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Design of an Incentive Based Carbon Tax System

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Abstract
This article describes a revenue neutral approach to reducing greenhouse gas emissions. The revenue from the carbon taxes is used to finance an environmental earned income credit. Different from other proposals, the proposal would be guaranteed for taxpayers with income under $ 50,000. For taxpayer with income in excess of these amounts they would receive the credit only if greenhouse emissions in their state of residence were reduced to a predetermined level. The advantage of this approach is to provide motivation for states, corporation and high income individuals to actively reduce greenhouse emissions. Current revenue neutral proposals that allow corporations to pass the tax to individuals with the individual receiving an equal credit may not provide sufficient motivation for a significant reduction in greenhouse gas emissions. This proposal encourages states to actively reduce greenhouse emissions so that all its citizens would receive the environmental credit.

Key words: Tax, Carbon Tax, Incentive Model, Modelling

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INTRODUCTION

The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change (UNFCCC or FCCC) that set binding obligations on the industrialized countries to reduce their emissions of greenhouse gases. The UNFCCC is an international environmental treaty with the goal of achieving the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

At negotiations, Annex I countries (including the US) collectively agreed to reduce their greenhouse gas emissions by 5.2% on average for the period 2008-2012 and 20% for the period 2012-2020. This reduction is relative to their annual emissions in a base year, usually 1990.

The United States has resisted endorsing the Kyoto Protocol, preferring to let the market drive CO_2 emission policy. The administration of Barack Obama has proposed aggressive energy policy, including the need for a reduction of CO_2 emissions, with a cap and trade program, designed to help encourage more cleanly renewable, sustainable energy development.

Although exceeded by China, the United States has historically been the world's largest producer of greenhouse gases. Some states, however, are much more prolific polluters than others. The state of Texas produces approximately 1.5 trillion pounds of carbon dioxide yearly, more than every nation in the world except five (and the United States): China, Russia, Japan, India, and Germany.

Makhijani (2007) argued that in order to meet goals of limiting global warming to 2 °C, the world will need to reduce CO_2 emissions by 85% and the U.S. will need to reduce emissions by 95%.

STATISTICS

Figure 1 reports the trend of energy consumption by sources since 1750. Also, statistics analysis depicts the energy consumption by categories as follows:

Electricity:
- production 4,126 TWh in 2010
- consumption 3,877 TWh in 2010

Electricity - production by source:

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- petroleum: 0.9%
- natural gas: 24%
- coal: 45%
- renewable: 10.4%
- nuclear: 20% (2010)

Oil:

- Production: 9.688-million-barrel-per-day (1,540,300 m³/d) (2010 EST.)
- Consumption: 19.15-million-barrel-per-day (3,045,000 m³/d) (2010 EST.)

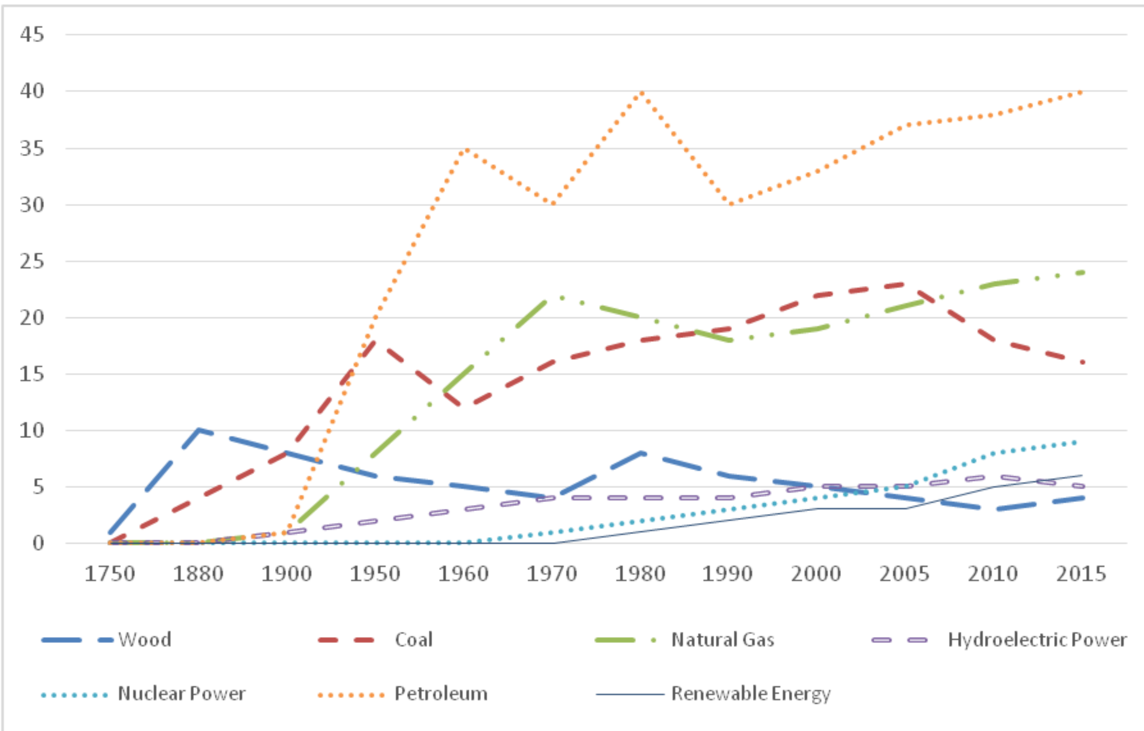

Figure 1. Trend of U.S. Primary Energy Consumption by Sources
US Energy Use: Quad BTU. (1 Quad/s=1 trillion MW; 1 Quad/year = 33.5 Gigawatts)

Carbon Dioxide Emissions

Figure 2 presents the atmospheric carbon dioxide versus time which shows a drastic increase.

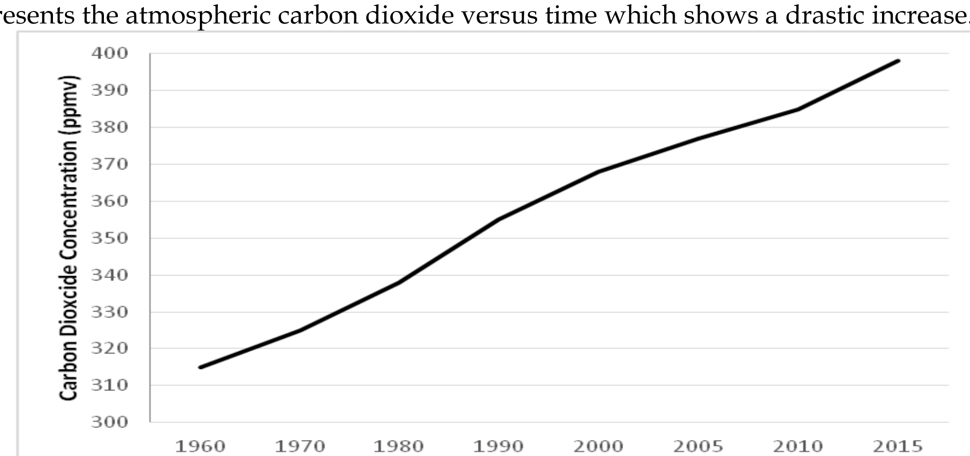

Figure 2. Atmospheric carbon dioxide trend

As is illustrated, greenhouse emissions have increased rapidly initially from the base year but the rate of increase has declined in recent years (Table 1). Moving to a decline in emissions from the 1990 base year will require an aggressive change in US energy policy.

Table 1. US carbon dioxide emissions (millions of metric tons of CO_2)

Year	CO_2	Change from 1990
1990	5,100.5	0.00%
2005	6,107.6	19.75%
2006	6,019.0	18.01%
2007	6,118.6	19.96%
2008	5,924.3	16.15%
2009	5,500.5	7.84%
2010	5,706.4	11.88%

Literature review on carbon taxes based on location, design model, revenue natural and environmental impact is shown in Tables 2 & 3. The Institute for European Environmental Policy and Carbon Tax Center reviewed the status and impact of existing carbon tax systems in selected localities. Table 1 summarizes their findings:

Table 2. Summary of findings

LOCALITY	DATE ENACTED	TAX DESIGN	REVENUE NEUTRAL	ENVIRONMENTAL IMPACT-CO2
Finland	1990	Energy tax and CO2 tax	Partial	7% reduction in emissions 1990-2005
Norway	1991	CO2 tax	Partial	12% reduction per unit of GDP 1991-2007
Denmark	1992	CO2 tax	No	23 % reduction 1992-97
Sweden	1991	Co2 tax	Yes	Reduction of .5 million tones per annum 1990-2007
The Netherlands	1996	Energy tax	Partial	3.5% reduction 1996-2007
Germany	1999	Energy tax	No	3% reduction in 2010
UK	2001	Climate change levy	No	Approximately 2% 2001-2010
British Columbia	2008	CO2 tax	Yes	9% reduction
Ireland	2009	CO2 tax		Reduction in consumption
Australia	2012	Carbon Pricing	No	5.4% reduction
Boulder, Colorado	2007	CO2 tax	No	

Table 3. Economic impacts

LOCALITY	ECONOMIC IMPACT
Finland	Positive GDP impact
Norway	No assessment
Denmark	Overall positive impact
Sweden	Average increase of .5% with some short term economic losses
The Netherlands	Small positive impact
Germany	No assessment
UK	Minimal economic impact
British Columbia	BC's economy outperformed the rest of the country
Ireland	No assessment
Australia	GNI estimated to decrease .01 percentage points a year
Boulder, Colorado	No assessment

ECONOMIC THEORY

A carbon tax is an indirect tax—a tax on a transaction—as opposed to a direct tax, which taxes income. In economic theory, pollution is considered a negative externality, a negative effect on a party not directly involved in a transaction, which results in a market failure. To confront parties with the issue, the economist Arthur Pigou proposed taxing the goods (in this case hydrocarbon fuels) which were the source of the negative externality (carbon dioxide) so as to accurately reflect the cost of the goods' production to society, thereby internalizing the costs associated with the goods' production. A tax on a negative externality is called a Pigovian tax, and should equal the marginal damage costs.

Within Pigou's framework, the changes involved are marginal, and the size of the externality is assumed to be small enough not to distort the rest of the economy.

Prices of hydrocarbon fuels are expected to continue increasing as more countries industrialize and add to the demand on fuel supplies. In addition to creating incentives for energy conservation, a carbon tax would put renewable energy sources such as wind, solar and geothermal on a more competitive footing, stimulating their growth.

The social cost of carbon (SCC) is the marginal cost of emitting one extra ton of carbon (as carbon dioxide) at any point in time. To calculate the SCC, the atmospheric residence time of carbon dioxide must be estimated, along with an estimate of the impacts of climate change. The impact of the extra ton of carbon dioxide in the atmosphere must then be converted to the equivalent impacts when the ton of carbon dioxide was emitted.

According to economic theory, if SCC estimates were complete and markets perfect, a carbon tax should be set equal to the SCC. In reality, however, markets are not perfect, and SCC estimates are not complete.

An amount of CO_2 pollution is measured by the weight (mass) of the pollution.

Estimates of the SCC are highly uncertain. Yohe *et al.* (2007:813) summarized the literature on SCC estimates: peer-reviewed estimates of the SCC for 2005 had an average value of \$43/tC with a standard deviation of \$83/tC.

Key factors of a successful carbon tax appear to include:

1. Drop in fuel consumption
2. Increase in GDP growth
3. Revenue neutrality or a partial offset for higher energy costs
4. Greenhouse gas emissions declining

Australia instituted a carbon Tax on July 1, 2012 and repealed it two years later on July 17,2014. The tax rate was \$23 per metric ton to \$19.60 (US). There were significant reductions in pollution levels but lack of revenue neutrality, high electrical utility cost to consumers, and inherent flaws in a cap and trade approach to reducing pollution doomed the tax.

Development of model to identify factors critical for a successful carbon tax

Empirical research on carbon taxes is not extensive due to the newness of the tax and typically falls in the following areas:

1. Economic impact
2. Tax burden
3. Carbon tax versus cap and trade
4. Design of a carbon tax system

The Congressional Budget office in a report on the "Effects of a Carbon Tax on the Economy and the Environment" (2013) concludes that the economic effect of a carbon tax will be impacted by the use of tax revenues. Some uses such as lowering tax rates would reduce total cost to the economy. The report then outlines the following effects of a carbon tax on labor, investment and output:

1. Increase Prices of Fossil Fuels
2. Increase Cost of Producing Goods and Services
3. Increase Cost of Producing Physical Capital
4. Increase Prices of Good and Services, Lowering Real (Inflation-Adjusted) Wages
5. Changes in mix of goods and services produced and in methods of production alter relative demand for labor and physical capital
6. Reduce Profits on Investment
7. Reduce Supply of Labor
8. Reduce Amount of Investment
9. Lower Output
10. Compound the Negative Economic Effects Caused by Existing Taxes on Individual and Corporate Income

Newcomer, et al (2008) developed a model to assess the magnitude of carbon dioxide emissions reductions from electric power plants in the short run due to a price on CO2 emissions. They concluded that consumers would utilize less electricity if a price increase occurred. They also concluded that a tax on CO2 emissions would impact the order in which existing generators are dispatched, based upon their carbon dioxide emissions and marginal fuel costs.

Development of a carbon tax system to accomplish the emissions reduction mandate

Given the mandate by the EPA that Texas Electrical utilities reduce emissions by 38%, develop, a carbon tax system is developed that would accomplish the emissions reduction mandate. Conefrey et al (2008) studied the impact of the carbon tax on economic growth in Ireland and found that a double-dividend exists if carbon tax revenue is recycled through reduced income taxes but not if a lump sum transfer occurs. They also concluded that the most of the impact on the economy is due to changes in the competitiveness of the manufacturing and service sectors.

Robson (2013) completed an economic evaluation of the unsuccessful Australian carbon tax and identified the following policy lessons:

Lesson 1:

In Assessing the Case for a Carbon Tax or Cap and Trade Scheme, Estimate the Incremental Net Benefits of All Feasible Policy Options, Rather than the Possible Costs of Climate Change

Lesson 2: Do Not Ignore the Effects and Costs of "Complementary" Policies, Which Are Likely to Result in Efficiency Losses Rather than Efficiency Gains, Compounding any Negative Effects of a Carbon Tax or Cap and Trade Scheme

Lesson 3: Cumulative Economic Costs are Likely to be Substantial Over the Long Term, with Lower Discount Rates Resulting in Higher Cumulative Costs in Present Value Terms

Lesson 4: Fiscal Impacts are Likely to be Uncertain, with both Carbon Taxes and Cap and Trade Schemes Adding to any existing Revenue Volatility

Lesson 5: Carefully Assess the Possibility and Costs of Carbon Leakage

Lesson 6: The Double Dividend is Elusive Carbon tax proponents often claim that carbon tax revenue can be "recycled" and used to reduce marginal income tax rates, thus providing a "double dividend." This is a dubious proposition in theory due to the interaction between the carbon tax and existing taxes. These interactions were never taken into account in the Government's modeling.

Lesson 7: Establishing a Robust, Sustainable and Credible Carbon Tax is Politically Difficult. Policy Uncertainty and Time Inconsistency are the Norm Rather than the Exception

Rezai and van der Ploeg (2016) utilized a calibrated integrated assessment model to evaluate the differential impact of additive and multiplicative damages from climate change. They concluded that how global warnings are modeled and calibrated matters for determining the optimal carbon tax for economic growth.

Impact of a revenue neutral carbon tax on labor, investment and output

Tax burden

The normal assumption in U.S. environmental studies is that the higher prices caused by a carbon tax would tend to be regressive imposing a larger burden on low-income households. However, global research indicates that this assumption does not always hold true. First, taxes on electricity and heating tend to be regressive while taxes on transport fuels are not always regressive. Also, research utilizing lifetime as opposed to annual income produced results that showed an environmental tax being less regressive. In addition, the tax burden across income levels also depends on how the tax revenues are utilized.

Poterba (1991) was one of the first researchers to utilize lifetime as opposed to annual income in analyzing the regressitivity of an environmental tax. His assumption was that households tend to base their expenditures on lifetime income as opposed to annual income. He found that a gasoline tax to be much less regressive utilizing lifetime as opposed to annual income with middle-income groups bearing the highest burden.Similar results finding less regressivity in environmental taxes were obtained in later studies by Smith (1992) and Barker and Kohler (1998).

In Europe, research findings identifie cross-country differences in the regressitivity of environmental taxes:

COUNTRY	ENVIRONMENTAL TAX	REGRESSITIVITY	RESEARCHER
UK	Motor fuels	Regressive	Smith (1992) Johnstone and Alavalapati (1998) Blow and Crawford (1997)
France	Motor fuels	Regressive	Bureau (2010)
Finland	Motor fuels	Not regressive	Tuuli (2009)
Sweden	Motor fuels	Not regressive	Ahola et al (2009)
Norway	Motor fuels	Regressive	Aasness and Larsen (2003)
Denmark	All environmental taxes	Mildly regressive	Jacobsen et al (2001)

As the research results indicate, there are cross-country differences in the regressitivity of environmental taxes. U.S. studies indicate that environmental taxes in the U.S. are more regressive than in European countries.

Assouline and Fodha (2012) state that in a very general framework, a budget-neutral environmental tax reform may result in a double dividend. They conclude that the conditions for the obtaining of a double dividend depend on the distributive properties of the labor taxes. Since an environmental tax deteriorates the welfare of all and is regressive, the low paid workers prefer an environmental tax reform balanced by a decrease in the tax rate component but the high paid workers prefer a decrease of the progressivity. They also conclude that whatever the degree of regressivity of the environmental tax alone, it is possible to re-design a recycling mechanism to obtain a Pareto-improving

Metcalf (1998) utilized 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. His found that a modest tax reform in which environmental taxes equal to 10% of federal receipts 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. He concluded that it is possible to maintain or increase progressivity of the tax system with environmental tax reform.

Mathur and Morris (2012) analyzed the distributional implications of an illustrative $15 carbon tax imposed in 2010 on carbon in fossil fuels. Their results suggest that a carbon tax is regressive when using annual incomes as the base for the incidence measure, but less regressive when using consumption. They suggests that if policymakers direct about 11 percent of the tax towards the poorest two deciles, for example through greater spending on social safety net programs than would otherwise occur, then those households would on average be no worse off after the carbon tax than they were before.

Rausch and Reilly (2012) use a general equilibrium model to study the distributional effects of a number of different approaches to using carbon tax revenue. They find that nearly all but the richest households are better off in a scenario in which a carbon tax is used to reduce payroll taxes or for social that aid the lower classes.

Carbon tax versus cap and trade

A carbon tax imposes a tax on each unit of greenhouse gas emissions and gives firms (and households, depending on the scope) an incentive to reduce pollution whenever doing so would cost less than paying the tax. As such, the quantity of pollution reduced depends on the chosen level of the tax. The tax is set by assessing the cost or damage associated with each unit of pollution and the costs associated with controlling that pollution. By contrast, a cap-and-trade system sets a maximum level of pollution, a cap, and distributes emissions permits among firms that produce emissions. Companies must have a permit to cover each unit of pollution they produce, and they can obtain these permits either through an initial allocation or auction, or through trading with other firms. A cap-and-trade policy has significant environmental advantages over a carbon tax as GHG emissions levels are clearly delineated. However, the economic consequences of an abrupt change to maximum GHG emission levels would be detrimental to economic growth and stability as energy providers would need to immediately provide alternative clean and renewable energy

Avi-Yonah and Uhlmann (2009) conclude that a carbon tax is preferable to cap and trade and would provide an immediate price signal. They indicate that the carbon tax could be implemented without the need for a new complex regulatory scheme. Additionally, they state that the revenue from a carbon tax could support research and the development of alternative energy and ease any regressive effects of the tax. Mann (2009) reaches a similar conclusion stating that a carbon tax is better than a cap and trade system because of its simplicity, transparency, efficiency and certainty of cost.

In a recent study, Goulder and Schein (2013) examined the relative attractions of a carbon tax, a “pure” cap-and-trade system, and a “hybrid” option (a cap-and-trade system with a price ceiling and/or price floor. They found that the various options are equivalent along more dimensions than often are recognized. A key finding was that exogenous emissions pricing (whether through a carbon tax or through the hybrid option) has a number of attractions over pure cap and trade. Beyond helping prevent price volatility and reducing expected policy errors in the face of uncertainties, they concluded that exogenous pricing helps avoid problematic interactions with other climate policies and helps avoid large wealth transfers to oil exporting countries.

DESIGN OF CARBON TAX SYSTEMS

The design of a carbon tax system requires will require a consideration of the following:

1. Determining the tax base
2. Setting the tax rate
3. Determination of estimated revenue to be generated
4. Determination of utilization of estimated revenue

5. Projecting the impact of carbon tax on labor, investment and output
6. Projecting the environmental impact
7. Selection of model to provide forecasting info

Mecalf and Weisbach (2009) indicate that many carbon pricing regimes are imposed on relatively narrow bases and are imposed midstream, on industrial users of energy. They conclude well-implemented carbon tax imposed upstream can easily cover 80% of U.S. emissions and can likely cover almost 90% with a modest additional cost. They further conclude that the benefits of the broad base and lower compliance costs are likely to be significant.

Williams et al (2014) states in designing a carbon tax system there a need to limit the burden on industries and households that are vulnerable of political powerful.

Morris and Mathur (2014) examined the issues and options for designing a carbon tax system and concluded that a successful carbon tax should:

1. Have a minimal economic cost
2. Be predictable
3. Start modestly
4. Ramp up gradually
5. Minimize administrative costs

Carbon tax models

IGSM - Integrated global system modeling framework (IGSM)

This comprehensive tool analyzes interactions among humans and the climate system. It is used to study causes of global climate change and potential social and environmental consequences.

The central research (http://globalchange.mit.edu/research) focus of IGSM is to improve the integration of climate science, technological change, economics, and social policy analysis into forecasts of the pressing issues in global change science and climate policy.

The MIT IGSM seeks to answer such questions as:

- How effective and costly would specific policy measures be in alleviating climate change?
- What are the advantages and risks of waiting for better scientific understanding of such change?
- How will the oceanic and terrestrial uptake of carbon dioxide and other greenhouse gases be affected by changing climate?

What nations, regions, and economic sectors are most likely to be affected?

The usrep model

The USREP model merges together economic data from IMPLAN (Minnesota IMPLAN Group, 2008, www.rosemonteis.us/documents/minnesota-implan-2008) with physical energy data from Energy Information Administration's State Energy Data System (SEDS). Most of the basic data are at the state level and so there is flexibility in the regional structure. The model aggregates from the state level to regions, with the regional aggregations determined to capture difference in electricity costs and to help focus on how regions and states differ.

The USREP model was constructed with multiple regions and multiple households in each region to allow determination of the distributional effects of a GHG mitigation policy endogenously. Past work has often used data on energy expenditure by region or household income class to estimate the cost incidence of policies based on energy cost increases. Since higher energy costs affect the cost of all goods and the policy has effects on returns to capital and resources and on wages, basing distributional effect purely on energy expenditure of different households can be misleading.

3. The National Energy Modeling System (NEMS) is a computer-based, energy-economy modeling system of U.S. through 2030. NEMS projects the production, imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics. NEMS was designed and implemented by the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE).

4. The Personal Carbon Footprint Spreadsheet is a simple tool to help measure the greenhouse gases generated to create and deliver all the resources one personally consumes. The annual emissions figure

calculated will almost certainly be greater than the result provided by other carbon calculators due to the inclusion of food, consumer goods, government activities etc. The model addresses carbon emissions at the consumption end.

Paltsev et al (2007) utilized the EPPA model to estimate the tax trajectory necessary to achieve a cumulative emissions goal of 237 billion metric tons of CO2 from 2012-2050. The tax would be $21 per metric ton in 2015 and apply to all GHGs.

Rausch & Reilly (2012) utilized the USREP model and also utilized a tax of $21 but it only applied to CO2 emissions only.

Shapiro et al (2008) utilized the NEMS model to derive a tax scenario that would stabilize emissions. The model assumed a tax rate that would increase each year.

Rausch et al (2010) utilized the USREP model with a focus on household consumption to stimulate cap and trade proposals.

No studies were found utilizing The Personal Carbon Footprint Spreadsheet.

Carbon tax calculations

A carbon tax that compensates for the SCC varies by fuel source. The carbon dioxide production of the fuel source per unit mass or volume is multiplied by the SCC to obtain the tax. Based on the mean peer reviewed value ($43/tC or $12/tCO$_2$), an excel table can de designed to estimates the tax.

Some policy makers have suggested utilizing revenue raised from a carbon tax to reduce the budget deficit. A billion dollars to the federal government is what a hundred dollars is to a typical person: nice to receive but not enough to really impact the budget. Today, anything less than a trillion dollars, or sizeable fraction thereof, is barely worthy of consideration. So let's determine what would be the impact of raising a trillion dollars using a carbon tax. Based upon research calculations we can raise about a trillion dollars at the cost of roughly doubling the retail price of energy. This is too high a price and such an amount would stifle economic growth and incense taxpayers. Therefore utilization of a carbon tax to reduce the deficit is not a practical proposition.

Metcalf has suggested a modest tax level initially of $15 a metric ton with the commitment to increase the rate over time. With approximately 6,000 million tons of CO2 emissions in 2005(energy Information Administration, 2006) approximately 90.1 billion in revenue would be raised. With 131.5 million tax returns filed annually his revenue neutral proposal would refund this amount to all taxpayers producing a credit of approximately $685 per tax return. However CO2 emissions are estimated to fall by only 8.4% well below the Kyoto Protocol target of 20% and the Makhijani target of 95%.

Dampening the impact on poor families was deemed a politically necessary design element for cap-and-trade and would likely be required in any carbon tax. Looking at compliance costs for cap-and-trade (with an allowance price around $20 per ton), the Congressional Budget Office found that the lowest quintile lost more than three times as much income (measured as a percentage) as the top quintile (2.5 percent as opposed to 0.7 percent). Because the poor spend a higher portion of their income on energy and the higher energy prices are passed on to the consumer, this result is not surprising.

Incentive based system design

The major elements of the proposed the incentive based carbon tax system follows:

- A tax on GHF at an initial rate of $15 per metric ton that would decrease over time if targeted reductions in emissions occur
- An automatic environmental payroll tax credit for taxpayers below a certain income level
- An increase in social security monthly benefits for unemployed social security tax recipients with total income below designated levels
- Individuals with income above designated level would receive the credit only if in their state of residence targeted reductions in emissions occur

A tax of $15 per metric ton of CO2 would raise approximately $90.1 billion in tax revenues. Including low income social security recipients, I would propose a credit of $500.00. The credit would be implemented as a payroll tax rebate for workers and carbon tax supplement for social security recipients (who are not in the work force).

For individuals with income in excess of these amounts, they would receive the credit only if their state of residence accomplished stipulated emissions reductions. Such an approach has several advantages including:

- Higher income individuals would be significantly motivated to actively participate in emissions reduction policies and strategies
- Rather than just a national initiative, each state would be motivated to develop emissions reduction strategies and policies to insure that all its citizens would receive the rebate.
- The incentive environmental credit would eliminate a major criticism of a carbon tax that while revenue is raised there is no motivation for a reduction in carbon emissions.
- Unreimbursed carbon taxes could support greenhouse reduction policy objectives such as climate change mitigation, energy efficiency and technological advances
- The tax will not negatively impact lower income households yet these individuals would reduce energy consumption as the price of goods and service's increased.

CONCLUSION

This paper has reviewed the global emphasis on the reduction of greenhouse emissions. The US as the major world power needs to be an active participant in these endeavors. Therefore the paper proposes an incentive based revenue neutral carbon tax. While the tax would be revenue neutral, neutrality would be guaranteed for low income taxpayers only. High income taxpayers would receive the credit only if their state of residence met stipulated emissions reduction goals. Significant advantages occur with this approach as each state along with the federal government is encouraged to develop energy policies that would result in the reduction of greenhouse emissions. States not obtaining specified greenhouse emission reductions would result in many of its citizens not receiving the proposed environmental energy credit.

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Joseph Boyd is currently a distinguished professor in the School Of Business. He competed all academic training including the Ph.D. in Accounting with a concentration in Taxation at the University of South

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