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State-based Climate Legislation: A Policy Analysis of Carbon Tax Proposals in Vermont, New York, and Massachusetts

John Doane
University of Vermont

State-based Climate Legislation: A Policy Analysis of Carbon Tax Proposals in Vermont, New York, and Massachusetts

John Doane

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Advisors:

Donna Ramirez Harrington. Associate Professor, Economics

Amy Seidl. Professor, Environmental Studies

Abstract

To date, there are a number of states that have proposed a carbon tax with meaningful support behind them. This paper will focus on New York, Massachusetts, and Vermont due to their political backing as well as each state's participation in the Regional Greenhouse Gas Initiative (RGGI). Many states are modeling their tax plans after the one conducted in British Columbia and focusing on tax rebates as a key feature. By recycling the revenue generated back to consumers and businesses, the negative effects of the tax can be mitigated.. This paper conducts a comparative analysis between the British Columbia carbon tax with three U.S. state legislative proposals. Furthermore, evidence of high observed tax salience on gasoline consumption is projected onto each carbon tax plan. Assuming similar aggregate consumer behavior between residents of British Columbia and these states, Vermont, Massachusetts and New York will see gasoline consumption reduced by 42.9 million gallons, 395 million gallons, and 2.887 billion gallons respectively. Vermont would see a reduction in emissions by 0.381 million metric tons from gasoline consumption over 8 years, a 3.8 percent reduction of their 9.99 million metric tons of carbon dioxide emissions (MMT CO_2e) in 2015. The Massachusetts proposal would reduce 3.5 MMT CO_2e from gasoline consumption, a 5% decline over 7 years. The New York proposal is the most stringent, with an estimated 25.657 MMT CO_2 being abated through decreased gasoline sales over 11 years, which represents 14 percent of 2015 total emissions.

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1. Introduction

Climate change poses a significant threat to the well-being of global society and the many diverse ecosystems that exist on Earth. If the world continues on the "business-as-usual" trend of carbon emissions, we will risk a planetary rise in temperature of above two degrees Celsius (United States Environmental Protection Agency, 2017). If this temperature level is exceeded, there is a serious risk of global ecological collapse, extreme weather in which adaptation for humans will be difficult, and the displacement of millions of climate refugees (United Nations Framework Convention on Climate Change, 2007).

The United States has not been a leader in the international efforts to respond to climate change. The country failed to ratify the Kyoto Protocol, and in 2018, the U.S. is the only country in the world to not sign the Paris Agreement. National legislation that would seek a significant decrease of greenhouse gases, specifically carbon dioxide, has seen repeated failure. The Obama administration sought a cap and trade bill around the time of the COP 15, and did not meet Congressional approval. With a lack of forward progress in the realm of national climate action, state and local governments have been trying to pass reformative legislation to reduce greenhouse gas emissions. One of the policies being used to combat climate change is the carbon tax, which is a tax per unit of carbon pollution.

First, this thesis will conduct a comparative analysis of the most popular, current carbon tax proposals in the states of Vermont (VT), New York (NY), and Massachusetts (MA). I pull inspiration from the framework created by Thomas Barthold in his research titled "Issues in the Design of Environmental Excise Taxes." Barthold has four major tax criteria that need to be answered: what is being taxed, who is being taxed, how much is being taxed, and what are the ancillary goals (Barthold, 1994). Using experience and research following the implementation of the British Columbia tax, I developed my own criteria to compare these taxes. I chose Bill H.726 from VT, Bill S.1821 from MA and Bill S.2846 from NY because each represents a highly co-sponsored bill relative to other carbon tax proposals. The analysis will involve looking at key features such as starting price, price cap and revenue usage included in each plan.

Second, this thesis looks at the effect that a carbon tax will have on gasoline consumption from mobile source emitters. VT, NY, and MA are all part of the Regional Greenhouse Gas Initiative (RGGI). RGGI regulates sources of fossil fuel powered electric generators with a capacity of 25 or more megawatts (MW), and requires that their emission levels equal the number of allowances held (Regional Greenhouse Gas Initiative, 2018). The largest source of emissions in each state is the transportation sector (State of Vermont Agency of Transportation, 2017; Commonwealth of Massachusetts, 2018). Carbon taxes are designed to make fossil fuels more expensive, and higher gasoline prices reduces consumption by drivers (United States Energy Information Administration, 2016). To estimate the impact the state carbon taxes will have on gasoline consumption, this thesis will use an elasticity estimate derived by Rivers and Schaufele (2015) in their research about tax salience. They find that a one cent increase a five cent increase in gas prices under a carbon tax program results in gasoline demand to decline by 0.084%, while an identical five cent increase in the market price of gasoline leads to a 0.021% reduction in litres consumed (Rivers and Schaufele, 2015). Their research concluded that consumers in British Columbia used less gasoline relative to the rest of Canada during the period studied, and the change in behavior is due to the presence of the tax (Rivers and Schaufele, 2015).

Section two of this paper will provide a literature review, followed by an introduction to the economic framework in section three. Section four is split into three subsections: the first discusses the British Columbia carbon tax, the second describes the criteria to be used, and the third subsection contains the comparative analysis. Section five is also split into three subsections. Subsection one will be an explanation of the values and their significance, two will explain the methodology used and subsection three will provide the results of the calculations with respect to gasoline consumption and carbon dioxide emissions. Section six will conclude the thesis.

2. Literature Review

<u>Externalities</u>

Externalities occur when a third party is impacted by an economic transaction that they were not involved in (Goolsbee et al., 2016). When economic activity harms the third party, it is known as a negative externality. (Goolsbee et al., 2017; Callan and Thomas, 2013). Pollution is considered to be a negative externality because it incurs added costs to a third party, and can also cause negative effects on human health and the environment (Callan and Thomas, 2013). In contrast, positive externalities lead to benefits being received by a third party. Examples include public infrastructure, education, and research and development (Goolsbee et al., 2016).

The effects of greenhouse gas emissions are not accounted for within the market transaction, and therefore become a cost burden placed on society (Callan and Thomas, 2013; Qian et al, 2013). This is considered a market failure, and one solution is to internalize the negative externality through a corrective tax, which seeks to improve resource allocation and rectify a market failure (Fischer and Newell, 2008; Siegmeier, 2018). Due to the negative externalities associated with greenhouse gas emissions, there is opportunity for corrective policy that internalizes these costs.

Policy Approaches to Greenhouse Gas Emissions Reduction

Governments across the world are responding to climate change and carbon dioxide emissions utilizing different methods (Aldy et al, 2012). There are various environmental policy measures that can be applied, including uniform technology and performance standards, or command and control caps on emissions, or market-based instruments (Fischer and Newell, 2008; Allan et al, 2014). In recent years there has been a trend towards favoring market-based instruments (MBI) as a means of reducing emissions (Aldy et al, 2012; Meckling and Jenner, 2016). Choosing the most effective policy is important when responding to a threat such as climate change. The MBI approach allows firms to achieve a greater level of cost- effectiveness, defined as achieving a business goal using the least costly approach, while abiding by the environmental standards or limitation. (Callan and Thomas, 2013). The two methods of achieving the policy goal using is through quantity instruments, seen in emissions trading schemes, and price instruments, which often take the form of taxes (Meckling and Jenner, 2016).

In 1920, Arthur Pigou introduced the concept of the market externality, and theorized that they could be corrected by using a Pigouvian tax (Metcalf, 2017). The tax would be set to equal the cost of the marginal social damages that are incurred. When applied to environmental economics, the Pigouvian tax is often represented as a price on greenhouse gas emissions per unit relative to damage caused by pollution (Metcalf, 2017). Market inefficiency is created when a negative externality is present because the firm does not have to pay the costs (Goolsbee et al., 2016). In the case of pollution, society bears the costs and firms are overproducing because the costs are taken on by firms, so they will have a higher output than would be considered efficient if the costs are internalized (Goolsbee et al., 2016). Pigouvian taxes are difficult to implement because it can be difficult to calculate the exact cost of an externality, but there are many researchers that have worked to estimate the third-party costs associated with greenhouse gas pollution.

The Social Cost of Carbon

The continued emission of carbon through the burning of fossil fuels contributes to an increasingly expensive agenda at the international level. The social cost of carbon (SCC) is a value used to calculate the damage associated with the emission of one unit of carbon dioxide (CO_2) into the atmosphere (van den Bijgaart, 2016). The Environmental Protection Agency (EPA) defines it as a comprehensive estimate of climate change damages, and its effect on human health, property, agriculture, and economic productivity over the long term (United States Environmental Protection Agency, 2017).

The monetization of this value helps with the creation of environmental policies (van den Bijgaart et al, 2016). Calculating the SCC relies on the use of discount rates to calculate future costs, and the rate that is chosen affects the outcome significantly (Golosov et al., 2014; van den Bijgaart et al, 2016). Discounting is used to calculate expected damage using percentage-based values, and the social cost of carbon increases each year.

The most recent estimate of the SCC by the U.S. government was approximately $37 per metric ton of CO_2 emissions in 2016 (EPA, 2016). They use a 3% discount rate, and the value of the SCC increases over time as cumulative emissions continue to go up, reaching $42 per metric ton emissions in 2020. This is due to the damages caused on environmental and economic systems becoming more severe from climate change. (EPA, 2017). It also factors in GDP growth over time, and many of the "damage categories" are calculated so as to be proportional to gross GDP (EPA, 2017).

Many economists have calculated the social cost of carbon, but the most noteworthy have come from Stern (2007) and Nordhaus (2008). The Stern report used a discount rate of 0.1%, and calculated the externality cost of coal to be $250 per ton CO_2 emissions. William Nordhaus and James Boyer calculated SCC with a discount rate of 1.5% per year, and concluded that $30 per ton CO_2 is required to cover externality costs (Nordhaus and Boyer, 2008). These two different models of calculation are used as reference in the development of a general equilibrium model, with the addition of the negative externality of carbon pollution (Golosov et al, 2014). With the only factors being discounting, expected damage elasticity, and the structure of carbon depreciation in the atmosphere, Golosov et al (2014) conclude higher costs. At a discount rate of 1.5%, they find a cost of $57 per ton of CO_2, and at 0.1%, they estimate a cost of $500 (Golosov et al, 2014). This analysis illustrates how different methodologies will lead to differing results, and that future costs and benefits are difficult to predict (Callan and Thomas, 2013).

Carbon Taxation in Practice

A carbon tax is considered by many economists to be the most efficient and cost effective way to reduce emissions (Perry et al., 2013). It is a price instrument that puts a cost on carbon dioxide per ton being emitted (Meckling and Jenner, 2016). The most common model involves taxing producers incrementally, and increasing the tax per ton of CO_2 each year (Scott & Taylor, 2012).

In 1990, the Inter-Governmental Panel on Climate Change (IPCC) released a comprehensive report on the impacts and risks of global warming (Al-Abdullah, 1999). Following this, the European Union committed to reducing CO_2 emissions in 1990, began evaluating policy options, and eventually decided that a tax would be the best option (Zhang et al., 2016; Al-Abdullah, 1999). Mainstream academic research began on the topic in the early

1990's, including findings that a carbon tax can "produce long-term market signals and thus improve energy efficiency and reduce the use of fossil fuels" (Zhang, Kun et al., 2016). As of 2018, however, the EU has not passed such a measure due to opposition by some of its member countries. (Kun et al., 2016). They have been implemented in some member countries such as Belgium, Finland, Denmark, Italy, Norway, and Sweden. The first place to implement a carbon tax in North America was the province of British Columbia in 2008 (Callan and Thomas, 2013).

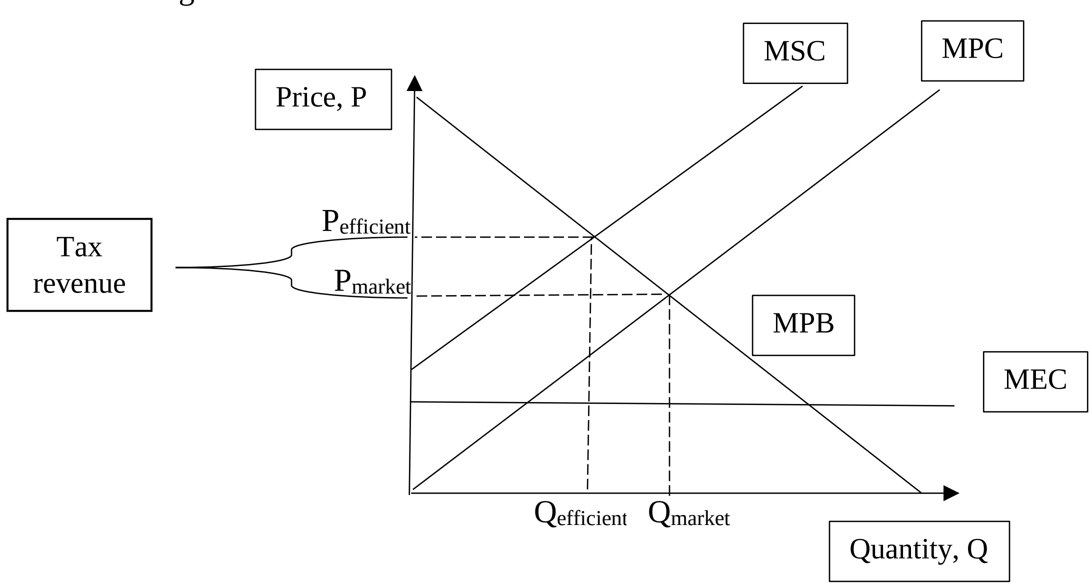
There has been research from many different countries modeling the effects of a carbon tax (Allan et al., 2014). Analysis shows that in many developed countries, this form of tax is regressive and disproportionately impacts lower income households (Qiao-Mei et al., 2013). In developed countries, the proportion of income in spending on fossil fuels decreases with the income levels, thus resulting in a higher tax burden for low-income groups (Qian et al., 2016). However, some developing countries like Pakistan have managed to make this a progressive tax, meaning that those with higher income pay more, and this is more difficult to accomplish in capital intensive countries (Qiao-Mei et al., 2013). Qian et al. state that it is up to policymakers to ensure that the tax is neither progressive nor regressive, but that revenue is recycled to achieve neutrality (Qian et al., 2016). Implementing a carbon tax effectively requires an analysis of the socioeconomic impacts that would be incurred.

3. Economic Framework

I will discuss two frameworks that model how the structure of a tax can influence the environmental outcome. First, I will introduce marginal costs and benefits curves. It graphs Marginal Private Cost (MPC) and Marginal Private Benefit (MPB), where the point of intersection between the two curves represents market equilibrium. MPC is the cost for each additional unit of output experienced by a firm, and the MPB is the utility gained by consumers for using a particular good or service (Callan and Thomas, 2013; Goolsbee et al. 2016). The marginal costs and benefit curves do not include externalities, and to include these costs, one can implement a Marginal Externality Cost (MEC) curve as well as a Marginal Externality Benefit (MEB) curve.

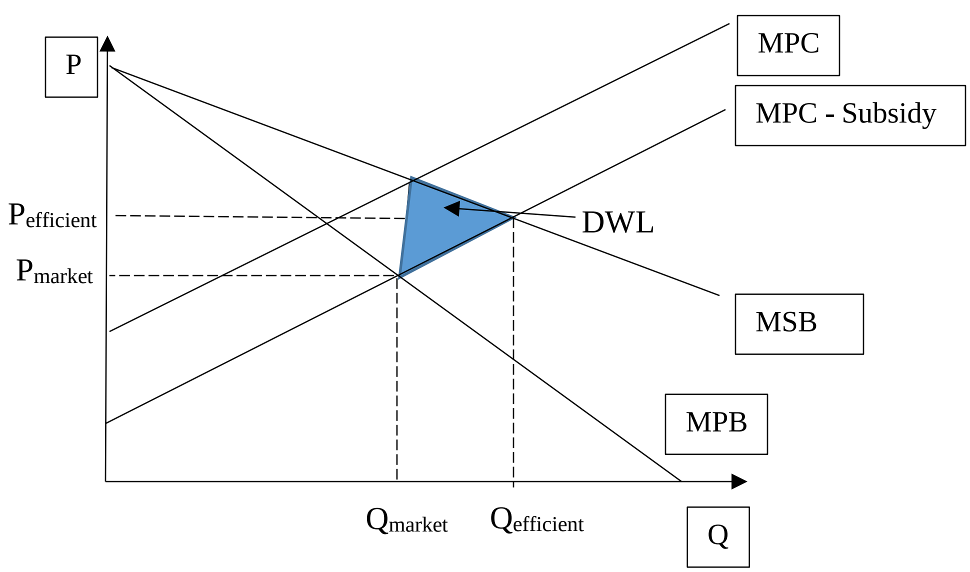
Due to environmental pollution being a negative externality, the costs associated with it can be represented as a MEC curve (Callan and Thomas, 2013). In this model, MPC + MEC = the Marginal Social Cost (MSC). MSC is the total cost burden placed on society when externalities are included in a market model (Callan and Thomas, 2013). When marginal costs and benefits curves are used with MEC and applied to a tax, the cost curve of the tax would raise be equal to the MSC (Callan and Thomas, 2013; Barthold, 1994). This is defined as allocative efficiency, the point at which benefits to society are equal to the costs being incurred (Callan and Thomas, 2013). The area between the MSC and MPC underneath the MPB represents what would be collected in tax revenue (Callan and Thomas, 2013). Where MSC and MPB intersect is the efficient, or socially optimal price and quantity.

Model 1: Marginal Costs and Benefits



Model 2 will build off of Model 1 in order to represent positive externalities. When an unregulated market has a positive externality, consumers pay a lower price and consume lower quantities than the socially efficient outcome (Goolsbee et al. 2016). This creates deadweight loss (DWL), or a net loss in social welfare. One way to achieve the socially efficient allocation is through government subsidy, which would decrease the DWL intrinsic within the market model (Goolsbee et al., 2016; Callan and Thomas, 2013). This subsidy raises the price at which producers can sell their products, making it profit-maximizing to reach the socially optimal level (Goolsbee et al., 2016). Subsidizing R&D can improve social welfare and the environment through innovation in areas such as carbon sequestration or renewable energy. Model 2 will be of greater note in section four during discussion of subsidies offered in carbon tax policy.

Model 2: Positive Externalities from R&D



These two models are important when discussing climate change because they illustrate how market failures caused by externalities can be corrected through government intervention. Model 1 can increase the price associated with carbon polluting activities through introducing a tax, while model 2 shows the price of clean alternatives being lowered through the use of a subsidy. By combining the two and having a tax invest its revenue in clean energy, two externalities can be corrected and move the market towards a more environmentally efficient level of economic output.

4. Proposed Tax System Design and Features

Section 4 will discuss the carbon tax in British Columbia to be used as a framework lens for the state taxes. Following this will be an introduction of criteria that will be used to evaluate the effectiveness of the taxes. Lastly, the taxes will be compared based on their features and their ability to meet social and environmental goals.

4.1- British Columbia Carbon Tax

The British Columbia (BC) carbon tax, introduced in 2008, has served as a model for other provinces, states, and countries seeking to price carbon pollution. The tax is applied to the combustion and usage of all greenhouse gases, and covers about 77 percent of BC's emissions (Beck et al, 2015; Government of British Columbia, 2018). Its significance can be observed in how the tax was structured, with an emphasis on equity and revenue neutrality (Beck et al, 2015).

All of the revenue that is collected by the tax is designed to go back to consumers. This recycling is put in place to offset the negative impacts that would result from the tax, namely increased energy and transportation costs (Farrell, 2017). 40 percent is returned to households, through programs like the Low-Income Climate Action Tax Credit, as well as the Northern and Rural Homeowner Benefit Program (Government of British Columbia, 2018). Furthermore, it allow for the reduction of personal income taxes for the lowest two income brackets by 5 percent each (Government of British Columbia, 2018). The remaining 60 percent of the revenue goes to businesses. Businesses received a corporate tax rate reduction from 12 to 10 percent, small business tax rates decreased from 4.5 to 2.5 percent, school taxes went down in rural areas, and an industrial property tax credit was introduced (Beck et al, 2015; Beck et al, 2016; Government of British Columbia, 2018). These tax cuts are paid for using the revenue, and it helps the business sector on aggregate afford the extra payments required for emitting greenhouse gases. Heavily polluting sectors pay more, while less carbon intensive sectors pay less and are economically better off.

The tax rate began at $10 Canadian dollars per ton of carbon dioxide emissions ($10 CAD/t$CO_2$), equivalent to approximately $10.66 US Dollars at the time (Fx Exchange, 2018). The tax was set to increase $5 CAD/t$CO_2$ each year until 2012, when it would reach $30 CAD/t$CO_2$ (Beck et al, 2015). Beginning on April 1, 2018, the tax rate was increased to $35 per ton, and will increase similarly until it reaches $50 CAD in 2021 (Government of British Columbia, 2018). Due to types of fossil fuels having different global warming potentials, they are given costs to reflect that. In 2018, the tax on gasoline is 7.78 ¢/liter, diesel has a tax of 8.95 ¢/ liter, while natural gas has 6.65 ¢/cubic meter, represented again in $CAD (Government of British Columbia, 2018).

The Carbon Tax Center (CTC) cites data showing that from 2008-2013, there was a 12.9% decline in per capita emissions in British Columbia (Carbon Tax Center, 2018). This is compared to the rest of Canada, which experienced a decline of 3.7% during the same period. One small caveat from this data the exclusion of electrical generations, which is only 2% of BC's emissions but is averaged to 20% of emissions in the rest of Canada (CTC, 2018). Ex-post analysis also shows that the tax had a negligible effect on economic growth. The province experienced an annual average of 1.55% growth, slightly higher than the rest of Canada which experienced an average of 1.48% growth (CTC, 2018).

The government of British Columbia is actively seeking to help industry reduce their emissions to promote clean energy growth (Government of British Columbia, 2018). First, they would prove incentives for meeting a low-emitting performance benchmark, and ideally, the cleanest facilities will receive more incentives. Second is investment in emission reduction projects (Government of British Columbia, 2018). This kind of policy emphasizes pollution abatement and can reward firms for doing so, rather than tax cuts or subsidies that will not promote the same behavior.

The carbon tax regulates approximately 77 percent of the province's greenhouse gas emissions (Beck et al, 2015; Government of British Columbia, 2018). As indicated in Table 3.1, 40% of the revenue goes to consumers, while 60% is set aside for businesses. Ex post analysis showed that the government did not achieve total neutrality and overestimated the amount of revenue that would be collected (Beck et al, 2016). It was found that total revenue from the carbon tax in fiscal year 2011/12 was $959 million, but the government of British Columbia paid out $1141 million in revenue recycling measures (Beck et al, 2016). Following the implementation of the tax, the province's greenhouse gas emissions declined at a rate faster than the rest of Canada. At the core of the British Columbia carbon tax is revenue neutrality. Although the government was losing money in its early years, they modified the spending so that recycling measures were more accurate relative to the revenue generated (Beck et al., 2016).

4.2- Criteria

In order to better compare these carbon taxes, we will be taking a very narrow definition of what a carbon tax should look like. The most conventional design, used by other countries across the world, addresses the regressive nature of the taxes through revenue recycling (Farrell, 2017). Others argue that a tax should include investment in sustainable initiatives, as seen in the NY plan (Qian et al, 2016).

Thomas Barthold argues that a Pigouvian tax is the ideal way to deal with environmental pollution. The tax aims to efficiently use a price that is equal to the *marginal externality cost* (Barthold, 1994). According to Barthold, there are four questions that need to be answered for a tax to be defined:

1. What is being taxed?

Barthold first requires a definition for what is being taxed by the government. In each of these, greenhouse gas emissions are being taxed based on their atmospheric warming potential (British Columbia is the model for comparison; it is revenue neutral, instituted rebate programs to help low-income and rural consumers, and will continue to reduce emissions., 2018; Golosov et al, 2014). Coal is given the highest price per unit, followed by gasoline, and then natural gas (Government of British Columbia, 2018). The subject of taxation is carbon dioxide emissions.

2. Who is being taxed?

The people being taxed are producers such as electrical utilities or fossil fuel distributors. Consumers are not taxed directly, but a carbon tax will result in increased prices for heating or transportation that use fossil fuels.

3. How much is being taxed?

The quantity being taxed depends on the plan and the policymakers behind it. Plans in North America generally increase the cost of the tax annually by 5$/ton CO_2 emissions. Many policymakers argue that carbon taxes should slowly increase year after year so as to not cause unnecessary economic harm to consumers and businesses. Furthermore, many proposals have a cap around $30 or $40 USD, and offer statutory requirements of reviewing the results annually or biannually.

4. What are the ancillary goals?

Each of the taxes in question share the same ancillary goal: to internalize the negative cost associated with greenhouse gas emissions. This is done through a per unit tax on consumption. Applying a Pigouvian tax for environmental pollution requires that the fee price be equal to the damage being caused (Barthold, 1994). However, the price point, also known as the Social Cost of Carbon, has been a subject of debate for many years (Golosov et al, 2014).

To compare each policy, I will be applying three criteria provided by Barthold with some concepts that have been learned about carbon taxes, particularly in British Columbia to develop my own criteria:

1. *Is the tax designed to achieve revenue neutrality?*
2. *Does the policy provide ways to reduce the adverse impacts caused by a regressive tax?*
3. *How does the tax rate compare to the social cost of carbon?*

Section 4.3 will discuss the key aspects of the three state tax proposals, and conclude by asking how each meets or fails to meet these criteria.

4.3- Comparative Analysis

The most popular carbon tax introduced in Vermont is based on the ESSEX plan, and it was given the most support in the form of Bill H.791, with a similar bill in the state Senate. The plan in question was developed by a coalition of non-profits, Vermont academics, and businesses interested in putting a price on pollution (Curran et al, 2017). This plan goes a different direction from what was used in BC, as its main focus is on reducing electricity costs and emphasizing energy efficiency infrastructure, which will be discussed at greater length in section 5 (Curran et al, 2017). It will combat the regressive nature of the tax through rebates to rural and low income consumers, but the revenue is recycled through decreased electricity prices rather than in the form of tax credits (Curran et al, 2017). The rebates would be additionally applied to each ratepayer's electrical bill. Families earning less than 400 percent of the federal poverty level are eligible for rebates, and rural families earning less than 400 percent would get an additional rebate (VT Bill H.791, 2018).

Bill H.791 was designed with a number of exemptions to protect some aspects of the Vermont economy. Most notably, the plan exempts electricity generated using fossil fuels because it is already regulated by the Regional Greenhouse Gas Initiative (VT Bill H.791, 2018). Others include aviation fuels, farm diesel for heavy equipment and agriculture, and biomass used for energy production, heating, and transportation (VT Bill H.791, 2018).

The Vermont plan would take 8 years to reach its cap of $40, and achieves revenue neutrality but through a less conventional method. Rather than using tax credits, all of the revenue is distributed through reduced costs on electrical bills (Curran et al, 2017). There is good reasoning behind this, partly related to Vermont's energy efficiency efforts. In 2017, the state was ranked fourth in the country by the American Council for an Energy Efficient Economy (ACEEE) for their advancement of efficiency measures (Buell, 2017). A low carbon economy most notably requires a transition for transportation and heating from fossil fuel inputs (such as motor vehicle fuel and natural gas) to being on the electrical grid (UNFCCC, 2007). By attaching the carbon tax to reduced electricity prices, the Vermont plan incentivizes consumers to switch from conventional heating and transportation to electric. The authors of the plan argue that there has been a standoff between advocates seeking revenue neutrality and those seeking investment in sustainable technology, and say that this resolves both, albeit indirectly (Curran et al, 2017).

The Massachusetts plan is most similar to the British Columbia tax, and seeks to recycle revenue to its residents and businesses using tax credits. The difference is that the rebates will be relative to the aggregate emissions of those two sectors, and this assessment is left to the agency of energy resources (MA Bill S.1821, 2017). The rural rebates are set up to assist people that have to drive more and commute farther, but is figured by municipality rather than individual need. People living in rural municipalities (defined as an area whose residents drive at least 130% the average miles driven per household in the state) will receive an additional rebate (MA Bill S.1821, 2017).

Proceeds returned to residents in rebates will be proportional to aggregate statewide emissions by residents, and businesses will receive an amount proportional to the aggregate amount of emissions made by businesses (MA Bill S.1821, 2017). When electrical generation is separated as a sector of GHG emissions, in 2015 the residential sector contributed 18 percent of emissions while industrial and commercial businesses contributed 20.3 percent (Commonwealth of Massachusetts, 2018). Depending on how the state handles transportation emissions and any potential program exemptions, revenue recycling would currently look like 47 percent to residents, and 53 percent to businesses (Massachusetts Executive Office of Energy and Environmental Affairs, 2018). There is only one exemption provided in Bill S.1821, and it exempts electrical generation regulated by RGGI.

The Massachusetts plan is arguably the most business friendly of the three. As a part of its revenue recycling feature, the bill distributes rebates to residents and businesses relative to their total greenhouse gas emissions (MA Bill S.1821, 2017). In Section 13B.d (3), the bill states:

> "The commissioner … shall, with special attention to manufacturing, identify economic sectors, economic sub-sectors or individual employers at risk of serious negative impacts due to the charges collected pursuant to this chapter. The commissioner may, as mitigation, calculate the total proceeds collected from said sectors, subsectors or individual employers and may apportion the entirety of said proceeds to the affected sector, sub-sector or employers" (MA Bill S.1821, 2017).

MA bill S.1821 leaves a lot of key policy to state agencies as to how the plan should be implemented. The state is given spending leeway to help carbon intensive industry offset what is referred to as serious negative impacts from the carbon charges. This is potentially counterproductive when it comes to reducing greenhouse gas emissions, but is also not guaranteed to happen.

Bill S.2846 is the most supported tax plan in recent years in New York, and would start more expensive with a higher annual fee increase, and a cap of $185 USD (NY Bill S.2846, 2017). It is the most stringent of the proposals being analyzed, but it is also contains less the least language to guide the outcome of the policy. For example, there is no mention of any sectors of the economy that would be exempt from the carbon tax, including RGGI which already regulates emissions from the electricity sector (NY Bill S.2846, 2017). It also differs because it offers no revenue recycling to businesses for their contribution to emissions, meaning that carbon intensive industry is more likely to be affected

The fee would start at $35 for its first year of implementation, and go up $15 annually until reaching the cap. 60 percent of the revenue will be given to very low income, low income, and moderate income residents in the form of tax credits (NY Bill S.2846, 2017). The NY tax should, in theory, combat the regressive nature of carbon taxes by recycling revenue to very low to moderate income households, while internalizing the SCC more than the VT and MA tax plans. The remaining 40% will be distributed to support the transition to 100% renewable energy, investment in mass transit, and climate change adaptation work. The legislation suggests: renewable energy subsidies, energy conservation and efficiency measures, protection of low-lying and coastal areas, as well as improving emergency response to extreme weather (NY Bill S.2846, 2017).

Although not analyzed in this paper, Model 2 from Section 3 suggests that investment in sustainable initiatives will further help lower greenhouse gas emissions. For example, allocating funds to renewable energy technology can reduce the Marginal Private Cost, thus increasing the socially optimal quantity of goods and services that can be created by the renewable energy sector. Although it is left to the discretion of the Department of Environmental Conservation to allocate that funding, subsidies for renewable energy and mass transportation give this policy a greater potential to reduce emissions over time.

The table below contains information from each tax such as starting price, price cap, scheduled rate of increase, and revenue allocation, which is further illustrated in Figure 4.31.

<u>Table 4.31: Carbon Tax Comparison</u>

	British Columbia Carbon Tax	Vermont (Bill H.791)	Massachusetts (Bill S.1821)	New York (Bill S.2846)
Starting price (per ton CO_2)	-$10/ton	$5/ton	$10/ton	$35/ton
The price cap	$30/ton in 2012. $50/ton in 2021.	$40/ton	$40/ton	$185/ton
Scheduled rate of increase	$5/year	$5/year	$5/year	$15/year
Revenue allocation	**Consumers**: 40% **Businesses**: 60%	**Consumers & Businesses**: Receive 100% in the form of electricity rebates. Additional rebates apply.	**Consumers**: ~47% **Businesses**: ~53%	**Consumers**: 60% (for very low to moderate income residents). **Sustainable Initiative Investment:** 40%

*Sources: * Government of British Columbia. * Vermont General Assembly Bill H.791/ The ESSEX Plan.*

**The 190th General Court of the Commonwealth of Massachusetts Senate. * New York State Senate*

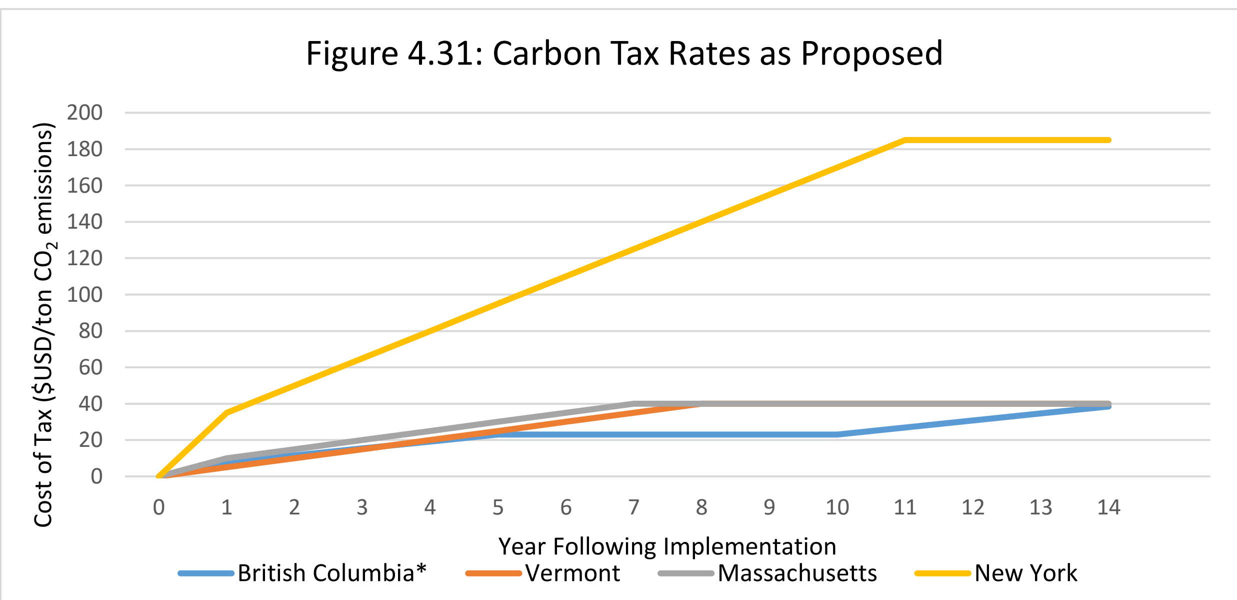


Figure 4.31: Carbon Tax Rates as Proposed

*- Converted from $CAD to $USD

Figure 4.1 compares the tax rates of each proposal over time. British Columbia does not increase from year five to year ten due to it reaching its cap in 2012, until the province increased the cap starting in 2018 (Government of British Columbia, 2018).

Is the tax designed to achieve revenue neutrality?

The Vermont tax and the Massachusetts tax meet criteria one because they both redistribute the carbon fees evenly to businesses and residents, with additional rebates. Vermont recycles the revenue via reduced electricity rates every month, while MA chooses to use introduce annual tax credits. The NY proposal does not meet the criteria of being revenue neutral. It instead earmarks a substantial part of its revenue, 40 percent towards environmental sustainability initiatives rather than businesses. This will improve its ability to meet environmental goals, with the trade-off being economic efficiency for consumers and businesses.

Does the policy provide ways to reduce the adverse impacts caused by a regressive tax?

Through its rebate programs, Bill H.791 helps people that would otherwise be disproportionately impacted by a carbon tax and thus meets criteria two. The VT tax sets aside 25 percent of residential revenue to low-income residents, and an additional 25 percent for low-income rural residents (Curran et al, 2017). 50 percent is distributed evenly to all Vermonters, and then the rebates are added if applicable (Curran et al, 2017).

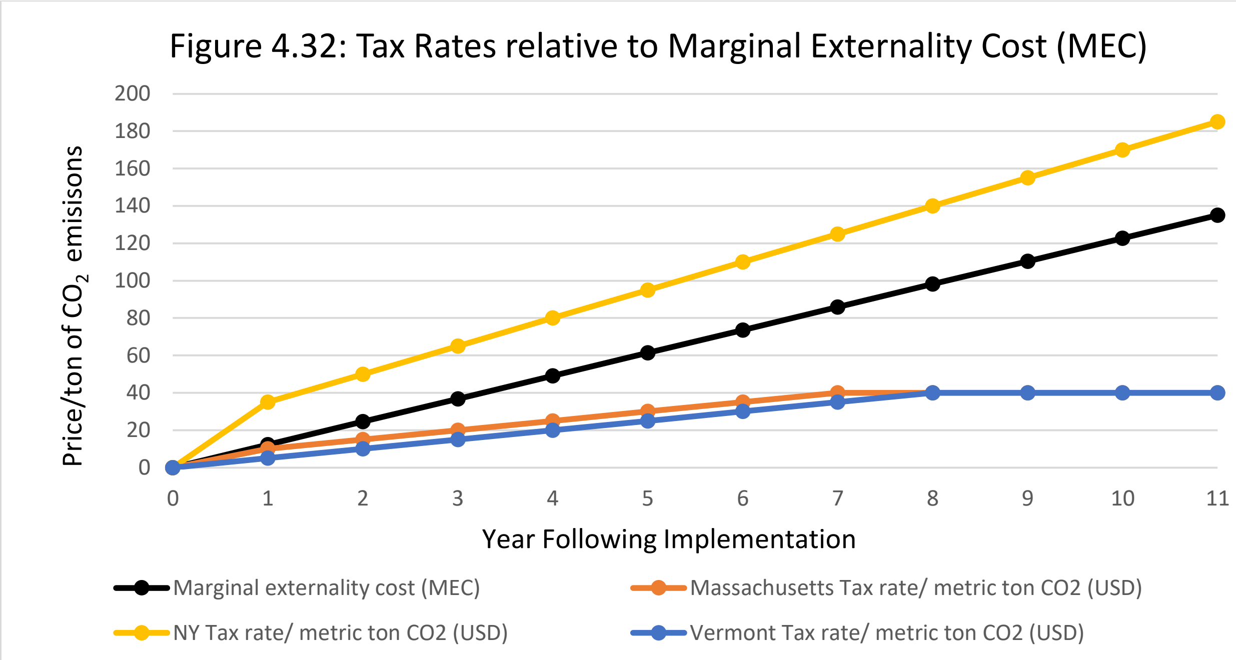
The MA tax helps rural homeowners with additional rebates, but does not provide additional assistance to low-income residents. As a result, he tax is more regressive for low-income residents, but the tax plan could be modified in the future to give additional rebates as was done in British Columbia. MA Bill S.1821 meets criteria two.

The NY tax focuses its revenue distribution on the lowest income groups: specifically very low income, low income, and moderate income households. While not meeting the revenue neutrality criteria, there is an effort to reduce the regressive properties of the tax on vulnerable income groups. As a result, NY Bill S.2846 also meets the criteria for providing ways to reduce tax regressivity.

How does the tax rate compare to the social cost of carbon?

The VT and MA taxes share a cap at $40/ ton, which is close to being consistent with more conservative estimates of the Social Cost of Carbon. Based on the EPA's most recent estimates the SCC would be approximately $46/ton CO_2e in 2025 (EPA, 2017). Due to its higher starting price and cap, the NY plan goes beyond lower estimates of the SCC, and will thus better internalize the costs of carbon dioxide pollution.

Ideally, a carbon tax should be equal to the social cost of carbon in order to offset the damages caused by it. In section 2, I discussed the different SCC values that have been developed. However, the International Panel on Climate Change (IPCC) report from October 2018 suggests that to keep global warming below 1.5^{o}C by 2050, then the globe needs a price per ton on carbon emissions ranging from $135-$5,500 USD per ton by 2030 (IPCC, 2018). This price is necessary to dis-incentivize carbon pollution. Figure 4.32 below simply represents how the taxes in VT, MA, and NY compare to the social cost calculated in the IPCC report, which found that global warming of 1.5^{o}C above preindustrial levels would have more drastic consequences on the climate than anticipated (IPCC, 2018). In Figure 4.32, the MEC represents the more conservative estimate of $135/ton CO_2e by 2030.



5. Effect of State Carbon Taxes on Gasoline Consumption

This section uses research by Rivers and Schaufele (2015) on the salience of gasoline consumption in British Columbia. The econometric analysis compared the short-run elasticity of purchasing liters of gasoline with a carbon tax of \$25CAD/tCO_2, with an equivalent increase of gasoline price without the presence of a carbon tax (Rivers and Schaufele, 2015). This thesis uses

5.1- Tax Salience

There have been many definitions of tax salience by researchers, but it generally refers to the complexity or public knowledge surrounding a given tax (Varela, 2016). A highly salient tax that is well understood or visible is more likely to create changes in consumer behavior or demand (Varela, 2016). Rivers and Schaufele use tax salience to compare "distinct demand responses from tax-induced price changes compared with equivalent market-determined price movements." (Rivers and Schaufele, 2015). It was found that a CAD$ 0.05 increase in the tax yielded a 0.084 percent decrease in the short-run consumption of gasoline, compared to a 0.021 percent decrease without the tax (Rivers and Schaufele, 2015). The researchers argue that this can be explained by behavioral economics; people in British Columbia bought less gas because of the existence of the tax, leading to a better environmental outcome (Rivers and Schaufele, 2015). Consumer behavior is influenced by social pressure, self-image, and changing preferences, and led to less driving and vehicle emissions. They calculated that the British Columbia carbon tax led to a reduction in emissions from gasoline combustion by 1.8 million metric tons (Rivers and Schaufele, 2015).

Beyond the normal shift in demand associated with increased prices, they calculated that there was a -0.0167 percent change in the quantity of gasoline consumed for each one cent increase in price per liter. This value is aggregated from 2007-2012, during which the carbon tax was introduced and raised to its cap at $30/ton. By applying this semi-elasticity to US data, it allows for a simple estimate of how consumer behavior can help reduce fossil fuel use under a carbon tax regime. -0.0167 percent is an estimate based on consumer behavior in British Columbia (BC).

For a carbon tax, the price is set and the reduction in emissions is determined by the response of consumers in the quantity of their emissions (Callan and Thomas, 2013). Consumer behavior under a tax scheme is difficult to predict, but can be expected to follow trends. For example, the Vermont proposal includes a projection that it would achieve a 15-25 percent reduction in carbon pollution below 1990 levels by 2025 (Curran et al, 2017). Research by

Nicholas Rivers and Brandon Schaufele used data observed in British Columbia to calculate the consumer response to a carbon tax by its tax saliency.

5.2- Methodology

The data can help predict that projected change in emissions might be influenced by more than just price demand, and this has implications both for the reduction of greenhouse gases and for tax revenue. If consumption goes down more than expected, as it did in the early years of the BC tax, then it means that the revenue being collected is also lower. Policymakers predicting how much to recycle back to consumers and businesses should be mindful of this, so as to achieve revenue neutrality more effectively.

The semi-elasticity was aggregated from 2008 to 2012 by testing different economic parameters and through robustness checks (Rivers and Schaufele, 2015). In the short run, there is a very low elasticity of demand for gasoline, and the effects will likely be below what is predicted (EIA, 2014). In the long run, consumers are more likely to act in response to the price effects, whether through decreased overall consumption, or investment in more fuel efficient vehicles (EIA, 2014; Rivers and Schaufele, 2015).

For each state, I used consumption data abstracted by the Kansas University Institute for Policy and Social Research. The original data was reported by the Energy Information Administration SEDS (State Energy Data System) with the most recent data available being from 2016. To calculate the data, I took the liters of gasoline consumed per day and multiplied it by the semi-elasticity factor. For each $5 per ton increment of the carbon tax, the cost of one liter of gasoline increases approximately 1.1 cents. This was done in Canadian currency due to the semi-elasticity being observed in British Columbia. For larger changes in the carbon fee, the variable is simply multiplied by a larger cents per liter value. The data is then converted into gallons, adjusted annually, and lastly, the estimated gasoline reductions are translated into reduced million metric tons of carbon dioxide emissions.

These calculations assume price stability in the market for gasoline. Unaccounted variables include the effect of an economic recession, which can cause drops in fuel consumption (Beck et al, 2015). Furthermore, each state has different relative transportation requirements, which influences the effectiveness of a carbon tax. For example, people in Vermont drive 20% more than the national average, and were ranked 10^{th} most Vehicle Miles Travelled (VMT) in the United States in 2011 and 2013 (VTrans, 2017). There is a lower availability of public transportation in a rural state, making the effect of a carbon tax more difficult to predict. Lastly, the data is a reflection of changes made by consumers outside of those caused by simple price changes, and is limited to gasoline consumption. Section 4.1 analyzes the tax saliency effect through the Vermont proposal, and sections 4.2 and 4.3 do the same for Massachusetts and New York, respectively.

5.3- Results

(a) -Vermont (Bill H.791)

Vermont recorded a consumption of 311,220 thousand gallons in 2016 (University of Kansas, 2018). Table 5.31 shows annual estimated reduction in gasoline consumption, as well as what that converts into abated state carbon dioxide emissions as a percentage of mobile sources and the total. These percent reductions are relative to 2015 emission levels rather than using 1990 emissions as the baseline.

Table 5.31: VT Tax Saliency effects on Gasoline Consumption and CO_2 Emissions

VT tax per ton	**Gasoline Tax (cents per Liter)**	**Annual estimated reduction (Thousand Gal of Gasoline)**	**Cumulative CO_2 Reduction as % of Mobile Sources**	**Cumulative CO_2 Reduction as % of Total State Emissions**
Year 1: $ 5.00	1.1	(5,717.73)	1.17%	0.51%
Year 2: $ 10.00	2.23	(5,612.70)	2.32%	1.01%
Year 3: $ 15.00	3.34	(5,509.59)	3.45%	1.50%
Year 4: $ 20.00	4.45	(5,408.38)	4.56%	1.98%
Year 5: $ 25.00	5.56	(5,309.03)	5.65%	2.45%
Year 6: $ 30.00	6.67	(5,211.50)	6.72%	2.92%
Year 7: $ 35.00	7.78	(5,115.77)	7.77%	3.37%
Year 8: $ 40.00	8.89	(5,021.79)	8.80%	3.82%

The VT carbon tax is estimated lead to a reduction in gasoline consumption of 42.9 million gallons over an eight year period in Vermont. The rate of decrease of emissions declines over time, although this is less predictable in practice due to factors such as recession, the market for gasoline prices, or carbon leakage (Rivers and Schaufele, 2015; Aldy et al, 2015). Carbon leakage refers to the relocation of individuals or firms to areas of lower environmental regulation, in this case causing carbon pollution elsewhere rather than the area operating under a carbon tax (Aldy et al, 2015). This is particularly important to acknowledge when observing state-based climate policy.

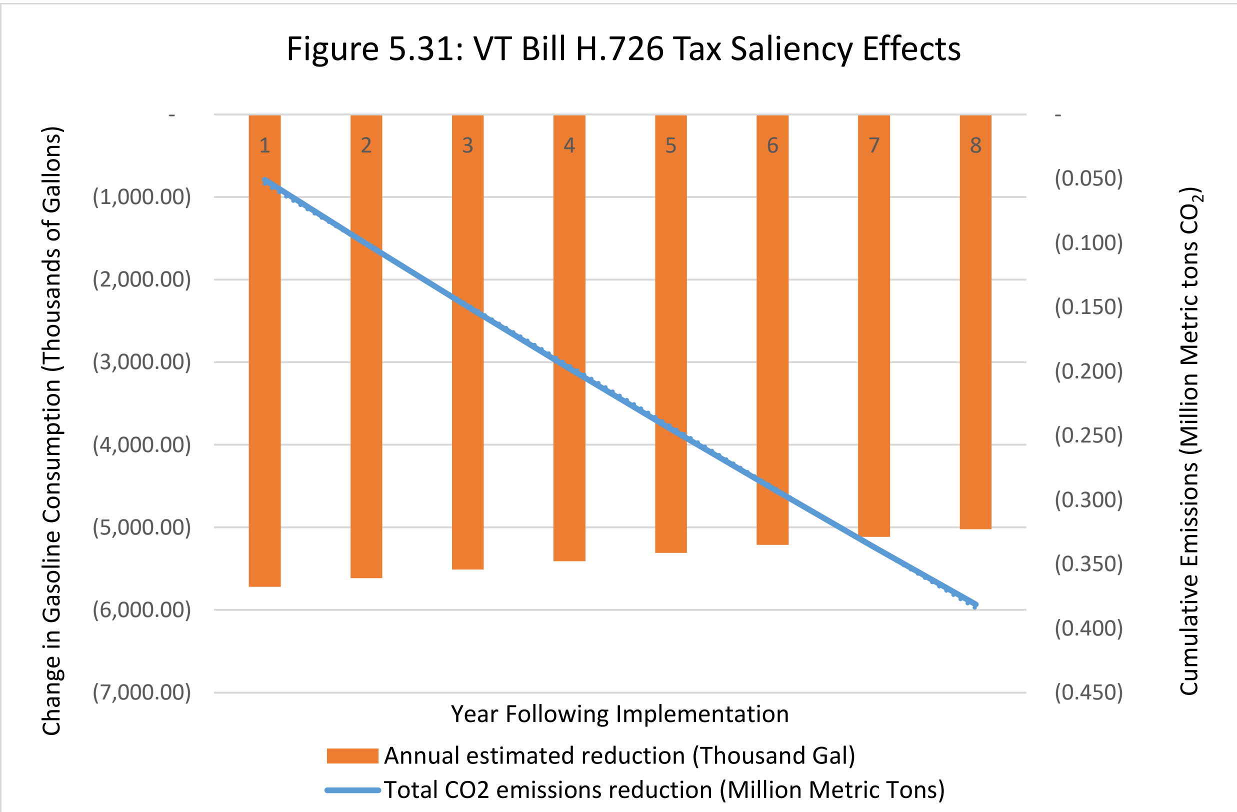


Figure 5.31 shows the amount of gasoline that is not being consumed annually as a result of the carbon tax. This is illustrated relative to the change in CO_2 emissions in metric tons instead of million metric tons.

This data holds assuming Vermont makes similar changes in consumption to that which was observed in British Columbia between 2007 and 2012. A reduction in emissions by 0.381 million metric tons seems small, but the state's GHG emissions totaled to 9.99 million metric tons in

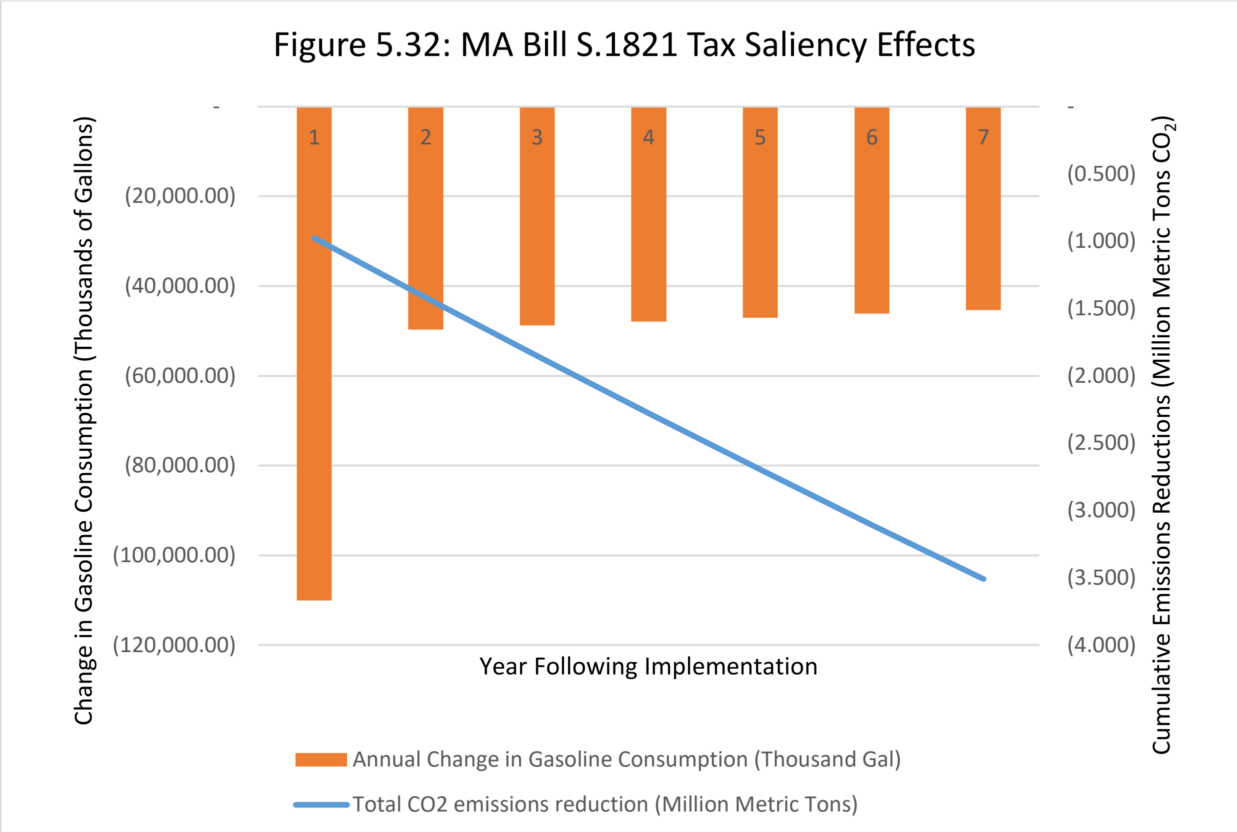
2015, which is a 3.8 percent reduction (Vermont Department of Environmental Conservation, 2018). Mobile sources are approximated to experience an 8.8 percent decline in emissions.

(b) -Massachusetts (Bill S.1821)

In 2016, Massachusetts consumed approximately 2,816,268 thousand gallons of gasoline (University of Kansas, 2018). Similar to the previous table, Table 4.21 represents the estimated reductions in gasoline consumption and carbon dioxide emissions.

Table 5.32: MA Tax Saliency effects on Gasoline Consumption and CO_2 Emissions

MA Tax/ ton	**Gasoline Tax (Cents per Liter)**	**Annual estimated reduction (Thousand Gal of Gasoline)**	**Cumulative CO_2 Reduction as % of Mobile Sources**	**Cumulative CO_2 Reduction as % of Total State Emissions**
Year 1: $10	2.23	(110,066.09)	3.29%	1.38%
Year 2: $15	3.34	(49,718.56)	4.78%	2.00%
Year 3: $20	4.45	(48,805.23)	6.24%	2.61%
Year 4: $25	5.56	(47,908.68)	7.68%	3.21%
Year 5: $30	6.67	(47,028.59)	9.08%	3.80%
Year 6: $35	7.78	(46,164.68)	10.46%	4.38%
Year 7: $40	8.89	(45,316.63)	11.82%	4.94%



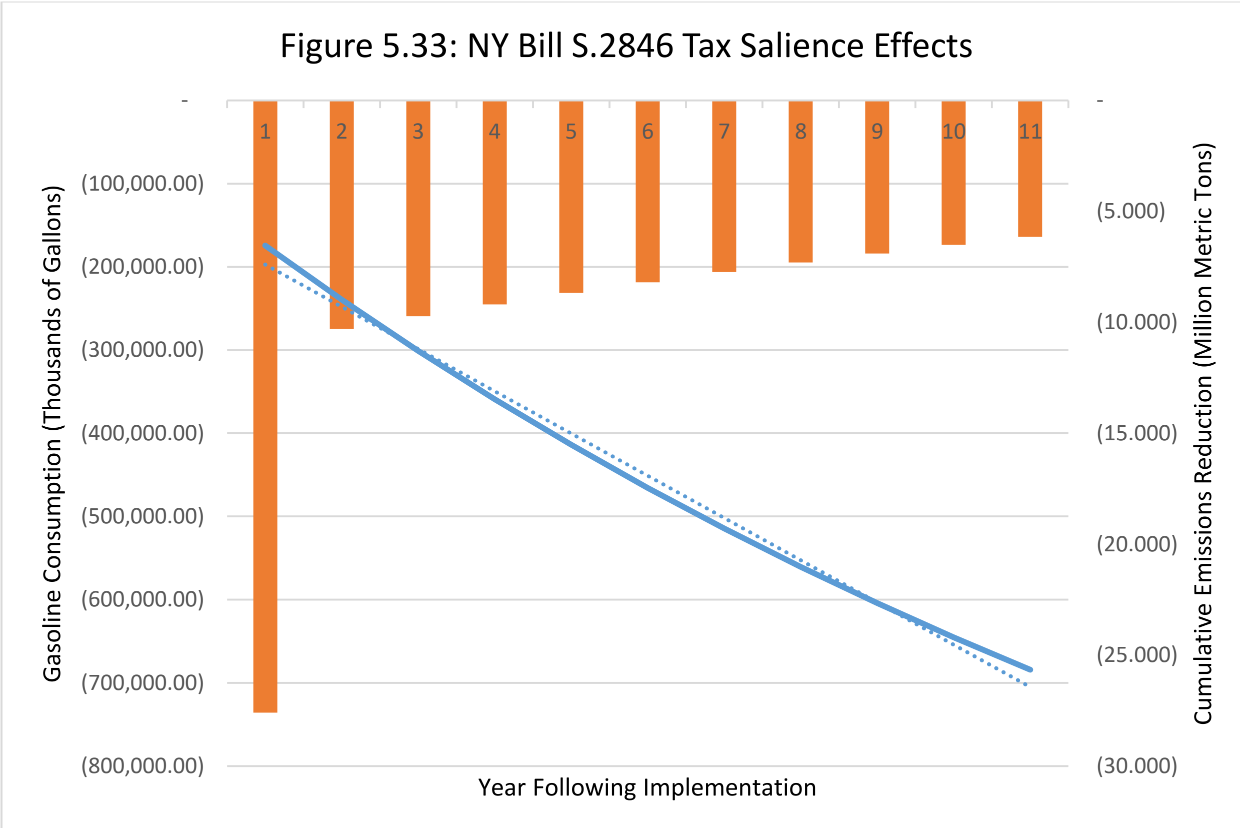
The estimated reduction of gasoline consumption is equal to 395,008,458 million gallons over 7 years. Relative to the total emissions, the reduction of 3.51 million metric tons is approximately 5.27 percent less emissions over seven years from changing consumer behavior. Mobile source emissions are estimated to go down nearly 12 percent in 7 years as a result of tax saliency effects. Massachusetts has 38.8 percent of its emissions come from its transportation sector, the largest source of emissions (Massachusetts Executive Office of Energy and Environmental Affairs, 2018). The data shows the MA tax achieving higher percentage emissions reductions in less time than the VT tax because of a higher starting price.

(c)-New York (Bill S.2846)

In 2016, New York consumed approximately 5,661,558.00 thousand gallons of gasoline (University of Kansas, 2018). As with the other state carbon taxes, Table 4.31 shows annual estimated reduction in gasoline consumption, and emissions reductions as a percentage of mobile sources and total emissions relative to the tax rate.

Table 5.33: NY Tax Saliency effects on Gasoline Consumption and CO_2 Emissions

NY Tax/Ton	Gasoline Tax (Cents per Liter)	Annual estimated reduction (Thousand Gal)	Cumulative CO_2 Reduction as % of Mobile Sources	Cumulative CO_2 Reduction as % of Total State Emissions
Year 1: $ 35.00	7.78	(735,663.61)	9.07%	3.62%
Year 2: $ 50.00	10.94	(274,790.89)	12.46%	4.98%
Year 3: $ 65.00	14.22	(259,463.61)	15.66%	6.26%
Year 4: $ 80.00	17.50	(244,991.25)	18.68%	7.46%
Year 5: $ 95.00	20.78	(231,326.12)	21.53%	8.60%
Year 6: $ 110.00	24.06	(218,423.22)	24.22%	9.68%
Year 7: $ 125.00	27.34	(206,240.01)	26.77%	10.70%
Year 8: $ 140.00	30.62	(194,736.35)	29.17%	11.65%
Year 9: $ 155.00	33.91	(183,874.35)	31.43%	12.56%
Year 10: $ 170.00	37.19	(173,618.20)	33.57%	13.42%
Year 11: $ 185.00	40.47	(163,934.13)	35.60%	14.22%



The New York proposal projects much more pronounced reductions because it is a more rigorous tax scheme by design. From the first year, it would apply a cap much higher than any other carbon pricing observed in North America, which increases the margin of error compared to the calculations for VT and MA. The original semi-elasticity derived from the British Columbia tax had a starting price of \$10 CAD/ton CO_2e (approximately \$7.52 USD), and the New York tax has a starting price of \$35 USD/ton CO_2e (Fx Exchange, 2018). I would cite this as a source of error, as it is difficult to predict the effect that a relatively high starting price would have on consumers. The data suggests that NY Bill S.2846 is estimated to be much more effective at achieving the environmental goal of reduced greenhouse gas emissions. According to the most recent New York State Greenhouse Gas Inventory, transportation accounted for 72.08

MMT CO_2e in 2015 (New York State Energy Research and Development Agency, 2018). Over the course of the program, this more rigorous tax would drop to 25.657 MMT CO_2e, which is a 35.6% reduction from that sector. Relative to the state's total greenhouse gas emissions, estimated at 180.39 MMT CO_2e, these calculations project a 14.22% overall reduction due to reduced gasoline consumption (NYSERDA, 2018).

6. Conclusion

Based on the projections, the New York proposal will reduce greenhouse gas emissions and fossil fuel consumption more than other carbon taxes. The Vermont and Massachusetts tax plans would likely follow similar emissions reductions trajectories by the time they reach their caps. Seeing as a carbon tax has yet to be implemented in the United States, it is difficult to predict the accuracy of the estimated tax saliency effects. There is no need for each carbon tax to be structured the same; the appeal of a state-based tax allows each state to specialize and protect aspects of their economy if need be, such as Vermont choosing to exempt farm diesel for agriculture.

There are a number of implications that can be garnered from this research. For the most part, each of the proposals analyzed meets most or all of the three criteria outlined, which makes for a socially equitable environmental tax. There are minor alterations that each could make to become more successful, such as changing the revenue distribution method, or changing the annual price cap.

The more salient a tax is to the people that it is impacting, the more effective the policy is going to be (Varela, 2016). While this represents a qualitative projection of that, it is applied to principles of economic behavior that are generally difficult to predict. If more policymakers were to advocate for high salience when implementing taxes, it may assist in more accurate predictions for revenue distribution, which was not achieved in the early years of the British Columbia tax. If the respective government spends adequate resources on educational outreach, and incentivizing alternatives, it is likely that consumer behavioral changes will be similar to those observed in British Columbia.

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