A DISTRIBUTIONAL ANALYSIS OF AN ENVIRONMENTAL TAX SHIFT

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ABSTRACT

I use data from the 1994 Consumer Expenditure Survey as well as other sources to measure the distributional impact of green tax reforms and consumption tax reforms using both annual income and lifetime income approaches to rank households.

A modest tax reform in which environmental taxes equal to 10% 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.

I then compare these reforms to a reform that shifts the tax base from income to consumption. In this case, it is difficult to maintain the level of progressivity that exists under the current income tax although ways exist by which the regressivity of the reform could be blunted. Whether the long term growth gains from consumption tax reform would offset the initial increase in regressivity remains to be determined.

A shift to greater reliance on environmental taxes would reduce the progressivity of the tax system. This analysis indicates that reforms can be designed to preserve the existing income distribution. In fact, it appears to be easier to maintain distributional neutrality with a Green tax reform than with a comprehensive consumption tax reform.

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I. 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. A "textbook" 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. Measurement problems abound: 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 the reform. 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. Using data from the 1994 Consumer Expenditure Survey and other sources, I show that a modest tax reform in which environmental taxes equal to 10 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.

I then compare these reforms to a reform that shifts the tax base from income to consumption[1]. In this case, it is difficult to maintain the level of progressivity that exists under the current income tax although ways exist by which the regressivity of the reform could be blunted. Whether the long term growth gains from consumption tax reform would offset the initial increase in regressivity remains to be determined. In addition to a wholesale replacement of the income tax with a consumption tax, I also consider a partial shift.

In sum, distributional concerns need not stand in the way of the increased use of environmental taxes. Whether welfare is improved overall by such reforms is a question beyond the scope of this paper but the results shown below suggest the value of continuing to study these reforms and to begin consideration of their adoption.

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. Section IV provides results from the analysis and a concluding section follows.

II. 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."[2] One strand of this literature (as typified by Terkla) considers a reform in which environmental regulations are

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[1] Examples of a consumption tax reform include proposals to replace the income tax with a Flat Tax, a Value Added Tax, and a National Retail Sales Tax.

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

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 (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 efficiency improvements are possible if tax reforms are designed carefully.

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. 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. 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.[3] 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

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

compare the distributional impact of an environmental tax reform to a reform that shifts from income to consumption taxation, a topic of some current policy interest.

III. Methodology

A. Incidence Assumptions

An incidence analysis attempts to answer the question who bears the burden of a particular tax. Any attempt to evaluate the "fairness" of a tax (or a change in the tax system) requires knowing whose disposable income is changed and by how much in response to the tax. Economists often refer to taxes as "regressive" or "progressive." There is often some confusion as to the meaning of these terms and so it is worth defining them carefully. The definition that most economists use relies on the average tax rate - the ratio of tax liabilities to income.[4] A tax is said to be regressive if the average tax rate falls with income. It is proportional if the average tax rate is constant and it is progressive if the average tax rate rises with income. Low income people pay a higher (lower) fraction of their income in taxes if the tax is regressive (progressive).

Early tax incidence studies used the results of partial or general equilibrium models to inform judgments about relevant incidence results. In effect, these studies used existing research results to generate plausible assumptions about the incidence of specific taxes. Pechman (1985) represents the classic example of this type of research.

An alternative approach utilizes estimates of lifetime income as a measure of the taxpaying unit's economic well-being. Invoking Friedman's (1957) permanent income hypothesis as well as

[4]More precisely, the numerator is the change in real disposable income resulting from the change in the tax law. If a new tax is imposed, the change in disposable income might occur because prices have gone up so that a given income purchases fewer goods and services or it might occur because wages or other sources of income have fallen.

life-cycle considerations, economists have long recognized that annual income may not be a very good measure of an individual's potential to consume[5]. With perfect capital markets, individuals should be grouped according to the present discounted value of earnings plus gifts received. This theory makes the difficulties with the annual incidence approach readily apparent. People tend to earn the highest incomes in their life around middle age and the lowest incomes in their youth and old age. Consequently in a cross section (annual) analysis, lower income groups are likely to include some young and elderly people (as well as some people with volatile incomes who have obtained a low realization) who are not poor in a lifetime sense. Similarly, higher annual income groups are likely to contain some people at the peak of their age earnings profile for whom peak earnings are a poor measure of annual ability to consume.

Relative to annual income, lifetime income is more difficult to measure. Poterba (1989, 1991) has proposed using consumption as a proxy for lifetime income, arguing that since household consumption tends to be smoother than income, total annual consumption is likely to be a better measure of household well-being than total annual income. Using data on total expenditures from the Consumer Expenditure Survey, Poterba finds that excise taxes on alcohol, tobacco, and gasoline are much less regressive than they appear when viewed in an annual income framework. Metcalf (1993a) has used a similar approach to analyze state and local tax systems. Like Poterba's findings for excise taxes, he finds that the system of state and local taxes is less regressive when consumption is used to proxy for lifetime income. Feenberg, Mitrusi, and Poterba (1996) also use the consumption proxy for lifetime income in a detailed analysis of a shift

[5] The Permanent Income Hypothesis states that people make consumption decisions on the basis of permanent (or lifetime average) income. Thus, temporary fluctuations in income should not lead to large changes in current consumption.

from the current income tax system to a national sales tax.

The advantage of the approach taken by Feenberg, Mitrusi, and Poterba is its simplicity. Distributional tables can be constructed using data readily available in a single year. The disadvantage is that current consumption may not be a very good proxy for lifetime income. In previous work I have shown (Caspersen and Metcalf (1994)) that distributional tables for consumption taxes using current consumption as a proxy for lifetime income underestimate the regressivity of a consumption tax. This is because the current consumption approach assumes that consumption is roughly constant over the lifetime. However, consumption exhibits the same kind of "hump" that income does over the lifetime (though not as pronounced). The same kinds of errors that occur when ranking people by annual income persist to an extent when people are ranked by consumption. Thus we should view the Feenberg, Mitrusi, and Poterba results as upper bounds on the progressivity of a shift from income to consumption taxation.

One approach to resolving this problem is to use an explicit computable general equilibrium lifecycle model to investigate the incidence of tax reforms. The work by Fullerton and Rogers (1993) is perhaps the best work in this area. Note that there are different "lifetime" experiments that one can analyze. As Poterba (1993) points out, one can look at lifetime tax burdens and/or lifetime income. Fullerton and Rogers look at the lifetime tax burden relative to lifetime income whereas Poterba (1989, 1991) and Metcalf (1993a, 1993b) look at annual tax burdens relative to lifetime income. The latter approach addresses the question of the burden of a particular year's taxes when households are classified by a measure of economic well-being that is less prone to measurement error than annual income. The annual tax/lifetime income approach is taken in this paper[6]. Strictly speaking, one cannot compare the results from a lifetime tax/lifetime income analysis (e.g. Fullerton and Rogers) to an annual tax/lifetime income analysis such as this one.

Despite the attraction of lifetime income, it 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 (1997), for example, consider the impact of tax changes on married families in the age range of 40 to 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 lifecycle. 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 a 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. Taking a multi-year window, as for example the Joint Committee on Taxation (1993) has in a number of studies addresses this problem to some extent. Unfortunately, our dataset does not provide multiple observations on the same household's income and consumption patterns with which we could smooth our income measure. Below, we will report a cohort distribution of taxes as an alternative measure to our lifetime income measure.

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[6] See Caspersen and Metcalf (1994) For a detailed description of my measure of annualized lifetime income.

I distribute taxes using conventional assumptions about incidence derived from previous economic incidence studies. 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). 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 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. Other incidence assumptions would lead to different results. For example, to the extent that consumers reduce their energy consumption in response to the carbon and gas taxes, the incidence could be shifted back to the factors of production in energy industries in the form of lower wages for workers in energy industries, lower returns for owners of capital in this sector, or lower rents to owners of energy resources. This would occur if factor supplies are not perfectly elastic in the area around the original equilibrium. Clearly the ultimate incidence effects could differ markedly if the tax is passed backwards rather than forwards.

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. Thus, this should be viewed as a first order incidence analysis. Clearly, one of the goals of the reform is to raise the price of pollution and consequently reduce polluting activities. To the extent that that is successful, 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[7]. 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.[8]

Another incidence result occurs if these taxes replace current regulations that are designed to mitigate pollution[9]. 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. [INSERT FIGURE 1 ABOUT HERE] The 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

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7 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.

8 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.

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

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. The government, however, has the revenue with 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.

B. Data

The basic data source for this analysis is the 1994 Consumer Expenditure Survey (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 3 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 National Medical Expenditure Survey (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. Third, I attribute corporate tax payments

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

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.

IV. Tax Shift Analysis

A. A Green Tax Shift Equal to 10 Percent of Federal Revenues

I begin with an analysis of a moderate shift in the income tax base in which I replace 10 percent of federal receipts with a cluster of environmental taxes. Since federal revenues totaled $1,258 billion in 1994 (see Table 1), this scenario requires raising roughly $126 billion in new taxes. I begin with a description of the environmental taxes that I consider followed by a description of the tax reductions that are funded by the environmental levies[11]. The new taxes that I implement are taxes on carbon emissions, gasoline consumption, air pollution, and the use of new (virgin) materials in production.

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 (.025 tons of carbon per billion BTUs) followed closely by oil (.020 tons per billion BTUs). Natural gas contains .015 tons per billion BTUs (Poterba, Table 3.3, 1991). The main attraction of a carbon tax is that it discourages carbon

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

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)).

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¢ per gallon of gasoline and 24.3¢ per gallon of diesel fuel (CBO, 1997). I model an increase in the gasoline tax of 15¢

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[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.

per gallon and an increase in the diesel fuel tax (for diesel in highway use) of 9.4¢ 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 NIPA accounts, 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 source or non-point sources of pollution. For point source emissions, I model a $150 per ton tax on sulphur dioxide (SO_2) emissions, a $1500 per ton tax on nitrogen oxide (NO_x) emissions, a $900 per ton tax on particulate matters (PM-10), and a $2000 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 2 provides information on emissions in 1990 from which I make this allocation[14]. Sulphur 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 NOX,

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

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 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 10 percent of federal receipts. Table 3 summarizes the revenues. Table 4 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 since 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

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

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

percent of the share of industry goods used by the electricity industry is subject to the tax. Other important industrial inputs into the electricity industry include construction (22 percent) and services (12 percent).

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, airline fares) with an increase of 0.6 percent. Air pollution taxes raise electricity and natural gas prices by 8 and 6 percent respectively while raising the price of other goods modestly. Jewelry and watch prices rise by nearly 4 percent due to the use of VOCs in their production. The virgin materials tax has a modest impact less than 1 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 2 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 the first $5,000 of tax base for each worker. For workers earning less than $5,000 of covered wages, I exempt them from the tax, both at the personal and business level. Based on data in the Consumer Expenditure Survey 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 (SOI, Winter 96-97), this will cut tax collections by $34.9 billion. Finally, I implement an across the board income tax cut of 4 percent. This reduces tax revenue by $21.3 billion in my data. Table 5 summarizes the tax cuts that are funded by the new environmental levies.

B. Distributional Impact of a Green Tax Reform

Table 6 provides incidence results for households in the Consumer Expenditure Survey[17]. As discussed above, I provide results using three different measures of income and group households into ten income groups with decile 1 representing households in the lowest 10 percent of the income distribution and decile 10 representing households in the top 10 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. 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 3 percent of their income while the group from 10th to 20th percentiles face an increase of over 1 percent of income. Given the small size of the redistribution ($125.6 billion), no single group faces a large tax increase. If the hope is to design a progressive tax shift, however, this proposal falls short on the basis of annual income measures.

The Suits Index provides a summary measure of income redistribution. 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. Figure 2 illustrates how the Suits Index is calculated. [INSERT FIGURE 2 ABOUT HERE] The horizontal axis indicates the

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[17] Households are weighted by consumption spending.

[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 5 percent of the income distribution from the analysis. Thus decile 1 only includes households in the 5th to 10th percentiles of the income distribution.

cumulative distribution of income (ranging from zero to one). The vertical axis indicates the cumulative distribution of taxes (again, ranging from zero to 1). We can then graph the cumulative tax collections from different portions of the income distribution in this graph. Such a graph is called a Tax Concentration Curve and I have drawn three possible curves. Consider first the curve in the lower right triangle of the box. This tax concentration curve represents a progressive tax system. To read it, consider the point (0.50, 0.15) that I have marked on this curve. This point indicates that the bottom 50 percent of the income distribution pays 15 percent of all taxes. Whenever a tax concentration curve lies entirely below the main diagonal of the box, the tax system is unambiguously progressive. The Suits Index is given by the ratio of the area B (area between the tax concentration curve and the main diagonal) and the area A + B (the lower right triangle of the box).

The diagonal line running from the lower left corner of the box to the upper right corner indicates a tax concentration curve for a proportional tax system. The bottom 50 percent (20 percent) of the population would pay 50 percent (20 percent) of the taxes. The Suits Index in this case would be zero. Finally, the dashed line above the main diagonal is a tax concentration curve for a regressive tax. The bottom half of the income distribution pays more than half of the taxes. In this case the Suits Index would be negative.

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 6), 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 degree of regressivity is fairly small, however, as the difference in Suits Indices is near 0.

One problem with this measure of tax shifting and distribution is that we are implementing a small tax and so should not expect large changes in the Suits Index. The Suits Index is also a single summary measure of tax redistribution and does not indicate the full flavor of the change in tax burdens following a tax reform. As a final measure of the degree of tax redistribution, I construct a variable that I call a "tax shift" measure. It is the additional aggregate taxes paid by each decile measured as a percentage of the total amount of taxes that are being replaced by the new tax. The tax shift variable measures redistribution *across* income deciles but ignores redistribution *within* income deciles[19]. For example, the tax reform modeled in Table 6 shifts $125.4 billion from income to environmental taxes. The households in the lowest decile face a higher tax burden equal to 0.9 percent of this shifted amount ($1.13 billion in additional taxes). A distributionally neutral tax reform would be a reform for which the tax shift variable equaled zero for each decile. The tax shift variable indicates that much of the variation in taxes cancels out within deciles and that across decile shifting is on the order of 5 percent of the total new tax revenues ($6.1 billion). The sixth and ninth deciles receive the greatest reductions in decile tax burden receiving nearly 2 percent (each) of the total new taxes.

The second set of columns uses the measure of annualized lifetime income that I have

[19] This is simply an alternative way of presenting information about the change in average tax payments within each decile.

proposed in Caspersen and Metcalf (1994). 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 10^{th} to 80^{th} percentiles face lower taxes. Measured as a percentage of income, no group sees a change in tax liability as large as ½ 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 tax shift variable shows that the top decile receives over 3 percent of the new tax revenues and that the lowest decile along with the top two deciles receive over 4 percent of revenues. Again, the degree of across decile tax shifting is not very large with this reform.

Given the criticisms of the lifetime income approach discussed above, 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. Measured as a fraction of income, the change is slightly larger for some groups. For example, households in the 20^{th} to 30^{th} percentiles receive a tax reduction equal to .7 percent of annual income as opposed to a reduction equal to .4 percent of annualized lifetime income[20]. The change

[20] Note that households in the third decile as measured by annualized lifetime income may not be the same as households in the third decile as measured by annual income. The first two income rankings also use all households while the last measure only uses a subset of households.

in Suits Indices for this group is 0.01 indicating that this is essentially a proportional reform when considered over the entire distribution.

Table 7 reports Suits Indices on components of the tax reform. Among the new environmental taxes, the carbon tax is most regressive and the virgin materials tax is least regressive. The differences among the various environmental taxes in terms of regressivity are not large however. 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. Since 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.

To measure the sensitivity of the distributional results to changes in the reform proposal, I increased the refundable tax credit from $150 per exemption to $200 per exemption while decreasing the proportional rate reduction to maintain revenue neutrality. The cost of the refundable exemption rises from $34.9 billion to $46.5 billion. The rate reduction on the personal income tax must be lowered to reduce the collections by $11.6 billion and the proportional rate reduction is now 1.7 percent. With this small change, the tax reform now looks progressive (as measured by the Suits Index) regardless of the income measure used or cohort considered (see

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Finally, note that the distribution of tax changes in the cohort measure is not revenue neutral. This group as a whole pays roughly $2.4 billion less in taxes as a result of this reform. Those revenues are recaptured through higher taxes on other age and marital status cohorts.

Table 8). Taking annual income as the appropriate measure of household well-being, the tax is now essentially proportional. Households in the 5th to 10th percentiles face an increase in taxes on average of $171 per year (2.2 percent of their income) while households in the 10th to 30th percentiles face smaller increases. Households in the 30th to 90th percentiles receive tax reductions with the largest reduction going to the 6th decile. The top decile faces the largest tax increase (in absolute terms though the increase is small relative to their income). The tax shift (as a percentage of tax collections from the new tax) is largest for this decile with the increase in their taxes equal to 2.9 percent of the $125 billion collected from the new taxes.

The degree of progressivity rises considerably under either of the two measures designed to account for lifecycle considerations. The lifetime income approach indicates that the 5th to 10th percentile households face very small tax increases (.2 percent of income) while households in the 10th to 80th percentiles face tax cuts up to .4 percent of income. The top 20 percent of the distribution face tax increases with the top decile facing an increase of .4 percent. A similar result holds for the married, middle-aged cohort except now the lowest income group receives a tax cut rather than a tax increase. The tax cuts range from a low of .01 percent to a high of 1.01 percent. The top decile has a modest tax increase of .18 percent and the change in the Suits Index is now .057. In summary, Table 8 demonstrates that it is possible to construct an environmental tax that is essentially distributionally neutral despite the regressivity of the various environmental levies.

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 9 presents results from this scenario.

Ranking households by annual income, the tax looks mildly progressive except in the lowest income group. Households in the income 10th through 70th 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 largest shift in terms of tax collections occurs in the top decile which faces a higher tax burden equal to nearly 6 percent of the revenues collected from the new taxes.

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 we 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 .084 and

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[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 .11 percent ($.5 billion).

.118.

Summing up, all of the reforms that I have considered can essentially be viewed as both revenue and distributionally neutral. Given the modest amount of revenue changes resulting from the reform, we should not expect large shifts in the income distribution. Despite the rather regressive nature of the taxes that make up the new environmental tax revenues (as measured by the Suits Index in Table 7), I have shown in 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 9, it would not be difficult to structure the tax reform to add progressivity to the tax system. An important question is the degree of tax shifting that occurs under any of these reforms relative to the tax shifting that would occur under alternative reforms. To address this issue, I next contrast the green tax shift to a shift from income to consumption taxation, a reform that has been discussed and debated at some length in the past few years.

D. A Retail Sales Tax Reform

It is instructive to contrast the distributional impact of a green tax reform to a reform that is currently under discussion: a shift from income to consumption taxation. In this section, I consider a shift from the current income tax to a broad based retail sales tax[23]. I consider two different reforms: first a replacement of the entire income tax with a national retail sales tax and then a replacement of 10 percent of the income tax with a small sales tax. This latter reform, while not under serious consideration, allows comparisons between the environmental tax reforms

[23] While I model a retail sales tax, the distributional results are identical to those that would result from analyzing a broad based value added tax or a Flat Tax with no family exemptions.

discussed above and the consumption tax reform discussed in this section.

The tax base for the national sales tax as modeled here is quite comprehensive. Housing services are not taxed per se but are taxed at the time of purchase of the house. The same approach is used for other durable goods. Medical services are included in the tax base as are other services. Assuming that non-profits and imputed financial services are included in the tax base, the revenue neutral tax rate would be 16.5 percent.[24] Table 10 shows the distribution of a shift from the income tax to a broad based income tax using an annual income incidence approach. Based on the annual income approach, the tax reform is very regressive. Tax liabilities increase for the bottom 70 percent of the income distribution and decrease for the top 30 percent. The changes are quite substantial with the lowest income group seeing their average tax rate increase by 34 percentage points. Meanwhile the top decile's average tax rate falls by 7 percent. Another way to measure the regressivity of the tax reform based on annual income is to note that the Suits Index falls from 0.202 (income tax) to -0.228 (retail sales tax) as a result of the reform. Given the size of the tax, the shift across deciles can be quite substantial. Each of the deciles from the 10th to the 40th percentiles faces an increase in taxes equal to 5 percent of the taxes collected under the personal and corporate income taxes. Meanwhile, the top decile enjoys a decrease in taxes equal to a quarter of tax collections.

The regressivity of the tax reform is reduced significantly when I shift to a lifetime income analysis. The variation in changes in tax liabilities across lifetime income deciles falls markedly relative to the annual income analysis. The reform is still regressive - the lowest 70 percent of the

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[24] Excluding imputed financial services and non-profits from the tax base would require a tax rate of 18.2 percent. See Metcalf (1997) for details.

income distribution face tax increases while the top 30 percent enjoy tax decreases. However the differences are not nearly as large as when measured using annual income to rank households. Moreover, the change in average tax rates is much smaller with the lowest lifetime income group facing an average increase in their average tax rate of 7.8 percentage points while the top decile's average tax rate falls by 3.5 percentage points. Ranking households by lifetime income, the Suits Index now falls from 0.068 to -0.045 with this tax reform. Unlike in the previous tax shifts, the cohort analysis provides results more similar to the annual income approach than to the lifetime income approach. The sensitivity of distributional results for a consumption tax reform to how lifetime income is measured suggests that one should be cautious in using annual income and consumption data to try to measure distributional effects based on lifetime or permanent income.[25]

One misconception about consumption tax reform (and, in particular, a reform that involves a value added tax or a national retail sales tax) is that it is by definition regressive. It would be possible to add progressive elements to the reform to mitigate regressivity. I next illustrate this point by modifying the national retail sales tax to incorporate a family rebate. I model the rebate on the proposal of Burton and Mastromarco (1996). Burton and Mastromarco (1996) have proposed providing universal rebates to households equal to the poverty level to

[25] An additional issue for consumption tax distributional analysis is that much of the suggested gains from tax reform result from increased capital accumulation and productivity, which in turn implies wage growth. The dynamic responses to tax reform cannot be captured in a "snap shot" distributional analysis and requires the use of large scale computable general equilibrium models. Fullerton and Rogers (1996) have applied such a model to a Flat Tax Reform and found the tax shift to be regressive. Altig et al. (1997) have also analyzed the Hall-Rabushka Flat Tax and concluded that a "clean" tax reform can raise incomes at the lowest income levels. The income gains at the bottom of the distribution diminish rapidly, however, as they add increased realism to their reform in the form of deviations of the actual tax reform from an idealized tax reform.

build progressivity into the tax system. Poverty thresholds for 1994 ranged from $7,107 for an elderly unrelated individual to $30,285 for a family of size 9 or more. The rebate would equal the tax rate times the poverty threshold for a given family size[26]. In effect, the rebate removes from the tax base an amount equal to the sum of poverty thresholds for each family unit in the United States added up over all family units. Call this amount the aggregate rebate base. Based on extrapolations from the Consumer Expenditure Survey data set for 1994, the aggregate rebate base would equal $1.15 trillion. Assuming that non-profits and imputed financial services are included in the tax base, the revenue neutral tax rate would rise from 16.5 percent to 22.8 percent.

Table 11 presents incidence results for a broad based national sales tax with a universal rebate based on poverty thresholds. Compared to Table 10, the tax is modestly less regressive when evaluated using the annual income approach. However it continues to look very regressive. The Suits Index for the sales tax with rebate is -0.171 indicating considerable regressivity (relative to the income tax system it replaces for which the Suits Index equals 0.202). Tax shifts continue to be quite substantial with the top decile receiving a decrease in aggregate taxes equal to nearly one quarter of tax collections under the national retail sales tax. The regressive nature of the reform falls when I rank people by lifetime income. The change in taxes ranges from a decrease of nearly 2 percent (decile 10) to an increase of 5.4 percent (decile 1). Ranking households by lifetime income the Suits Index for the sales tax with rebate (0.005) is much closer to the value of the index for the current income tax (0.068). The cohort measure, however, suggests that the tax reform is still quite regressive. The Suits Index rises substantially and across decile distributions

[26]Burton and Mastromarco propose grossing up the rebate so that disposable income after the rebate is brought up to the poverty threshold. Structuring the rebate that way would not change the distributional impact of the tax reform in any substantive way.

are also quite large (nearly one third of tax collections accrue to top decile in lower taxes).

Next I consider a more modest tax reform that is more comparable to the environmental tax reforms considered in the last section. A broadbased sales tax is imposed with a rate sufficiently high to raise $125 billion in revenue. The revenue is used to lower taxes as described in the first scenario (Table 6). Based on the annual income analysis, the tax reform is regressive with the lowest 30 percent of the income distribution along with the top 10 percent facing tax increases. Across decile tax shifts exceed one percent of tax revenue for the groups facing a tax increase. The change in Suits indices shows a shift toward greater regressivity in the tax system. Under either the lifetime income measure or the cohort measure, the tax shift looks modestly progressive with the Suits Index increasing in both cases. For the cohort analysis, taxes fall for all but the top 20 percent of the income distribution. Using the lifetime income measure, taxes fall for the 10^{th} through 80^{th} percentiles. The lowest decile faces a .3 percent increase in average tax rates.

If the desire in tax reform is to maintain or increase the progressivity of the tax system, it appears from this analysis that environmental tax reforms may be more effective than a comprehensive consumption tax reform. The differences between a ten percent shift to consumption tax versus a cluster of environmental taxes is much smaller. Focusing on the bottom of the distribution, the environmental taxes do not increase the tax burden for the lowest income decile as much as the consumption tax reform (using annual or lifetime income measures). A smaller fraction of the taxes collected are shifted onto the top decile, however, under the environmental taxes (0.5 percent versus 1.7 percent for the sales tax).

This paper has only focused on distributional considerations. Whether efficiency gains are greater under environmental than consumption tax reforms is an issue that I have not addressed in this paper. For environmental reforms, one efficiency gain is the closer alignment of marginal social costs with marginal social benefits in the use of pollution related inputs and goods. A second issue is the degree to which the efficiency distortions which arise from price changes in the face of pre-existing tax distortions are greater or less than distortions that can be reduced by lowering other taxes[27].

V. Conclusion

I have considered a number of environmental and other tax reforms in this paper to measure the distributional impact of changes in the tax system. A reform that raises environmental taxes and uses the proceeds to lower the personal income tax will affect consumers directly (paying the gasoline tax at the pump) and indirectly (through higher consumer prices). Using the 1992 Input-Output Accounts, I have traced through changes in intermediate goods prices resulting from taxes on these goods to changes in consumer prices. Assuming forward shifting of taxes, I allocate these taxes to households in the 1994 Consumer Expenditure Survey to measure the distributional impact using both annual income and lifetime income approaches to ranking households.

A modest tax reform in which environmental taxes equal to 10 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

[27] For more discussion of this point, see Fullerton and Metcalf (1997, 1998). Also, see the computational results in Bovenberg and Goulder (1996).

possible to increase the progressivity of the tax system with an environmental tax reform.

I then compared these reforms to a reform that shifts the tax base from income to consumption. In this case, it is difficult to maintain the level of progressivity that exists under the current income tax although ways exist by which the regressivity of the reform could be blunted. Whether the long term growth gains from consumption tax reform would offset the initial increase in regressivity remains to be determined[28].

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 certainly feasible.

[28] I have also ignored transition effects. It is possible that transition effects could offset some of the regressivity to the extent that the transition incorporates a lump sum tax on old capital by disallowing transition rules to protect old capital.

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Appendix A - Adjustments to Consumer Expenditure Survey Data

I. 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 National Medical Expenditure Survey (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[29], 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.

II. Imputing Corporate Tax Liabilities to Individuals

I follow the methodology set out in Feldstein (1988) to impute corporate tax liabilities to individuals. The approach compute two numbers: 1) the ratio of corporate taxes to total capital

[29] The income classes were 5000 to 10000, 10000 to 15000, 15000 to 20000, 20000 to 30000, 30000 to 40000, 40000 to 50000, 50000 to 75000 and above 75000.

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 non-distributed profits. This method assumes that corporate profits associated with an individual are proportional to dividends received. Thus μ gives the mark-up 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.

NIPA corporate profits (excluding Federal Reserve Bank 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 CPI was 2.6 percent. Thus corporate profits should be increased by (.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:

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 mo. Commercial Paper
Govt Bonds	362.5	48.7	7.1%	10 yr G bonds
Corp Bonds	233.4	31.4	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 = .602. Thus, real pension interest income is (.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:

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 mo. Commercial Paper
Govt Bonds	925.8	20.0	7.1%	10 yr G bonds
Corp Bonds	346.3	7.5	8.6%	Baa Bonds

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 expenses (excluding mortgage interest) is $117.2 billion. The nominal interest rate is based on:

Holding	Amount	Percentage	Interest Rate	Source
Consumer Credit	990.2	59.2	15.7%	credit card rates in FRB
Misc. Debt	681.9	40.8	9.2%	Prime Rate + 2%

This gives a nominal interest rate of 13.0 percent, a real rate of 10.1 percent and an adjustment factor of .780. Thus real interest expenses are (.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 or 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 .160. The ratio of pretax corporate profits to dividends (μ) equals 609.0/184.7 or 3.30. Finally, pretax corporate profits per dollar of dividends distributed equals $\theta\mu$ = .528. Finally, I use the adjusters for underreporting that Feldstein uses for dividends (.71) and interest income (.82). Thus my formula for attributing corporate tax liability is

(A3) Corporate Tax Liability = .528*Div/.71 + .160*Int/.82 + .160*Rent.

Appendix B. Using the 1992 Input Output Accounts[30]

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 industries. 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[31].

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[32], 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

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[30] The 1992 input-output accounts are described in Lawson (1997).

[31] For a more complete discussion, upon which this discussion is based, see Fullerton (1996).

[32] Fullerton (1996) terms this the Armington assumption following work by Armington (1969).

demand for goods from an industry to the value of output from that industry:

(B1)
$$\begin{aligned} x_{11}p_1 + x_{12}p_1 + ... + x_{1N}p_1 + d_1p_1 &= x_1p_1 \\ x_{21}p_2 + x_{22}p_2 + ... + x_{2N}p_2 + d_2p_2 &= x_2p_2 \\ &. \\ &. \\ &. \\ x_{N1}p_N + x_{N2}p_N + ... + x_{NN}p_N + d_Np_N &= x_Np_N \end{aligned}$$

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 1. 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)
$$\begin{aligned} x_{11}p_1 + x_{21}p_2 + ... + x_{N1}p_N + v_1 &= x_1p_1 \\ x_{12}p_1 + x_{22}p_2 + ... + x_{N2}p_N + v_2 &= x_2p_2 \\ &. \\ &. \\ &. \\ x_{1N}p_1 + x_{2N}p_2 + ... + x_{NN}p_N + v_N &= x_Np_N \end{aligned}$$

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

$$
\text{(B3)} \qquad
\begin{aligned}
(1-a_{11})p_1 - a_{21}p_2 - \dots - a_{N1}p_N &= v_1/x_1 \\
-a_{12}p_1 + (1-a_{22})p_2 - \dots - a_{N2}p_N &= v_2/x_2 \\
&\;\;\vdots \\
-a_{1N}p_1 - a_{2N}p_2 - \dots + (1-a_{NN})p_N &= v_N/x_N
\end{aligned}
$$

These equations can be expressed in matrix notation as

$$\text{(B3')} \qquad (I - A')P_I = V$$

where I is an NxN identity matrix, A is an NxN matrix with elements a_{ij}, P_I is an Nx1 vector of industry prices, p_i, and V is the Nx1 vector whose i^{th} element is v_i/x_i. Assuming that (I-A') is non-singular, this system can be solved for the price vector:

$$\text{(B4)} \qquad P_I = (I-A')^{-1}V.$$

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 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:

$$
\text{(B5)} \qquad
\begin{aligned}
x_{11}p_1(1+t_{11}) + x_{21}p_2(1+t_{21}) + \dots + x_{N1}p_N(1+t_{N1}) + v_1 &= x_1p_1 \\
x_{12}p_1(1+t_{12}) + x_{22}p_2(1+t_{22}) + \dots + x_{N2}p_N(1+t_{N2}) + v_2 &= x_2p_2 \\
&\;\;\vdots \\
x_{1N}p_1(1+t_{1N}) + x_{2N}p_2(1+t_{2N}) + \dots + x_{NN}p_N(1+t_{NN}) + v_N &= x_Np_N
\end{aligned}
$$

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

$$\text{(B6)} \qquad P_I = (I - B')V$$

where B is an NxN matrix with elements $(1+t_{ij})a_{ij}$.[33]

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 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

[33] 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.

information with which this transformation can be made. Let Z be an NxM matrix where z_{ij} represents the proportion of consumer good j (j = 1, ..., M) derived from industry i (i = 1, ..., N). The columns of Z sum to 1. If P_C is a vector of consumer goods prices (an Mx1 vector), then

(B7) $$P_C = Z'P_I.$$

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, Fullerton, Shoven, and Whalley (1985) and the table for 1977 in Fullerton and Rogers (1993).

Figure 1. Taxes and Quotas

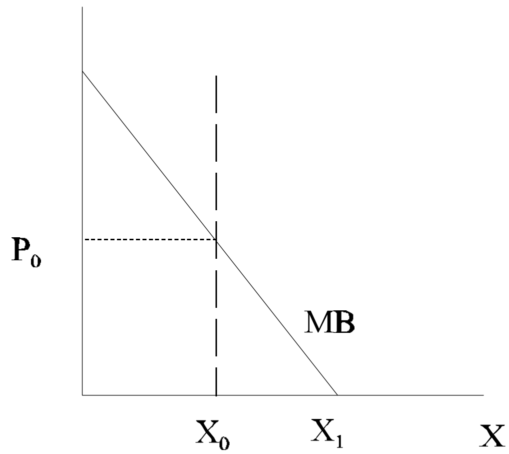

Figure 2. The Suits Index

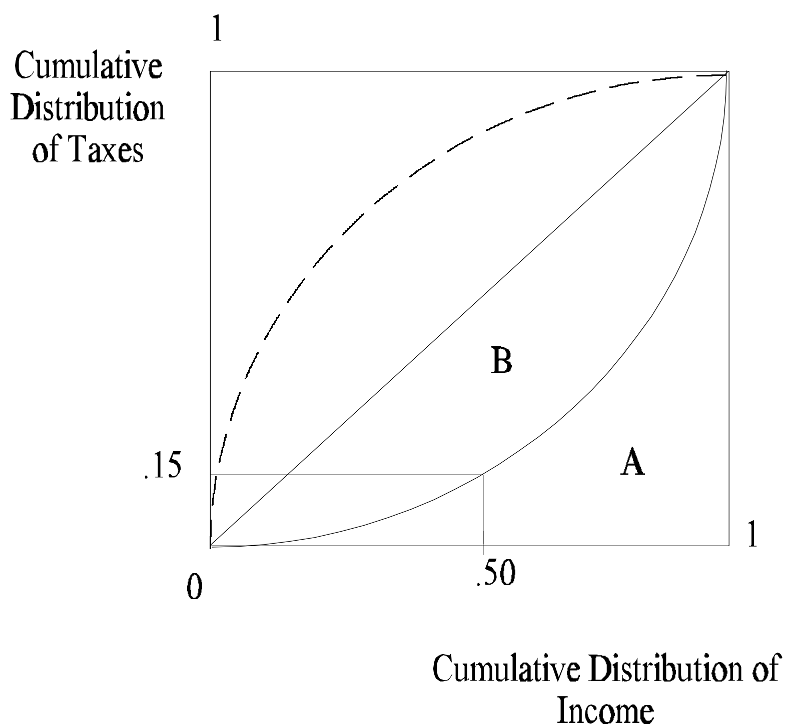

Table 1. Federal Revenues: 1994	
Source	Amount ($billions)
Income Taxes	683
Social Insurance Taxes	461
Excise Taxes	55
Estate & Gift Taxes	15
Other	44
Total	**1,258**

Source: *Statistical Abstract of the United States*, 1996.

Table 2. Stationary Source Emissions in 1990

	Pollutant			
	Sulphur Oxides	**Nitrous Oxides**	**Volatile Organic Compounds**	**Particulate Matter**
Total Emissions (Thousands of Tons Metric)	**20152.4**	**11535.3**	**8209.8**	**2950.1**
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 & 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 & Machinery	4.5%	0.4%	0.8%	9%
Motor Vehicles	0%	0%	2.2%	0%
Misc. 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% due to rounding error.
Source: Data collected by Goulder and described in Goulder (1994).

Table 3. Environmental Taxes	
Tax	Revenue (billions)
Carbon Tax	$56.0
Gasoline Tax	$19.8
Air Pollution Taxes	$40.5
Virgin Materials Tax	$9.3
Total	**$125.6**

Table 4. Impact of Environmental Taxes on Consumer Prices					
Consumption Items	**Carbon Tax**	**Motor Fuels Tax**	**Air Pollution Taxes**	**Virgin Materials Tax**	**Total Tax Rate**
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%

Table 4. Impact of Environmental Taxes on Consumer Prices					
Consumption Items	**Carbon Tax**	**Motor Fuels Tax**	**Air Pollution Taxes**	**Virgin Materials Tax**	**Total Tax Rate**
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%

Table 4. Impact of Environmental Taxes on Consumer Prices					
Consumption Items	**Carbon Tax**	**Motor Fuels Tax**	**Air Pollution Taxes**	**Virgin Materials Tax**	**Total Tax Rate**
Pari-Mutual 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.

Table 5. 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**

Table 6. 10% Green Tax Shift

	Annual Income					Lifetime Income					Married, Age 40-50				
Decile	Increase	Decrease	Δ Tax	Δ Average Tax Rate	Tax Shift	Increase	Decrease	Δ Tax	Δ Average Tax Rate	Tax Shift	Increase	Decrease	Δ Tax	Δ Average Tax Rate	Tax Shift
1	569	335	234	3.01	0.9%	695	645	51	0.23	0.2%	1,248	1,214	34	0.18	0.1%
2	681	533	148	1.29	1.2%	830	913	-83	-0.31	-0.7%	1,406	1,580	-174	-0.61	-0.9%
3	923	801	122	0.74	1.0%	917	1,056	-139	-0.44	-1.1%	1,382	1,681	-299	-0.72	-1.5%
4	1,048	975	73	0.32	0.6%	1,062	1,111	-48	-0.13	-0.4%	1,513	1,761	-248	-0.47	-1.3%
5	1,157	1,143	14	0.07	0.1%	1,199	1,282	-83	-0.20	-0.7%	1,861	1,903	-42	-0.05	-0.2%
6	1,131	1,375	-244	-0.62	-2.0%	1,266	1,297	-31	-0.06	-0.3%	1,706	2,097	-391	-0.57	-2.0%
7	1,410	1,457	-48	-0.10	-0.4%	1,272	1,384	-112	-0.21	-0.9%	1,761	2,163	-402	-0.51	-2.0%
8	1,485	1,591	-105	-0.17	-0.8%	1,440	1,502	-62	-0.11	-0.5%	1,972	2,133	-161	-0.17	-0.8%
9	1,712	1,924	-212	-0.27	-1.7%	1,659	1,571	88	0.13	0.7%	1,998	2,107	-110	-0.08	-0.6%
10	2,260	2,197	62	0.08	0.5%	2,095	1,688	408	0.44	3.3%	2,830	2,954	-124	-0.04	-0.6%
			ΔSuits					ΔSuits					ΔSuits		
Suits	-0.248	-0.207	**-0.041**			-0.056	-0.092	**0.036**			-0.224	-0.234	**0.010**		

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

Table 7. Suits Indices for Components of Tax Reform		
Tax Proposal	**Increased Tax**	**Decreased Tax**
Carbon Tax	-0.260	
Motor Fuels Tax	-0.250	
Air Pollution Taxes	-0.238	
Virgin Materials Tax	-0.214	
Payroll Tax Reductions		-0.230
Refundable Tax Credit		-0.358
Rate Reductions		0.129

Indices are computed for the annual income measure of well-being.

Table 8. 10% Green Tax Shift: Increased Refundable Tax Credit															
	Annual Income					**Lifetime Income**					**Married, Age 40-50**				
Decile	Increase	Decrease	Δ Tax	Δ Average Tax Rate	Tax Shift	Increase	Decrease	Δ Tax	Δ Average Tax Rate	Tax Shift	Increase	Decrease	Δ Tax	Δ Average Tax Rate	Tax Shift
1	569	398	171	2.22	0.7%	695	686	9	0.23	0.0%	1,248	1,308	-60	-0.33	-0.2%
2	681	608	73	0.64	0.6%	830	955	-125	-0.31	-1.0%	1,406	1,693	-287	-1.01	-1.5%
3	923	883	40	0.26	0.3%	917	1,086	-169	-0.44	-1.4%	1,382	1,765	-383	-0.93	-2.0%
4	1,048	1,050	-2	-0.02	-0.0%	1,062	1,119	-57	-0.13	-0.5%	1,513	1,788	-275	-0.52	-1.5%
5	1,157	1,192	-35	-0.08	-0.3%	1,199	1,287	-88	-0.20	-0.7%	1,861	1,947	-86	-0.12	-0.5%
6	1,131	1,401	-270	-0.69	-2.2%	1,266	1,306	-40	-0.06	-0.3%	1,706	2,080	-374	-0.54	-2.0%
7	1,410	1,469	-59	-0.12	-0.5%	1,272	1,389	-117	-0.21	-1.0%	1,761	2,127	-366	-0.46	-1.9%
8	1,485	1,565	-80	-0.13	-0.6%	1,440	1,488	-48	-0.11	-0.4%	1,972	2,050	-78	-0.08	-0.4%
9	1,712	1,858	-146	-0.19	-1.2%	1,659	1,541	118	0.13	1.0%	1,998	2,003	-5	-0.01	-0.0%
10	2,260	1,897	363	0.24	2.9%	2,095	1,585	510	0.44	4.2%	2,830	2,423	407	0.18	2.2%
			ΔSuits					ΔSuits					ΔSuits		
Suits	-0.248	-0.254	**0.006**			-0.056	-0.092	**0.036**			-0.224	-0.281	**0.057**		

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

Table 9. Green Tax Shift II: Payroll Tax Reduction Tied To Family Size and Increased Refundable Tax Credit

	Annual Income					**Lifetime Income**					**Married, Age 40-50**				
Decile	Increase	Decrease	Δ Tax	ΔAverage Tax Rate	Tax Shift	Increase	Decrease	Δ Tax	ΔAverage Tax Rate	Tax Shift	Increase	Decrease	Δ Tax	ΔAverage Tax Rate	Tax Shift
1	569	526	43	0.64	0.2%	695	738	-43	-0.19	-0.2%	1,248	1,448	-200	-1.13	-0.6%
2	681	758	-77	-0.64	-0.6%	830	1,020	-190	-0.70	-1.5%	1,406	1,945	-539	-1.87	-3.1%
3	923	1,083	-160	-0.87	-1.3%	917	1,152	-235	-0.74	-1.9%	1,382	1,739	-357	-0.88	-2.1%
4	1,048	1,187	-139	-0.53	-1.1%	1,062	1,108	-46	-0.12	-0.4%	1,513	1,588	-75	-0.14	-0.4%
5	1,157	1,283	-126	-0.37	-1.0%	1,199	1,280	-81	-0.19	-0.7%	1,861	1,790	71	0.15	0.4%
6	1,131	1,373	-242	-0.61	-1.9%	1,266	1,345	-79	-0.16	-0.6%	1,706	1,900	-194	-0.28	-1.1%
7	1,410	1,423	-13	-0.03	-0.1%	1,272	1,426	-154	-0.28	-1.3%	1,761	1,866	-105	-0.13	-0.6%
8	1,485	1,468	17	0.03	0.1%	1,440	1,428	12	0.02	0.1%	1,972	1,735	237	0.26	1.4%
9	1,712	1,673	39	0.05	0.3%	1,659	1,460	199	0.29	1.6%	1,998	1,651	347	0.31	2.0%
10	2,260	1,541	719	0.49	5.8%	2,095	1,482	613	0.67	5.0%	2,830	1,806	1,024	0.50	6.0%
			ΔSuits					ΔSuits					ΔSuits		
Suits	-0.248	-0.323	**0.075**			-0.056	-0.140	**0.084**			-0.224	-0.342	**0.118**		

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

Table 10. Broad Based Consumption Tax															
	Annual Income					Lifetime Income					Married, Age 40-50				
Decile	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift
1	3,119	337	2,782	34.49	2.4%	3,315	1,590	1,725	7.83	0.8%	5,399	1,508	3,891	19.89	2.3%
2	3,230	316	2,914	24.95	5.1%	3,962	2,504	1,458	5.33	1.5%	5,467	2,726	2,741	9.49	3.3%
3	4,115	1,044	3,071	17.54	5.3%	4,092	3,624	468	1.43	2.5%	6,220	2,822	3,398	8.34	4.1%
4	4,495	1,571	2,924	11.93	5.0%	4,996	4,261	735	1.95	0.8%	6,318	4,491	1,827	3.62	2.2%
5	5,000	3,013	1,987	6.30	3.5%	5,607	4,834	773	1.68	1.3%	8,682	4,858	3,824	6.69	4.6%
6	5,107	4,108	999	2.45	1.7%	5,610	5,398	212	0.43	0.4%	7,654	7,354	300	0.42	0.4%
7	6,679	5,050	1,629	3.47	2.8%	5,936	5,619	317	0.67	0.5%	7,635	8,001	-366	-0.48	-0.4%
8	6,551	6,813	-262	-0.38	-0.4%	6,436	7,550	-1,114	-1.75	-1.9%	9,581	9,460	121	0.15	0.1%
9	8,332	9,129	-797	-1.00	-1.4%	7,919	9,033	-1,114	-1.67	-1.9%	10,078	10,349	-271	-0.09	-0.3%
10	11,250	26,591	-15,341	-7.05	-26.6%	10,191	13,234	-3,043	-3.46	-5.3%	15,964	47,602	-31,638	-11.44	-38.4%
			Δ Suits					Δ Suits					Δ Suits		
Suits	-0.228	0.202	**-0.430**			-0.045	0.068	**-0.113**			-0.185	0.255	**-0.440**		

Author's calculations from CES. The column titled Increase measures the increase in taxes from consumption taxes, while Decrease measures the decrease in personal and corporate income taxes.

Table 11. Consumption Tax with Family Based Exemption															
	Annual Income					Lifetime Income					Married, Age 40-50				
Decile	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift
1	2,600	337	2,263	28.04	2.0%	2,776	1,590	1,186	5.40	1.0%	4,999	1,508	3,491	15.90	2.0%
2	2,626	316	2,310	19.85	4.0%	3,440	2,504	936	3.38	1.6%	4,542	2,726	1,816	5.59	2.0%
3	3,570	1,044	2,526	14.59	4.4%	3,533	3,624	-91	-0.33	-0.2%	5,936	2,822	3,114	7.35	3.5%
4	4,070	1,571	2,499	10.03	4.3%	4,845	4,261	584	1.55	1.0%	6,236	4,491	1,745	3.57	2.0%
5	4,814	3,013	1,801	5.75	2.9%	5,530	4,834	696	1.48	1.2%	9,181	4,858	4,323	8.05	4.9%
6	4,676	4,108	568	1.39	1.2%	5,468	5,398	70	0.13	0.1%	7,766	7,354	412	1.04	0.5%
7	6,913	5,050	1,863	3.96	3.2%	5,826	5,619	207	0.47	0.4%	7,796	8,001	-205	-1.06	-0.2%
8	6,670	6,813	-143	-0.16	-0.2%	6,492	7,550	-1,058	-1.65	-1.8%	10,597	9,460	1,137	2.89	1.3%
9	8,931	9,129	-198	-0.26	-0.3%	8,536	9,033	-497	-0.78	-0.9%	11,342	10,349	993	0.16	1.1%
10	13,090	26,591	-13,501	-5.78	-23.4%	11,652	13,234	-1,582	-1.86	-2.8%	19,303	47,602	-28,299	-9.11	-32.4%
			ΔSuits					ΔSuits					ΔSuits		
Suits	-0.171	0.202	**-0.373**			0.005	0.068	**-0.063**			-0.135	0.255	**-0.390**		

Author's calculations from CES. The column titled Increase measures the increase in taxes from consumption taxes, while Decrease measures the decrease in personal and corporate income taxes.

Table 12. Sales Tax to Replace 10% of Income Tax

	Annual Income					Lifetime Income					Married, Age 40-50				
Decile	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift	Increase	Decrease	ΔTax	ΔAverage Tax Rate	Tax Shift
1	668	335	333	4.15	1.3%	710	645	65	0.31	0.3%	1,157	1,214	-57	-0.41	-0.2%
2	691	533	158	1.46	1.3%	848	913	-65	-0.24	-0.5%	1,172	1,580	-408	-1.36	-2.3%
3	882	801	81	0.48	0.6%	876	1,056	-180	-0.56	-1.4%	1,333	1,680	-347	-0.83	-1.9%
4	962	974	-12	-0.02	-0.1%	1,070	1,110	-40	-0.11	-0.3%	1,354	1,760	-406	-0.77	-2.3%
5	1,090	1,143	-53	-0.16	-0.4%	1,200	1,281	-81	-0.20	-0.7%	1,861	1,903	-42	-0.05	-0.2%
6	1,075	1,375	-300	-0.75	-2.4%	1,201	1,297	-96	-0.20	-0.8%	1,640	2,096	-456	-0.66	-2.5%
7	1,430	1,457	-27	-0.06	-0.3%	1,271	1,383	-112	-0.21	-0.9%	1,636	2,162	-526	-0.67	-2.9%
8	1,402	1,590	-188	-0.30	-1.5%	1,378	1,501	-123	-0.21	-1.0%	2,053	2,132	-79	-0.08	-0.4%
9	1,784	1,923	-139	-0.19	-1.1%	1,695	1,570	125	0.18	1.0%	2,160	2,106	54	0.06	0.3%
10	2,408	2,195	213	0.18	1.7%	2,182	1,686	496	0.53	4.0%	3,421	2,950	471	0.33	2.7%
			ΔSuits					ΔSuits					ΔSuits		
Suits	-0.228	-0.207	**-0.021**			-0.045	-0.093	**0.048**			-0.185	-0.235	**0.050**		

Author's calculations from CES. The column titled Increase measures the increase in taxes from consumption taxes, while Decrease measures the decrease in personal and corporate income taxes.

Table B1. Industry Groupings		
Group No.	IO Groups	Industry Description
1	1-4	Agriculture, Forestry & 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 & 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 & Misc. 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 & 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 & 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 & Misc. 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 & 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 & 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 & Misc. 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.