THE ECONOMIC RENT POTENTIAL FROM CO_2 ABATEMENT POLICIES IN THE UNITED STATES

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1. INTRODUCTION

Increasingly, climate change has come to the fore as an environmental issue with nearly universal agreement that the current trend is unsustainable and must be addressed. Of particular concern is the amount of carbon dioxide (CO_2) emitted into the atmosphere, the primary contributor to climate change through the combustion of fossil fuels. In the United States alone, CO_2 emissions account for approximately 85% of all U.S. greenhouse gas emissions, most of which come from fossil fuels (EPA, 2008). Reducing the risk of the damage caused by climate change requires the world to substantially reduce CO_2 production. In the past five to ten years several proposals to address climate change have been suggested; most prominently cap-and-trade and carbon taxes. These market-based approaches differ from the traditional command-and-control policies, such as Corporate Average Fuel Efficiency (CAFÉ) standards which mandate minimum fleet mileage standards for vehicles sold in the United States, by providing firms a cost-effective and flexible form of environmental regulation. Other benefits also exist, such as technological innovation to reduce greenhouse gas emissions and potential revenue sources for governments; the more a firm emits CO_2, the more they pay, either in taxes or through purchased emission permits.

Not surprisingly, revenue generation from these fiscal regulatory policies is controversial as they contribute to the overall costs of the firm and there is concern over the distribution and equity of these costs that will be passed on to the consumer. Market-based approaches, such as carbon taxation and cap-and-trade, are preferred by economists to the command-and-control policies generally used by environmental protection agencies. However, from an economic efficiency point-of-view, a carbon tax is less costly because the tax is more broadly focused and better addresses the negative externality of carbon emissions than a tax on specific forms of fossil fuels (Metcalf, 2009).

For practical policy purposes, however, the immediate issue is how to develop a climate policy regime with a robust emissions mitigation effort as its centerpiece, one that can progressively incorporate rapidly industrializing nations, and that can adjust over time as more is learned about the science, economics, and technological change that characterizes the climate change problem (Aldy and Stavins, 2008). There is much debate throughout the world today as to what is the best policy mechanism to curb CO_2 emissions. In the United States several different versions of CO_2 abatement policies have been proposed and debated. However, the two most often mentioned are versions of carbon taxes and cap-and-trade, which are described in the following paragraphs.

2. AN OVERVIEW OF CARBON TAXES

2.1 Carbon Taxes

Simply put, a carbon tax is a tariff on the CO_2 emissions. Carbon is present in all forms of fossil fuels and converted to CO_2 when the fuel is burned. A carbon tax is easily administered if paid for upstream, the point where the fuels are extracted or imported, because the carbon content of all forms of fossil fuels are well-known. Of the three most popular fossil fuels used, coal, natural gas, and petroleum, coal produces the most CO_2 while natural gas emits the least. Thus, under a carbon tax coal would be taxed the highest, followed by petroleum, then natural gas.

The use of taxes as a method to reduce environmental degradation has a long history. Pigou (1920) argued that taxes can be used to mitigate the effects of a negative externality such as CO_2 emissions. William Baumol (1972) further developed these ideas by illustrating how taxes could be used to obtain environmental standards in a cost effective way. The key to implementing this policy is that the carbon tax must be set at a level that will counterbalance the negative externality; in other words, at any given emissions level, the tax rate should equal the social marginal damages (Figure 1) from producing an additional unit of emissions or, more or less equivalently, the social marginal benefit from abating a unit of emissions. If the marginal abatement costs are lower than the carbon tax, then firms will reduce their emissions. Figure 1 illustrates that the low marginal abatement cost (MAC) firm will pay abatement costs of area C and pays a tax to the government equal to area D+E. On the other hand the high marginal abatement cost firm will pay abatement costs of area D and pay a tax to the government equal to area B+C+D.

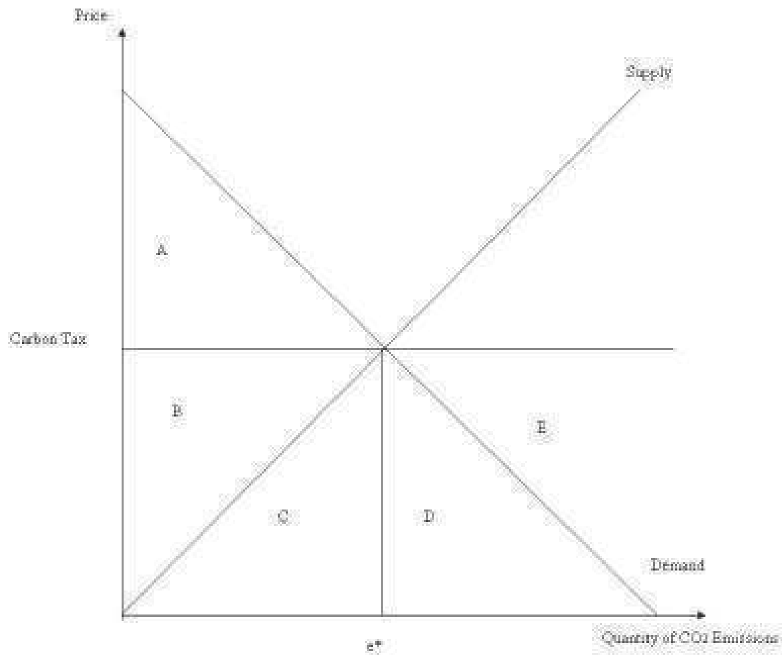


Figure 1. The Effects of a Carbon Tax on Individual Firms

The tax will increase production costs which will cause firms to reduce their supply. Thus, emissions levels are reduced, but at the same time part of the tax is shifted onto consumers. The amount of the price increase for consumers will depend upon the elasticity of demand for the product. However, at least part of the tax will be passed on to consumers to bear which is why detractors claim this option to be regressive in nature (see Figure 2).

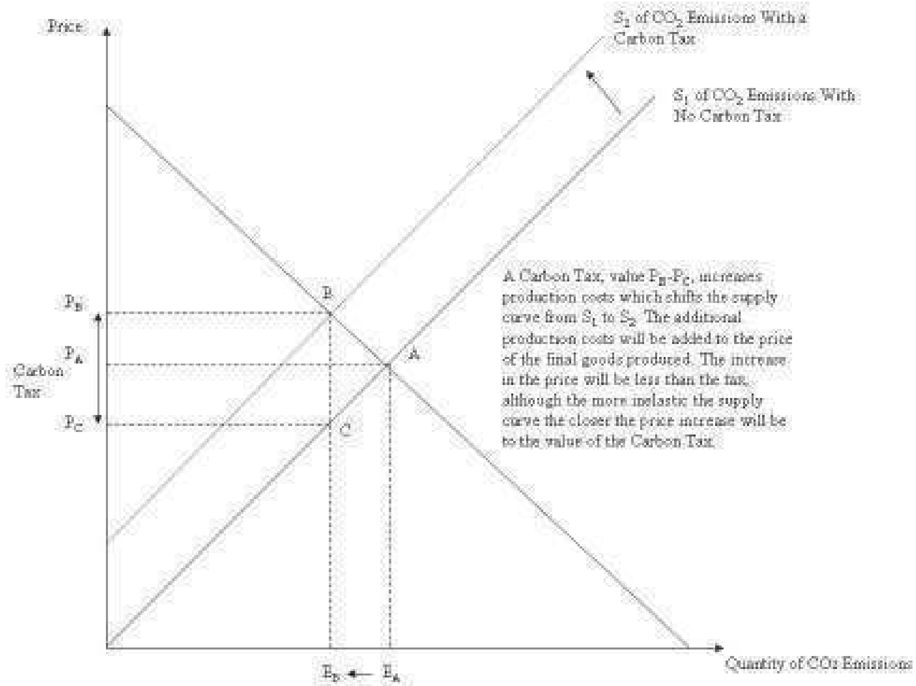


Figure 2. The Effects of a Carbon Tax on the Market

The central premise of a carbon tax therefore is to obtain large reductions in CO_2 emissions rapidly by creating an incentive to do so. The prices of carbon emitting fuels and energy do not include any of the costs of carbon emissions. Furthermore, as will be shown through examples from several European countries that tax carbon content, not using carbon taxes removes any incentive for individuals and corporations to take measures to reduce carbon emissions and alter their consumption behavior and choices. No one will argue that carbon taxes will completely eliminate climate change problems; however the taxes can be used in a positive manner.

Proponents argue that the carbon tax will send price signals throughout the market leading to new technologies and renewable energy sources. They claim that the price signals will provide economic incentives to reduce or eliminate emissions at the source, which will reduce clean-up costs from released emissions and substitute fossil fuels with renewable energy sources such as wind energy. Furthermore, advocates claim that the end result will be more energy-efficient technologies adapted (Andersen, 1999). In economics terms there would be a demand effect, a reduction in the demand for carbon producing energy sources as a result of the price increase, and a substitution effect, a substitution of fossil fuels for lower carbon based fuels.

On the other hand, opponents will argue that carbon taxation will have a negative impact on economic growth. They claim that an increase in taxes will depress real disposable incomes which will reduce overall demand leading to lower economic gross domestic product levels. In addition, adversaries argue that carbon taxation will lead to inflation because the taxes are levied on households and the whole tax will be reflected in the consumer price index if cheaper alternatives to fossil fuels are not readily available for industry and consumers. This is in contrast to a carbon tax that would be levied on producers which would pass some fraction of the tax onto consumers.

2.2 Carbon Taxes in Europe

While many economists find carbon taxes the preferable method for abating CO_2 emissions very few countries actually implement this policy. European environmental policies, based on the precautionary principle and the polluter pays principle, could be more easily implemented using carbon taxes. While not developed for the purpose of reducing greenhouse gas emissions, European Union member states have long used energy taxes. However, the implementation of these tax schemes has been very diverse, often differentiating among users, types of energy, and industry. Moreover, these energy taxes were not initiated with the intent of reducing CO_2 emissions but with the purpose of generating revenue to reduce taxes in other areas of the economy.

A few European countries have developed taxes with the purpose of reducing CO_2 emissions. In 1990 Finland initiated their version of the carbon tax, widely regarded to be the first country to use such a tax. The first adaptation of the tax was strictly on carbon content. However, the second derivation of the tax included energy. Sweden followed with their own version of a carbon tax soon after in 1991. The tax has been set to $150 per ton of carbon with the exception of fuels used for electricity generation and industries only have to pay one-half of the tax (Johansson, 2000). Swedish energy policy requires that non-industrial consumers pay a tax on electricity but exempts fuels from renewable sources such as biofuels and biomass (Johansson, 2000). Due to this tax policy the use of renewable fuels for heating and industry has vastly expanded in Sweden. The next European country to use a carbon tax was Great Britain in 2001 which instituted the tax for the industrial, commercial, and public sectors. Tax revenues are partially used to provide subsidies for energy efficiency and renewable energy initiatives. Since 2003 with the development of the Energy Taxation Directive, Europe has had an European Union level carbon tax policy. However, that is not to say that individual member states do not have their own policies aimed at carbon emissions. The policies of several such countries (Denmark, Sweden, and the United Kingdom) will be briefly examined below. Abatement policies differ greatly between the countries so providing a complete and detailed account of the various policies is difficult. Therefore, specifics, such as the amount of taxation, will not be discussed as these details change often and will provide little information as for the purposes of the discussion in this paper. Since there are many derivations to the carbon and CO_2 tax policies of every country, particularly those examined below, the reader is encouraged to go to the European Union's internet sites related to energy and the environment, as well as each country's energy and environment web sites for complete information.

Denmark has a three-pronged tax system aimed at energy, CO_2, and sulfur. The energy tax is imposed on the carbon content of fossil fuels with the exception of natural gas (Speck, 2008). The CO_2 tax is self explanatory. The sulfur tax is levied on all fossil fuels with a 0.05% or higher sulfur content (Speck, 2008). The purpose of this tax scheme is to reduce the amount of emissions into the atmosphere by encouraging reduced consumption of energy products with carbon or sulfur content or by promoting technology that prevents CO_2 or sulfur emissions. However, Denmark has a complex tax differentiation program established for industries. Industries can receive a complete energy tax refund for energy used for purposes other than space heating in which case industries must pay the full tax. The CO_2 tax scheme is even more complex as industries pay according to type of usage. However, industries can reduce their level of taxation through a variety of agreements available with the government.

Sweden uses four types of taxes on energy and carbon indexed to their Consumer Price Index to ensure that the real value of the taxes remain constant over time. Energy taxes were first used on gasoline in 1924 and then extended to include oils and coal in 1957, liquefied petroleum gas in 1964, and natural gas in 1985 (Speck, 2008). The country developed both a CO_2 tax and a sulfur tax in 1991. The CO_2 tax rates are based upon the carbon content of the fossil fuel being used. The sulfur tax is only implemented on heavy fuel oil, peat fuel, and coal. Any fuel with a sulfur content less than 0.05% in weight is exempt from the tax. The last type of tax to abate greenhouse gas emissions that Sweden uses is a nitrogen oxide (NO_x) charge which was first initiated in 1992. Originally, the NO_x tax was imposed on emissions from energy plants fifty gigawatt hours or larger, but later decreased to twenty-five gigawatt hours (Speck, 2008).

In contrast to the above, the tax scheme that the United Kingdom has developed to reduce CO_2 emissions is relatively simple. In 1990 the United Kingdom introduced the Fossil Fuel Levy for all consumers of electricity. The revenues generated from this tax were used to subsidize renewable energy projects, especially nuclear power. In 2001 the Climate Change Levy was introduced. This tax was on non-domestic energy use and did not include household use. The revenues from this tax have been used as a tax shifting program (Speck, 2008).

The main components of the CO_2 abatement programs of three European countries have been briefly examined due to their complexity and often-changing nature. However, the CO_2 abatement policies that exist in individual countries must be just the beginning as the European Union has created a European-wide policy aimed at reducing CO_2 emissions. The first such effort was the Energy Taxation Directive (ETD) created in 2003 and implement January 1, 2004. The ETD created minimum taxation levels for all forms of energy products aimed at the consumer level (Hasselknippe and Christiansen, 2003). The second effort, the European Union Emissions Trading Scheme (ETS) targets the energy sector and energy-intensive sectors at the producer level but are different from energy and carbon taxation. Double taxation of emissions is not supposed to occur between these two schemes, so countries are restricted from additional emissions taxes on installations already covered by the ETD (Hasselknippe and Christiansen, 2003). Therefore, the two abatement programs have been developed to work in conjunction with each other rather than in competition. The next section will explain how cap-and-trade schemes work and then show the European Union uses cap-and-trade for abatement. Furthermore, the cap-and-trade proposals currently under discussion in the United States will be explained.

3. AN OVERVIEW OF CAP-AND-TRADE

3.1 Cap-and-Trade

Cap-and-trade programs are based on the economic theories developed by Ronald Coase (1960) who argued that property rights can improve environmental conditions, which he found to be more effective than taxes (Raymond and Shively, 2008). A cap-and-trade program sets a ceiling on the total greenhouse gas emissions, where each firm is issued a permit to emit one unit of pollution during a given time period. For CO_2 for example, a firm must have one permit to emit one ton of CO_2 emissions. Over time, the ceiling for allowable emissions is lowered until the target level is reached. Such a method is what was used to reduce sulfur emissions in the United States; a major factor in reducing acid rain (Benkovic and Kruger, 2001).

The idea behind this concept is that some firms will be able to reduce their emissions below the required levels much easier than other firms. As shown in Figure 3, low polluting firms have smaller abatement costs and can then sell their allocated pollution permits to high polluting firms with greater abatement costs because these firms have more difficulty lowering their emissions levels. Thus, the preset level of pollution is reached while at the same time minimizing the marginal abatement costs by rewarding firms that are able to reduce their emissions efficiently. The firms with high marginal abatement costs will either purchase permits from low marginal abatement cost firms or invest in new infrastructure or technology to reduce their pollution levels. In either case, the total amount of emissions will be reduced to the amount specified by the regulatory body. Proponents of cap-and-trade claim that a cap-and-trade system allows for more efficiency and information sharing in the market which will enables firms to lose less profits. Advocates also argue that permits are a more flexible regulatory option because prices can be adjusted depending upon economic conditions. They will also point out that under cap-and-trade regulation all firms have the same marginal cost of abatement. Opponents on the other hand, argue that cap-and-trade is regressive; most negatively affecting poorer households (Galbraith, 2009). Furthermore, challengers claim that the cap-and-trade system does not provide firms any incentive to reduce pollution levels beyond what is allowable.

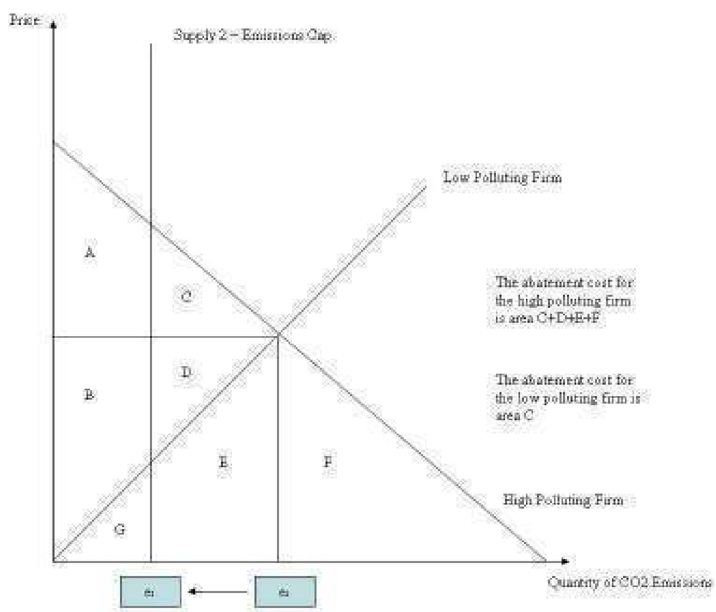


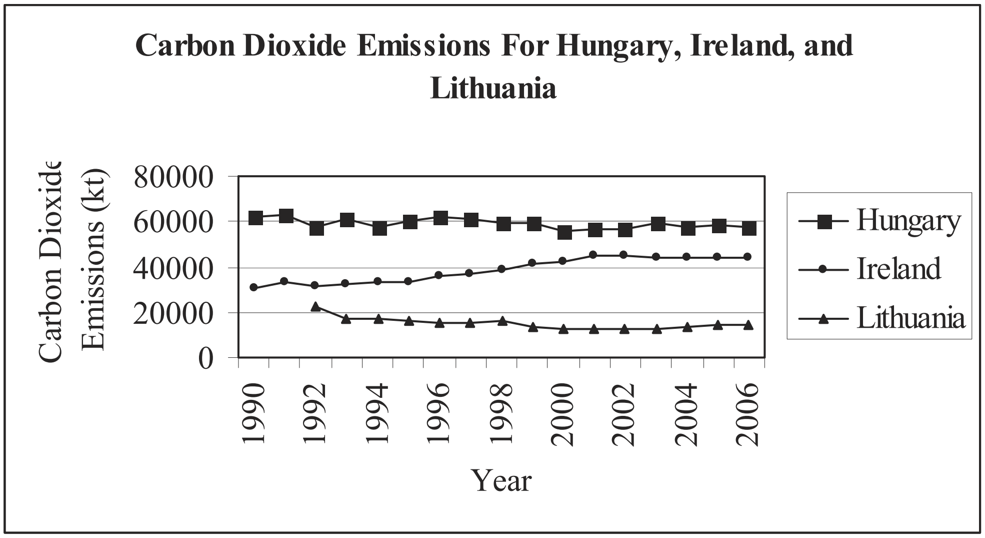
Figure 3. The Effects of Cap-and-Trade on the Market

3.2 European Union Emissions Trading Scheme

The European Union instituted the Emissions Trading Scheme (ETS) in efforts to comply with the Kyoto Protocol. The ETS program works in conjunction with individual member states carbon and energy tax programs, as well as the European Union ETD scheme which sets minimum energy tax rates, creating an incredibly complex CO_2 regulatory agenda. Under the European Union ETS agreement each member state is allowed a certain number of allowances based on their national allocation plan (Convery and Redmond, 2007). The objective of the European Union ETS is to reduce CO_2 emissions by 2020 by at least twenty percent of 1990 emissions levels. Each European Union allowance enables a firm to emit one ton of CO_2. Those firms that emit less than their allowances can sell any excess permits to firms that have difficulty keeping their emission levels low. These high-polluting firms either have to continue purchasing allowances from low-polluting firms or invest in CO_2 reducing technology. The ETS program is aimed towards large firms; for example, power plants that are larger than twenty megawatts (Andersen, 1999). The ETS program also covers the most energy intensive industries (ferrous metal plants, cement factories, glass factories, ceramic products, as well as pulp and paper factories) and refineries (Andersen, 1999).

Similar to the carbon tax programs that have been developed, one of the premises behind cap-and-trade programs such as the European Union ETS is to send a price signal or price signals throughout the market. In the case of the European Union ETS there are two types of costs that are imposed on industries. First, there are the direct costs that firms must incur when they purchase allowance permits. The level of these costs will be dependent upon the amount of CO_2 emissions the industry produces and whether or not the company must purchase additional permits from less polluting companies. Additionally, there is an indirect cost to households as carbon producing firms factor the costs of emissions certificates into consumer prices. Therefore, the implementation of the European Union ETS program is of prime importance.

Phase I of the European Union ETS was launched in 2005. For this first phase the European Union gave nearly all of the total allowances, valued at €65 to €130 billion, to firms for free (Convery and Redmond, 2007). Only three European Union members, Ireland, Hungary, and Lithuania, chose to auction some of their allowances which accounted for 0.12 percent of the total permits (Hahn, 2009). All three of these countries used the revenues generated from the auctions to offset some of the administrative costs of conducting the auctions. As shown in Figure 4, the auctioning of allowances in these three countries has had little effect, albeit in a small sample of three years. During that time period the CO_2 emissions for these three countries remained relatively constant.

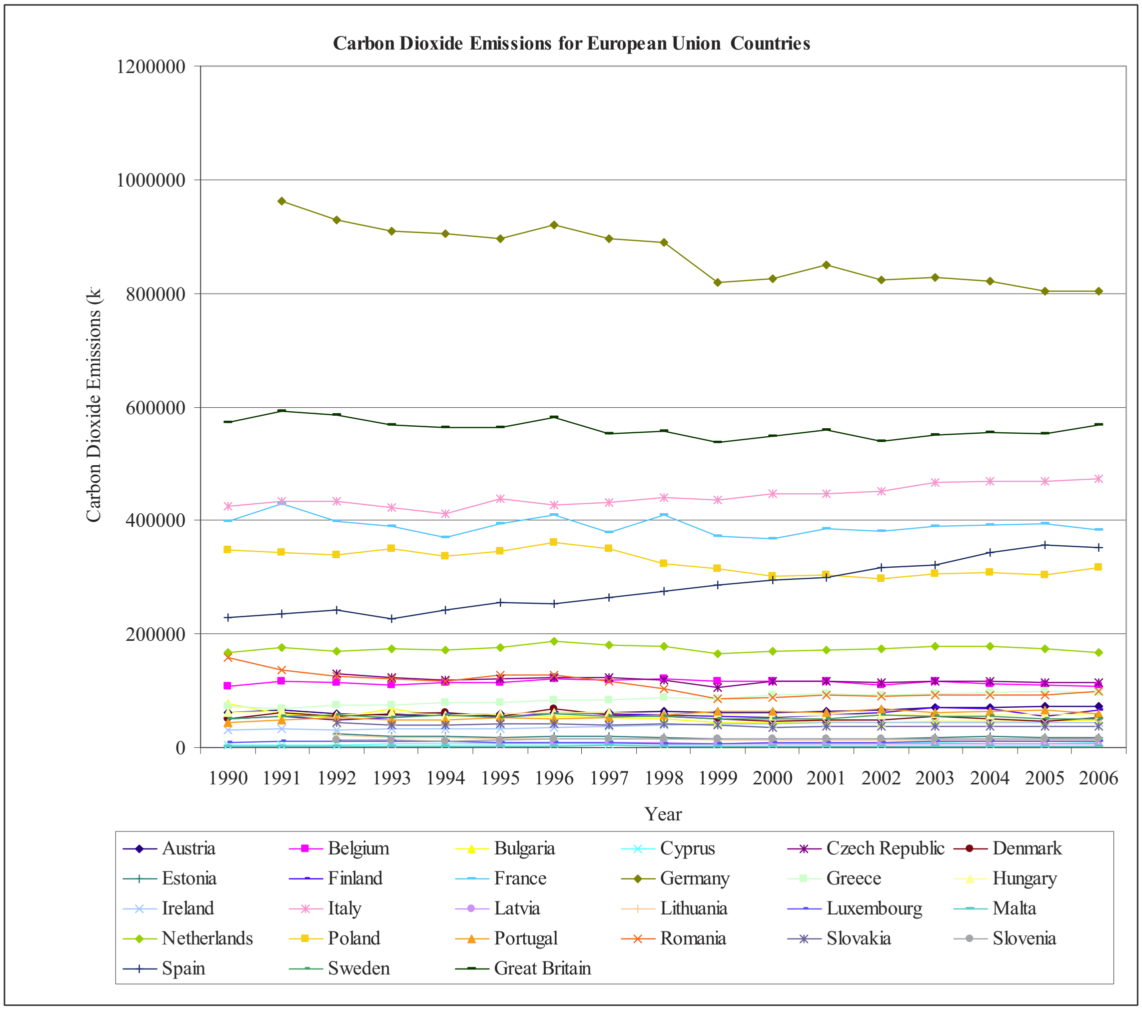


Source: Carbon Dioxide Emissions data obtained from the World Bank World Development Indicators.

Figure 4. CO_2 Emissions in Ireland, Hungary, and Lithuania 1990 - 2006

Phase II, which was instituted in 2008 required that no more than ten percent of the allowances be auctioned to firms. However, the policy of the other European Union member states of giving permits away has largely been a failure as CO_2 emissions has increased throughout the European Union. Therefore, the use of auctions will need to be expanded to create more incentives for firms to reduce their emissions level. Phase II is also the first time new European Union member countries, such as Romania, are included in the scheme. Phase III of the European Union ETS program, set to begin in 2013, calls for at least two-thirds of the permits to be auctioned (European Commission, 2008). A minimum of twenty percent of the revenues that are generated from the auctioning of the permits will be used for climate change mitigation and adaptation efforts (European Commission, 2008).

As shown in Figure 5, in the limited time that the European Union ETS has been in existence there has been little effect on carbon dioxide emissions. Some countries, such as Germany, have been experiencing decreasing emissions. However, most countries in the European Union have slightly increasing or relatively constant levels of CO_2 emissions.



Source: Carbon Dioxide Emissions data obtained from the World Bank World Development Indicators.

Figure 5. CO_2 Emissions for European Union Countries 1990-2006

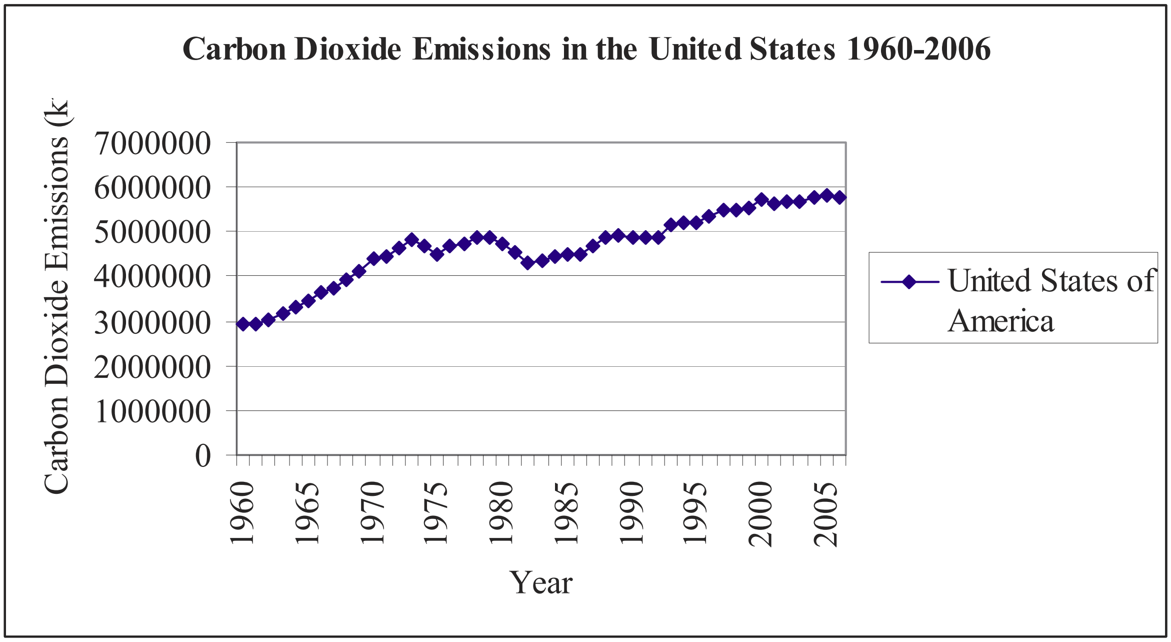
As stated previously, the European system of reducing carbon emissions is complex with the various levels of regulation that are imposed. Not surprisingly, many are concerned about double-taxation. However, the ETS program, at least in theory, has been developed to prevent double-taxation from occurring. The European Union ETS program creates two sectors of carbon emitters, the ETS and the non-ETS (Andersen, 1999). The carbon emitters designated as ETS are regulated under the European Union ETS program and, as such, are not eligible to have any additional tax levied on them. Furthermore, because the European Union ETS sets an emissions cap from the companies delegated to the ETS sector, if these companies wish to emit more carbon then they must purchase additional allowances on the market. Theoretically, this directive should prevent double-taxation of companies.

Since this directive has been developed to prevent double-taxation, a number of European Union countries have been considering eliminating their carbon and energy taxation programs in favor of the ETS provisions. However, for any individual European Union member-state to remove taxes selectively, as would be the case if the ETS sector was excluded, they would need approval from the European Commission (Andersen, 1999). The ETD, in contrast to the European Union ETS, was developed with a directive beyond carbon taxation; the ETD also attempts to equilibrate the energy supply with tax rates. However, by definition of the directive, the European Union ETS is heavily dependent upon the specific regional power markets (Andersen, 1999). Therefore, there can be no guarantee that the European Union ETS can synchronize energy tax rates across regions. As such, companies in different European Union countries can be at a competitive disadvantage with each other.

4. THE UNITED STATES

4.1 Comparison of Carbon Reduction Policies in the United States

Figure 6 presents the carbon dioxide emissions for the United States since 1960. As can be seen, CO_2 emissions have steadily trended upwards since 1960. In comparison to carbon emissions in Europe, the United States emits considerably more carbon into the atmosphere.



Source: Carbon Dioxide Emissions data obtained from the World Bank World Development Indicators.

Figure 6. CO_2 Emissions in the United States 1960-2006

Due to these high levels of emissions, many policies have either been used or proposed to reduce carbon dioxide emissions in the United States. As stated previously, market-based approaches to reduce CO_2 emissions such as taxes or cap-and-trade schemes are the preferred methods of economists. While carbon taxes are fairly straight-forward, there are a few different approaches to cap-and-trade programs. The Congressional Budget Office (2008) developed a chart, presented in Table 1, which summarizes the key aspects of each program for the United States.

Table 1. Comparison of CO_2 Emissions Policies

Comparison of Selected Policies for Cutting CO_2 Emissions

Policy	Efficiency: Ranking	Efficiency: Considerations	Implementation Considerations	International Consistency Considerations
Carbon Dioxide Tax	1	A tax would avoid significant year-to-year fluctuations in costs. Setting the tax equal to the estimate of the marginal benefit of emission reductions would motivate reductions that cost less than their anticipated benefits but would not require reductions that cost more than those benefits. Research indicates that the net benefits of a tax could be roughly five times as high as the net benefits of an inflexible cap. Alternatively, a tax could achieve a long-term target at a fraction of the cost of an inflexible cap.	An upstream tax would not require monitoring emissions and could be relatively easy to implement. It could build on the administrative infrastructure for existing taxes, such as excise taxes on coal and petroleum.	A U.S. tax could be set at a rate consistent with carbon dioxide taxes in other countries. Consistency would require comparable verification and enforcement. If countries imposed taxes at different points in the carbon supply chain, special provisions could be needed to avoid double-taxing or exempting certain goods. Setting a U.S. tax that would be consistent with allowance prices under other countries' cap-and-trade systems would be somewhat more difficult because it would require predicting allowance prices in different countries.
Cap With Safety Valve and Either Banking or a Price Floor	2	A cap-and-trade program that included a safety valve and either banking or a price floor could have many of the efficiency advantages of a tax. The safety valve would prevent price spikes and could keep the costs of emission reductions from exceeding their expected benefits. Banking would help prevent the price of allowances from falling too low, provided that prices were expected to be higher in the future. A price floor, however, would be more effective at keeping the cost of emission reductions from falling below a target level.	An upstream cap would not require monitoring emissions. It would require a new administrative infrastructure to track allowance holdings and transfers. Implementing a safety valve would be straightforward: The government would offer an unlimited number of allowances at the safety-valve price. Banking has been successfully implemented in the U.S. Acid Rain Program. A price floor would be straightforward to implement only if the government chose to sell a significant fraction of emission allowances in an auction.	Either a safety valve or banking would become available to all sources of CO_2 emissions in a linked international cap-and-trade program. Some countries could object to linking with a U.S. program that included those features, because linked countries could not ensure that their emissions would be below a required level in a given year. Linking would also create concerns about inconsistent monitoring and enforcement among countries and international capital flows (as described below in the inflexible cap policy). Countries with different cap-and-trade programs could capture many of the efficiency gains that would be achieved by linking—while avoiding some of the complications—if they each included banking (or set a similar price floor) and agreed on a safety-valve price.

Policy	Efficiency Ranking	Efficiency Considerations	Implementation Considerations	International Consistency Considerations
Cap With Banking and Either a Circuit Breaker or Managed Borrowing	3	Allowing firms to bank allowances would help prevent the price of allowances from falling too low, provided that prices were expected to be higher in the future. Including a circuit breaker—or increasing the ability of firms to borrow allowances—would help keep the price of allowances from climbing higher than desired, but would be significantly less effective at doing so than a price ceiling.	An upstream cap would not require monitoring emissions. It would require a new administrative infrastructure to track allowance holdings and transfers. Banking has been successfully implemented in the U.S. Acid Rain Program. Determining when to trigger a circuit breaker, or modify borrowing restrictions, would require judgment about current and future allowance prices. Such interventions could aggravate price fluctuations if those judgments were incorrect.	Including banking and either a circuit breaker or borrowing in the U.S. program could reduce the likelihood of linking because it would cause uncertainty about the stringency of the U.S. cap relative to other countries' caps and about the total supply of allowances in the global trading market.
Inflexible Cap	4	Allowance prices could be volatile. An inflexible cap could require too many emission reductions (relative to their benefits) if the cost of achieving them was higher than anticipated and could require too few reductions if the cost of meeting the cap was lower than policymakers had anticipated.	An upstream cap would not require monitoring emissions. It would require a new administrative infrastructure to track allowance holdings and transfers.	Linking an inflexible U.S. cap with other countries' cap-and-trade systems would create a consistent global incentive for reducing emissions. However, inconsistent monitoring and enforcement in any one country could undermine the entire linked trading system. Further, linking would alter allowance prices in participating countries, create capital flows between countries, and possibly encourage countries to set their caps so as to influence those flows.

Source: Congressional Budget Office.

Note: An "upstream" tax or cap would be imposed on suppliers of fossil fuel on the basis of the carbon dioxide (CO_2) emitted when the fuel was burned. A "safety valve" would set a ceiling on the price of allowances. "Banking" would allow firms to exceed their required emission reductions in one year and use their extra allowances in a later year. Under a "circuit breaker," the government would stop a declining cap from becoming more stringent if the price of allownces exceeded a specified level.

4.2 Carbon Taxes in the United States

The United States has a long history of using taxes to reduce pollution. In the 1970s, President Richard Nixon proposed two different taxes aimed at reducing pollution, a tax on lead additives in gasoline and a tax on sulfur dioxide emissions. Neither of these taxes was implemented. However, a tax on fuel inefficient cars was instituted in 1978, soon followed by the Superfund in 1980 which was developed to clean hazardous waste sites. The pollution tax that most Americans are familiar with is the gasoline tax, but this regulatory action is not a widely applied energy tax because the levy is limited to gasoline.

Since that time, other forms of environmental taxation in the United States have been attempted. Soon after his election, President Bill Clinton proposed an energy tax aimed at reducing the deficit and pollution. At the time he stated, “it also combats pollution, promotes energy efficiency, promotes the independence economically of the country …” (139^{th} Congressional Record, 1993). However, the Clinton energy tax was never implemented, instead replaced by an increase in the gasoline tax.

Although the Clinton energy tax was never implemented, some important information can be obtained from examining that potential legislation. The proposed energy tax by President Clinton covered a wide range of energy products including fossil fuels, ethanol and methanol fuels, and nuclear and hydroelectric power. An interesting provision of the proposed energy tax was a supplemental tax on petroleum, without which natural gas would have actually had a higher percentage of market price than oil, which would likely have discouraged the shifting of consumption from petroleum to natural gas which is a lesser polluting fuel (United States Department of Treasury, Office of Tax Policy, 1993). Another important lesson that can be learned from is that the proposed tax was an energy tax, not a carbon tax which would have reduced CO_2 emissions much more than the energy tax. Why this distinction is important is because the differentiation illustrates the importance of politics in environmental policy. Had the proposal been a carbon tax instead of an energy tax then coal would have been taxed the highest, which would have impacted coal mining in West Virginia and other coal producing states and states that are heavily dependent on coal for energy or heat. The coal example further highlights the considerable regional differences that make the passing of any carbon tax extremely difficult in the United States. Besides the regional differences that must be addressed so would any differentiation among energy types. For example, in the Clinton energy tax proposal hydroelectric power would be taxed but not solar electricity. This certainly would have brought considerable objection from hydroelectricity proponents, claiming unfair practices and that solar electricity would be receiving favored status. Questions of equity and potential impact on both the national and regional economies will have to be addressed with any carbon tax proposal. In addition to these two lessons, the Clinton energy tax proposal also underscores the need to treat imports the same as domestic products in regards to the tax in order to keep domestic products on equal competitive ground.

In the past several years, the United States has considered a few different regulatory actions aimed at creating a carbon tax. The bills that have been considered differ from the Clinton energy tax proposal in that they focus on fossil fuels while the Clinton energy tax proposal also included nuclear power and hydroelectric power. The first proposed legislation that will be examined is the "Save Our Climate Act of 2007," which was legislation H.R. 2069 drafted and introduced by Congressmen Fortney Stark and Jim McDermott (110^{th} Congressional Record, 2007). This bill proposed a $10 per ton tax of carbon content on coal, petroleum, petroleum products, and natural gas. This $10 per ton tax of carbon content would increase $10 annually until CO_2 emissions in the United States were reduced to eighty percent below the 1990 level. The tax would be imposed on the manufacturer, importer, or producer of the fuel, but could be refunded if the fuel was used for carbon sequestration. In addition, exporters were exempt from the tax (110^{th} Congressional Record, 2007). The bill also proposes that that the tax be used to reduce taxes on low and middle class households and to fund alternative energy development. The bill also proposes that studies be done every five years to determent the environmental and economic impacts of the tax.

The second proposed legislative act is "America's Energy Security Trust Fund Act of 2007," which was legislation H.R. 3416 introduced by Congressman John Larson (110^{th} Congressional Record, 2007). This bill is similar to the Stark-McDermott bill except the Larson bill proposes a tax levy of $15 per ton increasing ten percent every year plus one per cent more than the annual cost of living adjustment (110^{th} Congressional Record, 2007). There are other differences as well. Fuels used for exports and feedstock are exempt from the tax, and taxpayers that sequester greenhouse gases, perform carbon offset projects, or eliminate hydrofluorocarbons in the United States can qualify for a tax credit or tax refund for taxes they paid (110^{th} Congressional Record, 2007). In contrast to the Stark-McDermott bill the Larson bill would create a trust funded by the revenues from the tax to finance tax credits for clean energy technology, to assist industries negatively affected by the tax transition to less polluting production methods, and to provide an income tax credit for individual taxpayers. The income tax credit would be equal to the per capita share of the taxpayer's portion of the trust fund's revenue, but would be capped at the level of federal payroll taxes paid by that taxpayer or ten percent of the social security benefits the taxpayer may have received that year (110^{th} Congressional Record, 2007).

Carbon taxes have been used by other levels of government in the United States. In 2006, Boulder, Colorado instituted the Climate Action Plan Tax that levied a tax on the end users of electricity. The energy tax is collected by the utility companies when consumers pay their bills. The revenue generated from the tax is used by the city to finance their climate action program. Their climate action program seeks to reduce local greenhouse gas emissions to seven percent below 1990 levels by the year 2012.

The Bay Area Air Quality Management District levies a fee that is very similar to a carbon tax. The tax that is imposed is based on the level of emissions but also covers other greenhouse gases beyond CO_2 (Bay Area Air Quality Management District, 2008). The tax is levied on industrial facilities and businesses that must abide by air quality permit requirements. The revenues generated from this tax are used by the Bay Area Air Quality Management District's climate programs.

A list of recent carbon tax initiatives that have either been instituted or suggested are listed in Table 2.

Table 2. Carbon Taxes Used in the United States

Tax	Tax Base	Tax Rate	Taxpayer	Use of Revenue
Federal gas tax now in effect (not including taxes on diesel, aviation fuel)	Gasoline	18.4 cents per gallon	Oil refiner; Position holder of fuel in terminal; Importer	Highway Trust Fund; Leaking Underground Storage Tank Trust Fund
Clinton Btu tax proposal in 1993	Fossil fuels; Hydropower; Nuclear; Ethanol (in original proposal)	25.7 cents per million Btus, with 34.2 cents per million Btus supplemental rate for oil	Oil refiner; End user of coal, electricity; Importer	Deficit reduction; Regressivity offsets in budget package
H.R. 2069 Save Our Climate Act of 2007 (Stark-McDermott)	Coal; Petroleum and petroleum products; Natural gas	$10 per ton of carbon, increased by $10 per year until emissions 80% below 1990 level	Manufacturer Producer Importer	Not mandated
H.R. 3416 America's Energy Security Trust Fund Act of 2007 (Larson)	Coal Petroleum and petroleum products; Natural gas	$15 per ton of carbon dioxide, increased each year by 10% plus cost of living adjustment	Manufacturer Producer Importer	Dedicated to: Tax credit for clean energy technology; Transitional industry assistance; Carbon tax rebate
Boulder, Colorado, Climate Action Plan Tax	Electricity	Capped per kilowatt hour at: 0.49 cents (residential) 0.09 cents (commercial) 0.03 cent (industrial)	End user (collected by electric utility)	Climate action program
San Francisco, Bay Area Air Quality Management District Fee	Greenhouse gas emissions	4.4 cents per ton of greenhouse gas emissions	Industry, businesses subject to air quality permits	Climate protection programs

5. CAP-AND-TRADE IN THE UNITED STATES

The United States was the first to implement a cap-and-trade scheme, first in the 1980s to regulate lead in gasoline and ozone depleting chemicals, and then again in 1990 to reduce sulfur dioxide (Harrison, Jr., 1999). The most recent carbon reducing policies discussed in the United States have been of the cap-and-trade variety.

Table 3. Cap-and-Trade Proposals in the United States

Cap-and-Trade	Covered Emissions	Cost per Permit	Regulated Entity	Use of Revenue
S. 3036 Lieberman-Warner Climate Security Act of 2008 (Amendment 4825)	Carbon dioxide Methane Nitrous oxide Sulfur hexaflouride Perfluorocarbons Hydrofluorocarbons	Unknown; ability to provide relief if economy subject to harm	Coal user; Importer or producer of natural gas, petroleum, coal-based fuel, or certain greenhouse gases; Producers of HCFCs	Broad range of purposes including: worker assistance; consumer relief; greenhouse gas reduction programs; deficit reduction
Regional Greenhouse Gas Initiative (RGGI)	Carbon dioxide from electricity generation	Unknown; potential for liberalized offset provisions if price above $7/ton	Electricity generator	Extent of auctioning and use of revenue varies with state
Western Climate Initiative (proposed)	Carbon dioxide Methane Nitrous oxide Sulfur hexaflouride Perfluorocarbons Hydroflurocarbons	Unknown; anticipates rigorous offset program to reduce cost	Broad range of sectors for facilities, starting with electricity sector in 2012 and expanding to other sectors in 2015	Minimum of 10% allowances auctioned in 2012, 25% in 2020, possibly higher thereafter; within guidelines, use of proceeds can vary by jurisdiction

Starting in 2007, the momentum for a national cap-and-trade policy for the United States really started to take hold. The most relevant legislation introduced in 2007 was the Lieberman-Warner Climate Security Act of 2008, S. 3036 by Senators Joseph Lieberman and John Warner. This legislation proposed a national cap-and-trade program that sought to reduce greenhouse gas emissions to 19% below 2005 levels by 2020 and 71% below 2005 levels by 2050 (Pew Center on Global Climate Change, 2008; Eilperin, 2008). The bill would have imposed carbon caps on upstream producers or users. The proposed cap-and-trade bill would have applied to firms that use more than 5,000 tons of coal per year, process or import petroleum or coal-based liquid or gaseous fuels, methane, nitrous oxide, sulfur hexafluoride, manufacture or import more than 10,000 tons of CO_2 or equivalent, or manufacture hydrochlorofluorocarbons (110th Congressional Record, 2007). The Lieberman-Warner bill states that for each ton of CO_2 or downstream emissions potential that a firm will need one allowance starting in 2012 (110th Congressional Record, 2007). The bill also institutes a decreasing number of allowances between 2012 and 2050, which would significantly reduce the amount of CO_2 emissions. Additionally, there are provisions in the bill the significantly restricts the use of domestic offset projects from foreign trading programs and allows firms to have limited borrowing capabilities against future years' allowances (110th Congressional Record, 2007). In order to try to maintain competitive equilibrium, the Lieberman-Warner bill has a provision that requires importers of products that produce high levels of greenhouse gas emissions during the manufacturing process to purchase emission allowances if the country where the product was produced does not have similar climate change regulations (110th Congressional Record, 2007).

As the number of allowances decrease over time, how these allowances will be distributed also chances. The bill calls for an ever increasing number of the available allowances to be auctioned off to firms with the revenues used to fund a variety of programs such as: tax relief for low income families impacted by the cap-and-trade program, energy efficiency programs, mass transit infrastructure development, research and development, greenhouse gas emission reductions not covered by the bill, international funding initiatives, and for deficit reduction among others (110th Congressional Record, 2007). Additionally the bill will provide allowances for free to industries that are dependent on fossil fuels, such as petroleum refiners and electricity generators that use fossil fuels, and to firms that would use the allowances to encourage the transition to an economy with fewer emissions, provide relief to consumers, reward early action, and attend to adaptation on an continuing basis (110th Congressional Record, 2007). The Lieberman-Warner bill also creates a separate cap-and-trade program for hydrofluorocarbon emissions.

Although the Lieberman-Warner bill was never passed and to date no federal cap-and-trade program exists, there are a couple regional cap-and-trade programs in the United States. One such initiative is the Regional Greenhouse Gas Initiative created by ten Northeast and Mid-Atlantic States. The states involved in the Regional Greenhouse Gas Initiative are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. This regional cap-and-trade program targets electricity generating firms that produce at least twenty-five megawatts of electricity. The objective of this Regional Initiative is to stabilize current level emissions by 2014 and reduce emissions to ten percent below 2009 levels by the year 2018 (Regional Greenhouse Gas Initiative, 2005). Each state in the Initiative has some autonomy over the implementation details. However, the Initiative permits offset projects for up to 3.3% of the emissions and allows for more moderate offsets if the price of the permits reaches seven dollars per ton or higher (Regional Greenhouse Gas Initiative, 2005). The distribution of the permits is primarily by auction, with the first auction of the Initiative taking place in September of 2008.

A different regional cap-and-trade program takes place in the western United States. The Western Climate Initiative is composed of seven western states, Arizona, California, Montana, New Mexico, Oregon, Utah, and Washington and four Canadian provinces, British Columbia, Manitoba, Ontario, and Quebec. The objective of the Western Climate Initiative is to reduce greenhouse gas emissions fifteen percent below 2005 levels by the year 2020 (Western Climate Initiative, 2007). The Initiative recommends a broad range of ideas to reduce greenhouse gas emissions covering electricity generation, industrial and commercial facilities, upstream residential, commercial, and industrial fuels, and gasoline and diesel-based transportation (Western Climate Initiative, 2007). The Western Climate Initiative is designed to work in conjunction with carbon taxes. This is an important distinction from other programs because British Columbia, Canada uses carbon taxes. The Initiative enables each of the states and provinces in the Initiative how to decide how to incorporate the carbon tax used in British Columbia with the cap-and-trade program (Western Climate Initiative, 2007). The Initiative is continuously changing to match California's commitment to decrease greenhouse gas emission levels to 1990 levels by the year 2020 (California Health and Safety Code, 2007).

The regional cap-and-trade initiatives described above, as well as the Lieberman-Warner proposal, have paved the way and created momentum for the current bill in Congress, the Waxman-Markey Climate Change Bill, H.R. 2454, the American Clean Energy and Security Act of 2009. This bill was introduced by Representative Henry Waxman and Representative Edward Markey and is far more comprehensive than any previous cap-and-trade initiative. The bill was passed by the United States House of Representatives on May 21, 2009 is currently under consideration in the United States Senate.

The American Clean Energy and Security Act of 2009 would create a renewable electricity program that would require large utilities to increase their production levels of renewable sources of electricity, such as solar, wind, biogas, biomass, biofuels, geothermal, and marine and hydrokinetic energy (111^{th} Congressional Record, 2009). Specifically the Act would require that six percent of electricity come from renewable sources by 2012 and that twenty percent of electricity come from renewable sources by 2020, of which up to five percent of these targets can be met through energy efficiency measures. The Act does provide states some leeway in meeting these requirements. If an individual state does not think that these requirements can be met by the utilities in their state, the percentage of renewable energy sources can be reduced to twelve percent and the energy efficiency measures can be increased to eight percent (110^{th} Congressional Record, 2007). The Act will allocate 85% of pollution permits to industry for free and will hold an auction for the remaining 15%. Furthermore, the Act requires a seventeen percent of the level of carbon emissions in 2005 by 2020.

Since this legislation has been passed in the House of Representatives, the bill has stalled in the United States Senate. So, as a refreshed effort at getting climate legislation passed, Senator Maria Cantwell and Senator Susan Collins introduced the Carbon Limits and Energy for America's Renewal (CLEAR) Act, S. 2877 (111^{th} Congressional Record, 2009). The proposed bill calls for the President to set an initial target amount of fossil fuels that can be emitted starting in 2012, remaining at that level for three years, and then decreasing the amount of carbon emissions by a quarter of a percent each year thereafter (111^{th} Congressional Record, 2009; Cantwell, 2009). The legislation is aimed at producers and importers of coal, natural gas, and oil; in other words an upstream regulatory action. The objectives of the bill is to reduce emissions to twenty percent less the 2005 carbon emissions by 2020, to thirty percent less the 2005 carbon emissions by 2025, to forty-two percent less the 2005 carbon emissions by 2030, and eighty-three percent less the 2005 carbon emissions by 2050 (111^{th} Congressional Record, 2009; Cantwell, 2009). The carbon permits would be distributed among fossil fuel companies through monthly auctions. Seventy-five percent of the revenues generated from the auction would be distributed to consumers every month on an equal per capita basis to offset increases in energy costs (111^{th} Congressional Record, 2009; Cantwell, 2009). Cantwell and Collins estimate that the transfer of the revenues of the cap-and-trade program will result in eighty percent of the American public incurring no net costs from the higher energy prices with low income households receive positive net benefits and high income households experiencing a 0.3% decrease in income (111^{th} Congressional Record, 2009; Cantwell, 2009). The other twenty-five percent of the revenues from the permit auctions would go to a Clean Energy Reinvestment Trust Fund that would be used to further reduce greenhouse gas emissions, climate change adaptation, low-carbon energy investment, and regional economic development adjustment projects (111^{th} Congressional Record, 2009; Cantwell, 2009).

6. POTENTIAL ECONOMIC RENT FROM CO_2 PERMIT AUCTIONS

The mere mention of the American Clean Energy and Security Act of 2009 causes great debate. The Act will allocate 85% of pollution permits to industry for free and will hold an auction for the remaining 15%. However, by auctioning-off only 15% of the permits, the bill fails to capture the maximum potential economic rent. This section seeks to measure the amount of economic rent that could potentially be captured if 100% of the permits were auctioned off.

Calculating the economic rent from any cap-and-trade program requires knowledge of the elasticity of demand for each firm. However, the elasticity of demand for every firm cannot be known. On the other hand, an approximate elasticity of demand for individual sectors is known. Therefore, the elasticity of demand for the most important sectors in the United States with regard to carbon emissions (electricity, gasoline, aviation, and other) will be used to calculate the potential economic rent. Additionally, the number of permits that would initially be auctioned to firms would need to be known, as would how much of a decrease in CO_2 emissions would be required annually. This information is also unknown.

Therefore, since the necessary information to calculate the potential economic rent that can be generated from auctioning CO_2 emissions permits is unavailable a spreadsheet developed by the Carbon Tax Center[1] to illustrate the decrease in carbon emissions from a carbon tax will be used. Although this spreadsheet was developed for a carbon tax, the calculations were made based upon carbon emitted instead of the carbon content of the energy. Therefore, in this particular case, the spreadsheet can be used to approximate the potential economic rent from auctioning pollution permits. Various assumptions are built into the model and the reader should follow his or her own curiosity to the Carbon Tax Center for complete information. In addition to the assumptions built into the model, other assumptions have been made for the purpose of this project.

The most important assumption made is about the price of the pollution allowance permit. First, each permit sold in auction is assumed to be an allowance for one ton of CO_2 emitted. Second, for the purposes of this paper the price of the permit will be assumed to be the average price of a permit sold in an auction. As stated previously to calculate the economic rent that could be generated from an auction would require the elasticity, marginal abatement costs, and marginal benefits for each individual firm.

[1] Carbon Tax Center. http://www.carbontax.org

The other assumptions made are related to the amount of economic rent generated. First, the average amount the permits sell for will be assumed to be between the ranges of $5 per permit to $1,600 per permit. The $5 per ton figure was chosen because that price is below the amount of the initial tax in the proposed Save Our Climate Bill by Stark and McDermott of $10 per ton. The assumption is that the United States Congress would propose an initial value that would allow firms an opportunity to adjust to new carbon regulations without being harmed. Additionally, the $5 per ton assumption is below the range that allowance permits have been trading for in Europe (€10 to €33) in the past year (European Climate Exchange and Point Carbon). The price of European Union ETS permits have ranged from a low of €0.29 in May of 2007 to a high of €31.50 (Point Carbon; Shapiro, 2007; Shrum, 2007). The $1,600 upper limit for CO_2 allowance permits was based on the upper range of SO_2 and NO_x permits (Shapiro, 2007). Second, the average auction price is assumed to increase over time as their supply decreases. Third, the increase of the auction price is assumed to increase between the ranges of 2% and 6%. These values were chosen because they represent the typical historical inflation rates in the United States since 1990. During this time period, the inflation rate has never been more than 6%, either on an annual or monthly basis, and has rarely gone below 2% during this time-frame. Lastly, to calculate the potential economic rent from a CO_2 permit auction, the number of permits available in the first year of the abatement program and the annual decrease in the number of permits would need to be known, which as previously discussed is unavailable. Therefore, the number of permits available is assumed to be a constant number with the annual increase in permits serving as a proxy for the decrease in permits. The price increase will cause a decrease in the amount of CO_2 emissions, which in effect is equivalent to a reduction in the number of permits available. Furthermore, the annual price increase would be consistent with higher auction prices which would likely result from a decrease in the permits available.

Since a more exact figure cannot be calculated for the potential economic rent generated from CO_2 allowance permit auctions, sensitivity analysis is performed to get a range of the potential economic rent generated. Several variables will be altered to make these calculations. Those variables which sensitivity analysis will be performed with are the initial average auction price for an emissions permit and the annual increase in price of the allowance permits.

The results are shown in Tables 4, 5, and 6. Table 4 corresponds to an annual increase in permit prices of 2%, Table 5 with a 4% annual increase in permit prices, and Table 6 with a 6% increase in permit prices. As shown in Tables 4, 5, and 6 the potential economic rent that could be generated from auctioning CO_2 permits to firms is very large. The rent generated from these auctions could be redistributed back to the populace, used to fund a variety of projects, or used to reduce the budget deficit. In either case, the proposals currently being debated in Congress do not capture the potential economic rent that is available and belongs to the populace because the atmosphere is common to each of us.

Table 4. Potential Economic Rent From Permit Auctions Assuming a 2% Annual Price Increase

	2% Annual Increase in Permit Price	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
$5	**CO_2 emissions, millions of metric tons**	5727.48	5799.09	5871.45	5944.54	6018.39	6092.98	6168.32	6244.42	6321.26	6398.86	6487.77	6577.91	6669.31	6762.25	6856.76	6952.87
	Reduction in CO_2 relative to moving trajectory, million metric tons	115.587	129.007	143.006	157.604	172.823	188.683	205.207	222.419	240.343	259.002	267.865	277.028	286.503	296.034	305.617	315.245
	Economic Rent, $ millions (rounded to nearest hundred million)	30600	31600	32600	33700	34800	35900	37100	38300	39500	40800	42200	43700	45200	46700	48300	50000
$10	**CO_2 emissions, millions of metric tons**	5718.45	5780.64	5843.19	5906.06	5969.27	6032.8	6096.63	6160.75	6225.16	6289.84	6375.16	6461.61	6549.19	6638.43	6729.35	6822.02
	Reduction in CO_2 relative to moving trajectory, million metric tons	124.619	147.455	171.266	196.083	221.938	248.867	276.903	306.083	336.442	368.019	380.468	393.333	406.625	419.861	433.024	446.099
	Economic Rent, $ millions (rounded to nearest hundred million)	61000	62900	64900	66900	69000	71100	73300	75600	77900	80300	83000	85800	88800	91800	94900	98100
$25	**CO_2 emissions, millions of metric tons**	5692.92	5728.7	5763.94	5798.6	5832.67	5866.12	5898.93	5931.06	5962.49	5993.21	6069.3	6146.24	6224.05	6303.79	6385.53	6469.34
	Reduction in CO_2 relative to moving trajectory, million metric tons	150.151	199.398	250.514	303.544	358.537	415.541	474.605	535.777	599.109	664.65	686.332	708.696	731.764	754.493	776.845	798.781
	Economic Rent, $ millions (rounded to nearest hundred million)	151900	155900	160000	164300	168600	173000	177400	182000	186700	191400	197800	204300	211000	218000	225300	232800
$50	**CO_2 emissions, millions of metric tons**	5654.78	5651.67	5647.27	5641.57	5634.56	5626.23	5616.57	5605.57	5593.24	5579.55	5644	5709.01	5774.59	5842.43	5912.62	5985.23
	Reduction in CO_2 relative to moving trajectory, million metric tons	188.288	276.428	367.18	460.577	556.651	655.436	756.963	861.264	968.368	1078.31	1111.63	1145.93	1181.22	1215.85	1249.76	1282.89
	Economic Rent, $ millions (rounded to nearest hundred million)	301800	307700	313700	319800	325800	332000	338100	344300	350500	356800	368200	379900	392000	404600	417700	431300
$100	**CO_2 emissions, millions of metric tons**	5590.87	5524.02	5456.14	5387.26	5317.43	5246.71	5175.16	5102.82	5029.74	4955.99	5005.37	5055.03	5104.99	5157.53	5212.76	5270.78
	Reduction in CO_2 relative to moving trajectory, million metric tons	252.203	404.075	558.313	714.89	873.778	1034.95	1198.37	1364.02	1531.86	1701.87	1750.26	1799.91	1850.83	1900.75	1949.62	1997.34
	Economic Rent, $ millions (rounded to nearest hundred million)	596800	601700	606500	611100	615500	619700	623800	627700	631400	634800	654100	673900	694200	715500	737700	760900
$250	**CO_2 emissions, millions of metric tons**	5455.95	5260.25	5069.53	4883.77	4702.96	4527.06	4356.06	4189.91	4028.57	3872	3901.41	3930.9	3960.46	3992.75	4027.86	4065.89
	Reduction in CO_2 relative to moving trajectory, million metric tons	387.123	667.847	944.921	1218.38	1488.25	1754.6	2017.47	2276.92	2533.03	2785.86	2854.22	2924.04	2995.36	3065.54	3134.51	3202.23
	Economic Rent, $ millions (rounded to nearest hundred million)	1456400	1433300	1410100	1386600	1363000	1339300	1315500	1291600	1267700	1243700	1278400	1314100	1350600	1389100	1429500	1472000

	2% Annual Increase in Permit Price	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
$500	**CO_2 emissions, millions of metric tons**	5317.03	4996.31	4693.56	4407.89	4138.49	3884.53	3645.23	3419.85	3207.67	3007.97	3026.21	3044.47	3062.75	3083.53	3106.86	3132.81
	Reduction in CO_2 relative to moving trajectory, million metric tons	526.034	931.785	1320.9	1694.26	2052.72	2397.14	2728.3	3046.98	3353.94	3649.89	3729.42	3810.47	3893.06	3974.75	4055.51	4135.3
	Economic Rent, $ millions (rounded to nearest hundred million)	2839500	2724500	2613300	2505900	2402300	2302300	2206000	2113100	2023700	1937600	1988700	2041000	2094600	2151300	2211200	2274600
$750	**CO_2 emissions, millions of metric tons**	5224.67	4824.94	4455.14	4113.15	3796.97	3504.75	3234.73	2985.29	2754.91	2542.17	2555.81	2569.48	2583.16	2599.09	2617.31	2637.87
	Reduction in CO_2 relative to moving trajectory, million metric tons	618.396	1103.16	1559.31	1989	2394.24	2776.92	3138.8	3481.55	3806.7	4115.69	4199.82	4285.46	4372.66	4459.2	4545.07	4630.25
	Economic Rent, $ millions (rounded to nearest hundred million)	4186100	3948000	3722800	3510000	3309000	3119100	2939900	2770700	2611000	2460400	2523400	2588000	2654200	2724400	2798700	2877500
$1,000	**CO_2 emissions, millions of metric tons**	5155.67	4699.01	4282.79	3903.52	3557.96	3243.16	2956.4	2695.22	2457.34	2240.68	2251.81	2262.96	2274.13	2287.34	2302.64	2320.07
	Reduction in CO_2 relative to moving trajectory, million metric tons	687.396	1229.09	1731.66	2198.63	2633.25	3038.51	3417.13	3771.61	4104.27	4417.18	4503.82	4591.98	4681.69	4770.94	4859.73	4948.04
	Economic Rent, $ millions (rounded to nearest hundred million)	5508500	5128000	4773600	4443800	4136900	3851300	3585600	3338500	3108600	2894700	2967700	3042500	3119100	3200400	3286700	3378200
$1,250	**CO_2 emissions, millions of metric tons**	5100.72	4599.98	4148.96	3742.75	3376.9	3047.39	2750.6	2483.27	2242.43	2025.44	2034.97	2044.52	2054.1	2065.56	2078.94	2094.29
	Reduction in CO_2 relative to moving trajectory, million metric tons	742.349	1328.12	1865.49	2359.4	2814.31	3234.27	3622.93	3983.57	4319.17	4632.42	4720.66	4810.41	4901.72	4992.73	5083.43	5173.83
	Economic Rent, $ millions (rounded to nearest hundred million)	6813000	6276200	5782400	5328200	4910500	4526200	4172800	3847800	3548800	3273700	3355300	3439000	3524700	3615700	3712400	3815000
$1,500	**CO_2 emissions, millions of metric tons**	5055.13	4518.68	4040.21	3613.42	3232.69	2893	2589.87	2319.3	2077.73	1862.01	1870.43	1878.87	1887.34	1897.56	1909.57	1923.41
	Reduction in CO_2 relative to moving trajectory, million metric tons	787.934	1409.42	1974.24	2488.72	2958.52	3388.66	3783.66	4147.54	4483.87	4795.85	4885.2	4976.07	5068.48	5160.73	5252.81	5344.71
	Economic Rent, $ millions (rounded to nearest hundred million)	8103300	7399600	6758700	6175000	5643200	5158800	4717300	4315000	3948300	3613900	3703400	3795000	3888900	3988700	4094700	4207400
$1,600	**CO_2 emissions, millions of metric tons**	5038.88	4489.88	4001.93	3568.18	3182.56	2839.65	2534.65	2263.3	2021.82	1806.84	1814.9	1822.99	1831.1	1840.92	1852.48	1865.82
	Reduction in CO_2 relative to moving trajectory, million metric tons	804.186	1438.21	2012.52	2533.96	3008.65	3442.02	3838.88	4203.53	4539.79	4851.02	4940.73	5031.95	5124.72	5217.37	5309.89	5402.29
	Economic Rent, $ millions (rounded to nearest hundred million)	8616000	7843100	7141700	6504900	5926900	5402100	4925500	4492500	4099100	3741500	3833900	3928600	4025500	4128600	4238100	4354500

Table 5. Potential Economic Rent From Permit Auctions Assuming a 4% Annual Price Increase

	4% Annual Increase in Permit Price	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
$5	**CO_2 emissions, millions of metric tons**	5727.48	5796.79	5866.46	5936.48	6006.8	6077.41	6148.26	6219.33	6290.57	6361.95	6443.9	6526.57	6609.94	6694.64	6780.69	6868.14
	Reduction in CO_2 relative to moving trajectory, million metric tons	115.587	131.309	147.987	165.67	184.408	204.256	225.271	247.51	271.035	295.91	311.726	328.367	345.874	363.647	381.683	399.979
	Economic Rent, $ millions (rounded to nearest hundred million)	30600	32200	33900	35600	37500	39500	41500	43700	46000	48400	50900	53700	56500	59600	62700	66100
$10	**CO_2 emissions, millions of metric tons**	5718.45	5778.18	5837.71	5896.98	5955.95	6014.56	6072.74	6130.45	6187.62	6244.17	6320.24	6396.75	6473.68	6552.2	6632.38	6714.27
	Reduction in CO_2 relative to moving trajectory, million metric tons	124.619	149.919	176.744	205.165	235.26	267.107	300.787	336.384	373.987	413.686	435.39	458.19	482.136	506.082	529.997	553.852
	Economic Rent, $ millions (rounded to nearest hundred million)	61000	64100	67400	70800	74400	78100	82100	86200	90500	95000	100000	105200	110800	116600	122800	129300
$25	**CO_2 emissions, millions of metric tons**	5692.92	5725.81	5757.17	5786.9	5814.92	5841.15	5865.51	5887.9	5908.24	5926.45	5987.85	6049.13	6110.24	6173.62	6239.38	6307.64
	Reduction in CO_2 relative to moving trajectory, million metric tons	150.151	202.287	257.285	315.25	376.289	440.51	508.022	578.937	653.363	731.412	767.777	805.81	845.577	884.665	922.995	960.48
	Economic Rent, $ millions (rounded to nearest hundred million)	151900	158900	166200	173800	181600	189800	198300	207000	216100	225500	237000	249000	261600	275000	289000	303900
$50	**CO_2 emissions, millions of metric tons**	5654.78	5648.23	5638.84	5626.57	5611.35	5593.14	5571.89	5547.56	5520.13	5489.57	5533.57	5576.96	5619.7	5665.52	5714.57	5766.99
	Reduction in CO_2 relative to moving trajectory, million metric tons	188.288	279.872	375.609	475.58	579.862	688.527	801.643	919.273	1041.47	1168.29	1222.06	1277.98	1336.12	1392.77	1447.81	1501.13
	Economic Rent, $ millions (rounded to nearest hundred million)	301800	313600	325700	338100	350700	363700	376900	390400	404200	418200	438500	459700	481800	505200	530100	556400
$100	**CO_2 emissions, millions of metric tons**	5590.87	5519.83	5445.54	5368.09	5287.57	5204.08	5117.75	5028.71	4937.09	4843.04	4866.62	4889.32	4911.12	4936.9	4966.8	5000.99
	Reduction in CO_2 relative to moving trajectory, million metric tons	252.203	408.266	568.906	734.057	903.644	1077.58	1255.78	1438.12	1624.51	1814.82	1889.01	1965.62	2044.7	2121.39	2195.57	2267.13
	Economic Rent, $ millions (rounded to nearest hundred million)	596800	613100	629300	645500	661500	677500	693200	708800	724100	739100	772600	807400	843600	882100	923100	966900
$250	**CO_2 emissions, millions of metric tons**	5455.95	5255.05	5056.21	4859.77	4666.02	4475.27	4287.79	4103.84	3923.66	3747.45	3748.91	3749.66	3749.72	3754.4	3763.77	3777.92
	Reduction in CO_2 relative to moving trajectory, million metric tons	387.123	673.052	958.24	1242.38	1525.19	1806.39	2085.74	2362.99	2637.95	2910.41	3006.72	3105.28	3206.09	3303.89	3398.61	3490.2
	Economic Rent, $ millions (rounded to nearest hundred million)	1456400	1460000	1462100	1462700	1461700	1459200	1455200	1449700	1442700	1434200	1492500	1552900	1615400	1682500	1754500	1831900

	4% Annual Increase in Permit Price	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
$500	**CO_2 emissions, millions of metric tons**	5317.03	4990.6	4679.11	4382.35	4100.06	3831.95	3577.69	3336.93	3109.28	2894.32	2887.46	2880.21	2872.59	2869.32	2870.4	2875.87
	Reduction in CO_2 relative to moving trajectory, million metric tons	526.034	937.495	1335.34	1719.8	2091.15	2449.71	2795.84	3129.9	3452.33	3763.54	3868.17	3974.73	4083.22	4188.97	4291.98	4392.24
	Economic Rent, $ millions (rounded to nearest hundred million)	2839500	2774800	2708500	2641000	2572500	2503200	2433200	2362800	2292100	2221400	2305300	2392100	2481800	2578700	2683400	2796600
$750	**CO_2 emissions, millions of metric tons**	5224.67	4819.09	4440.53	4087.7	3759.32	3454.1	3170.8	2908.16	2665	2440.13	2431.42	2422.48	2413.31	2408.1	2406.83	2409.52
	Reduction in CO_2 relative to moving trajectory, million metric tons	618.396	1109.01	1573.92	2014.44	2431.89	2827.56	3202.73	3558.67	3896.6	4217.73	4324.21	4432.46	4542.51	4650.19	4755.55	4858.6
	Economic Rent, $ millions (rounded to nearest hundred million)	4186100	4020600	3857700	3697900	3541200	3388100	3238600	3093000	2951300	2813800	2916500	3022700	3132400	3251400	3380400	3520200
$1,000	**CO_2 emissions, millions of metric tons**	5155.67	4693.13	4268.26	3878.51	3521.42	3194.65	2895.97	2623.26	2374.53	2147.9	2138.81	2129.56	2120.16	2114.39	2112.23	2113.66
	Reduction in CO_2 relative to moving trajectory, million metric tons	687.396	1234.97	1746.19	2223.63	2669.79	3087.01	3477.56	3843.57	4187.07	4509.96	4616.82	4725.38	4835.65	4943.89	5050.15	5154.46
	Economic Rent, $ millions (rounded to nearest hundred million)	5508500	5222100	4946100	4680600	4425700	4181300	3947200	3723500	3509900	3306100	3424600	3546900	3673300	3810700	3959800	4121800
$1,250	**CO_2 emissions, millions of metric tons**	5100.72	4594.11	4134.58	3718.25	3341.48	3000.85	2693.22	2415.64	2165.41	1940.01	1930.98	1921.84	1912.61	1906.72	1904.17	1904.94
	Reduction in CO_2 relative to moving trajectory, million metric tons	742.349	1333.99	1879.87	2383.89	2849.73	3280.81	3680.31	4051.2	4396.2	4717.85	4824.65	4933.1	5043.21	5151.56	5258.21	5363.18
	Economic Rent, $ millions (rounded to nearest hundred million)	6813000	6391200	5990800	5611300	5252000	4912400	4591700	4289100	4004100	3735900	3868000	4004600	4145700	4299100	4465900	4647300
$1,500	**CO_2 emissions, millions of metric tons**	5055.13	4512.83	4026.01	3589.43	3198.29	2848.2	2535.09	2255.3	2005.47	1782.53	1773.71	1764.82	1755.87	1750.04	1747.32	1747.69
	Reduction in CO_2 relative to moving trajectory, million metric tons	787.934	1415.26	1988.44	2512.72	2992.92	3433.47	3838.44	4211.53	4556.14	4875.33	4981.92	5090.12	5199.95	5308.24	5415.06	5520.43
	Economic Rent, $ millions (rounded to nearest hundred million)	8103300	7535100	7002000	6502400	6034800	5597600	5189300	4808200	4452900	4121900	4266500	4415900	4570200	4738200	4921000	5119800
$1,600	**CO_2 emissions, millions of metric tons**	5038.88	4484.05	3987.8	3544.38	3148.54	2795.48	2480.82	2200.6	1951.22	1729.43	1720.72	1711.94	1703.11	1697.33	1694.58	1694.83
	Reduction in CO_2 relative to moving trajectory, million metric tons	804.186	1444.05	2026.65	2557.77	3042.67	3486.18	3892.71	4266.23	4610.38	4928.43	5034.91	5143	5252.7	5360.96	5467.8	5573.28
	Economic Rent, $ millions (rounded to nearest hundred million)	8616000	7986700	7398600	6849700	6337900	5861300	5417800	5005400	4622400	4266800	4416000	4570200	4729500	4903000	5091700	5297200

Table 6. Potential Economic Rent From Permit Auctions Assuming a 6% Annual Price Increase

	6% Annual Increase in Permit Price	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
$5	**CO_2 emissions, millions of metric tons**	5727.48	5794.49	5861.4	5928.13	5994.61	6060.74	6126.45	6191.62	6256.15	6319.93	6393.23	6466.36	6539.23	6612.92	6687.43	6762.76
	Reduction in CO_2 relative to moving trajectory, million metric tons	115.587	133.61	153.055	174.018	196.603	220.92	247.085	275.22	305.456	337.929	362.401	388.582	416.585	445.365	474.948	505.362
	Economic Rent, $ millions (rounded to nearest hundred million)	30600	32800	35100	37700	40400	43300	46400	49700	53300	57000	61200	65600	70300	75400	80800	86700
$10	**CO_2 emissions, millions of metric tons**	5718.45	5775.72	5832.14	5887.6	5941.98	5995.14	6046.95	6097.27	6145.94	6192.82	6257.7	6321.91	6385.36	6450.08	6516.1	6583.5
	Reduction in CO_2 relative to moving trajectory, million metric tons	124.619	152.381	182.311	214.546	249.234	286.525	326.581	369.568	415.659	465.036	497.933	533.029	570.453	608.209	646.273	684.621
	Economic Rent, $ millions (rounded to nearest hundred million)	61000	65300	69900	74900	80100	85700	91600	97900	104700	111800	119800	128300	137400	147100	157600	168800
$25	**CO_2 emissions, millions of metric tons**	5692.92	5722.93	5750.3	5774.87	5796.45	5814.86	5829.92	5841.45	5849.26	5853.18	5897.67	5940.56	5981.73	6025.32	6071.46	6120.3
	Reduction in CO_2 relative to moving trajectory, million metric tons	150.151	205.171	264.148	327.278	394.762	466.805	543.612	625.389	712.344	804.681	857.959	914.38	974.085	1032.97	1090.92	1147.82
	Economic Rent, $ millions (rounded to nearest hundred million)	151900	161900	172400	183600	195400	207800	220900	234700	249200	264400	282500	301600	322000	343900	367400	392700
$50	**CO_2 emissions, millions of metric tons**	5654.78	5644.79	5630.33	5611.25	5587.41	5558.7	5525.01	5486.25	5442.35	5393.25	5414.76	5434.04	5451.01	5471.81	5496.61	5525.6
	Reduction in CO_2 relative to moving trajectory, million metric tons	188.288	283.306	384.122	490.901	603.799	722.961	848.517	980.582	1119.25	1264.61	1340.87	1420.9	1504.8	1586.48	1665.77	1742.52
	Economic Rent, $ millions (rounded to nearest hundred million)	301800	319400	337800	357000	376900	397600	419100	441300	464200	487800	519300	552500	587700	625400	666100	710000
$100	**CO_2 emissions, millions of metric tons**	5590.87	5515.66	5434.9	5348.68	5257.11	5160.37	5058.62	4952.08	4841	4725.64	4722.26	4716.62	4708.71	4706.21	4709.24	4717.96
	Reduction in CO_2 relative to moving trajectory, million metric tons	252.203	412.437	579.55	753.47	934.096	1121.3	1314.91	1514.75	1720.6	1932.22	2033.37	2138.32	2247.1	2352.08	2453.14	2550.15
	Economic Rent, $ millions (rounded to nearest hundred million)	596800	624400	652500	681000	709900	739000	768300	797700	827100	856400	907400	960900	1017200	1077900	1143700	1214800
$250	**CO_2 emissions, millions of metric tons**	5455.95	5249.89	5042.93	4835.74	4628.96	4423.23	4219.17	4017.39	3818.45	3622.9	3596.98	3569.74	3541.25	3519.32	3503.94	3495.11
	Reduction in CO_2 relative to moving trajectory, million metric tons	387.123	678.212	971.52	1266.41	1562.25	1858.44	2154.36	2449.44	2743.15	3034.96	3158.65	3285.2	3414.57	3538.96	3658.43	3773.01
	Economic Rent, $ millions (rounded to nearest hundred million)	1456400	1486700	1515000	1541100	1565100	1586600	1605600	1622000	1635700	1646500	1733400	1824000	1918700	2021800	2134400	2257400

	6% Annual Increase in Permit Price	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
$500	**CO_2 emissions, millions of metric tons**	5317.03	4984.96	4664.79	4356.97	4061.88	3779.77	3510.81	3255.08	3012.57	2783.19	2752.68	2721.66	2690.17	2664.93	2645.82	2632.73
	Reduction in CO_2 relative to moving trajectory, million metric tons	526.034	943.139	1349.67	1745.18	2129.33	2501.9	2862.72	3211.76	3549.03	3874.67	4002.95	4133.28	4265.64	4393.35	4516.56	4635.39
	Economic Rent, $ millions (rounded to nearest hundred million)	2839500	2825000	2805200	2780400	2750700	2716300	2677400	2634300	2587300	2536700	2660300	2789000	2923000	3070300	3232100	3410000
$750	**CO_2 emissions, millions of metric tons**	5224.67	4813.32	4426.07	4062.51	3722.07	3404.12	3107.9	2832.62	2577.39	2341.32	2311.88	2282.26	2252.48	2228.4	2209.86	2196.74
	Reduction in CO_2 relative to moving trajectory, million metric tons	618.396	1114.78	1588.38	2039.64	2469.14	2877.55	3265.63	3634.22	3984.21	4316.54	4443.75	4572.68	4703.34	4829.89	4952.52	5071.37
	Economic Rent, $ millions (rounded to nearest hundred million)	4186100	4093100	3994700	3891500	3784200	3673300	3559500	3443300	3325300	3206100	3356700	3513600	3677000	3857100	4055600	4274500
$1,000	**CO_2 emissions, millions of metric tons**	5155.67	4687.32	4253.9	3853.8	3485.37	3146.93	2836.73	2553.07	2294.24	2058.55	2030.86	2003.15	1975.42	1952.91	1935.47	1922.96
	Reduction in CO_2 relative to moving trajectory, million metric tons	687.396	1240.78	1760.55	2248.35	2705.84	3134.74	3536.8	3913.76	4267.37	4599.31	4724.77	4851.79	4980.4	5105.37	5226.91	5345.16
	Economic Rent, $ millions (rounded to nearest hundred million)	5508500	5316000	5121100	4924700	4727800	4531100	4335600	4141900	3950800	3762700	3936000	4116400	4304300	4511900	4741100	4994300
$1,250	**CO_2 emissions, millions of metric tons**	5100.72	4588.32	4120.38	3694.07	3306.58	2955.14	2637.1	2349.85	2090.95	1858.02	1832.02	1806.07	1780.18	1759.13	1742.76	1730.92
	Reduction in CO_2 relative to moving trajectory, million metric tons	742.349	1339.78	1894.07	2408.07	2884.63	3326.52	3736.43	4116.98	4470.66	4799.84	4923.61	5048.87	5175.63	5299.15	5419.62	5537.19
	Economic Rent, $ millions (rounded to nearest hundred million)	6813000	6506000	6202400	5903100	5609300	5321900	5041500	4768800	4504400	4248800	4442000	4643100	4852600	5084400	5340600	5624000
$1,500	**CO_2 emissions, millions of metric tons**	5055.13	4507.07	4011.98	3565.76	3164.44	2804.26	2481.62	2193.18	1935.76	1706.42	1681.91	1657.51	1633.21	1613.43	1598	1586.8
	Reduction in CO_2 relative to moving trajectory, million metric tons	787.934	1421.03	2002.47	2536.38	3026.77	3477.41	3891.91	4273.66	4625.85	4951.44	5073.72	5197.43	5322.61	5444.86	5564.38	5681.32
	Economic Rent, $ millions (rounded to nearest hundred million)	8103300	7670300	7248900	6840000	6444500	6063000	5696100	5344200	5007300	4685700	4896900	5116900	5345900	5599500	5880200	6190800
$1,600	**CO_2 emissions, millions of metric tons**	5038.88	4478.29	3973.85	3520.91	3115.08	2752.18	2428.3	2139.77	1883.18	1655.36	1631.4	1607.55	1583.82	1564.49	1549.41	1538.45
	Reduction in CO_2 relative to moving trajectory, million metric tons	804.186	1449.81	2040.6	2581.24	3076.13	3529.48	3945.23	4327.07	4678.43	5002.5	5124.23	5247.39	5372	5493.79	5612.97	5729.67
	Economic Rent, $ millions (rounded to nearest hundred million)	8616000	8129900	7659300	7205100	6767800	6348200	5946400	5562800	5197200	4849700	5067700	5294700	5531100	5793000	6082900	6403800

7. Discussion

While the exact calculations are difficult to obtain because of a lack of specific information, such as the individual firm elasticities of demand, the potential economic rent from carbon abatement policies, specifically cap-and-trade and carbon taxes, are substantial. However, the economic rent figures in the tables above are not net of taxes. For an overview of the Georgist perspective on taxes and rent the reader is encouraged to follow his or her curiosity to examine the work of Foldvary (2010). Despite these shortcomings, the findings presented in this paper are meaningful and robust. The results of the scenario analyses show that the potential economic rent that could be captured from carbon abatement programs is in the order of billions of dollars, and in some scenarios trillions of dollars.

Three different scenarios, a 2% annual permit price increase from the starting permit price, a 4% annual permit price increase, and a 6% annual permit price increase, illustrate how much economic rent is available from CO_2 abatement programs. Not surprisingly, economic rent increases with each annual price increase. However, an interesting result is the corresponding decrease in CO_2 emissions. As shown in the tables, the decrease in CO_2 as a result of the increase in the price of permits initially increases. At some permit price level, however, the reduction of CO_2 emissions reaches an apex and then starts to decrease. This result could be due to a few reasons. First, and the most likely reason, is that firms have shifted to new technologies that reduce their CO_2 emissions. As the price of permits increase, the cost of investment in new technology to reduce CO_2 emissions is cheaper than the cost of the permits. The new technologies will result in fewer emissions. However, at some point there will be a flood of new technology and additional investment will not be feasible preventing additional reductions in CO_2 emissions. Second, the permits will reduce emissions to a point where further increases in reductions are not possible. Therefore, additional reductions will occur but at a diminishing rate.

As shown in this paper, the two main schemes for CO_2 abatement are carbon taxes and cap-and-trade. Furthermore, the economic rent that can be captured with the two schemes is nearly identical if the calculations are made based upon carbon emitted instead of the carbon content of the energy. The economic rent would be similar if the calculations were made on the carbon content of the energy, although the rent would likely be higher. Thus, a cap-and-trade program that auctions all of the abatement permits can obtain the economic rent levels estimated in Tables 4, 5, and 6. Despite the benefits of a cap-and-trade program, many people favor carbon taxes over a cap-and-trade program. The reasons for this preference are that taxes are predictable and the increased prices would be expected by firms and consumers, while cap-and-trade auctions are volatile in their price ranges and cannot be anticipated by actors in the market place. Furthermore, cap-and-trade auctions could potentially be manipulated by firms to keep the prices of the permits low, whereas carbon taxes are set per ton of CO_2 by a regulatory agency.

Despite some drawbacks, the results presented in this paper suggest that either carbon taxation or a cap-and-trade scheme that auctions all the abatement permits can work. Furthermore, the findings indicate that applying Georgist principles to environmental problems, such as those that affect the commons like air and water, can be an effective method for reducing environmental degradation while capturing the economic rent that rightfully belongs to society. The rent captured can then be redistributed back to society to ensure that the abatement policies are, at worst, tax neutral and not regressive. As Barnes (2001) argues, treating environmental assets as commons and making those that pollute pay, the redistribution of the captured economic rent is an equitable method of reducing environmental degradation.

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