Environmental Taxation:
What Have We Learned in This Decade?

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Prepared for
the American Enterprise Institute Conference

Tax Policy Lessons From the 2000s

May 30, 2008
Washington, DC

I. Introduction

Environmental taxes in the United States are much like Virtue: much discussed but little practiced. This paper surveys the use of environmental taxes in the United States noting that our reliance on these taxes is much below the standards of other developed countries. Moreover, I note that what taxes are included as environmental in nature are in fact quite imperfect as they typically are taxes on attributes correlated with but not coterminous with pollution.

In contrast, our theoretical understanding of environmental taxes in a second-best world made major advances in the past fifteen years. I review this recent literature and make some assessment of the most important policy lessons gleaned from this new knowledge.

Finally I discuss the momentum that appears to be building in this country to institute some form of carbon pricing to reduce U.S. greenhouse gas emissions. Here the message is more optimistic. I argue that the advances that economists have made in their understanding of important efficiency and distributional issues have translated into significant policy advances in proposals wending their way through Congress.

II. The U.S. Experience with Environmental Taxes

I begin with a brief overview of the use of environmental taxes in the United States and a comparison with other countries. The major environmental tax at the federal level is the motor fuels excise tax equal to 18.4¢ per gallon of gasoline. Of that, 0.1¢ is dedicated to the Leaking Underground Storage Tank Trust Fund and the remaining 18.3¢

to the Highway Trust Fund.[1] Of that 18.3¢ per gallon, 2.86¢ is dedicated to the Mass Transit Account and the remaining 15.44¢ to the Highway Account.

The Gas Guzzler Tax was enacted as part of the Energy Tax Act of 1978. It levies a tax on automobiles that obtain fuel mileage below 22.5 miles per gallon.[2] Tax rates range from $1,000 to $7,700 per vehicle. In 2004 the tax collected $141 million (Guenther (2006)). The gas guzzler tax explicitly excludes sport utility vehicles, minivans, and pickup trucks, which represent 51 percent of the new vehicle sales in 2006 U.S. Census Bureau (2008), Table 1027). The light truck category (comprising SUVs, minivans, and pickup trucks) is the fastest growing segment of the new vehicle market, growing at an annual rate of 2.5 percent between 1990 and 2006. In contrast, new car sales are falling at an annual rate of 0.7 percent.

The Energy Policy Act of 2005 (EPACT) resurrected the Oil Spill Liability Trust Fund tax at the original rate of 5¢ per barrel. This tax had previously been in effect from 1990 through 1994. The Joint Committee on Taxation estimates that this tax will raise $1.25 billion between 2005 and 2010. The tax is imposed on crude oil received at U.S. refineries as well as imported petroleum products. Domestic crude oil for export is also subject to the tax if the tax had not been previously paid.

The coal excise tax funds the Black Lung Disability Fund. It is levied on coal mined in the United States at a rate of 4.4 percent of the sales price up to a limit of $1.10 per ton of underground coal and $.55 per ton of surface mined coal. This tax raised $639 million in 2007.

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[1] The tax was most recently raised to 18.3¢ per gallon for gasoline on Oct. 1, 1993. See Jackson (2006) for a history of changes to this tax.

[2] The mileage rating is calculated approximately as 55 percent of the EPA city mileage rating and 45 percent of the highway rating.

Gasoline sold for sport motorboats is taxed at the same rate as highway gasoline and diesel fuel and the funds allocated to the Aquatic Resources Trust Fund (subject to an annual cap on transfers that effectively reduces the share of tax on motorboat fuels shifted to this trust fund). Finally the Inland Waterways Fuels Tax levies a tax of 22.4¢ per gallon of fuel sold to commercial vessels using the Inland Waterway System (barges for the most part).

States levy a variety of environmental taxes starting with a tax on motor fuels. Rates vary across states but averaged 18.2¢ per gallon as of the beginning of this year.[3] In addition to excise taxes, states levied on average an additional 10.4¢ per gallon, typically through a general sales tax on gasoline purchases. State governments also levy a variety of pollution fees, hazardous waste charges, tire disposal fees, and other assorted charges. U.S. Environmental Protection Agency (2001) describes these in considerable detail. Unfortunately, data are not readily available that provide aggregate amounts collected from these taxes and charges.

The OECD and European Environment Agency (EEA) maintain a database on instruments used for environmental policy. They report for the United States aggregate revenues from environmental taxes and charges of $74.9 billion in 2005. Of this, 94 percent is federal and state taxes on motor fuels.[4]

Comparing the use of environmental taxes across countries, the United States ranks low in its reliance on these taxes. Table 1 shows environmental tax collections as a percentage of GDP. The U.S. collects 0.9 percent of GDP in these taxes at the federal and state level. Only Mexico is lower with a share of 0.8 percent. In contrast, the Czech

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[3] American Petroleum Institute State Motor Fuel Excise Tax Report available at http://www.api.org/policy/tax/stateexcise/index.cfm and accessed on May 9, 2008.

[4] The OECD/EEA database is at http://www2.oecd.org/ecoinst/queries/ and was accessed on May 8, 2008.

Republic, Denmark, Finland, Italy, Luxembourg, the Netherlands, Portugal, and Turkey all collect more than three percent of GDP from environmental taxes and charges. The pattern does not change if taxes are reported as a percentage of total tax revenues (Table 2). The U.S. is still at the bottom of the pack with environmental taxes equal to 3.5 percent of total tax collections. If the U.S. had relied on environmental taxes to the same extent as other OECD countries in 2005 (2.23 percent of GDP), the U.S. would have collected over $100 billion more in 2005 than it actually did, an increase of over 150 percent.

Since motor fuel taxes are such a dominant source of environmental tax revenues in all OECD countries, it is instructive to compare gasoline tax rates across these countries. Table 3 shows the tax rate (in dollars per gallon) for various OECD countries as of the beginning of 2007. The total excise tax rate for the U.S. is over 40¢ per gallon.[5] In contrast the average unweighted tax on gasoline in the other countries in this chart exceeds $2.00 per gallon. The rate is particularly high in the UK, Germany, and the Netherlands where it exceeds $3.00 per gallon.

Below I discuss the treatment of carbon emissions in the EU and the United States. A carbon pricing policy change under the next administration could change the relative importance of environmental taxes and charges (including the value of auctioned permits in a cap and trade system) in government budgets. But as of now, the summary data show that the United States is an outlier to a considerable extent in its reliance on environmental revenues. In fact one could make a case that taxes on motor fuels do not really count as an environmental tax since they are for the most part earmarked in the

[5] The OECD/EEA rate for the United States is slightly below that of the American Petroleum Institute dataset. It may be that different weighting schemes are used to construct the averages in the two datasets.

United States for the Highway Trust Fund. That earmarking suggests they might better be characterized as a benefit tax.

Is the United States taxing pollution at the right level? Clearly not for those pollutants where taxes do not exist.[6] Parry and Small (2005) consider the range of externalities associated with driving (congestion, tailpipe pollution, health externalities, etc.) and conclude that the U.S. tax on gasoline is roughly half its optimal level. The tax in the United Kingdom, in contrast, is roughly twice as large as its optimal level.

Beyond gasoline taxation, little work has been done on other pollution taxes. A small literature exists on the use by states of fees on hazardous waste. Levinson (1999a, b) considers how state-level taxes affect the interstate transport of hazardous waste and finds that in-state disposal is highly sensitive to taxes. Sigman (2003) reviews the literature on state-level hazardous waste taxes and argues that the taxes influence behavior but that they may not be welfare enhancing given the extant regulations and liability facing waste generating firms. The research suggests the benefits of co-ordinated national legislation as opposed to state-level legislation as well as co-ordination among the various policy instruments used to discourage improper hazardous waste disposal.[7]

The contrast between the United States and other OECD countries suggests considerable scope for increasing its reliance on environmental taxes. In the next section

[6] Where firms are subject to regulations that restrict pollution, an important question is the relative cost of regulatory approaches to a tax based approach. Some pollutants, most notably SO_2 emissions from electric utilities, are subject to caps with tradable permits. These act like taxes in setting a price on pollutions and letting firms use market mechanisms to drive pollution reduction. I discuss the relative merits of taxes versus cap and trade systems below.

[7] A limited literature from this past decade exists on the use of taxes to control other externalities. One recent paper by Brueckner and Girvin (2008) considers optimal tax design to address noise pollution from aircraft.

I turn to a review of recent advances in our understanding of efficiency and distributional issues associated with these taxes.

III. Advances in the Theory

A. Efficiency Considerations of Environmental Taxation

A flurry of intellectual activity in the late 1990s led to some important advances in our understanding of the efficiency implications of environmental taxation and optimal design of environmental tax rates. These theoretical developments took as their point of departure the Pigouvian principle that the optimal tax rate on a pollutant is equal to it social marginal damages. Beginning in the mid-1980s the concept of the environmental "Double-Dividend Hypothesis" began to gain currency. The concept is straightforward: an environmental tax pays a dividend through the discouragement of polluting activities. It then pays a second dividend by raising revenue that can be used to lower other distorting taxes. So far so good. Therefore, so policy activists concluded, it must be the case that the optimal tax on pollution should exceed the social marginal damages of the pollutant since there is this extra dividend (or benefit) arising from the use of this tax.[8]

This conclusion, while intuitively appealing, is incorrect. What it ignores is the fact that the environmental tax, while beneficial in discouraging pollution, adds to distortions in production or consumption and has a first-order excess burden in the presence of other distortionary taxes.[9] The theory is laid out in complete rigor by Bovenberg and de Mooij (1994) and by Parry (1995).[10]

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[8] Fullerton and Metcalf (1998) provide a detailed history of the Double-Dividend Hypothesis and the debate over the optimal setting of environmental tax rates.

[9] This distortionary impact is of second-order importance and can be ignored in the absence of other distortionary taxes. This is the case developed by Pigou (1938).

[10] Goulder (1995) termed the positive welfare impact of using environmental revenue to lower other distorting taxes as the *revenue-recycling* effect and the negative welfare impact of the tax's first-order distortionary impact as the *tax-interaction* effect.

Bovenberg and de Mooij's model assumed a "clean" good, a "dirty" good and endogenous labor supply. Taxes were levied on the dirty good and labor. Fullerton (1997) pointed out that in a general equilibrium setting, identical tax outcomes can be achieved with different sets of instruments. Thus, Bovenberg and de Mooij could have obtained the same equilibrium with differential commodity tax rates and no tax on labor supply. While the equilibrium is unaffected, Fullerton notes that the finding that the optimal tax on pollution falls short of social marginal damages is affected. As Bovenberg notes in correspondence with Fullerton quoted in Fullerton's paper, the precise result is that the Pigouvian tax *increment* falls short of social marginal damages in the optimum. In other words, if Bovenberg and de Mooij's model had considered commodity taxes rather than a tax on the dirty good and labor supply, their result would have been that the difference in tax rates of the dirty good less that of the clean good would have been less than social marginal damages.

This has been formalized in a number of papers as the finding that the second-best Pigouvian tax increment equals social marginal damages divided by the marginal cost of public funds (e.g. Bovenberg and van der Ploeg (1994)). Since the marginal cost of public funds tends to exceed one in the presence of distortionary taxation, this gives the desired result.[11] This finding follows in a model with an income tax and no non-environmental commodity taxes Williams (2001) generalizes the result to allow for a fully general linear system of income and commodity taxes. Changing the tax normalization changes the dollar measured value of marginal social damages. But this is

[11] One must be careful in making the leap from the magnitude of the marginal cost of public funds and excess burden. The MCPF depends critically on the tax normalization and only captures the distortion between a taxed good and the normalized commodity. See Section 5 of Auerbach and Hines (2002) for an excellent discussion of this issue.

just a units issue. Williams shows that the ratio of the optimal tax differential to social marginal damages is constant across normalizations and less than one for a system of linear commodity and income taxes. This is reassuring since the tax normalizations used in the literature are a far cry from the actual tax normalization in the actual tax code. The United States uses a complex combination of income and commodity taxes. It would be discomfiting if one needed to assess the environmental tax differential relative to social marginal damages using the actual U.S. tax code normalization.

An extra set of assumptions drives these results. Bovenberg and de Mooij as well as Fullerton assume homothetic sub-utility function for commodities that is weakly separable from leisure. With this assumption, it would be optimal to employ a uniform commodity tax in the absence of the externality. Therefore the point of departure in adding externalities is to compare the difference between the rates on the dirty and clean goods. Parry (1995) considers a more general model in which the polluting consumption good is a relatively strong or weak substitute with leisure. The distortionary impact of the environmental tax is strengthened (weakened) to the extent that the dirty good is a relatively strong (weak) substitute with leisure.[12] This is a straightforward application of the Corlett and Hague (1953) result that in the absence of the ability to tax leisure separately from the time endowment, it is desirable to tax goods that are complements of leisure.[13]

While Parry focuses on consumption externalities, the Bovenberg and de Mooij result can be easily modified to allow for production side externalities. Williams (2002)

[12] This assumes that labor is the only endogenous factor of production.

[13] Pirttila (2000) develops this idea explicitly. West and Williams (2007) estimate the cross-price elasticity between labor supply and gasoline consumption and find that gasoline is a relative complement with leisure. Hence the optimal tax on emissions associated with gasoline use will tend to be higher taking this complementarity into account.

considers potential health impacts of pollution in a more expansive framework and notes that how pollution affects health can have significant implications for the optimal tax rate. If the health impacts of pollution, for example, diminish labor productivity then an additional benefit arises from reducing pollution. This suggests a higher tax rate on pollution than in the absence of the health impact. If, on the other hand, reducing pollution lowers medical expenses, consumers receive a positive income effect from the environmental tax that discourages labor supply (assuming leisure is a normal good). This leads to a lower optimal environmental tax than occurs in the absence of the health interaction. Williams terms this a benefit-side tax-interaction effect that has broader implications than health and pollution. It does illustrate the important point that modeling the entire impact of pollution is important for determining the optimal second-best tax on pollution and its relation to the social marginal damages of pollution.

Kaplow (2006) notes that the various environmental tax reforms discussed in the literature above limit themselves to linear income taxes and argues that one should think about an environmental tax reform as a two-step process. In the first step, the income tax is adjusted so that the environmental tax reform cum income tax adjustment is distributionally neutral (taking into account the distribution of environmental benefits). In this first step, the first-best Pigouvian rule holds that the environmental tax rate should be set equal to social marginal damages. In the second step, the income tax is adjusted to obtain whatever income tax outcome actually occurs under the proposed environmental tax reform. His conclusion is that the deviation of the environmental tax rate from the first-best Pigouvian prescription arises from the increased redistribution arising from the reform rather than from any pre-existing tax distortions.[14] Kaplow's point is essentially one of interpretation. One can analyze environmental taxes in a distribution-free environment. Or one can recognize that general environmental tax reforms will induce redistribution and that this will affect the relationship between the Pigouvian tax increment and social marginal damages. Policy makers will suggest specific environmental tax reforms and the message from the Kaplow analysis is that those reforms will induce different amounts of redistribution and as a result the relation between the optimal environmental tax rate and social marginal damages will be reform-specific.

This is an unsatisfying result at one level. Part of the difficulty is that this discussion is focusing on a variable of secondary interest. Knowing the optimal tax rate and its relation to social marginal damages is important. But what we really care about is the optimal level of pollution. All of the results above focus on the relation between the tax rate on pollution and its social marginal damages. A different question is the impact of the need for government revenue and reliance on distortionary taxes on the optimal level of environmental pollution. Metcalf (2003) uses a simple general equilibrium model to show that an increase in the need for tax revenues to finance government spending can lead to a fall in the optimal Pigouvian tax increment even while environmental quality improves. The falling Pigouvian tax increment gives rise to a commodity substitution effect as consumers shift towards more consumption of the pollution generating commodity. The increased level of overall taxes lowers the real

[14] The first-best result also requires that leisure be weakly separable from consumption and that consumption be modeled as a homothetic sub-utility function. This avoids situations where the environment is a substitute or complement with leisure among other things. It also abstracts from heterogeneity of preferences.

wage giving rise to a leisure substitution effect as labor supply falls. Since leisure has no effect on pollution in this model, the ultimate impact of the higher overall tax rates on environmental quality is ambiguous. Metcalf demonstrates that for reasonable parameter assumptions pollution falls as government revenue needs rise. The point here is not that Metcalf has correctly captured the complexity of the economy in his simple model but rather that one cannot draw any inferences about the amount of pollution by noting that the Pigouvian tax increment is falling in response to a rise in required government revenue.

Metcalf's analysis is marginal in nature taking as its point of departure an optimal tax system. Gaube (2005) considers a related experiment where he compares the optimal provision of environmental services in a second-best world in which distortionary taxes must be used relative to a first-best world where lump-sum taxes are available. Assuming that the we are not in a Laffer world where increasing environmental tax rates reduce environmental revenue, he shows that the provision of environmental services in this second-best world is higher than in the first-best world. This is in striking contrast to the result in Atkinson and Stern (1974) that the second-best provision of public goods will be lower than the first-best provision.[15] Gaube's example assumes quasi-linear preferences with a homothetic sub-utility function over consumption. The intuition, however, is quite general for understanding the contrasting results for public goods and pollution control in a second-best world. While an increase in the supply of a public good requires additional public revenue (at potentially high social cost), an increase in the

[15] Atkinson and Stern's result is more general. But the specification of preferences in Gaube's example ensures that the result holds as stated in the text.

supply of environmental quality can generate additional public revenue through the tax on pollution.

B. Distributional Considerations with Environmental Taxation

One concern with increasing reliance on environmental taxes is the perceived or real regressivity of these taxes. Measuring the distributional impact requires 1) determining which environmental tax is to be changed (or implemented); 2) what will be done with the revenue; 3) on what basis is the welfare of households to be determined; and 4) over what time period will the burdens be measured. Environmental damages tend to be associated with the production or consumption of commodities. This means that an environmental tax acts to a large extent like a commodity tax. Commodity taxes in general tend to be regressive when viewed in an annual income framework. Metcalf (1999), for example, finds that a carbon tax, a gasoline tax, air pollution taxes, and taxes on the use of virgin materials are all to a greater or lesser degree regressive. He makes the point that while an environmental tax may be regressive, an environmental tax reform can have any desired distributional outcome. The key is to focus on how the revenue from an environmental levy is used. If it is recycled through reductions in regressive taxes, the overall reform can be distributionally neutral or even progressive. This insight has been brought to bear in a proposal to implement a revenue and distributionally neutral carbon tax reform in Metcalf (2007c, d).

Distributional analyses require that households be ranked by some measure of economic well-being. Typically annual income is used for this ranking. As is now well know in the literature on tax incidence annual income measures of well-being tend to bias distributional analyses of consumption taxes in a regressive direction (see Fullerton and

Metcalf (2002) for a general discussion of this point). This occurs for two reasons. First, young and old households with annual income at great variance from their lifetime expected (or realized) income tend to show up in the lowest income deciles. These groups will have consumption to income ratios that are not sustainable in the long-run. For the young, they may be borrowing against future earnings possibilities while the elderly may be drawing down on a lifetime of savings. In either case, using annual income for these groups will bias consumption taxes towards regressivity. Second, households engaging in consumption smoothing in the presence of temporary income fluctuations will also generate a regressive bias. A consumption smoothing household with a negative (positive) income shock will have a temporarily high (low) consumption to income ratio contributing to a regressive bias.

To overcome this bias some measure of lifetime income is required. Poterba (1989) used current consumption as a proxy for lifetime income under the assumption that households make consumption decisions on the basis of lifetime income in an analysis of federal excise taxes. The consumption proxy reduces the regressivity of the taxes considerably. Bull, Hassett and Metcalf (1994) used this approach along with a variant on the current consumption approach to better control for transitory consumption fluctuations to assess the Clinton Administration's BTU tax proposal. Hassett, Mathur and Metcalf (2007) have applied that approach to a U.S. carbon tax and find that a lifetime incidence approach mitigates much of the regressivity of the tax that appears in the annual income analysis.

Hassett, Mathur and Metcalf's approach assumes the tax is fully shifted forward to consumers. This is consistent with short-run results from CGE modeling of carbon taxes.

See, for example, Metcalf et al. (2008). They also find that roughly half the burden of the tax comes from the indirect portion of the tax. This is the increase in the prices of non-energy commodities (food, clothing, entertainment, etc.) brought about by the higher cost of energy consumed in the production of those commodities. While the percentage price increases for any of these commodities is quite small, the vast majority of consumer expenditures on average are on these commodities. This is important because the burden of the direct portion of the tax (price rises in energy purchases) is more regressive than the indirect burden whether one uses an annual or lifetime income approach. See Figures 4 and 5 for results from their analysis.

Finally, these analyses have assessed environmental taxes at a point in time using a measure of lifetime income. An alternative approach would be to assess lifetime environmental tax burdens relative to lifetime income. This approach was used to evaluate the lifetime progressivity of the U.S. tax system by Fullerton and Rogers (1993) but has not been applied to environmental taxes. Such an approach requires making assumptions about the long-term tax code since this would be a prospective looking analysis. Nevertheless, it would be a useful contribution to the literature.

The analyses discussed above are partial equilibrium in nature (although informed by results from general equilibrium analysis) and focus on the uses-side of income. Fullerton and Heutel (2007) undertake a sources-side general equilibrium analysis of pollution taxes and explore a number of special cases. One would expect that the burden of pollution taxes would fall disproportionately on the factor which is a closer complement to pollution. While that tends to be the case, they show examples where that pattern does not occur.[16] The experiment is useful both for identifying the importance of measuring the degree of substitutability or complementarity between pollution and other factors as well as for identifying key parameters about which better information is required to carry out a general equilibrium incidence analysis.

As noted in the first section, the United States relies predominantly on gasoline taxes as an environmental tax. Using data from the Consumer Expenditure System, West (2004) models the choice of vehicle as well as driving patterns and argues that while gasoline taxes are regressive their regressivity is limited to the upper half of the income distribution given the lower probability of car ownership among lower-income households. She also notes that policy makers have been more inclined to adopt indirect taxes on gasoline consumption such as a gas guzzler taxes, essentially a tax on engine size, or to provide subsidies to new vehicle purchase. She notes that these indirect taxes may be more regressive than a gasoline tax. Similarly West (2005) finds that a tax on emissions is more regressive than a tax on gasoline consumption given the higher propensity to drive older less efficient vehicles among lower income households.

In summary considerable progress has been made in understanding optimal environmental tax rates in a second-best world.[17] Two points bear emphasizing. First, the literature made the important point that the revenue use from environmental levies has potentially important efficiency as well as distributional consequences in a second-

[16] In their numerical analysis, they do not actually model existing taxes on pollution but rather the shadow price of pollution arising from various regulatory restrictions on pollution. They then consider an experiment where the pollution "tax" is increased by 10 percent and measure the resulting changes in factor prices.

[17] Bovenberg and Goulder (2002) provide an exhaustive review of different ways in which environmental externalities affect consumption and production in perfect and imperfect markets.

best world.[18] Second the literature advanced our understanding of the relationship between the Pigouvian tax increment and social marginal damages in a second-best world. While of theoretical importance, this result is of second-order importance for U.S. policy makers who have not yet embraced the use of taxes to address environmental concerns. This is particularly true when one recognizes the difficulties that exist in precisely measuring the social marginal damages of important pollutants. Getting a price in the right neighborhood of social marginal damages is probably about as much as we can hope for.

IV. The New Frontier: Carbon Pricing

On January 1, 2005 twenty-five countries in Europe embarked on a major policy experiment in the use of market-based instruments to control greenhouse gas emissions. That date marked the beginning of the first phase of the European Union's Emissions Trading Scheme (ETS). The ETS is a cap and trade program in which country-by-country caps on carbon emissions in energy-intensive industries and the utility sector were set and permits issued that must be surrendered upon emissions. The permits could be traded among, within and across countries in the EU thereby putting a price on carbon emissions.[19] This is the second large cap and trade program set up to address environmental concerns following the successful implementation of a cap and trade program for sulfur dioxide emissions from large power plants in EPA's Acid Rain Program (see Ellerman et al. (2000) for a description and assessment of this program).

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[18] Goulder, Parry and Burtraw (1997) stress this point and Fullerton and Metcalf (2001) make the more general point of the efficiency benefits of government capturing the scarcity rents from environmental regulation.

[19] Ellerman, Buchner and Carraro (2007) describe the design and allocation process in the first phase of the ETS.

Cap and trade programs have emerged as a popular alternative to environmental taxes as a market based incentive to reduce pollution. Since all the major candidates running for the presidency in the United States have committed to significant reductions in U.S. greenhouse gas emissions, I turn to an assessment of the benefits and drawbacks of a tax-based versus permit-based approach to reducing emissions.

Cap and trade programs (CaT) and taxes (Tx) are in many ways duals of each other. A pure CaT program fixes the amount of emissions over some timeframe and lets the interplay between demand for and supply of permits determine their price. A pure Tx program fixes the price of emissions but lets the amount of emissions fluctuate depending on supply and demand. Under both systems, firms will operate at the point where the marginal cost of abatement equals the price of emissions (either the permit price or the tax rate). Since the marginal cost of abatement is equalized across firms, emissions are reduced in a cost-effective manner.[20]

It is now well understood that in the absence of uncertainty over the marginal cost of abatement CaT and Tx systems have the same economic effect. If the permits are fully auctioned then the systems are entirely identical except in appearance. The two market based approaches differ 1) under uncertainty over marginal abatement costs and 2) administrative and implementation details.

Once one allows for uncertainty in marginal abatement costs, the two policy approaches differ in an expected net benefit sense. Weitzman (1974) provided conditions under which a tax provides higher or lower expected social benefits than a cap and trade

[20] A CaT or Tx system should provide for the possibility of carbon sequestration, for example through carbon capture and storage. No carbon price should be levied on fossil fuels where sequestration takes place. In practice this means that no permits would be required for sequestered carbon in a CaT system and a tax credit would be allowed under a Tx system.

system in a world with uncertainty.[21] His analysis demonstrated the importance of the relative slopes of marginal damages and abatement costs in choosing the optimal instrument.

Weitzman's analysis needs some modification in the case of greenhouse gases since marginal abatement costs are a function of the *flow* of emissions while marginal damages are a function of the *stock* of gases in the atmosphere. Hoel and Karp (2002) analyze the problem with stock effects in which governments may employ either an *open loop* or a *feedback* policy. In an open loop setting, policy-makers choose a set of policies *for all time* in the current period to maximize expected net benefits. In the more realistic (but more complicated) feedback setting, policy makers choose a set of policies but are allowed to adjust the policy as uncertainty is revealed moving forward. They set out conditions that allow one to rank tax versus cap and trade policies and find that taxes dominate cap and trade systems for a set of parameters consistent with scientific understanding of the global warming problem. Hoel and Karp's analysis assumes that cost shocks are uncorrelated across time. This is a significant limitation as many of the sorts of cost shocks that might occur (e.g. technology shocks) are likely to have high levels of persistence over time. Newell and Pizer (2003) generalize Hoel and Karp's open loop analysis to allow for serial correlation of cost shocks and find that across a broad range of parameter assumptions about abatement costs and marginal damages that carbon taxes are more efficient than cap and trade systems in the face of uncertainty. Karp and Zhang (2005) provide an analysis of the more realistic setting in which cost shocks are

[21] The relative advantage of price versus quantity instruments depends on uncertainty in the marginal abatement cost curve only. Uncertainty over the marginal damages of emissions affects the net benefits of an emissions control policy but does not affect the relative superiority of one policy instrument over another.

correlated over time and policymakers use feedback policies and continue to find that taxes dominate tradable permit systems.

The one caveat to the extant literature favoring taxes over cap and trade systems is the presence of "tipping points," abrupt or discontinuous increases in marginal damages at some level of greenhouse gas concentrations in the atmosphere. Such a tipping point might occur if concentrations above some amount lead to sufficiently high temperature increases that the West Antarctic Ice Shield were to break off and raise sea levels by perhaps five meters (see Schneider et al. (2007), Table 19-1, page 789). What concentrations would make such an event likely are unknown. In the absence of tipping points that are known to policy makers a commitment to reduce emissions to fixed levels regardless of cost cannot be justified by any model of social welfare maximization. To give primacy to specific emission reductions regardless of the cost implausibly makes controlling emissions the top policy priority, trumping all others.

From an administrative perspective a Tx system can be more quickly implemented than a CaT system. Coal producers already pay an excise tax to fund the Black Lung Trust Fund and oil producers pay a tax to fund the Oil Spill Trust Fund (see Metcalf (2007b) for a description of these funds). We also have precedents for refundable credits for sequestration activities in federal fuels tax credits. In contrast, we have no administrative structure in place for running a carbon cap-and-trade program.[22]

It is clear that either the CaT or Tx approach is preferable to a regulatory approach. Ellerman, Jacoby and Zimmerman (2006) consider how Corporate Average Fuel Efficiency (CAFE) standards could be integrated into a CaT system and estimate

[22] The Acid Rain Program is a helpful precedent but the value of permits is an order of magnitude smaller than the potential value of carbon emission permits. It also was highly concentrated among a small set of electric utilities.

that the cost of carbon emission reductions through CAFE is in the neighborhood of $350 per ton of CO_2 equivalent, considerably higher than estimates of permit prices under the Lieberman-Warner Climate Security Act (S. 2191) (see Appendix D to Paltsev et al. (2007)). This estimate helps make two points. First, sector-based regulatory policies that are not integrated more broadly into a carbon reduction scheme can be very expensive. Second, the early reductions in carbon emissions are likely to occur in industry and the electric utility industry rather than in the transport sector. Since the source of emissions has no bearing on damages associated with climate change, sector based approaches are likely to be quite inefficient.[23]

While most economists view a carbon tax as a preferred approach to controlling emissions than a cap and trade system, policy makers have shown a distinct preference for cap and trade. This preference for CaT systems over Tx systems can be explained by a number of factors. First the success of the Acid Rain Program in the U.S. and the introduction of emissions trading in the EU's ETS create some familiarity with trading systems and a desire to emulate a successful system. The choice by the EU of a CaT approach over a Tx approach is particularly cited as evidence of the political advantages of the former over the latter approach. But the European experience is not entirely applicable to the United States. In the early 1990s, the EU had attempted to institute EU-wide taxes on carbon and energy but were unable to overcome the EU requirement for unanimous agreement among member countries to enact EU-wide fiscal policy. A CaT approach, in contrast, is deemed a regulatory policy requiring a only majority of countries to support the policy (see Convery and Redmond (2007)).

[23] Other pollutants or market failures may provide a rationale for reducing oil consumption or tailpipe emissions. This simply reflects the fact that multiple instruments are generally needed to address multiple market failures.

Second environmentalists have preferred the apparent certainty of emissions control under a CaT system. This certainty is illusory however. Even if a law is passed that sets a fixed cap with no possible relief for high permit prices in the unhappy event that the marginal costs of abatement are unexpectedly high, Congress can always amend the law in the future to loosen the caps in the face of high permit prices. In effect, Congress serves as the ultimate safety valve.

Third the United States has been resistant to the introduction of new taxes since the Reagan Revolution in 1980. This resistance reflects in large part an on-going debate over the appropriate size of the federal government and its role in the U.S. economy. Metcalf (2007d) has proposed a revenue-neutral carbon tax swap to sidestep this debate. A carbon tax swap would require that the revenue raised through a carbon tax be used to reduce existing taxes so that the U.S. tax burden on average would remain unchanged.[24]

Fourth, policy makers have used the free allocation of permits as a device to build political support for CaT programs. This comes at considerable efficiency and distributional costs. There always exists an environmental tax swap that is welfare enhancing relative to a lump-sum return of the revenue.[25] While permits under EPA's Acid Rain Program and the EU's ETS were given away to affected sectors, newer CaT proposals auction an increasing number of the permits. The Warner-Lieberman bill (S. 2191), for example, auctions just over one-quarter of the permits in 2012 with the share

[24] Revenue could also be used to achieve efficiency gains. Orszag (2008) claims that the costs of a fifteen percent reduction in carbon emissions from a CaT program could be cut in half if the revenue were used to cut taxes on capital income. See also Metcalf (2007a).

[25] This is a statement of the Weak Double Dividend (see Goulder (1995) for a taxonomy of double dividends. Not every tax swap is welfare preferred to a lump-sum distribution. Babiker, Metcalf and Reilly (2003) provide an example of an apparently reasonable tax swap in Europe that is inferior to lump-sum distribution.

rising to nearly seventy percent by 2031. Stavins (2007) calls for initially auctioning half of the permits with the percentage rising to one hundred percent over twenty-five years.

While a carbon tax appears to be a more straightforward approach with greater efficiency benefits than cap-and-trade, the political obstacles remain large. What has emerged is a number of proposals to modify CaT systems to take on the attributes of a Tx system. Recall that the major difference between a CaT and Tx system is the fixing of emissions or price. Certainty over price is useful for firms making long-term capital investments, for politicians who must answer to interest groups if carbon prices are unexpectedly high, and for the economy which would be adversely affected by high carbon prices. S.2191 implements a Carbon Market Efficiency Board that can adjust borrowing rules and other provisions to try to reduce the likelihood of high carbon prices. It is unclear how successful such an approach could be. One of the Board's functions, for example, would be to shift emission allowances forward in time to release more permits in the short-run. But with the total stock of permits between 2012 and 2050 fixed, such a shifting reduces permit prices in the short-run at the expense of higher prices in the long-run. Firms who see high prices in the near-term as a signal of even higher prices in the longer-term will have an incentive to bank any newly released permits and so undo the efforts of the Board to reduce prices.

A more straightforward way to reduce price volatility is through a combined safety-valve and price floor thereby creating a band within which prices will vary. The price cap can be achieved through the government standing ready to sell permits at a fixed price (the safety valve price). If this cap is reached, the CaT system in effect converts to a Tx system. The floor can be maintained by the government setting a reserve price on permits that it auctions.[26]

With a tighter band within which prices can fluctuate, the CaT system has economic impacts increasingly like a Tx system. Such an approach has been suggested by Orszag (2008) among others. The upper limit on the band protects the economy against the adverse effects of high carbon prices. The lower limit provides certainty for utilities and industries that they will receive a reasonable return on investments in carbon-free or emission reducing capital.

This approach as well as other safety-valve approaches serve to make the CaT system operate like a Tx system. The similarities go further. One argument that has been made on behalf of CaT is that the federal government will have to buy off the energy industry to obtain their support for carbon pricing. If this must occur it is better, so the argument goes, to provide the industry with a lump-sum distribution in the form of an allocation of free permits rather than distortionary tax breaks in the form of exemptions under a carbon tax.[27] The argument suffers from a failure of creativity in tax design. One can replicate *any* lump-sum distribution of permits in a CaT system with tax breaks in a Tx system. One could replicate the free allocation, for example, by taxing the energy sector's emissions above some floor.

The United States is likely to enact some sort of carbon pricing scheme in the next presidential administration. While efficiency and administration considerations point to

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[26] This approach only works if most if not all of the permits are auctioned. Alternatively, the government could charge a permit acquisition fee for permits it gives away or auctions. This approach has the advantage that it need not be modified as the mix of free and auctioned permits changes over time.

[27] Bovenberg and Goulder (2001) have calculated that only a small portion of permits would need to be freely allocated to the energy sector to avoid a loss in equity values. This follows from the ability to pass the tax forward to consumers.

the carbon tax as a preferred pricing device, political obstacles to a tax remain. An interesting development in the past ten years has been the reshaping of a cap and trade system to preserve the political appeal of a permit based system while taking on many of the best attributes of a tax. It may be that this hybridization of policies is what is required to get an effective policy enacted in Congress. We shall see.

V. Conclusion

In reviewing where the United States stands in its attitude towards and use of environmental taxes, several points emerge. First, the most obvious fact is that the United States relies very little on environmental taxes in comparison with other developed countries. Moreover, the review of the environmental taxes in place make clear that these are not textbook examples of environmental taxes as they tend to be taxes on consumption or production attributes correlated with pollution but not the pollution itself.[28]

Second the theoretical literature made important advances in our understanding of environmental instrument design in a second-best world. The literature made the important point that the revenue use from environmental levies had important efficiency as well as distributional consequences in a second-best world. It also advanced our understanding of the relationship between the Pigouvian tax increment and social marginal damages in a second-best world. While of theoretical importance, this result is of second-order importance for U.S. policy makers who have not yet embraced the use of taxes to address environmental concerns. This is particularly true when one recognizes

[28] Fullerton, Hong and Metcalf (2001) assess the welfare losses arising from employing taxes on imperfect proxies for pollution.

the difficulties that exist in precisely measuring the social marginal damages of important pollutants.

Finally the current focus on climate change and the need to control greenhouse gas emissions suggests that the United States may soon significantly increase its reliance on environmental taxes either explicitly or implicitly. While the United States may not enact a carbon tax directly, any cap and trade system that emerges is likely to have many of the attributes of a tax. If this occurs, it will be in large part due to the advances made in our understanding of environmental policy design over the past ten to fifteen years.

Table 1.

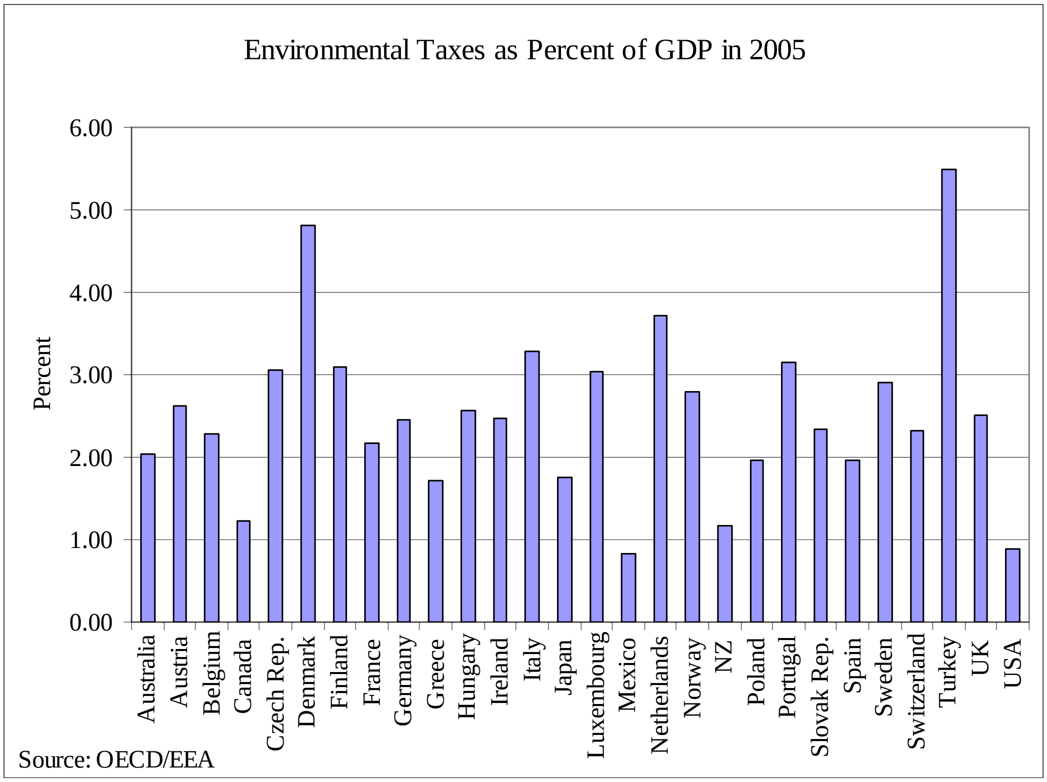


Table 2.

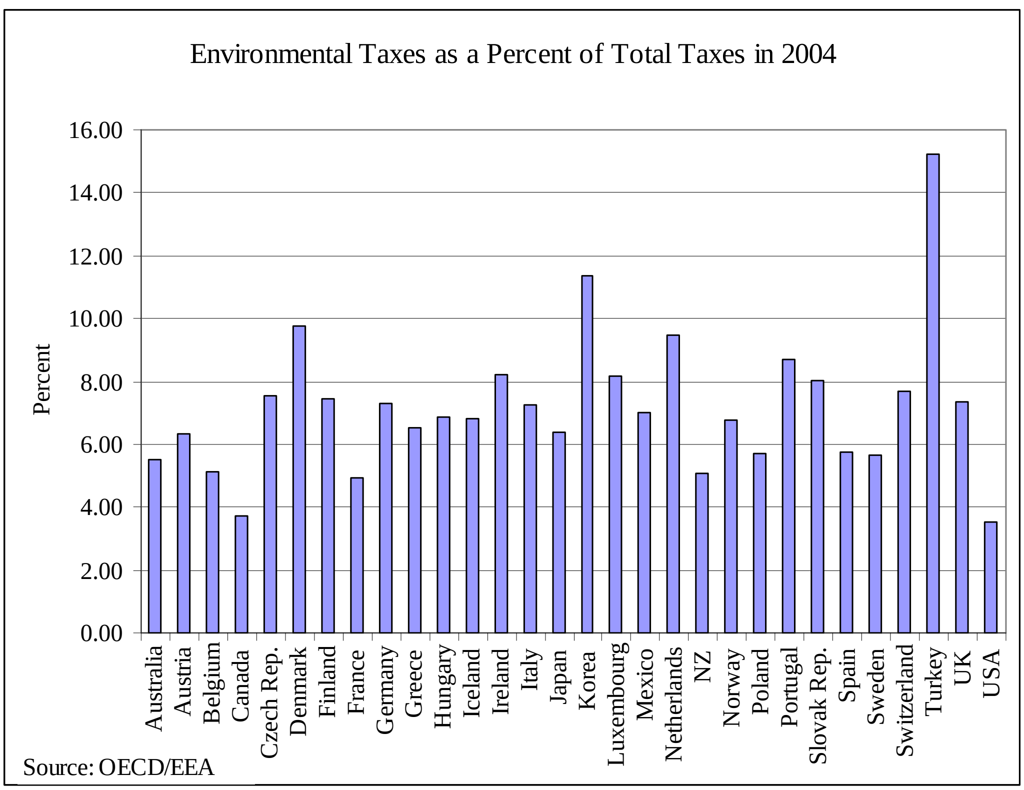


Table 3.

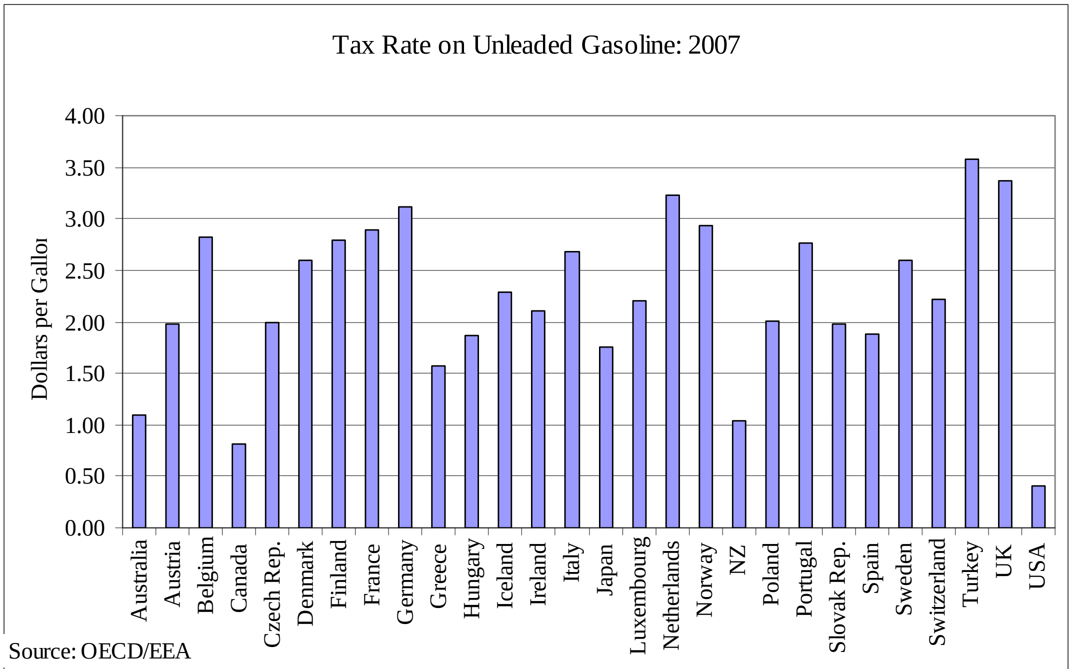


Table 4.

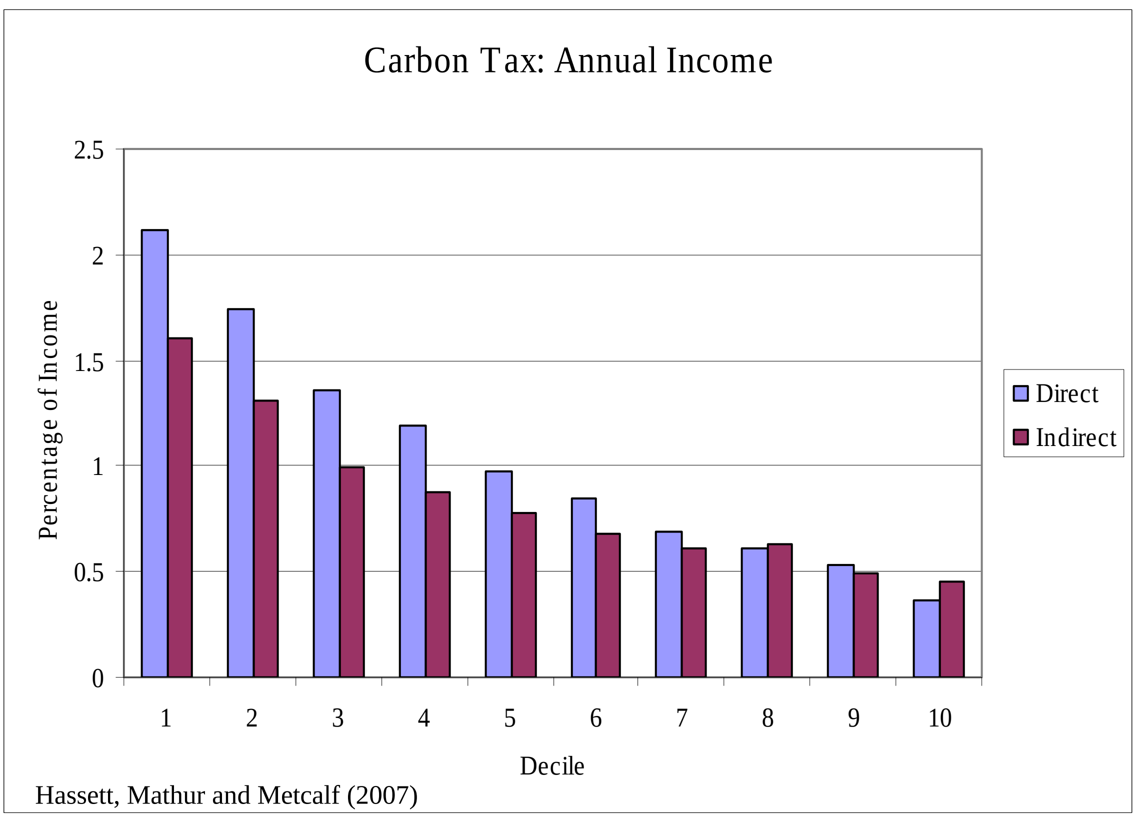
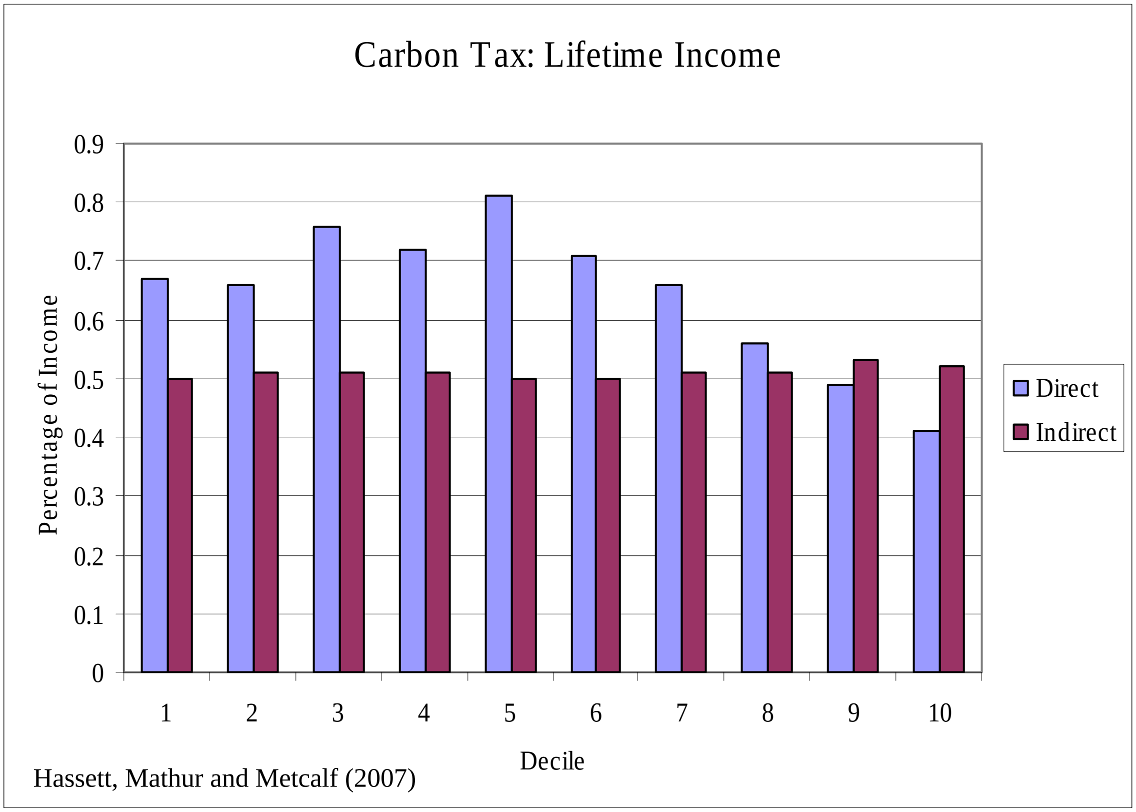


Table 5.



Carbon Tax: Lifetime Income
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Percentage of Income
1
2
3
4
5
6
7
8
9
10
Decile
Direct
Indirect
Hassett, Mathur and Metcalf (2007)

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