated to households through reductions in the payroll tax and personal income tax. I also analyze trade-offs among competing goals of efficiency, equity, and ease of administration in the design of a green tax reform.*

INTRODUCTION

Should we raise environmental taxes? This question has been asked increasingly in the face of widespread environmental problems, including global warming, air and water pollution, and a host of other environmental problems that we face today. If one is concerned exclusively with efficiency, the answer to this question would be yes, we certainly should raise taxes to the point where the tax equals the marginal social damage from pollution. Unfortunately, the real world is more complicated than a textbook world. How do we measure marginal social damages? Concerns about economic efficiency intrude given the widespread prevalence of other taxes. Finally, distributional concerns come into play. Environmental taxes tend to be regressive: poor people pay a disproportionate share of their income in these taxes relative to rich people.

This paper addresses how one could design an environmental tax reform such that it reduces or even eliminates the regressive nature of environmental taxes. It considers reforms that combine environmental taxes with reductions in other taxes such that the increased regressivity of the environmental taxes is offset by increased progressivity resulting from reductions in other taxes. I also analyze trade-offs among competing goals of efficiency, equity, and ease of administration in the design of a green tax reform.

The next section provides some background on the issue of environmental (or green) tax reforms. Next, I describe how I measure the distributional impact of tax reforms and describe the data. The fourth section provides results from the analysis and a concluding section follows.

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National Tax Journal
Vol. LII, No. 4

BACKGROUND ON GREEN TAX REFORMS

There has been a great deal of interest in recent years in the use of environmental tax revenues to substitute for some portion of existing tax collections. The issue of a substitution of environmental for other taxes can be traced back to Tullock (1967) and more recently Terkla (1984). This early literature focused on the efficiency implications of an environmental reform and led to a debate over what has been dubbed the "Double Dividend Hypothesis."[1] One strand of this literature (as typified by Terkla) considers a reform in which environmental regulations are replaced with tax instruments in such a fashion that pollution activities are unaffected. But the switch from a regulatory to a taxation mechanism for limiting pollution raises revenue that can be used to lower other distorting taxes. This shift has unambiguous welfare gains. Another strand of the literature (typified by Pearce (1991) and Repetto et al. (1992)) focuses on the use of environmental taxes both to reduce pollution and to raise revenue to lower other taxes. While it is clear (see Bovenberg and deMooij (1994) as well as Parry (1995)) that there are also efficiency costs with environmental taxes (separate from the environmental benefits), it is also clear that the efficiency costs depend importantly on which taxes are reduced. Clearly, the benefits of the new revenues are greatest when used to lower the most distorting taxes.

The debate over a green tax shift and the Double Dividend Hypothesis has focused on efficiency considerations. In addition, distributional considerations are clearly important and little work has been done in this area. These concerns are relevant given the sense that most energy and environmental taxes are regressive. While some authors have challenged this perception by taking into account lifetime considerations (e.g., Poterba, 1991a; Bull, Hassett, and Metcalf, 1994), it is clear that distributional concerns limit political support for the greater use of environmental taxes.

Previous discussion of the distributional problem suffers by looking at the environmental taxes in isolation—that is, with lump-sum recycling of the tax revenues. While it might be the case that the imposition of an environmental tax by itself is regressive, it is quite possible that a revenue neutral tax reform, where an environmental tax replaces some other tax, could be progressive.[2] A recent study by Hamond et al. (1997) emphasizes this point. Below, I will consider reforms (based on suggestions in Hamond et al.) that are designed to maintain or perhaps increase the progressivity of the tax system. I will also consider other reforms to emphasize the trade-offs among equity, efficiency, and ease of administration.

METHODOLOGY

Incidence Assumptions

Incidence analyses rest on a number of important assumptions. First, researchers must make assumptions about the direction of shifting of the various taxes under analysis. Second, researchers must determine how to rank people by some measure of "well-being." Typically, annual income has been used to sort people or households (e.g., Pechman, 1985; Gale, Houser, and Scholz, 1996). Recognizing that annual income may not always be a good measure of resources available to households given life-cycle and permanent income considerations, a number of researchers have either tried to measure lifetime income explicitly or constructed

[1] See Fullerton and Metcalf (1998) for a survey of this literature.

[2] In economic terms, the former is an example of an absolute tax incidence analysis, while the latter is a differential tax incidence analysis.

proxies for lifetime income (Poterba, 1989, 1991a; Feenberg, Mitrusi, and Poterba, 1997; Metcalf, 1993, 1994; Caspersen and Metcalf, 1994) or have constructed computable general equilibrium models (Fullerton and Rogers, 1993; Altig et al., 1997). This paper uses a measure of lifetime income constructed by Caspersen and Metcalf from the Panel Study on Income Dynamics (PSID) and the Consumer Expenditure Survey (CES). In brief, the procedure constructs wage profiles from the PSID based on information available in both the PSID and the CES and then computes a measure of lifetime income for households in the CES.[3] In this paper, I will provide distributional results using both an annual income measure and a lifetime income measure.

Despite its attraction, lifetime income is difficult to measure and whatever measure is employed rests on strong assumptions. An alternative approach is to employ a cohort analysis. Gale, Houser, and Scholz (1996), for example, consider the impact of tax changes on married couples in the age range of 40–50. By restricting the analysis to households who are likely to be at the same stage of their earnings profile, they avoid mixing people from different stages of the life cycle. The approach is conceptually appealing and does reduce the measurement problem described above. It does not, however, address the problem of transitory income shocks. Households with a one time negative income shock may maintain previous consumption levels under the assumption that the poor income realization is a temporary setback that is likely to be offset by positive income shocks in the future. Hence, consumption to income ratios will be high for this group and any tax that approximates a consumption tax in its effect will look more regressive than it would if transitory income shocks were taken into account. Despite this drawback, I will report a cohort distribution of taxes as an alternative measure to my lifetime income measure.

While the methodology in this paper is similar to that in Caspersen and Metcalf (1994), there are two important differences. First, the Caspersen and Metcalf analysis is an example of an absolute tax incidence analysis, while the analysis in this paper is a differential tax incidence analysis. Therefore, in addition to distributing the new taxes, I also have to consider the distribution of existing taxes, in particular the corporate and personal income taxes. Second, the CES data on health expenditures only reflects out of pocket spending on health care. In this paper, I replace the CES spending amounts with amounts based on information drawn from the National Medical Expenditure Survey (NMES).

I distribute taxes using conventional assumptions about incidence derived from previous economic incidence studies.[4] Individual taxes on wages and factor payments are assumed to be borne by the individual. Corporate taxes are assumed to be borne by owners of capital and are distributed to households in my data set using a methodology developed by Feldstein (1988). This assumption is consistent with the model results from Harberger (1962) and Shoven (1976). As a check on the importance of this assumption, I consider an alternative incidence assumption in which half the burden falls on capital income and half on labor.[5] Finally, taxes on products are passed forward to consumers in the form of higher product prices, and taxes on intermediate inputs flow through to consumers in

[3] The methodology is described in detail in Caspersen and Metcalf (1994).

[4] My assumptions are the same as those used by Pechman (1985), Gale, Houser, and Scholz (1996), and the Joint Committee on Taxation (1993), among others.

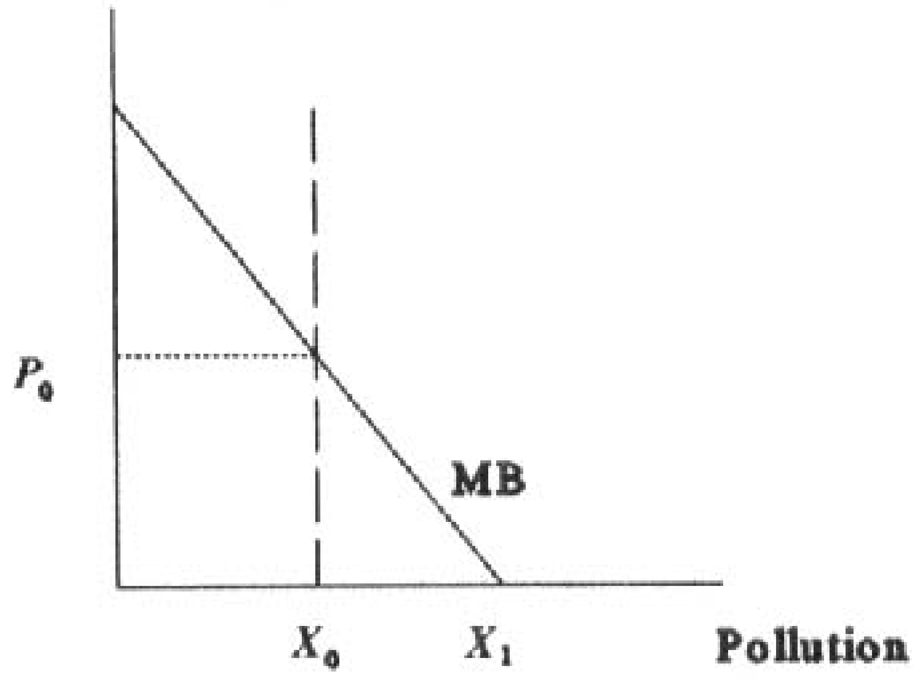
[5] This assumption is modeled by the Congressional Budget Office and is discussed by Gale, Houser, and Scholz (1996).

the form of higher consumer prices. This assumption is valid for industries composed of identical firms with free entry and exit in which the supply of factors is perfectly elastic. In this case, factor prices are fixed and the supply of consumer goods is perfectly elastic.

The analysis that I undertake in this paper measures the burden of taxes under the assumption that substitution in production or consumption in response to price changes does not occur. Clearly, one of the goals of the reform is to raise the price of pollution and consequently reduce polluting activities. To the extent that pollution decreases, tax collections will fall and either environmental tax rates will have to be increased or other tax rates will have to rise to keep revenue collections constant.[6] This suggests a "problem" for environmental taxes as revenue raising instruments. To the extent that they are successful in reducing pollution, they will not raise the hoped for revenue. Note though that while tax collections may fall, product prices are still likely to rise as firms engage in costly activities to avoid the use of taxed polluting inputs. Thus, even if pollution drops significantly as a result of a green tax reform, the incidence results described here may not be substantially changed.[7]

Another incidence result occurs if these taxes replace current regulations that are designed to mitigate pollution.[8] Consider, for example, a simple example where pollution (X) is restricted to an amount (X_0) by regulatory efforts. Now we replace those regulations with a system of pollution taxes that induces firms to reduce their pollution to X_0. To see how this would work, consider Figure 1. The

Figure 1. Taxes and Quotas



downward sloping line graphs marginal benefits of pollution (MB) to the firm. In the absence of any government intervention, firms would pollute to the point where marginal benefits equal marginal costs. If marginal costs are zero, then firms would pollute up to an amount equal to X_1 in the figure. A quota designed to reduce pollution to X_0 is represented by the vertical dashed line in the figure. With this quota, the marginal benefit of pollution is now equal to P_0. Costs are increased by the use of a quota regulation. The restriction on pollution means that pollution now has scarcity value and a shadow price equal to its marginal benefit (P_0). This scarcity value translates into higher prices. The incidence of the environmental reform now depends on (1) whose income is ultimately reduced by the imposition of environmental taxes and (2) whose purchasing power is increased by the reduction in the price of goods following the elimination of a quota. But these two effects exactly offset so that the net impact of the environmental tax from an incidence point of view is zero.[9] The government, however, has the revenue with

[6] Alternatively, government spending can be reduced. Note, though, that reduction in pollution may reduce health costs, which could lead to lower spending in Medicare or Medicaid.

[7] The degree to which prices will rise as pollution reducing activities occur depends, in part, on the elasticity of substitution between pollution and other production inputs.

[8] See Fullerton and Metcalf (1997) for a discussion of various environmental policy experiments and their revenue and efficiency implications.

[9] This argument does not depend on regulations being set optimally. The point only requires a tax that leads to the same level of pollution as under the previous regulatory scheme, optimal or not.

which it can reduce other taxes. In this case, the appropriate incidence analysis is simply an absolute incidence analysis focusing on the reduction of taxes financed by the environmental tax revenues. I hold environmental regulatory policy fixed in this analysis and so ignore these additional distributional effects.

DATA

The basic data source for this analysis is the 1994 CES. The CES has detailed household level data on consumption patterns as well as some data on household income, taxes, and household demographic characteristics.[10] There are three adjustments I must make to the CES data before I can analyze any tax reform. First, the CES reports out-of-pocket medical expenditures and ignores spending on a consumer's behalf by HMOs and insurance companies. I use data from the NMES to attribute medical spending to individual households to replace the health spending reported in the CES. Second, I make adjustments to the CES income and consumption categories to match aggregate numbers in the National Income and Product Accounts (NIPAs). Third, I attribute corporate tax payments to individual households using a methodology developed by Feldstein (1988). I provide details on these adjustments in Appendix A.

Most of the environmental taxes that I will consider are applied to industries in production. Attributing these taxes to consumer goods is a somewhat more complicated process. I use the 1992 Benchmark Input-Output Accounts to follow the flow of price increases arising from taxation of intermediate goods through to consumer price increases. I describe the use of this data set in Appendix B.

TAX SHIFT ANALYSIS

A Green Tax Shift Equal to Ten Percent of Federal Revenues

I begin with an analysis of a moderate shift in the income tax base in which I replace ten percent of federal receipts with a cluster of environmental taxes. Because federal revenues totaled $1,258 billion in 1994, this scenario requires raising roughly $126 billion in new taxes. The new taxes that I implement are taxes on carbon emissions, gasoline consumption, air pollution, and the use of new (virgin) materials in production.[11]

A carbon tax is a tax on the carbon content of fossil fuels. As such, it differs across fuel types. Coal contains the most carbon per BTU (0.025 tons of carbon per billion BTUs) followed closely by oil (0.020 tons per billion BTUs). Natural gas contains 0.015 tons per billion BTUs (Poterba, 1991b, Table 3.3). The main attraction of a carbon tax is that it discourages carbon emissions on two fronts. First, the increase in overall energy prices encourages energy conservation and investment in energy efficiency leading to a reduction in energy consumption overall. Second, the tax encourages the substitution of low carbon for high carbon fuels. Specifically, it would encourage the use of hydropower, nuclear energy, and renewable energies (solar and wind).

In 1994, 1,399 million metric tons of carbon (MtC) were emitted in the United States (*Annual Energy Review 1996*). Under the assumption that carbon emissions are inelastically supplied in the short run, a $40 per ton tax would raise $56 billion. A carbon tax at this level would be roughly the optimal tax if marginal environmental damages from carbon emissions were between $50 to $75 per ton (Bovenberg and Goulder, 1996).

[10] I use the CES data sets prepared by John Sabelhaus and documented in Sabelhaus (1996).

[11] These tax proposals are designed to correspond roughly to the proposals contained in Scenario 1 of Hamond et al. (1997).

The carbon tax is allocated to petroleum products (42 percent), natural gas (22 percent), and coal (35 percent) on the basis of aggregate carbon dioxide emissions in 1995.[12] Based on this breakdown, I allocate $24 billion of carbon tax to petroleum, $12 billion to natural gas, and $20 billion to coal. The tax on coal is allocated to the coal mining industry, while I allocate the tax on natural gas to the output of the crude oil and natural gas industry used by electric and gas utilities.[13]

In addition to a carbon tax, I model a motor fuels excise tax. This is a tax on gasoline and diesel fuel sales. Currently, federal excise taxes on motor fuels are 18.3 cents per gallon of gasoline and 24.3 cents per gallon of diesel fuel (Congressional Budget Office, 1997). I model an increase in the gasoline tax of 15 cents per gallon and an increase in the diesel fuel tax (for diesel in highway use) of 9.4 cents per gallon. Based on fuel consumption in 1994 (and assuming inelastic demand), these taxes would raise an additional $19.8 billion in tax revenue. Gasoline is used directly by consumers and is used by businesses. The former is allocated directly to households, while the latter is allocated to the transportation industry in the Input-Output Accounts. Based on gasoline expenditures reported in personal consumption expenditures in NIPAs, personal gasoline consumption accounts for 85 percent of total gasoline expenditures. Thus, I allocate 85 percent of the gasoline tax revenues to consumers directly and the remaining 15 percent along with the diesel tax revenue as an additional cost of production (higher transportation costs) and allocate the tax based on industry use of transportation.

Taxes on air pollution can be levied on point or nonpoint sources of pollution. For point source emissions, I model a $150 per ton tax on sulfur dioxide (SO_2) emissions, a $1,500 per ton tax on nitrogen oxide (NO_x) emissions, a $900 per ton tax on particulate matters (PM-10), and a $2,000 per ton tax on volatile organic compounds (VOC). In order to distribute these taxes to consumer goods, I need to allocate emissions across industries. Table 1 provides information on emissions in 1990 from which I make this allocation.[14] Sulfur oxide (SO_x) emissions arise predominately from coal and fuel oil combustion. I allocate the tax to SO_2 on the basis of SO_x emissions with the tax on coal applied to the coal mining industry and the tax on fuel oil applied to the use of output from the fuel oil and natural gas industry by the petroleum refining industry. Industry emissions are allocated to their respective industries.

A similar approach is used for the other pollutants. Because a significant amount of NO_X, VOC, and PM-10 emissions are due to motor vehicles, I also include a $35 per new vehicle tax to proxy for a tax on motor vehicle emissions[15]. In total, these air pollution taxes would raise $40.5 billion.

In 1994, 209 million tons of solid waste were generated and 49 million tons were recovered through recycling efforts. The remaining 160 million tons was disposed in landfills (127 million tons) or burned (33 million tons), primarily for energy recovery.[16] While burning solid waste for energy production was initially viewed as a valuable energy source, it has increasingly been recognized that it creates its own air and solid waste pollution problems. In an effort to reduce the amount of

[12] See Table 12.3, *Annual Energy Review 1996*.

[13] See Appendix B for more details on how industry level taxes are implemented as well as the process for tracing price effects through to consumer prices.

[14] I am grateful to Larry Goulder for providing me with these data.

[15] These air pollution taxes are based on revenue scenarios contained in Congressional Budget Office (1997).

[16] Table 380, *Statistical Abstract of the United States 1996*.

TABLE 1
STATIONARY SOURCE EMISSIONS IN 1990

	Pollutant			
	Sulfur Oxides	Nitrous Oxides	Volatile Organic Compounds	Particulate Matter
Total emissions (thousands of tons metric)	20,152.4	11,535.3	8,209.8	2,950.1
Coal combustion	77.2%	61.7%	0.7%	5.2%
Natural gas combustion and pipelines	0%	28.4%	0.9%	1.0%
Fuel oil combustion	7.3%	4.8%	0.1%	1.8%
Industry				
Agriculture	0%	0%	2.1%	44.7%
Coal Mining	0%	0%	0%	11.2%
Crude petroleum and NG	0%	0%	6.6%	0%
Petroleum refining	3.3%	1.9%	8.6%	0.9%
Electric utilities	0%	0%	0%	0%
Gas utilities	0%	0%	0%	0%
Construction	0%	0%	9.3%	0%
Metals and machinery	4.5%	0.4%	0.8%	9%
Motor vehicles	0%	0%	2.2%	0%
Miscellaneous manufacturing	7.7%	2.7%	62.6%	26.1%
Services	0%	0%	6%	0%
Housing services	0%	0%	0%	0%

Columns may not sum to 100 percent due to rounding error.
Source: Data collected by Goulder and described in Goulder (1994).

materials disposed of either in landfills or by burning, I include a tax on unrecovered waste of $55 per ton. Hamond et al. (1997) refer to this as a virgin materials tax. Based on 1994 quantities of unrecovered waste, this tax would raise $9.3 billion. I allocate this tax to industries on the basis of materials that make up the waste being generated.

A combination of taxes on energy, air pollutants, and unrecovered solid wastes as described above will raise revenue equal to roughly ten percent of federal receipts.[17] Table 2 summarizes the revenues. Table 3 gives a detailed breakdown of the increase in consumer prices that results from this collection of taxes. The carbon tax primarily raises the price of utilities as well as gasoline products. The largest increase is for natural gas. This may seem surprising because coal is an important component of electricity production. The reason that electricity prices do not rise as much as do natural gas prices is that while 79 percent of the share of industry goods used by the natural gas industry are subject either directly or indirectly to the carbon tax, only 37 percent of the share of industry goods used by the electricity industry are subject to the tax. Other important industrial inputs into the electricity industry include construction (22 percent) and services (12 percent).

TABLE 2
ENVIRONMENTAL TAXES

Tax	Revenue (Billions)
Carbon tax	$56.00
Gasoline tax	$19.80
Air pollution taxes	$40.50
Virgin materials tax	$9.30
Total	$125.60

The motor fuels tax increases the price of gasoline over 13 percent. The remaining tax increases the price of other goods quite modestly, with the largest increase occurring in various transportation services (mass transit, taxicab, and airline

[17] Rates are set to raise revenue equal to ten percent of federal receipts net of increased federal government costs due to the environmental taxes on items purchased by the federal government.

TABLE 3
IMPACT OF ENVIRONMENTAL TAXES ON CONSUMER PRICES

Consumption Items	Carbon Tax	Motor Fuels Tax	Air Pollution Taxes	Virgin Materials Tax	Total Price Increase
Food off-premise	0.9%	0.2%	0.8%	0.3%	2.2%
Food on-premise	0.5%	0.1%	0.6%	0.2%	1.3%
Food furnished employees	1.0%	0.2%	1.0%	0.4%	2.6%
Tobacco products	0.4%	0.1%	0.5%	0.2%	1.2%
Alcohol off-premise	0.8%	0.2%	0.8%	0.3%	2.0%
Alcohol on-premise	0.5%	0.1%	0.6%	0.2%	1.3%
Clothing and shoes	0.8%	0.1%	1.0%	0.3%	2.2%
Clothing services	0.5%	0.1%	0.6%	0.2%	1.3%
Jewelry and watches	0.7%	0.1%	3.8%	0.3%	4.9%
Toilet articles and preparations	0.8%	0.1%	0.7%	0.3%	2.0%
Barbershops, beauty parlors, health clubs	0.5%	0.1%	0.6%	0.2%	1.3%
Tenant-occupied nonfarm dwellings—rent	0.2%	0.0%	0.3%	0.1%	0.6%
Other rented lodging	0.5%	0.1%	0.6%	0.2%	1.3%
Furniture and durable household equipment	0.8%	0.1%	0.9%	0.3%	2.1%
Nondurable household supplies and equipment	0.0%	0.0%	0.0%	0.1%	0.1%
Electricity	12.0%	0.2%	8.1%	0.1%	20.4%
Natural gas	19.6%	0.1%	6.0%	0.1%	25.8%
Water and other sanitary services	0.6%	0.0%	0.4%	0.1%	1.1%
Fuel oil and coal	12.1%	0.2%	1.8%	0.1%	14.2%
Telephone and telegraph	0.3%	0.1%	0.5%	0.1%	1.0%
Domestic service, other household operation	1.0%	0.2%	0.6%	0.4%	2.1%
Medical care	0.5%	0.1%	0.6%	0.2%	1.3%
Business services	0.3%	0.1%	0.5%	0.1%	1.0%
Expense of handling life Insurance	0.3%	0.1%	0.5%	0.1%	0.9%
New and used motor vehicles	0.8%	0.2%	0.7%	0.2%	1.9%
Tires, tubes, accessories, and other parts	0.9%	0.2%	0.6%	0.3%	2.0%
Repair, greasing, washing, parking, storage, rental	0.5%	0.1%	0.6%	0.2%	1.3%
Gasoline and oil	11.6%	13.7%	1.7%	0.1%	27.1%
Bridge, tunnel, ferry, and road tolls	0.6%	0.0%	0.4%	0.1%	1.1%
Auto insurance	0.3%	0.1%	0.5%	0.1%	0.9%
Mass transit systems	1.9%	0.6%	0.8%	0.1%	3.4%
Taxicab, railway, bus, and other travel expenses	1.9%	0.6%	0.8%	0.1%	3.4%
Airline fares	1.9%	0.6%	0.8%	0.1%	3.4%
Books and maps	0.7%	0.2%	0.6%	0.7%	2.2%
Magazines, newspapers, Other nondurable toys, etc.	0.8%	0.1%	1.9%	0.4%	3.3%
Recreation and sports equipment	0.7%	0.1%	1.2%	0.2%	2.2%
Other recreation services	0.5%	0.1%	0.6%	0.2%	1.3%
Pari-mutuel net receipts	0.5%	0.1%	0.6%	0.2%	1.3%
Higher education	0.5%	0.1%	0.6%	0.2%	1.3%
Nursery, elementary, and secondary education	0.5%	0.1%	0.6%	0.2%	1.3%
Other education services	0.5%	0.1%	0.6%	0.2%	1.3%
Religious and welfare activities	0.5%	0.1%	0.6%	0.2%	1.3%

Source: Author calculations. See text for details.

fares) with an increase of 0.6 percent. Air pollution taxes raise electricity and natural gas prices by eight and six percent, respectively, while raising the price of other goods modestly. Jewelry and watch prices rise by nearly four percent due to the use of VOCs in their production. The virgin materials tax has a modest impact less than one percent. Taken as a group, these taxes predominately raise the price of energy for consumers. Except for jewelry and watches, consumer price increases for other goods rarely exceed two percent.

I use these revenues to fund three tax changes in the payroll and personal income tax. First, I exempt from the OASDI payroll tax (at both the personal and business levels) the first $5,000 of tax base for each worker. For workers earning less than $5,000 of covered wages, I exempt them entirely from the tax. Based on data in the CES on the distribution of workers, this will reduce payroll tax collections by $71.2 billion. Next, I implement a refundable $150 tax credit for each exemption taken in the personal income tax. Based on the 232.7 million exemptions taken in 1994 (*Statistics of Income*, Winter, 1996–7), this will cut tax collections by $34.9 billion. Finally, I implement an across-the-board income tax cut of four percent. This reduces tax revenue by $19.3 billion in my data. Table 4 summarizes the tax cuts that are funded by the new environmental levies.

TABLE 4
TAX REDUCTIONS

Proposal	Amount (Billions)
Payroll tax	71.2
$150 refundable tax credit	34.9
4% personal income tax reduction	19.3
Total	$125.4

DISTRIBUTIONAL IMPACT OF A GREEN TAX REFORM

Table 5 provides incidence results for households in the CES. As discussed above, I provide results using three different measures of income and group households in ten income groups, with decile 1 representing households in the lowest ten percent of the income distribution and decile 10 representing households in the top ten percent of the income distribution.[18] Using annual income to rank households, I find that this scenario reduces the progressivity of the tax system slightly with an increase in taxes paid by the bottom half of the distribution and tax cuts for most of the top half. Focusing on the total change in average tax rate, we see that the top decile faces a very small increase in taxation. In percentage terms, the increase in taxes is substantial for the bottom 20 percent of the income distribution: the income group in the 5th to 10th percentiles see their taxes go up on average three percent of their income, while the group in the 10th to 20th percentiles face an increase of over one percent of income. If the hope is to design a progressive tax shift, however, this proposal falls short on the basis of annual income measures. We can decompose the change in average tax rates into changes for the new environmental taxes and the reduced personal taxes. The regressive nature of the environmental taxes is quite stark, with the lowest income group facing an increase in taxes equal to seven percent of income, while the top income group faces an increase equal to 1.6 percent of income. The regressivity is blunted by the progressive tax reductions, with the first three deciles receiving tax reductions on the order of four percent of income, while the top three deciles receive reductions of 1.5 to 2.7 percent of income.

[18] Because of considerable income measurement problems in the bottom of the income distribution, I follow the approach of Pechman (1985) as well as Gale, Houser, and Scholz (1996) by excluding the bottom five percent of the income distribution from the analysis. Thus, decile 1 only includes households in the 5th to 10th percentiles of the income distribution.

TABLE 5
10 PERCENT GREEN TAX SHIFT

	Annual Income						Lifetime Income						Married, Age 40–50					
	Change in Taxes			Change in ATR			Change in Taxes			Change in ATR			Change in Taxes			Change in ATR		
Decile	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total
1	569	335	234	7.05	4.04	3.01	695	645	51	3.13	2.90	0.23	1,248	1,214	34	6.51	6.33	0.18
2	681	533	148	5.68	4.4	1.29	830	913	–83	3.08	3.39	–0.31	1,406	1,580	–174	4.6	5.22	–0.61
3	923	801	122	5.16	4.42	0.74	917	1,056	–139	2.87	3.31	–0.44	1,382	1,681	–299	3.36	4.08	–0.72
4	1,048	975	73	4.27	3.95	0.32	1,062	1,111	–48	2.88	3.01	–0.13	1,513	1,761	–248	2.92	3.39	–0.47
5	1,157	1,143	14	3.64	3.58	0.07	1,199	1,282	–83	2.84	3.04	–0.20	1,861	1,903	–42	3.22	3.26	–0.05
6	1,131	1,375	–244	2.88	3.49	–0.62	1,266	1,297	–31	2.67	2.73	–0.06	1,706	2,097	–391	2.48	3.04	–0.57
7	1,410	1,457	–48	2.92	3.02	–0.10	1,272	1,384	–112	2.40	2.61	–0.21	1,761	2,163	–402	2.26	2.78	–0.51
8	1,485	1,591	–105	2.49	2.66	–0.17	1,440	1,502	–62	2.42	2.53	–0.11	1,972	2,133	–161	2.16	2.33	–0.17
9	1,712	1,924	–212	2.16	2.43	–0.27	1,659	1,571	88	2.40	2.28	0.13	1,998	2,107	–110	1.73	1.81	–0.08
10	2,260	2,197	62	1.64	1.57	0.08	2,095	1,688	408	2.38	1.95	0.44	2,830	2,954	–124	1.49	1.52	–0.04
			Δ Suits						Δ Suits						Δ Suits			
Suits	–0.248	–0.207	–0.041				–0.056	–0.092	0.036				–0.224	–0.234	0.01			

Author's calculations from the CES. The columns titled "Increase" measure the increase in taxes from the new environmental taxes, while those titled "Decrease" measure the decrease in taxes from cuts in excise and personal income taxes. ATR refers to average tax rate.

The Suits Index provides a summary measure of income redistribution.[19] I constructed Suits Indices for the incremental taxes (both positive and negative) that follow the reform. The Suits Index for the environmental taxes is –0.248, indicating that this new tax levied in isolation would be a regressive tax. We are reducing a tax, however, in a progressive fashion. If we had levied an incremental tax equal in magnitude to the tax that we are eliminating (the "decrease" column in Table 5), that tax would also have been regressive (as measured by a Suits Index of –0.207). Note, however, that the regressivity of the income tax component that we propose to eliminate is smaller than the regressivity of the new tax (as measured by Suits Indices). Thus, the shift is regressive (as measured by the difference in Suits Indices).

The second set of columns uses the measure of annualized lifetime income proposed by Caspersen and Metcalf (1994).[20] Ranking households by this measure of income makes the tax reform look slightly more progressive. The lowest income group and the highest two income groups see their taxes go up modestly, while the groups in the 10th to 80th percentiles face lower taxes. Measured as a percentage of income, no group sees a change in tax liability as large as one-half of one percent. The difference in Suits Indices is now positive, albeit close to zero, indicating a slight increase in progressivity with this reform. The regressivity of the environmental levies (as well as the progressivity of the income tax cuts) is damped markedly with the use of lifetime rather than annual income. This reflects the fact that environmental taxes to a large extent are consumption taxes and consumption taxes typically become less regressive when evaluated on a lifetime income basis.

As an alternative to an explicit lifetime income measure, I have also constructed a distributional table for households with married couples in which the head of household is between the ages of 40 and 50. While households in this group may still suffer from transitory income shocks (both positive and negative), we can be reasonably confident that income differences in this group do not arise from lifecycle considerations. The distributional story is essentially the same as the story when I rank households by my measure of lifetime income. The lowest income group is the only group for whom tax liabilities increase (though on a percentage basis, the increase is very small), while other groups face slightly lower taxes. The change in Suits Indices for this group is 0.01, indicating that this is essentially a proportional reform when considered over the entire distribution. Interestingly, the components of the tax reform exhibit greater variation in average tax rates across deciles than in the case with lifetime income. The regressivity of the environmental tax is offset, however, by the greater progressivity of the tax cuts.

Table 6 reports Suits Indices on components of the tax reform. The first two columns sort people by annual income. Among the new environmental taxes, the carbon tax is most regressive and the virgin materials tax is least regressive. However, the differences among the various environmental taxes in terms of regressivity are not large. That fact suggests that adjusting the components of the environmental revenue package will not affect the distribution very much. On the other hand, the differences in degree of regressivity are quite large for the components of the tax reduction. Because

[19] The Suits Index is a tax-based analogue to the Gini Coefficient. It ranges from –1 to 1, with negative values indicating a regressive tax and positive values a progressive tax.

[20] The measure has been updated to reflect the use of the 1994 CES data as opposed to the 1988 CES data used by Caspersen and Metcalf.

TABLE 6
SUITS INDICES FOR COMPONENTS OF TAX REFORM

Tax Proposal	Annual Income: Increased Tax	Annual Income: Decreased Tax	Lifetime Income: Increased Tax	Lifetime Income: Decreased Tax
Carbon tax	−0.260	—	−0.068	—
Motor fuels tax	−0.250	—	−0.042	—
Air pollution taxes	−0.238	—	−0.051	—
Virgin materials tax	−0.214	—	−0.029	—
Payroll tax reductions	—	−0.230	—	−0.097
Refundable tax credit	—	−0.358	—	−0.153
Rate reductions	—	0.129	—	0.027

these are rate reductions, a negative sign on the Suits Index indicates the system becomes more progressive as this tax is reduced, while a positive sign indicates an increase in regressivity. The refundable tax credits add the most progressivity to the system (as measured by the Suits Index), while proportional rate reductions add the least progressivity. In fact, rate reductions diminish the progressivity of the tax system. The lifetime income Suits Indices are all closer to zero, reflecting the reduction in distribution arising from taxation when shifting from an annual to a lifetime income measure. The only significant difference in the relative rankings when shifting from an annual to a lifetime income approach is that air pollution taxes are now slightly more regressive than motor fuels taxes.

Next, I consider a reform that increases the progressivity of the tax system. The environmental taxes are the same but the use of the proceeds differs. Rather than give each worker a $5,000 wage exemption from payroll taxes, I tie the size of the exemption to family size. In particular, I provide each worker an exemption equal to the poverty level for a family of their size divided by the size of number of workers.[21] This costs $55.1 billion and allows an increase in the refundable tax credit from $150 per exemption to $300.[22] Table 7 presents results from this scenario. Ranking households by annual income, the tax looks mildly progressive except in the lowest income group. Households in the 10th through 70th income percentiles face lower taxes, while the top three deciles face tax increases. Note, though, that the greatest tax increase (as measured by change in average tax rate) falls on the households in the lowest income group. As measured by the change in Suits Index, the tax reform adds some progressivity to the system.

The lifetime income approach eliminates the regressivity at the lower end of the income distribution. Now, the lowest 70 percent of the income distribution face lower taxes, with the additional burden falling on the top three deciles and predominantly on the top 10 percent of the distribution. A similar result holds if I use annual income to rank households but focus on the married 40- to 50-year old cohort. Taxes fall for the bottom 40 percent of the distribution, with the largest decreases in the 10th to 20th percentiles. Taxes also fall for the households in the 50th to 70th percentiles. The fifth decile faces a small increase in taxes. Again, the largest increase occurs in the top decile of the distribution. Measured either by the lifetime or cohort income approach, the tax looks slightly more progressive with a change in the Suits Index now between 0.084 and 0.118.

Despite the rather regressive nature of the taxes that make up the new environmental tax revenues (as measured by the Suits Index in Table 6), I have shown in

[21] The size of exemption is limited to covered wages for each worker up to the *individual's* contribution.

[22] To maintain revenue neutrality, I also lower gross of credit personal tax collections by 0.11 percent ($0.5 billion).

TABLE 7
GREEN TAX SHIFT II: PAYROLL TAX REDUCTION TIED TO FAMILY SIZE AND INCREASED REFUNDABLE TAX CREDIT

	Annual Income						Lifetime Income						Married, Age 40–50					
	Change in Taxes			Change in ATR			Change in Taxes			Change in ATR			Change in Taxes			Change in ATR		
Decile	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total
1	569	526	43	7.05	6.41	0.64	695	738	–43	3.13	3.32	–0.19	1,248	1,448	–200	6.51	7.64	–1.13
2	681	758	–77	5.68	6.33	–0.64	830	1,020	–190	3.08	3.79	–0.70	1,406	1,945	–539	4.60	6.47	–1.87
3	923	1,083	–160	5.16	6.03	–0.87	917	1,152	–235	2.87	3.61	–0.74	1,382	1,739	–357	3.36	4.24	–0.88
4	1,048	1,187	–139	4.27	4.80	–0.53	1,062	1,108	–46	2.88	3.00	–0.12	1,513	1,588	–75	2.92	3.06	–0.14
5	1,157	1,283	–126	3.64	4.01	–0.37	1,199	1,280	–81	2.84	3.03	–0.19	1,861	1,790	71	3.22	3.07	0.15
6	1,131	1,373	–242	2.88	3.49	–0.61	1,266	1,345	–79	2.67	2.83	–0.16	1,706	1,900	–194	2.48	2.76	–0.28
7	1,410	1,423	–13	2.92	2.95	–0.03	1,272	1,426	–154	2.40	2.69	–0.28	1,761	1,866	–105	2.26	2.39	–0.13
8	1,485	1,468	17	2.49	2.46	0.03	1,440	1,428	12	2.42	2.40	0.02	1,972	1,735	237	2.16	1.90	0.26
9	1,712	1,673	39	2.16	2.12	0.05	1,659	1,460	199	2.40	2.11	0.29	1,998	1,651	347	1.73	1.43	0.31
10	2,260	1,541	719	1.64	1.16	0.49	2,095	1,482	613	2.38	1.71	0.67	2,830	1,806	1,024	1.49	0.98	0.50
			Δ Suits						Δ Suits						Δ Suits			
Suits	–0.248	–0.323	0.075				–0.056	–0.140	0.084				–0.224		0.118			

Author's calculations from the CES. The columns titled "Increase" measure the increase in taxes from the new environmental taxes, while those titled "Decrease" measure the decrease in taxes from cuts in excise and personal income taxes.

this section that it is possible to choose ways to reduce income tax collections in a progressive fashion to offset the regressivity of the environmental taxes. And, as demonstrated in Table 7, it would not be difficult to structure the tax reform to add progressivity to the tax system.

The reforms analyzed in this section have focused narrowly on distributional goals. One problem with this narrow focus is that it ignores administrative considerations as well as efficiency losses. In the next section, I analyze reforms that take into account these additional goals in tax design and consider distributional impacts.

EQUITY, EFFICIENCY, AND ADMINISTRATION

The previous section focused on distributional considerations only. One concern with the package of environmental tax reforms that were discussed in the last section is that they involve a large number of taxes on difficult-to-monitor emissions. To address that issue, I next consider a motor fuels tax that raises the same revenue as the previous collection of environmental taxes. Following the same approach as in the previous section to determine tax rates, I find that a gasoline tax of $0.95 per gallon and a diesel fuel tax of $0.60 per gallon would be required, assuming no behavioral response. Such a tax raises two clear problems. First, such a large tax increase would bring about a significant behavioral response. This has revenue implications as well as implications for incidence. Following the argument made before about measuring welfare impacts of taxes with behavioral effects, we can treat the incidence results in the distributional tables as an approximation to the welfare impact. Second, as previous policy debates about green taxes have shown, the likelihood of such a large tax increase on motor fuels being enacted is quite small. While administratively more complex, a cluster of environmental taxes may be easier to implement on political grounds. Having noted those two concerns, I present the distributional impact in Table 8. In addition to the direct effect on consumers through an increase in the price of gasoline, the motor fuels tax increase raises the price of other commodities with an average price increase of 0.6 percent. Mass transit and air transportation faces the largest price increase of over three percent. Comparing Tables 5 and 8, the motor fuels tax looks less regressive over most of the (annual) income distribution. The top decile faces a very small decrease in taxes as opposed to a small increase in Table 5. These two effects cancel out in terms of the change in the Suits Index for annual income. The lifetime income approach shows a small increase in progressivity, while the cohort approach suggests the motor fuels tax would be less progressive than the collection of environmental taxes in Table 5.

The difference in these two tables for the cohort approach suggests a limitation with this proxy for lifetime income. Recall that a large problem with annual income as a ranking measure is the composition of households in the lowest decile. We should expect measures of the tax burden that are closer (between the annual and cohort approach) for households in the higher deciles, where the measurement problem is less severe. Note that there are large differences in the change in tax burden between the annual and cohort tables for several of the top five deciles. The cohort approach is missing redistribution across cohorts. Thus, the redistribution captured in the cohort approach might be misleading to the extent that there is redistribution across cohorts in addition to redistribution within cohorts.

The double dividend literature has focused on the use of environmental taxes as a source of revenue with which other distorting taxes can be reduced. The gains

TABLE 8
GREEN TAX SHIFT III: MOTOR FUELS TAX

	Annual Income						Lifetime Income						Married, Age 40–50					
	Change in Taxes			Change in ATR			Change in Taxes			Change in ATR			Change in Taxes			Change in ATR		
Decile	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total
1	486	335	151	6.01	4.04	1.96	640	645	–4	2.87	2.90	–0.03	1,693	1,214	480	9.18	6.33	2.85
2	599	533	66	4.95	4.40	0.55	764	913	–149	2.83	3.39	–0.56	1,731	1,579	152	5.58	5.21	0.36
3	894	804	89	4.90	4.42	0.49	881	1,055	–175	2.75	3.31	–0.56	1,533	1,680	–147	3.72	4.08	–0.36
4	1,073	970	103	4.40	3.95	0.45	1,027	1,110	–83	2.79	3.01	–0.22	1,589	1,760	–170	3.08	3.39	–0.31
5	1,254	1,146	108	3.95	3.58	0.37	1,243	1,281	–38	2.94	3.03	–0.09	1,680	1,902	–222	2.90	3.26	–0.36
6	1,241	1,371	–130	3.16	3.49	–0.33	1,298	1,296	1	2.74	2.73	0.01	1,774	2,095	–321	2.57	3.04	–0.47
7	1,450	1,462	–11	3.00	3.02	–0.02	1,306	1,383	–77	2.47	2.61	–0.14	1,883	2,161	–278	2.42	2.78	–0.36
8	1,496	1,584	–89	2.51	2.66	–0.15	1,488	1,501	–13	2.50	2.53	–0.02	2,052	2,131	–79	2.25	2.33	–0.08
9	1,730	1,922	–192	2.19	2.43	–0.24	1,673	1,570	103	2.42	2.28	0.15	2,025	2,105	–80	1.75	1.81	–0.06
10	2,158	2,194	–36	1.58	1.57	0.01	2,126	1,686	440	2.42	1.94	0.48	2,629	2,948	–319	1.38	1.52	–0.14
			Δ Suits						Δ Suits						Δ Suits			
Suits	–0.250	–0.207	–0.043				–0.042	–0.093	0.051				–0.26	–0.235	–0.025			

Author's calculations from the CES. The columns titled "Increase" measure the increase in taxes from the new environmental taxes, while those titled "Decrease" measure the decrease in taxes from cuts in excise and personal income taxes.

TABLE 9
GREEN TAX SHIFT WITH REDUCTION IN CORPORATE INCOME TAX

	Annual Income						Lifetime Income						Married, Age 40–50					
	Change in Taxes			Change in ATR			Change in Taxes			Change in ATR			Change in Taxes			Change in ATR		
Decile	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total
1	569	5	564	7.05	0.06	6.99	695	132	564	3.13	0.59	2.55	1,248	12	1,236	6.51	0.08	6.43
2	681	18	663	5.68	0.15	5.54	830	251	579	3.08	0.95	2.13	1,406	9	1,397	4.60	0.03	4.58
3	923	58	869	5.16	0.32	4.83	917	615	302	2.87	1.91	0.96	1,382	123	1,259	3.36	0.31	3.05
4	1,048	197	847	4.27	0.80	3.47	1,062	539	524	2.88	1.46	1.42	1,513	29	1,483	2.92	0.06	2.87
5	1,157	387	769	3.64	1.23	2.41	1,199	558	641	2.84	1.35	1.49	1,861	140	1,721	3.22	0.24	2.98
6	1,131	459	673	2.88	1.20	1.68	1,266	922	344	2.67	1.96	0.71	1,706	199	1,507	2.48	0.28	2.19
7	1,410	683	731	2.92	1.40	1.52	1,272	1,069	203	2.40	1.99	0.41	1,761	219	1,542	2.26	0.29	1.97
8	1,485	716	765	2.49	1.20	1.29	1,440	1,787	–347	2.42	2.93	–0.51	1,972	361	1,610	2.16	0.41	1.75
9	1,712	822	890	2.16	1.06	1.11	1,659	2,468	–809	2.40	3.58	–1.17	1,998	571	1,427	1.73	0.50	1.23
10	2,260	9,023	–6,764	1.64	4.53	–2.88	2,095	3,753	–1,658	2.38	4.06	–1.68	2,830	19,422	–16,592	1.49	7.68	–6.19
			Δ Suits						Δ Suits						Δ Suits			
Suits	–0.248	0.459	–0.707				–0.056	0.213	–0.269				–0.224	0.739	–0.963			

Author's calculations from the CES. The columns titled "Increase" measure the increase in taxes from the new environmental taxes, while those titled "Decrease" measure the decrease in taxes from cuts in the corporate income tax. The corporate income tax is borne by capital.

TABLE 10

GREEN TAX SHIFT WITH REDUCTION IN CORPORATE INCOME TAX ALTERNATIVE INCIDENCE ASSUMPTIONS

	Annual Income						Lifetime Income						Married, Age 40–50					
	Change in Taxes			Change in ATR			Change in Taxes			Change in ATR			Change in Taxes			Change in ATR		
Decile	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total	Increase	Decrease	Total
1	569	23	546	7.05	0.26	6.79	695	286	409	3.13	1.27	1.86	1,248	363	885	6.51	1.88	4.63
2	681	98	583	5.68	0.79	4.89	830	510	320	3.08	1.90	1.18	1,406	485	921	4.60	1.59	3.02
3	923	235	692	5.16	1.27	3.89	917	787	130	2.87	2.46	0.42	1,382	821	561	3.36	1.98	1.38
4	1,048	425	619	4.27	1.72	2.55	1,062	771	291	2.88	2.09	0.79	1,513	965	548	2.92	1.86	1.07
5	1,157	657	499	3.64	2.05	1.59	1,199	896	302	2.84	2.14	0.70	1,861	1,072	789	3.22	1.84	1.38
6	1,131	841	291	2.88	2.14	0.74	1,266	1,090	176	2.67	2.30	0.37	1,706	1,296	410	2.48	1.89	0.59
7	1,410	1,112	303	2.92	2.29	0.63	1,272	1,231	40	2.40	2.31	0.09	1,761	1,459	302	2.26	1.87	0.39
8	1,485	1,256	225	2.49	2.10	0.39	1,440	1,726	−286	2.42	2.87	−0.45	1,972	1,763	209	2.16	1.93	0.23
9	1,712	1,651	61	2.16	2.09	0.08	1,659	2,076	−417	2.40	3.01	−0.60	1,998	2,096	−98	1.73	1.81	−0.08
10	2,260	6,069	−3,809	1.64	3.47	−1.83	2,095	2,880	−785	2.38	3.17	−0.79	2,830	11,207	−8,377	1.49	4.66	−3.18
			Δ Suits						Δ Suits						Δ Suits			
Suits	−0.248	0.193	−0.441				−0.056	0.087	−0.143				−0.224	0.274	−0.498			

Author's calculations from the CES. The columns titled "Increase" measure the increase in taxes from the new environmental taxes, while those titled "Decrease" measure the decrease in taxes from cuts in the corporate income tax. The corporate income tax is borne half by capital and half by labor.

from the tax shift depend importantly on which taxes are being reduced. Goulder (1995), for example, has shown that welfare loss from the imposition of a $25 per ton carbon tax is reduced by ten percent when the environmental tax revenue is used to lower corporate income taxes rather than personal income taxes.[23] If green taxes are going to be implemented, a strong argument for their use is their possible use to lower other distorting taxes, in particular, taxes on capital income. The use of environmental taxes for efficiency reasons suggests a tension between equity and efficiency, a tension I explore in Table 9.

Table 9 reports results from a reform where the environmental tax revenues are used to lower the corporate income tax. I lower the latter tax on a proportionate basis and allocate the tax reduction to owners of all capital following the methodology described in Appendix A. Not surprisingly, this reform sharply worsens the income distribution regardless of the income measure used to sort households. Overall, tax liabilities fall only for the top decile if annual income is used to rank households, while taxes fall for the top 30 percent of the income distribution if lifetime income is used to rank households. The change in the Suits Index is very large in all three distributional rankings. As a check on the importance of the assumption that corporate income taxes are distributed to owners of all capital, I revise Table 9 with an alternative assumption about the incidence of this tax. Table 10 provides an analysis in which half the corporate income tax is attributed to capital and half to labor. While the regressivity of the tax shift is reduced considerably, this reform is still quite regressive.

Given the nature of this analysis, any dynamic response cannot be measured and so any offset to the regressivity through increases in the capital labor ratio and increases in the wage rate are not captured in this analysis. From a political economy point of view, however, there is a clear tension between equity and efficiency with respect to green tax reforms.

CONCLUSIONS

A modest tax reform in which environmental taxes equal to ten percent of federal receipts are collected has a negligible impact on the income distribution when the funds are rebated to households through reductions in the payroll tax and personal income tax. The degree of income shifting can be adjusted with changes in how the revenues are returned to households, and it is possible to increase the progressivity of the tax system with an environmental tax reform. It appears from this analysis that any distributional concerns about the greater use of environmental taxes can be addressed through a careful menu of tax reductions that are targeted to low-income households. While it is true that environmental reforms could be designed that are quite regressive, this analysis indicates that distributionally neutral (or even mildly progressive) reforms are entirely feasible.

Efficiency and administrative considerations are also important in designing welfare improving tax reforms. The consideration of a shift from capital income taxation to environmental taxation illustrates an important tension between equity and efficiency in designing green tax reforms. It is likely to be the case that green tax reforms that are most effective at improving economic efficiency (taking into account environmental improvements as well as reductions in tax distortions) will be quite regressive. Obtaining the optimal balance between redistribution and efficiency gains is an important part of any policy discussion on green tax reforms.

[23] See Table 3 in Goulder (1995).

Acknowledgments

This research was partially supported by funds from Redefining Progress and the National Science Foundation (SBR-9811324), the latter through a grant to the National Bureau of Economic Research. I wish to thank Larry Goulder for providing data on industry level emissions, John Sabelhaus for allowing me to use his family and member level extracts constructed from the CES, and Don Fullerton for advice in working with the Input-Output Accounts. I also have benefited from comments by Bill Gale and Jeff Hamond.

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Appendix A

Adjustments to CES Data Attributing Health Care Spending to Individuals

While the bulk of spending on health care is done on behalf of households by insurance companies and health care organizations, the

CES only records out-of-pocket spending by households. Moreover, this spending can often be negative if the household has received a refund from an insurance company for medical spending in the current survey period. Therefore, I exclude the out-of-pocket spending recorded in the CES and replace it with a prediction of spending on behalf of a household using data from the NMES, a nationally representative sample that followed spending by roughly 20,000 families in 1987. Total medical spending for a household is the sum of employer provided and individual health insurance, out-of-pocket spending, and spending reimbursed by government insurance (Medicare and Medicaid). The 1987 data are inflated to 1994 values using the NIPA aggregates for the two years. I regressed total medical spending on income indicator variables,[1] an indicator variable for the presence of elderly family members, an indicator for the presence of children under the age of 18, and family size. The coefficients are precisely estimated with the expected signs. I then forecast income in the CES using the estimated coefficients and replaced the medical related spending in the CES with this forecasted value.

Imputing Corporate Tax Liabilities to Individuals

I follow the methodology set out in Feldstein (1988) to impute corporate tax liabilities to individuals. The approach computes two numbers: (1) the ratio of corporate taxes to total capital income (θ) and (2) the ratio of pretax corporate profits to dividends (μ). Under the assumption that corporate income taxes are borne by all capital income, θ represents the average tax rate on capital income. Taxes on corporate income are taxes on distributed and nondistributed profits. This method assumes that corporate profits associated with an individual are proportional to dividends received. Thus, μ gives the markup to associate corporate profits with households.

Capital income (K) is the sum of corporate profits (C), net interest received by households (I), and rental income (R). Once I compute K and its components along with the corporate tax liability (T) and personal dividends (D), I can compute θ and μ:

[A1] $\theta = T/K$

[A2] $\mu = C/D.$

Pretax corporate profits are the sum of NIPA corporate profits plus the decrease in the value of corporate debt resulting from inflation plus real interest earned by pension funds.

The NIPA corporate profits (excluding Federal Reserve Bank (FRB) profits) equaled \$506.0 billion in 1994. Credit market instrument liabilities of the corporate sector equaled \$2,627.4 billion (Flow of Funds). The inflation rate for 1994 based on the consumer price index was 2.6 percent. Thus, corporate profits should be increased by (0.026)(\$2,627.4) = \$68.3 billion.

Interest income received by pension funds equaled \$57.6 billion. To convert to real interest income, I use nominal interest rates weighted by holdings of pension funds and convert using the inflation rate (π). The holdings are as shown below.

Holding	Amount	Percentage	Interest Rate	Source
Time deposits, etc.	116.9	15.7	3.0%	FRB source; assumed based on various rates
Money funds	31.2	4.2	4.9%	6-month commercial paper
Government bonds	362.5	48.7	7.1%	10-year G bonds
Corporate bonds	233.4	31.4	8.6%	Baa bonds

[1] The income classes were 5,000–10,000, 10,000–15000, 15000–20,000, 20,000–30,000, 30,000–40,000, 40,000–50,000, 50,000–75,000 and above 75,000.

Holding	Amount	Percentage	Interest Rate	Source
Time deposits, etc.	2994.8	64.8	3.0%	FRB source; assumed based on various rates
Money funds	352.2	7.6	4.9%	6-month commercial paper
Government bonds	925.8	20.0	7.1%	10-year G bonds
Corporate bonds	346.3	7.5	8.6%	Baa bonds

This implies a nominal interest rate (ρ) of 6.8 percent. The real rate (r) is given by $(1 + \rho)/(1 + \pi) - 1$, which in this case equals 4.1 percent. The adjuster to convert nominal interest into real interest is the ratio of real to nominal interest: 4.1/6.8 = 0.602. Thus, real pension interest income is (0.602)(57.6) = $34.7 billion. Corporate profits are the sum of reported corporate profits (506.0), the decrease in corporate debt due to inflation (68.3), and real pension interest income (34.7) for a total of $609.0 billion.

Interest received by households from NIPA is $661.6 billion. This is converted to real interest by the same method as pension interest income. The interest rate weights are based on holdings of households in Flow of Funds, as shown above.

This gives a nominal interest rate of 4.4 percent and a real interest rate of 1.8 percent. Thus, real personal interest income is (1.8/4.4)(661.6) = $263.8 billion.

Personal interest expense (excluding mortgage interest) is $117.2 billion. The nominal interest rate is based on the following shown below.

This gives a nominal interest rate of 13.0 percent, a real rate of 10.1 percent, and an adjustment factor of 0.780. Thus, real interest expenses are (0.780)(117.2) = $91.4 billion. Net real interest income is the difference of real interest income (263.8) and real interest expenses (91.4) or $172.4 billion.

Finally, rental income in the NIPA tables is 116.6 billion. Capital income (K) is the sum of corporate income (609.0), net real interest income (172.4), and rental income (116.6) for a total of $898.0 billion.

Corporate tax liabilities come from the NIPA tables and equal $144.0 billion in 1994. Personal dividends (D) are the NIPA dividends paid to persons (211.0) less dividends attributable to pension funds (26.3) or $184.7 billion.

The average tax rate on corporate income (θ) is the ratio of corporate tax collections to capital income and equals 144.0/898.0 or 0.160. The ratio of pretax corporate profits to dividends (μ) equals 609.0/184.7 or 3.30. Finally, corporate taxes per dollar of dividends distributed equals $\theta\mu = 0.528$. Finally, I use the adjusters for under-reporting that Feldstein uses for dividends (0.71) and interest income (0.82). Thus, my formula for attributing corporate tax liability is

[A3] $$\text{Corporate Tax Liability} = 0.528*\text{Div}/0.71 + 0.160*\text{Int}/0.82 + 0.160*\text{Rent}.$$

Appendix B

Using the 1992 Input Output Accounts[2]

The Input-Output accounts trace through the production of commodities by industries and the use of those commodities by other industries. Taken together, one can trace the use of inputs by one industry by all other indus-

Holding	Amount	Percentage	Interest Rate	Source
Consumer credit	990.2	59.2	15.70%	credit card rates in FRB
Miscellaneous debt	681.9	40.8	9.20%	prime rate + 2%

[2] The 1992 Input-Output accounts are described in Lawson (1997).

tries. Various adding-up identities along with assumptions about production and trade allow the accounts to be manipulated to trace through the impact of price changes in one industry on the products of all other industries in the economy. A brief description of the use of the Input-Output accounts follows.[3]

Tracing price changes through the economy on the basis of Input-Output accounts dates back to work by Leontief (documented in Leontief (1986)). The model makes a number of important assumptions, the most important of which are (1) goods are produced and sold in a perfectly competitive environment such that all factor price increases are passed forward to consumers, (2) domestic and foreign goods are sufficiently different that the price of domestic goods can adjust following changes in factor prices,[4] and (3) input coefficients (the amount of industry i used in the production of industry j) are constant. Thus, input substitution is not allowed as factor prices change. This last assumption means that price responses are only approximate as they don't allow for product mix changes as relative prices change. In effect, the Input-Output accounts can be used to trace first-order price effects through the economy.

Two sets of equations define the basic Input-Output accounts. The first set relates the demand for goods from an industry to the value of output from that industry:

$$[B1] \quad x_{11}p_1 + x_{12}p_1 + \dots + x_{1N}p_1 + d_1p_1 = x_1p_1$$

$$x_{21}p_2 + x_{22}p_2 + \dots + x_{2N}p_2 + d_2p_2 = x_2p_2$$

$$x_{N1}p_N + x_{N2}p_N + \dots + x_{NN}p_N + d_Np_N = x_Np_N$$

where x_{ij} is the quantity of the output from industry i used by industry j, p_i is the unit price of product i, d_i is the final demand for output i, and x_i is the total output of industry i. These N equations simply say that the value of output from each industry must equal the sum of the value of output used by other industries (intermediate inputs) plus final demand. Without loss of generality, we can choose units for each of the goods so that all prices equal one. This will be convenient as the expenditure data in the Input-Output accounts can then be used to measure quantities prior to any taxes that I will impose.

The second set of equations relates the value of all inputs and value added to the value of output:

$$[B2] \quad x_{11}p_1 + x_{21}p_2 + \dots + x_{N1}p_N + v_1 = x_1p_1$$

$$x_{12}p_1 + x_{22}p_2 + \dots + x_{N2}p_N + v_2 = x_2p_2$$

$$\vdots$$

$$x_{1N}p_1 + x_{2N}p_2 + \dots + x_{NN}p_N + v_N = x_Np_N$$

where v_i is value added in industry i. Define $a_{ij} = x_{ij}/x_j$, the input of product i as a fraction of the total output of industry j. The system [B2] can be rewritten as

$$[B3] \quad (1 - a_{11})p_1 - a_{21}p_2 - \dots - a_{N1}p_N = v_1/x_1$$

$$-a_{12}p_1 + (1 - a_{22})p_2 - \dots - a_{N2}p_N = v_2/x_2$$

$$\vdots$$

$$-a_{1N}p_1 - a_{2N}p_2 - \dots + (1 - a_{NN})p_N = v_N/x_N$$

These equations can be expressed in matrix notation as

$$[B3'] \quad (I - A')P_I = V$$

where I is an $N \times N$ identity matrix, A is an $N \times N$ matrix with elements a_{ij}, P_I is an $N \times 1$ vector of industry prices, p_i, and V is the $N \times 1$ vector whose ith element is v_i/x_i. Assuming that $(I - A')$ is nonsingular, this system can be solved for the price vector:

$$[B4] \quad P_I = (I - A')^{-1}V.$$

With the unit convention chosen above, P_I will be a vector of ones. However, we can add taxes to the system in which case the price vector will now differ from a vector of ones as intermediate goods taxes get transmitted through the system. Specifically, let t_{ij} be a unit tax on the

[3] For a more complete discussion, upon which this discussion is based, see Fullerton (1996).
[4] Fullerton (1996) terms this the Armington assumption following the work by Armington (1969).

use of product i by industry j. In this case, the value of goods used in production (grossed up by their tax) plus value added now equals the value of output:

$$[B5]\quad x_{11}p_1(1+t_{11}) + x_{21}p_2(1+t_{21}) + \ldots$$
$$+ x_{N1}p_N(1+t_{N1}) + v_1 = x_1p_1$$
$$x_{12}p_1(1+t_{12}) + x_{22}p_2(1+t_{22}) + \ldots$$
$$+ x_{N2}p_N(1+t_{N2}) + v_2 = x_2p_2$$
$$\vdots$$
$$x_{1N}p_1(1+t_{1N}) + x_{2N}p_2(1+t_{2N}) + \ldots$$
$$+ x_{NN}p_N(1+t_{NN}) + v_N = x_Np_N.$$

This set of equations can be manipulated in a similar fashion to the equations above to solve for the price vector:

$$[B6]\quad P_I = (I - B')V$$

where B is an $N \times N$ matrix with elements $(1 + t_{ij})a_{ij}$.[5]

I regrouped industries in the Input-Output accounts into 40 industry groupings. Table B1 lists the groups along with the Input-Output accounts grouping. Tax rates are computed as the ratio of required tax revenue from the industry divided by the value of output from that industry. For the carbon tax, for example, the tax rate equals

$$t_{3.} = \frac{20}{\sum_{j=1}^{N} x_{3j}}$$

where the tax is designed to collect $20 billion from the coal industry (industry 3). This tax is applied to all variables in the third equation of Eq. [B5]. Other industry level taxes are computed in a similar fashion. Some taxes only apply to the output of certain industries used by certain other industries. The treatment of industry 4, crude oil and natural gas, provides an example. The crude oil and natural gas industries are combined into one industry by the Input-Output accounts. Natural gas, however, is predominantly used by the utilities industries (industries 33 and 34), while crude oil goes to the petroleum refining industry. Thus, I allocate the tax on natural gas to output from the crude oil and natural gas industry (industry 4) used by the utilities (industries 33 and 34), while the carbon tax on petroleum is allocated to the use of industry 4 by the petroleum refining industry (industry 19).

Equation [B6] indicates how prices change in response to the industry level taxes. I next have to allocate the price responses to consumer goods. The Input-Output accounts provide the information with which this transformation can be made. Let Z be an $N \times M$ matrix, where z_{ij} represents the proportion of consumer good j ($j = 1, \ldots, M$) derived from industry i ($i = 1, \ldots, N$). The columns of Z sum to 1. If P_C is a vector of consumer goods prices (an $M \times 1$ vector), then

$$[B7]\quad P_C = Z'P_I.$$

Selected columns from the price transformation matrix, Z, are given in Table B2. The table for 1992 is similar to the table for 1972 constructed by Ballard et al. (1985) and the table for 1977 in Fullerton and Rogers (1993).

[5] I restate the 1992 Input-Output accounts data in 1994 dollars by grossing up the data by the ratio of 1994 to 1992 industry level output as measured in the NIPA accounts.

TABLE B1
INDUSTRY GROUPINGS

Group Number	IO Groups	Industry Description
1	1–4	agriculture, forestry and fisheries
2	5, 6, 9, 10	mining (other than coal)
3	7	coal mining
4	8	crude oil and natural gas
5	11, 12	construction
6	14	food and kindred products
7	15	tobacco
8	16–19	textile products
9	20, 21	lumber and wood products
10	22, 23	furniture and fixtures
11	24, 25, 26A	paper and paperboard products
12	26B	printing and publishing
13	27A	industrial and other chemicals
14	27B	agricultural fertilizers and chemicals
15	28	plastics and synthetic materials
16	29A	drugs
17	29B	cleaning and toilet preparations
18	20	paints and allied products
19	31	petroleum refining
20	32	rubber and miscellaneous plastics
21	33, 34	leather goods
22	35	glass products
23	36	stone and clay products
24	37, 38	primary metals
25	13, 39–42	fabricated metals
26	43–52	machinery, not electrical
27	53–58	electrical machinery
28	59A–61	motor vehicles
29	62–63	scientific instruments
30	64	miscellaneous manufacturing
31	65A–65E	transportation
32	66, 67	communications
33	68.01	electric utilities
34	68.02	gas utilities and distribution
35	69A	wholesale trade
36	69B	retail trade
37	70	finance and insurance
38	71	real estate
39	72–77	services
40	68.03, 78–85	government and other enterprises

TABLE B2
PRICE TRANSFORMATION MATRIX FOR SELECTED CONSUMPTION ITEMS

Industry Description	Food Off-Premise	Tobacco	Alcohol Off-Premise	Clothing and Shoes	Gasoline
Agriculture, forestry, and fisheries	0.0486	0	0	0	0
Mining (other than coal)	0	0	0	0	0
Coal mining	0	0	0	0	0
Crude oil and natural gas	0	0	0	0	0
Construction	0	0	0	0	0
Food and kindred products	0.5932	0	0.5202	0	0
Tobacco	0	0.6331	0	0	0
Textile products	0	0	0	0.3724	0
Lumber and wood products	0	0	0	0	0
Furniture and fixtures	0	0	0	0	0
Paper and paperboard products	0	0	0	0.0151	0
Printing and publishing	0	0	0	0.0009	0
Industrial and other chemicals	0.0016	0	0	0	0
Agricultural fertilizers and chemicals	0	0	0	0	0
Plastics and synthetic materials	0	0	0	0	0
Drugs	0	0	0	0	0
Cleaning and toilet preparations	0	0	0	0	0
Paints and allied products	0	0	0	0	0
Petroleum refining	0	0	0	0	0.4542
Rubber and miscellaneous plastics	0	0	0	0.0171	0
Leather goods	0	0	0	0.0723	0
Glass products	0	0	0	0	0
Stone and clay products	0	0	0	0	0
Primary metals	0	0	0	0	0
Fabricated metals	0	0	0	0	0
Machinery, not electrical	0	0	0	0	0
Electrical machinery	0	0	0	0	0
Motor vehicles	0	0	0	0	0
Scientific instruments	0	0	0	0	0
Miscellaneous manufacturing	0	0	0	0.0017	0
Transportation	0.0235	0.0038	0.0226	0.0043	0.0261
Communications	0	0	0	0	0
Electric utilities	0	0	0	0	0
Gas utilities and distribution	0	0	0	0	0
Wholesale trade	0.0888	0.1805	0.2311	0.0697	0.3242
Retail trade	0.2463	0.1826	0.2261	0.4481	0.1955
Finance and insurance	0	0	0	0	0
Real estate	0	0	0	0	0
Services	0	0	0	0.0003	0
Government and other enterprises	–0.0020	0	0	–0.0019	0

TABLE B2 (Continued)

Industry Description	Fuel Oil	Motor Vehicles	Health Care	Household Operations
Agriculture, forestry, and fisheries	0	0	0	0.0005
Mining (other than coal)	0	0	0	0.0005
Coal mining	0.0056	0	0	0
Crude oil and natural gas	0	0	0	0
Construction	0	0	0	0
Food and kindred products	0	0	0	0
Tobacco	0	0	0	0
Textile products	0	0	0	0.0019
lumber and wood products	0.0086	0	0	0
Furniture and fixtures	0	0	0	0
Paper and paperboard products	0	0	0.0026	0.1371
Printing and publishing	0	0	0	0.0002
Industrial and other chemicals	0.0284	0	0.0001	0.0027
Agricultural fertilizers and chemicals	0	0	0	0.0135
Plastics and synthetic materials	0	0	0	0
Drugs	0	0	0.0591	0
Cleaning and toilet preparations	0	0	0	0.1576
Paints and allied products	0	0	0	0.0071
Petroleum refining	0.4668	0	0.0001	0
Rubber and miscellaneous plastics	0	0	0.0007	0.0047
Leather goods	0	0	0	0
Glass products	0	0	0	0
Stone and clay products	0	0	0	0.0055
Primary metals	0	0	0	0
Fabricated metals	0	0	0	0.0081
Machinery, not electrical	0	0	0	0
Electrical machinery	0	0	0.0003	0
Motor vehicles	0	0.6499	0	0
Scientific instruments	0	0	0.0087	0
Miscellaneous manufacturing	0	0	0	0
Transportation	0.0358	0.0169	0.0038	0.1106
Communications	0	0	0	0
Electric utilities	0	0	0	0
Gas utilities and distribution	0	0	0	0
Wholesale trade	0.1395	0.0297	0.0115	0.0597
Retail trade	0.3122	0.1905	0.0364	0.1155
Finance and insurance	0	0	0.0583	–0.0036
Real estate	0	0	0	0
Services	0	0	0.8185	0.2302
Government and other enterprises	0.0031	0.1130	0	0.1482

Source: Author's calculations from 1992 Input-Output Accounts. A complete price transformation table is available from the author upon request.