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Pollution Patrol: An Analysis of Carbon Taxes

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ABSTRACT

In recent decades, climate change has become a central issue of discussion as policymakers scramble to reduce emissions and mitigate one of the most pressing problems in the world. While command-and-control policies have existed for several years, countries are slowly transitioning to market-based policies that rely on incentive structures to reduce carbon emissions. One of the most popular types of market-based policies are carbon taxes, which price carbon emissions at a certain rate in order to encourage firms to reduce their emissions. However, carbon tax policies are not perfect; difficulties in implementation and the inequitable distribution of costs reveal mixed results in the effectiveness of carbon taxes. The purpose of this thesis is to analyze carbon taxes based on their implementation and effectiveness in emission reduction through case studies of Finland and Japan. While Finland experienced more emission reduction than Japan, the country also experienced increased welfare inequality as a result of carbon taxes. Lower-income households in Finland paid a higher percentage of their income towards the carbon tax than higher-income households. Japan's low carbon tax rate hindered emission reduction, but its effect on welfare and inequality is yet to be seen.

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Chapter 1

Introduction

Out of all the fossil fuels available in the world, coal is by far the most abundant. Coal was likely first used between 100 and 200 AD by the Romans in England (Fossil Energy Study Guide, n.d.). However, coal was not used in its full capacity until centuries later in England, when James Watt invented the steam engine. Americans began using coal in weapons factories during the Civil War and coal replaced charcoal in iron-blast furnaces used to make steel. Coal was first used to make electricity in the 1880s and had become the primary source for electricity production in the United States by 1965 (Fossil Energy Study Guide, n.d.).

Other fossil fuels have similar stories. The first discoveries of natural gas were sometime between 6000 and 2000 BCE in Iran, though the first evidence of its documentation was in China around 900 BCE (Carruthers et al., 2021). However, the first commercial use of natural gas was in North America in Fredonia, New York in 1821 (Carruthers et al., 2021). On the other hand, oil was first discovered by ancient civilizations in Italy, China, and Egypt. One of the biggest changes in oil use occurred with the creation of the Pennsylvania Rock Oil Company in 1855 (Burclaff, 2005).

The common thread here is that fossil fuel use increased dramatically with the onset of the Industrial Revolution. But the inventions and economic benefits of the Revolution came with consequences that have led to one of the world’s most pressing issues today: climate change. Anthropogenic climate change from fossil fuel use and resulting greenhouse gas emissions is actively harming the planet and requires immediate solutions. Fossil fuel use is increasing by the day, nearly doubling since the 1980s, as more of the world economy develops (Ritchie and Roser, 2020). Though the use of coal on a global scale is decreasing, the use of and emissions from oil and gas continue to grow (Ritchie and Roser, 2020).

The Intergovernmental Panel on Climate Change, or IPCC, is arguably the most reputable source on climate change. It releases reports about the science, impacts, and policy implications of climate change every six to seven years. Its Sixth Assessment Report, released in 2022, reveals that greenhouse gas emissions increased by an average of 1.3% annually between 2010 and 2019 (Climate Change, 2022). In the data since 1970, the absolute increase in average annual emissions of greenhouse gases globally was highest in the same time period. The data on increasing emissions raises questions about possible solutions to address the problem.

Debates and discussions about which policies are most effective in reducing emissions without hindering economic growth have occurred for decades. The intersection of the environment, economics, and politics makes such policy decisions extremely difficult. Which policies are best at reducing emissions? Will these policies cause economic inequality or reduction in welfare? What does it take to implement such a policy and to ensure its effectiveness in the long run? Any locality, country, or region that wishes to implement a policy regarding emission reduction needs to consider each of these questions carefully and assess the costs and benefits of the policy.

There are two main strategies employed by countries addressing greenhouse gas emissions and climate change: command-and-control or market-based solutions. Command-and-control solutions involve the strict regulation of technologies implemented by firms and households to reduce the effects of emissions. On the other hand, market-based solutions attempt to reduce emissions by creating incentives for firms to reduce their emissions by choice. Carbon pricing is a market-based solution where the price placed on carbon makes it more expensive for firms to emit carbon dioxide and other greenhouse gases than to abate emissions.

The two key types of carbon pricing are cap-and-trade systems, where firms buy permits that allow them to emit greenhouse gases, and carbon taxes. Both have gained popularity over the last few decades, especially carbon taxes, as they allow firms to have freedom over their choices while encouraging emission reduction. But the effectiveness of carbon pricing is up for debate. The environmental effectiveness of carbon taxes, specifically, is mixed. Within Western European countries, Finland has experienced significant impacts from its carbon tax policy while Denmark and the Netherlands have not experienced the same (Climate Change, 2022). In other countries around the world, the carbon tax rates are too low to see significant differences in emission levels. In addition, many studies do not consider the social and economic impacts of carbon taxes, which adds flaws to the evaluation of the effectiveness of carbon taxes.

This thesis will discuss how carbon taxes are implemented in different countries and their effectiveness in reducing greenhouse gas emissions, specifically those of carbon dioxide, and in reducing inequality on a national level. Chapter 2 will explain the immediate need to reduce greenhouse gas emissions through an environmental analysis of the effects of emissions on the health of the planet. Chapter 3 will address the potential solutions that have been proposed and implemented to reduce emissions in different scenarios, along with a brief overview of their effectiveness. Chapter 4 will discuss the specific criteria used to analyze carbon taxes and provide a detailed background on carbon taxes and the theory behind them. Chapters 5 and 6 will explore carbon tax policies implemented in Finland and Japan, respectively. These case studies will include an analysis of the implementation and effects of the carbon tax in each scenario.

Finally, Chapter 7 will conclude with a discussion of the theories and case studies about carbon taxes and address further opportunities for research and analysis.

Chapter 2

Environmental Issues and the Need for Emission Reduction

Before attempting to understand the effects of carbon emissions on the environment, it is important to establish an understanding of how environmental damage on the planet is measured and how it impacts the assessment of different policies. This chapter will begin with a discussion on the measurement of environmental damage before addressing the impacts of carbon emissions on the environment.

Measurement of Environmental Damage

The measurement of environmental damage involves the consideration of ecosystem services. Ecosystem services are benefits provided by the environment to the human population (Ecosystem Services, n.d.). The four major types of ecosystem services are provisioning, regulating, cultural, and supporting services. While provisioning services involve benefits that can be directly extracted from nature, such as crops and livestock, regulating services are those processes which help improve the health of the preexisting environment regardless of human consumption of the service (Ecosystem Services, n.d.). Cultural services include the role of nature in global cultures and on the human mind. Finally, supporting services are those which allow life forms to exist on Earth, such as photosynthesis, the water cycle, and nutrient cycling (Ecosystem Services, n.d.).

Note that the damage caused by carbon dioxide emissions into the atmosphere is exponential. The damage caused by each additional ton of carbon dioxide, or marginal damage, increases as the total amount of carbon dioxide in the atmosphere increases (Mohan and Muller, 2020). Though slowly reducing emissions will help with the current trajectory of the atmosphere and the planet, each additional unit of emission is causing more damage to the atmosphere than the one before it.

There are two key methods to determining the value of environmental damage, caused by emissions, to ecosystems: ecological footprints and monetary valuation. Both of these measurements will play key roles in effective carbon dioxide emission reduction. Ecological footprints are a common and effective strategy in calculating the amount of environmental damage caused by individuals and populations. Generally, ecological footprints are expressed in square meters by calculating the area required to generate the resources consumed and dispose of the waste generated by an individual or group (CSUSM, n.d.). Therefore, a larger area would imply a greater ecological footprint and more damage to the environment.

Carbon footprints, specifically, are a measurement of the impacts of a variety of different greenhouse gases on the atmosphere. While it is possible to measure the amount of carbon dioxide emission alone, other greenhouse gases also contribute to the warming of Earth. Carbon dioxide equivalent, or CO_2e, is the most common method of measuring the impacts of different greenhouse gases on the planet. Because these measurements are conducted in terms of carbon dioxide, the impact of greenhouse gases on the planet is known as a “carbon footprint” (Kaper, 2013). Measuring the impacts of different greenhouse gases in CO_2e, including carbon dioxide itself, allows for the measurement of several different gases combined.

The biggest issue with measuring carbon footprints is the large amount of uncertainty regarding the amount of greenhouse gas emissions that come from a specific source. The creation of a product involves a series of variables ranging from production, shipping, and technology needed for the product, all of which influence its carbon footprint (Weber, 2010).

Accurately calculating the value of the carbon footprint at each level is difficult because of the number of variables involved. To avoid this problem, analysts often use monetary valuation in calculating environmental damage.

The second, most common method of measuring environmental damage is by assigning monetary values to the benefits of the environment. This is often calculated by assessing consumers' willingness to pay for a certain project to curb the environmental damage it will cause (Johansson, 1990). Monetary valuation could also be completed through an assessment of the minimum amount of monetary compensation an individual or group needs to be paid in order to reject the implementation of the damage-causing project (Johansson, 1990).

The benefits of monetary valuation of ecosystem services, however, are highly debated. On one hand, the utilitarian perspectives state that monetary valuation and market strategies should be a central strategy to addressing environmental damage because they allow for the quantification of environmental values. However, many conservationists strongly reject this argument because of the inability to properly estimate the monetary value of environmental services, stating that these values will almost always be underestimated (Gómez-Baggethun and Ruiz-Pérez, 2011). It is almost impossible, according to conservationists who subscribe to this way of thinking, to correctly estimate the value of an ecosystem service because of the positive feedback loops within the environment. Each ecosystem service harmed causes harm to other ecosystem services and calculating these effects will never match the actual amount of damage caused because of the number of variables involved in the calculation. There is a subset of conservationists, however, who believe that monetary valuation can exist as a short-term and transitory policy choice for environmental protection.

Neoliberalism, which emerged and was embedded into international policy in the 1980s, has played a significant role in encouraging the monetary valuation of environmental damage (Gómez-Baggethun and Ruiz-Pérez, 2011). The idea of neoliberalism includes privatization, less government intervention in economic matters, and market valuation for non-monetary issues. Governing practices which attempted to reconcile economic growth with conservation became increasingly common, along with the commodification of ecosystem services and environmental damage (Gómez-Baggethun and Ruiz-Pérez, 2011). Monetary valuation of the environment, when used alongside other methods of valuation of environmental damage, can be extremely useful in improving the environment. Carbon taxes are one form of such monetary valuation, placing a price on an environmentally-damaging factor. A carbon price is often notated as dollars per tonne of carbon dioxide emitted, or $/t-Co2. This notation will be used throughout the rest of this paper.

Damage from Carbon Emissions

Climate Change

Climate change has been directly linked with carbon emissions into the atmosphere. The burning of fossil fuels is the primary driver of carbon emissions due to the greenhouse effect (Lindsey, 2021). Greenhouse gases, like carbon dioxide, methane, or nitrous oxide, are those absorbing heat radiated by the Earth’s land and ocean surfaces in the form of thermal infrared energy. Greenhouse gases are beneficial in limited levels because they prevent the temperature of the Earth from getting too low. However, the burning of fossil fuels increases the concentration of greenhouse gases in the atmosphere, specifically carbon dioxide, and causes irreversible change to the contents of the atmosphere (Solomon et al., 2009).

Though carbon dioxide is the least potent of the greenhouse gases, it is the most abundant and stays in the atmosphere longer than other greenhouse gases. According to Lindsey (2021), two-thirds of the energy imbalance which causes the rising temperature of Earth can be attributed to increases in atmospheric carbon dioxide. Other major greenhouse gases such as methane and nitrous oxide absorb significantly more heat than carbon dioxide, but they do not persist as long in the atmosphere (Solomon et al., 2009).

The connection between climate change and carbon dioxide signifies a clear need for carbon emission reductions and policies. The goal of the Paris Climate Accord is to keep Earth's temperature from rising by 1.5℃ or more in the future, and this will require stringent policies that effectively reduce carbon dioxide emissions. A key part of creating these policies is the process of measuring environmental damage, both in terms of emissions and the monetary damage that results from them.

The Oceans

Carbon emissions can be extremely damaging to oceans due to two key impacts: the rise of sea levels and ocean acidification. The two main reasons for sea level rise include expansion of water molecules due to heat and the melting of glaciers and ice sheets, both of which are linked to the increasing temperature of Earth (Solomon et al., 2009). As the temperature rises, water molecules expand to consume larger areas. Even if the world suddenly ends all carbon emissions, heat from prior emissions into the atmosphere continues to mix with the ocean and cause rising sea levels. The melting of glaciers, ice sheets, and permafrost on the planet further increases the overall volume of oceans.

The second effect, ocean acidification, is related directly to carbon emissions. When carbon dioxide is absorbed by the ocean, it reacts with water molecules to produce carbonic acid and lower the pH value of the ocean. Since the Industrial Revolution, the pH value of oceans has reduced from 8.21 to 8.10 (Lindsey, 2021). Though this metric seems small in number, a 0.1 unit change in pH indicates a 30% increase in acidity. A significant portion of marine life is dependent on extraction of calcium from the ocean to build shells and skeletons. The acidification of oceans causes significant damage to these shells.

Pteropods, also known as sea butterflies, are currently experiencing the effects of ocean acidification, especially in the Southern Ocean encircling Antarctica. These tiny sea snails provide food for organisms like krill and whales. When pteropods were placed in treated water with carbonate levels equal to those predicted for 2021, their shells dissolved in 45 days. Because of their susceptibility to acidification, pteropods are frequently used as indicators of ocean acidification (Acidification Impedes Shell Development, 2021).

Figure 1: Healthy pteropod (left) versus damaged pteropod (right) (Acidification Impedes Shell Development, 2021).

Coral reefs are also experiencing significant amounts of damage due to rising sea levels and ocean acidification. Currently, more than 500 million people around the world rely on coral reefs for food, income, and protection against storm surges and waves (Acidification Impedes Shell Development, 2019). Reefs provide jobs to local communities through tourism and offer opportunities for recreation. Fishing, snorkeling, and diving create hundreds of millions of dollars for local businesses (Coral Reef Ecosystems 2019).

The effects of carbon emissions on climate change also include increasing severe weather events such as storms and hurricanes, which can destroy coral reefs. If coral reefs cannot keep up with rising sea levels and increasing extreme weather events, around 200 million people in coastal communities could be displaced due to the lack of protection against ocean currents (Global Threats to Coral Reefs, n.d.).

Ocean acidification plays a key role in the destruction of coral reefs. Acidification weakens the skeletons of corals and, as a result, makes them more vulnerable to disease and destruction by storms (Global Threats to Coral Reefs, n.d.). High levels of carbon dioxide in oceans also decreases the productivity of corals and increases their risk of bleaching by 50% (Global Threats to Coral Reefs, n.d.).

Figure 2: A healthy (left) versus unhealthy, bleached portion (right) of the Great Barrier Reef (Grace, n.d.).

The Atmosphere and Air Pollution

Climate change resulting from carbon emissions increases the production of allergenic air pollutants like mold and pollen (Mackenzie and Turrentine, 2021). The increased frequency and intensity of storms and flooding from climate change create humidity, which allows mold to thrive. Meanwhile, the changing climate often results in a longer pollen season, therefore increasing its production (Mackenzie and Turrentine, 2021). Smog, a mixture of smoke and fog, is also worsened by the increased heat due to warmer weather and higher levels of ultraviolet radiation. Smog is essentially ground-level ozone which occurs when emissions from fossil fuels react with sunlight (Mackenzie and Turrentine, 2021). Smog is known to irritate the eyes and throat and can cause significant damage to the lungs.

Carbon emissions and climate change also increase the presence of soot, a type of particulate matter, in the atmosphere. Small particles like chemicals, soil, smoke, dust, and allergens can exist in the atmosphere as soot in gaseous or solid form. The source of both soot and smog is emissions from combustible fuels, specifically coal, oil, and natural gas, in cars, factories, power plants, incinerators, and engines (Mackenzie and Turrentine, 2021). All of these factors are either directly or indirectly related to carbon emissions into the atmosphere.

Given the effects of greenhouse gas emissions into the atmosphere, the necessity to implement policies to reduce emissions becomes increasingly urgent. Several nations have tried to reduce emissions through policy changes, but some policies have proven to be more effective than others. Specifically, command-and-control policies have decreased in popularity as market-based policies have begun to replace them because of their incentive-based structure. The details of these types of policies are discussed in the following chapter.

Chapter 3

Proposed Solutions

The two most frequently utilized types of solutions to carbon emission reduction and, as a result, climate change mitigation have been command-and-control policies and market-based policies. This chapter will provide a brief background on each and address the various subtypes of market-based policies.

Command-and-Control

Command-and-control policies rely on strict regulation in the form of permission, prohibition, and universal standards for technology designed to reduce carbon emissions (Glossary of Statistical Terms, 2001). These policies are not based on incentive structures; instead, they rely on government enforcement of rules and regulations. Examples of command-and-control policies that have been enforced in the past to improve the environment include limits on deforestation, maximum allowed pollution, and technological requirements on vehicles to reduce pollution (Elazegui, 2002). There are three key types of environmental quality standards which make up command-and-control policies: ambient, emission, and technology (Elazegui, 2002).

Ambient standards and emission standards both operate on a “never exceed” principle, limiting the amount of pollutants released into an environment (Elazegui, 2002). Ambient standards are those which are placed on a specific environment to maintain the health of that environment. For example, an ambient standard may define the maximum amount of pollution a river can have at any given time to maintain its proper functioning. Meanwhile, emission standards determine the overall level of pollution permitted by firms in a given region (Hamilton and Requate, 2010). Finally, technological standards are those which specify the technologies and practices to which firms have to adhere through engineering, input and output standards, and others (Elazegui, 2002). Though the purpose of each of these policies is to improve the environment, the results are mixed.

Command-and-control policies which limit resource use or pollution are generally effective in the beginning phases of their development and implementation. In response, resource management agencies begin to emphasize efficiency of control instead of continuing to research and monitor the problem (Holling and Meffe, 1996). Instead of being able to adjust to changes in the environment and the environment's response to the policy, the structure of the agencies becomes rigid and nearsighted. At the same time, society becomes increasingly dependent on command-and-control policies because the technologies and standards being maintained hinder society's ability to shift from one technology to the other or to adjust to new standards. Both of these issues, combined, create a need for even more command-and-control policies, and the cycle continues (Holling and Meffe, 1996).

Command-and-control policies have historically been difficult to implement because of the diversity of industries and industrial processes that exist in countries. Regulatory agencies need to write detailed and complex policies to address the legal challenges of applying command-and-control policies to different industries (Harrington and Morgenstern, 2004). Implementation of these overarching policies on different types of industries is also extremely difficult.

Several other explanations also highlight the failure of command-and-control policies in the long term. Li et al. (2018) state that command-and-control policies have high costs and low flexibility levels which make the policies inherently inferior to and less efficient than market-based policies. The high costs of implementing such policies stem from asymmetry of information between firms and the government. The firm may be more knowledgeable about its level of pollution than the government, thereby decreasing the government's ability to implement effective requirements for technology. Command-and-control also fails to consider differences in costs between firms as smaller firms will likely have to spend higher proportions of their income to meet the requirements of the policy (Li et al., 2018).

The effectiveness of command-and-control strategies is mixed within industries. A study of several paper mills between 1979 and 1990 revealed that some mills have a much more difficult experience in changing their production process (Gray and Shadbegian, 2003). As a result, command-and-control policies which instituted technological requirements on these plants had different effects on different plants with different existing technology. Though neither of these results are surprising, both exemplify why command-and-control policies are often unsuccessful. Because of these reasons, command-and-control has lost favor in much of the world.

Despite these shortcomings, command-and-control policies remain some of the most commonly used policies in the developing world (Li et al., 2018). The study, which explains the effect of command-and-control policies in China between 2004 and 2016, found that command-and-control policies have a statistically significant adverse effect in the Eastern region of China, a significant positive effect in the West, and an insignificant effect in central regions of the country (Li et al., 2018). India currently has the most effective command-and-control legislation on emissions by requiring catalytic converters in vehicles (Li et al., 2018).

One of the most significant reasons why these policies are still in play in the developing world is because developing nations often lack the capacity to monitor and enforce market-based policies. Credible information can be difficult to find and self-reporting firms will likely be the ones with the highest environmental standards, creating a response bias. Given these flaws in command-and-control policies, the world is slowly transitioning to support market-based policies.

Market-Based Policies

Market-based policies to address climate change through emissions reduction include subsidies and carbon pricing initiatives. Emission trading systems (ETS), also known as cap-and-trade systems, and carbon taxes are examples of carbon pricing. Often, market-based policies are implemented in combination with others in order to increase the amount of emission reduction overall. The extent to which each of these policies is implemented can vary greatly.

Subsidies

Subsidies are a form of market-based incentives in which firms that reduce pollution are monetarily compensated by the government for their costs of pollution abatement. Though subsidies are often used in conjunction with other market-based policies like carbon taxes, they have been used as standalone solutions to emissions reduction for decades. Subsidies function as an important part of a firm’s resources which, in turn, enhance the firm’s competitive advantage in their market (Ren et al., 2021). Subsidies provide firms with compensation for the cost of upgrading and adopting new technology to reduce emissions. They also increase a firm's legitimacy and reputation by allowing them to adopt new technologies (Ren et al., 2021).

China, since the 1980s, has passed several policies that are based on subsidies to promote conservation and emission reduction. However, though environmental subsidies from the Chinese government have boosted firms' environmental management skills and innovation, they have not had a statistically significant effect on technological innovation that may be even more effective at emissions reduction (Ren et al., 2021). Issues with these subsidies included the inability of the Chinese government to assess which firms needed subsidies and the misuse of subsidies for purposes other than environmental benefit (Ren et al., 2021). In essence, subsidies have tried, in the past, to help firms create new technologies, but their effects on technological development are unclear. Nevertheless, the creation of new technologies is different from the adoption of preexisting, "greener" technology. Subsidies have still been successful in helping environmentally conscious firms adopt renewable energy sources.

Subsidies seem to be more effective at encouraging environmentally conscious firms to become more eco-friendly than at reducing emissions from firms in general. If the subsidy does not cover the total cost of renewable energy, firms that are not concerned about the environment will likely avoid adopting the necessary technologies for renewable energy. In theory, a better way to reduce greenhouse gas emissions is through carbon pricing.

Carbon Pricing

The main principle behind carbon pricing is to pay for externalities which, in this case, happen to be the cost of pollution exerted on communities as a whole. The costs are moved from those who experience the negative effects of pollution to the polluters themselves, allowing polluters to decide whether to pay for their externalities (emissions) or to abate pollution (Pricing Carbon, n.d.). The basic logic behind carbon pricing is that it will be cheaper for firms to abate pollution than to pay a tax for or permits for emissions. The price of emissions, whether through carbon taxes or through emission trading systems, should be determined by emission targets.

Currently, carbon pricing initiatives cover about 8 gigatons of emissions annually around the world. This is equal to 20% of fossil fuel emissions and 15% of total carbon dioxide-equivalent greenhouse gas emissions (Boyce, 2018). Prices on carbon in 2017 ranged from less than $1 per megatonne to $140 per megatonne. However, most of the prices on carbon around the world are significantly below the recommended levels to reduce climate change (Boyce, 2018). Prices on carbon need to be high enough to cover the social costs of emission, which include climate damages, catastrophic risks and discount rates. The International Monetary Fund (IMF) recommends a carbon tax level of between $35/t-Co2 and $70/t-Co2 by 2030 in order to keep climate change from increasing the Earth's temperature by two degrees Celsius (Parry, 2021).

Carbon prices are beneficial to society in addition to simply the impact of mitigation because they provide a source of revenue to national governments and can aid long-term investors by allowing them to allocate capital toward low-carbon and climate-resilient firms and activities (Pricing Carbon, n.d.). However, one of the biggest issues with carbon pricing as a whole is that of equitable distribution. Upper-income households tend to emit more carbon dioxide, meaning that they will pay a higher amount overall. But middle and lower-income households will likely pay more for their emissions relative to their household income and expenditure (Boyce, 2018). A successful carbon price, as a result, would take the inequality in expenditure into consideration and adjust tax rates based on income level, or create a policy that taxes firms rather than individual households, to reduce the negative effect of the price.

Cap-and-trade

A cap-and-trade policy, or ETS, provides certainty about future levels of emissions without providing information about the price of those emissions. If a state has a specific emissions target to meet, distributing limited permits for carbon emissions is an effective strategy in climate change mitigation (Cap-and-trade Basics, 2021). Companies can buy and sell carbon permits as they see fit, and this exchange of permits defines the market price of the permits. Many cap-and-trade programs around the world have been modeled after the Acid Rain Program in the United States, where the Environmental Protection Agency set caps on the total amount of sulfur dioxide emitted into the atmosphere by electric generating units (Acid Rain Program, 2014). Between its implementation in 1995 and 2010, the program slowly lowered the cap on emissions to increase emission reduction. As of 2020, sulfur dioxide emissions were 95% below their emission levels in 1990 because of the Acid Rain Program (Acid Rain Program, n.d.).

Cap-and-trade systems for carbon emissions have existed in the world for years, implemented in European countries since 2005, Chinese provinces and cities since 2013, and Mexico since 2020 (Cap-and-trade Basics, 2021). In 2009, several states in the United States instituted the Regional Greenhouse Gas Initiative (RGGI), designed to implement a cap-and-trade program for carbon emission mitigation. This program is still promoted throughout the country today.

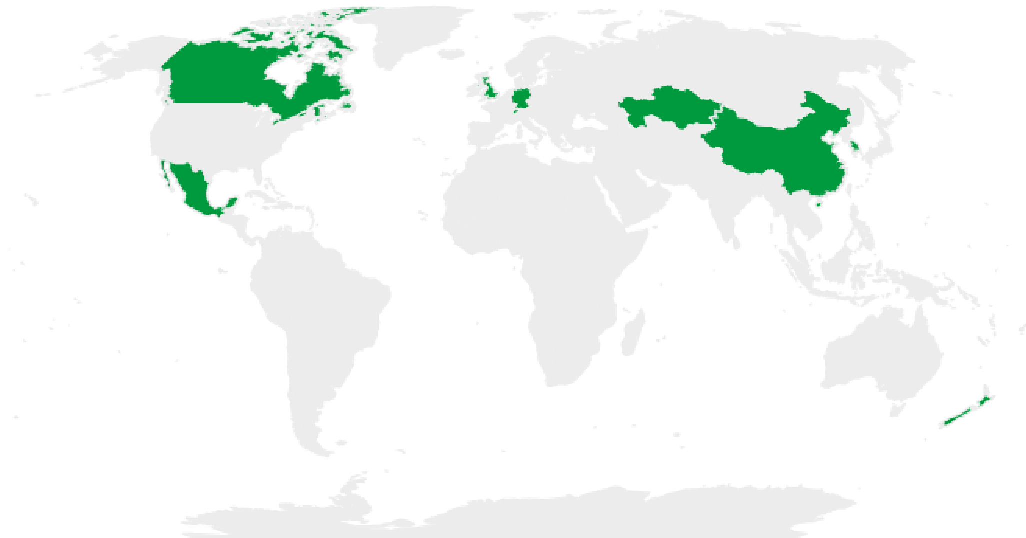

Figure 3: A map of all countries where an emissions trading system has been implemented on a national level in 2021 (Carbon Pricing Dashboard, n.d.).

Several considerations are necessary when a government is attempting to institute a cap-and-trade system to mitigate carbon emissions. The scope and target for emissions are two of these considerations. The policy needs to define which greenhouse gas emissions to include as well as where the limit on emissions should be, and whether these should change over time (Cap-and-trade Basics, n.d.). Along with deciding the price at which permits will be sold to firms, the government also needs to decide whether ETS alone is enough to significantly reduce emissions.

Other considerations include whether banking and saving permits for the future or borrowing "future" permits will be allowed. One of the most significant of these considerations, however, is the ability for the government to prevent market manipulation by companies through transaction tracking and market oversight. Only when the terms for these conditions of cap-and-trade systems are explicitly defined can such a system be effective.

Carbon Taxes

The second type of carbon pricing, a carbon tax, will be the focus of this thesis. Carbon taxes are fees placed on the combustion of fossil fuels for energy. Most commonly, these fuels include coal, oil, and natural gas. Unlike a cap-and-trade system, carbon taxes do not provide certainty in the amount of emissions that would be reduced, but they set a specific price on carbon emissions. Carbon taxes act as a monetary disincentive which makes it economically rewarding to move towards energy efficiency (What's a Carbon Tax, n.d.).

Carbon taxes can either be implemented "downstream" where the emissions occur or "upstream" where the resources are extracted and used for fuel. Generally, the tax is placed upstream to make calculating the amount of emissions easier. The firm can displace the cost downstream to consumers of energy (What's a Carbon Tax, n.d.). So far, there have been 35 carbon tax programs in the world, the first of which was in Finland in 1990. In 2006, the government of Boulder, Colorado implemented the first carbon tax in a city in the United States (Carbon Tax Basics, 2021).

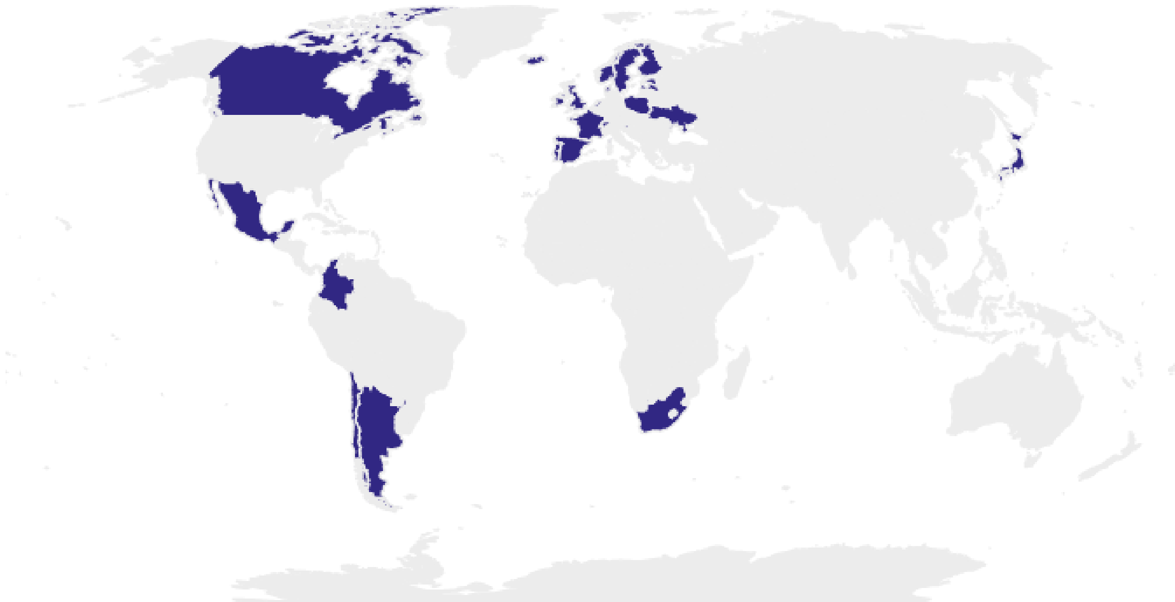

Figure 4: A map of all countries where a carbon tax policy has been implemented on a national level in 2021 (Carbon Pricing Dashboard, n.d.).

Much like cap-and-trade policies, a major consideration when implementing carbon taxes is whether the tax will cover only carbon emissions or whether it will include other greenhouse gas emissions. The next decision would be the point at which carbon is taxed, whether that is upstream or downstream. One of the biggest issues with carbon taxes, however, is the fact that lower-income households will likely end up paying a higher proportion of their income because of their emissions than higher-income households (Carbon Tax Basics, n.d.). In addition, placing a tax on firms in one country can decrease their absolute and/or comparative advantage in the international market for their product. The final choice made by the government would be about the use of revenue generated by carbon taxes, whether that is to subsidize green technology or for another purpose entirely.

The use of carbon taxes has been increasing over the last few decades, with Finland implementing the very first carbon tax in 1990. However, theories behind carbon taxes developed decades prior to Finland's implementation. The "Pigouvian" tax, as described in the following chapter, applied to firms' externalities and was primarily focused on ways to price those externalities. Its implementation for carbon emissions, specifically, followed as one method to mitigate climate change, especially as the urgency of and knowledge about climate change increased globally.

Chapter 4

Carbon Taxes: Background

Because of the growing global support for carbon taxes, I have chosen to analyze carbon taxes as the primary method of carbon emission mitigation on a national level. Carbon taxes are quickly gaining popularity around the world as an effective way to mitigate climate change. The BBC World Service polled over 30,000 people in 31 different countries in June and July 2021. Results showed that 62% of people support carbon taxes, while 33% opposed them (New Global Poll, n.d.). In 28 of the 31 countries surveyed, the majority of people supported taxing climate change-inducing energy sources. The only two countries with significant opposition were Germany, with 52% of respondents opposing the tax, and Saudi Arabia, with 50% opposition (New Global Poll, n.d.). In 17 countries tracked since 2007, support for a carbon tax remained stable from 2007 to 2015 but increased to 62% by 2021. China was the most supportive of implementing a carbon tax policy (New Global Poll, n.d.).

Local, national, and international organizations have also been showing increasing support for carbon taxes. Organizations like Citizens' Climate Lobby, the United States Climate Task Force, Earth Policy Institute, and Institute for Policy Studies represent some of these organizations (Other Organizations Supporting Carbon Taxes, n.d.). Bipartisan support for carbon taxes is evident from the support from the Progressive Democrats of America and the Republican Leadership Network (Other Organizations Supporting Carbon Taxes, n.d.). 25 countries currently have some version of a national carbon tax implemented (Carbon Pricing Dashboard, n.d.). Given the growing global support for carbon taxes, the importance of studying carbon taxes becomes increasingly relevant.

This chapter, as mentioned in the Introduction, will discuss the theories behind carbon taxes and their implementation. The theories will then be applied to the carbon tax policies in Finland and Japan. Finland was the first country to adopt a federal carbon tax in 1990, meaning that the decisions made in Finland were primarily based on prior experience with environmental taxes and Pigouvian theory. Because of the experimental nature of the first carbon tax implemented, Finland was chosen as one of the two case studies in this paper.

The second country chosen for analysis is Japan for a couple of reasons. The first is that following the implementation of a carbon tax in Finland and other European countries, the Japanese began formulating plans for a carbon tax in 1995. However, it took decades for the Japanese government and its ministries to decide on a carbon tax. In 2012, Japan became the first Asian country to institute a carbon tax, basing its model on those implemented in Europe. That being said, key differences between the tax in Japan and in Finland stem from differences in politics and culture and result in different effects and levels of effectiveness.

Each of the case studies is divided into three sections: carbon tax policies and their evolution, implementation, and effects. The first of these sections will address the specifics of each country's carbon tax and its tax rates. The second section will address how the key aspects of implementation, which include political trust and corruption perception and preexisting world views, have influenced the formation of carbon tax policies in Finland and Japan. Finally, each chapter will analyze the effects of the carbon tax policy in each country, primarily based on emission reduction and impacts on economic inequality and revenue loss.

Theory

The idea of reducing the cost of externalities created by pollution was first proposed by Arthur Cecil Pigou in the *Economics of Welfare* in 1920. Pigou's theory was based on the example of a railroad built through a forest. The issue, according to Pigou, was that the railroad owner would cut down much of the forest area surrounding the railroad in order to maximize their profit. He had two solutions to address the resulting deforestation: either have the railroad owner compensate the landowner or levy a tax on the railroad owner (Keohane and Olmstead, 2007). At this time, however, Pigou was not addressing climate change as a key issue; his motivation was primarily based on taxation policy. This tax on the producer of externalities is often referred to as a Pigouvian tax.

The counterpoint to Pigou's revolutionary theory was developed by British economist Ronald Harry Coase in 1960. Coase's argument was that government intervention in the market through taxes creates market inefficiencies because of its high costs and that allocation of property rights, along with bargaining power among firms, would be a better solution than a Pigouvian tax (Keohane and Olmstead, 2007). However, issues with the Coase Theorem, as it came to be known, include the high costs of bargaining and the need for law enforcement to enforce deals among actors. The collective action problem in bargaining among large groups of people or communities adds to the difficulty in enforcing such policies (Keohane and Olmstead, 2007).

Pigouvian taxes are currently employed as carbon taxes in the context of increasing climate change. The idea behind the tax is to set the tax level equal to the social marginal cost of pollution, which, in simpler terms, is the cost of the environmental and social damage caused by pollution.

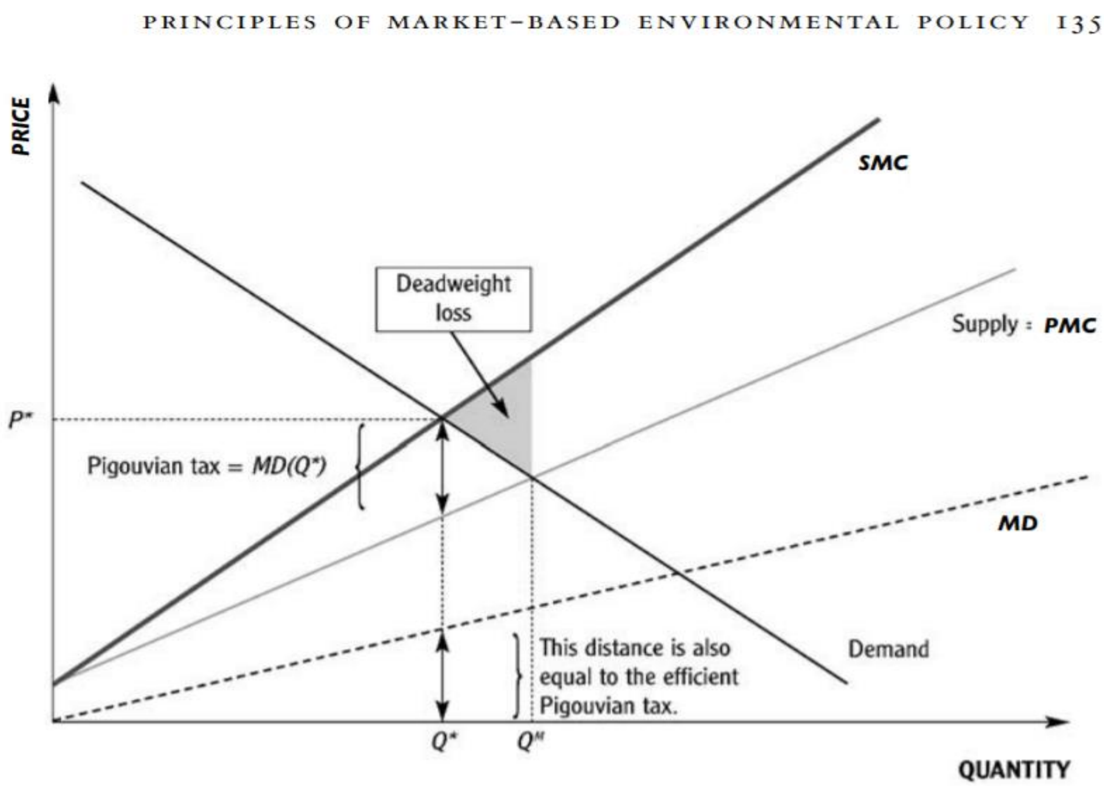

Figure 5: Graphical representation of Pigouvian taxes (Keohane and Olmstead, 2007).

Here, the private marginal cost (PMC) is simply the supply of goods or services in the market. However, when externalities are added to the PMC, the total becomes the social marginal cost (SMC) in the market. The optimal and socially efficient level of tax is indicated as the difference between the PMC and SMC at a given production quantity (Keohane and Olmstead, 2007). If the Pigouvian tax, as indicated by the graph above, is set at a level equal to this difference, no other government intervention is necessary because all externalities have been considered. The exclusion of social costs from a supply curve that only accounts for private costs creates a deadweight loss in the market and the Pigouvian tax corrects for this market failure (Keohane and Olmstead, 2007).

In order to raise revenues, in cases that do not include externalities, taxes are generally considered distortionary because they drive a wedge between supply and demand by interfering with smooth market operations. However, with externalities at play, Pigouvian taxes are correctional as they make up for the absence of government intervention (Keohane and Olmstead, 2007). Pigouvian taxes are most often used to address issues regarding public goods like clean air and water.

The implementation and success of a carbon pricing policy, specifically a carbon tax, is dependent on a variety of factors. Carbon taxes can often be unappealing to the public and to firms because they raise the price of energy and energy use overall by setting a tax on emissions or fuel. Regardless of whether the tax is placed upstream or downstream in the production chain, without renewable energy sources, carbon taxes can increase production costs and living expenses. As a result, trust in the government can improve the public's perception of the benefits that would come from a carbon tax. Low levels of political trust and high levels of corruption perception are associated with higher amounts of greenhouse gas emissions along with weaker policies to mitigate climate change (Funke and Mattauch, 2018).

Another factor influencing the success of carbon policies and public support for the same is how benefits and costs are distributed among the population. Though an even distribution of both costs and benefits may seem like the best way to ensure support, imbalances in power amongst different groups and constituencies can reduce the likelihood that a policy is passed. As a result, the most effective policies will have costs diffused among different groups and benefits concentrated on groups which are more likely to support the policy (Funke and Mattauch, 2018).

Political, economic, and cultural world views also play a key role in ensuring the success of a carbon tax. The most well-supported policies will align with the public's cultural understanding of the world, while policies that contradict the public's underlying predispositions can result in solution aversion (Funke and Mattauch, 2018). The labeling of a carbon tax is related to the perception of a carbon tax as well. Calling the policy a carbon tax may be less effective in implementation and support than calling it a “fee and dividend” policy or a “CO2 levy,” as it is known in Switzerland and Alberta (Funke and Mattauch, 2018).

Finally, the salience and visibility of the benefits from the policy plays a key role in its acceptability. The more explicit the benefits of the carbon tax, the more likely they are to support the policy (Funke and Mattauch, 2018). The “obviousness” of benefits goes hand in hand with public trust in the government and perceptions of corruption. Trust in the government often stems from a level of transparency. A highly-trusted and transparent government will likely result in clearer visibility of the effects of a policy. With low trust in the government, the public may not believe the benefits of a carbon tax as presented by the government and may be unlikely to support the policy.

Both Finland and Japan, the two case studies for this thesis, have implemented a combination of ETS and carbon taxes. Finland’s ETS exists as part of the European Union’s regional ETS, while Japan implemented its cap-and-trade system in 2010. However, for the purposes of this thesis, the primary focus will remain on the implementation process and effects of the carbon tax specifically.

Chapter 5

Finland

Tax Rates and Evolution

In 1990, Finland became the first nation in the world to institute a carbon tax. The tax introduced was set at a value equivalent to €1.12/t-Co2 ($1.41) in 2015. The tax was based on the carbon content of the fossil fuel being burned (Nachmany et al., 2015). Finland had a previously existing excise tax on fossil fuels used for transportation and heating (Bavbek, 2016). The carbon tax which followed was instituted as a component of this excise tax. The carbon tax was solely based on the carbon content of the fossil fuel being used (Sumner et al., 2009).

The initial carbon tax included exemptions for the peat, natural gas, and the wood industry to maintain its comparative advantage in the international market. Other exempted fuels included any fuels which were used as raw materials or inputs for manufacturing. The policy taxed all other sources of fuel. Though the carbon tax was intended to decrease emissions, its effectiveness was limited because of these exemptions. Over time, the Finnish government increased the carbon tax rate and amended its policies in order to further reduce carbon emissions.

Finland's carbon tax underwent several changes within the first decade of its institution. Until 1994, the carbon tax remained based on the carbon content of the fuel being burned. In 1994, the tax changed to include both the carbon content and energy contents of the fuel in a 60/40 relative weight ratio (Hoerner and Bosquet, 2001). At this point, Finland's carbon tax was still in a somewhat experimental phase, where frequent changes were made to policies to figure out which versions were most effective in reducing emissions while maintaining a growing economy. The tax based on carbon content was FIM 22.10/t-Co2 while the tax based on energy content was FIM 2.10 per megawatt hour, or FIM 2.10/MWh (Finland's National Report, 1995). However, Finland was primarily dependent on coal as a source of electricity at the time. This meant that the energy component of the tax, which included the tax on coal for electricity generation, needed to be amended in order to make electricity more affordable for the general population. In 1997, the tax reverted back to being solely based on carbon contents for all fuel use except electricity generation, likely because of the high price of electricity. (Hoerner and Bosquet, 2001).

In order to compensate for the harm that the domestic coal industry was experiencing due to the high carbon tax rates, the Finnish government wanted to start taxing imported electricity. For context, in 2016, around 17% of Finland's total electricity consumption was imported, mostly from Sweden and Russia (Maljanen, 2019). However, being part of the European Union prevented the government from being able to institute such a tariff because EU policies prohibit taxes on member states that differ from the state's own production of the good or service being taxed. As a result, the government decided to change the carbon tax so that it was levied on the amount of electricity used, rather than the carbon content of the fuel used to produce electricity (Hoerner and Bosquet, 2001).

Finland reduced carbon tax rates for commercial uses of electricity in 1997, most likely to make electricity more affordable, maintain international competitive advantages, and ensure economic growth. The amendment allowed the mining, manufacturing, and greenhouse cultivation sectors of the economy to pay 54% of the tax rates paid by other sectors like households, services, agriculture, and others (Hoerner and Bosquet, 2001). The 1997 reform also allowed for the complete waiving of taxes if wood or wood-based fuels, wind, or waste gases were the source of electricity, primarily to keep electricity prices low. In 2001, these reduced rates for specific sectors increased from the previous 54% to 61% of the general tax rate (Hoerner and Bosquet, 2001).

Also in 1997, the Finnish government decided to implement a system of tax-shifting packages, where it would reduce personal income taxes and employers' social security contributions in order to offset the costs of the carbon tax and other environmental taxes, namely the landfill tax. Nevertheless, the carbon and landfill tax rates were not high enough to compensate for all the government revenue lost from reductions in the tax rates in 1997 (Hoerner and Bosquet, 2001). The hope was that the generation of additional employment in the future would cover the gap.

Carbon tax rates in Finland have been on the rise since the implementation of the policy despite changes in the structure of the policy itself. The carbon tax is centered around the transportation sector of the economy. The tax levels in 2008 rose to €20/t-Co2 (Ghazouani et al., 2020). The next dramatic increase in Finland's carbon tax rate occurred in 2011. By 2013, the tax on carbon and energy combined was set at €18.05/t-Co2 ($22.65 at the time) and €66.20 ($83.10 at the time) per tonne of carbon (Nachmany et al., 2015). In 2018, the carbon tax was set at around $77/t-$CO_2$e emissions (Khastar et al., 2020). As of 2021, carbon tax rates were between around €62 per metric tonne of CO_2e (Asen, 2021). A comparison of the tax rates between 2018 and 2021 is shown Table 1.

Carbon Taxes by Major Fuel Type in Finland, €/tonne

Sector/fuel type	2018	2021
Electricity		
Coal and other solid fuels	0	0
Industry		
Coal and other solid fuels	25	36
Natural gas	74	87
Road transport		
Gasoline	311	337
Diesel	199	224
Buildings		
Diesel	92	104

Table 1: A description of the changes in carbon tax rates between 2018 and 2021 by fuel type in euros per tonne (Parry and Wingender, 2021).

Implementation

Political Trust and Corruption Perception

Finland has always experienced relatively high levels of political trust. The average value of political trust in OECD countries, of which Finland is a part, is 45%. Comparatively, in 2019, 64% of the public in Finland reported trusting the government (OECD, 2021). However, the government has experienced a decrease of trust from 76% in 2007. Overall, trust was lower for rural residents, lower-income households, and less educated people (OECD, 2021). As mentioned earlier, a carbon tax may not be appealing as a policy because it can often increase production costs and living expenses. However, because the Finnish public's level of trust in the government is high, the public may perceive higher benefits from a carbon tax and trust that the government supports its best interest. Trust in the government is related to the public's perception of corruption as well.

Finland has the highest ranking in the world, in terms of the Corruption Perception Index, according to the global coalition against corruption. In 2021, it was ranked 1/180 countries and had a score of 88/100, meaning that it has the lowest level of corruption perception in the world. (Finland, 2021). With low levels of corruption perceived in the country, the belief in the fact that the government has the best intentions for its citizens increases. This in turn provides the government with necessary support to pass policies which may be undesirable on an individual level, such as a carbon tax. A carbon tax, much like many other taxes, can be difficult to market to the public. Low levels of perception of corruption help ameliorate this process.

World Views

Nordic countries including Finland, Denmark, and Norway have always been at the forefront of environmental issues. The Finnish government organized a conference in Helsinki in 1974 to get countries to multilaterally sign the Convention on the Protection of the Marine Environment of the Baltic Sea Area, or the Helsinki Convention (Räsänen and Laakkonen, 2007). This was one of the first environmental conferences organized and the first multilateral convention signed by two competing military alliances: the North Atlantic Treaty Organization (NATO) and the Warsaw Pact (Räsänen and Laakkonen, 2007). Since then, Finland has led the path to sustainability and environmental conservation, including climate change mitigation. The Finnish government has long prioritized environmental issues in national and international politics.

The Finnish public expresses a high level of concern for environmental issues as well. Parliamentary elections in 2019 revealed that voters' number one concern was the climate crisis (Henley, 2019). In addition, a survey conducted by the previous, majority center right government found that 80% of the Finnish public believed that urgent climate action was necessary and 70% believed that the next government should do more to address the issue (Henley, 2019). In a separate poll conducted in 2019, as represented in Figure 7, the Finnish public ranked the environment, climate, and energy issues as the second most important issue facing the country (OECD, 2021). Given that the Finnish public is highly concerned with environmental issues, their likelihood of supporting a carbon tax policy to reduce emissions increases and the government's ability to raise carbon tax rates without major pushback.

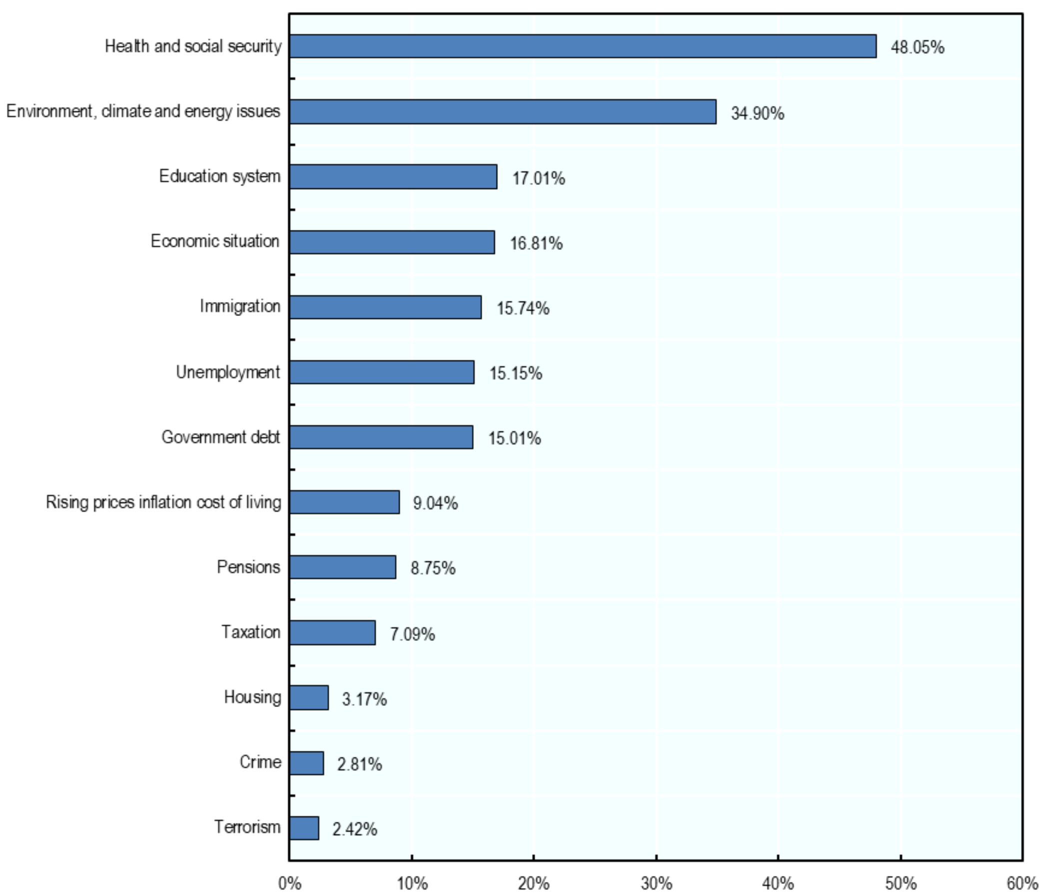

Figure 6: The concerns of the Finnish public in 2019, ranked (OECD, 2021).

The way in which Finland's education system addresses environmental issues may also play a role in its public's overall world views. Finland's education system generally teaches issues of environmental sustainability and climate change in scientific subjects like biology and geography. However, most students did not consider environmental issues as particularly concerning (Juuti et al., 2011). One potential reason for this may be that people, in general, tend to worry more about proximal concerns like unemployment and their family. Climate change, relative to these issues, is a more distant problem (Swim et al., 2014). Also, people generally only have an ability to worry about a limited number of issues, meaning that political concerns about war, healthcare, or other topics may take precedence over concerns about climate change (Swim et al., 2014). A way to address this may be to include climate change education in the social sciences to direct discourse about climate change towards ethical and political discussions. This could help students understand the importance of climate change and increase their knowledge of climate change in a political context.

Regardless of the implementation of the carbon tax policy in Finland, however, understanding the effects of the tax on emissions and the economy provides a basis for its evaluation.

Effects and Limitations

The amount of greenhouse gas emissions from Finland earned the country a rank of 59 among all countries in 2010. Between 2010 and 2016, its ranking increased to 57, indicating a small increase in emissions relative to the rest of the world (Khastar et al., 2020). However, carbon emissions decreased by 9% between June 2020 and July 2021 (Annual Climate Report, 2021). The decreased energy usage during the COVID-19 pandemic, which was a global phenomenon, played a role in lowering carbon emissions. Average emissions from household consumption of energy, which includes emissions from production of goods and services and overseas emissions from production chains of imported goods, decreased between 2010 and 2015, but have stayed constant since then (Annual Climate Report, 2021).

The carbon tax rate in Finland has been increasing annually. The fact that emissions from household consumption of energy in Finland have not decreased implies that the carbon tax has not been significantly effective in that sector of the economy. However, a key reason for the lack of change in household consumption of energy and, as a result, emissions is that households primarily use energy for necessities.

One-third of overall energy consumption in Finland in 2019 was electricity, 46% of which was used for indoor heating and 38% for household appliances (Rouhiainen, 2019). Another third of it was from district heat, though the consumption of district heat had decreased by 2% over the preceding two years (Rouhiainen, 2019). Household consumption of electricity remained mostly unchanged between 2015 and 2019. Indoor heating, household appliances, and district heat are generally considered economic necessities to maintain quality of life. The use of these necessities is not likely to change drastically, meaning that emissions from electricity will not change.

Despite the lack of change in emissions from household energy consumption, there has been a statistically significant negative impact on the growth of carbon dioxide emissions per capita due to the carbon tax in Finland (Ghazouani et al., 2020). This is not the case in other Scandinavian countries, which experienced negative but insignificant impacts of the carbon tax on emission reduction per capita (Ghazouani et al., 2020). The reason for this difference, according to Ghazouani et al., could be because other Scandinavian countries like Denmark and Sweden distinguish between private and industrial tax rates. Finland has no exemptions for industry taxes, making its carbon tax policy more effective at reducing emissions overall (Ghazouani et al., 2020).

Finland's carbon tax is centered around the transportation sector of the economy, so much of the reduction in emissions was evident in this sector. A study conducted by Jean-David Elbaum from the University of Neuchâtel explored the difference in emissions between a synthetic Finland and "real" Finland through the synthetic control method. Synthetic Finland was composed of a combination of data from Denmark, Turkey, New Zealand, Luxembourg, Greece, the United States, and Switzerland (Elbaum, 2021). The study revealed the statistically significant effect of government intervention through the carbon tax on carbon emissions per capita in "real" Finland. Carbon emissions reduced by around 10% after one year of intervention and by 28% by 2005 (Elbaum, 2021). Nevertheless, the study suggests that carbon emissions outside the transportation sector increased in Finland despite the institution of the carbon tax in 1990, and only began to decrease in 2003 (Elbaum, 2021).

The slow speed of emission reduction in carbon emissions before 2003 may be because of the lower carbon tax rates in the beginning phases of the policy, along with the experimental nature of the policy in the 1990s. Emission reduction due to carbon tax implementation has been studied at various tax levels and by type of fuel in Finland. The empirical results and predictions of the impacts of a carbon tax on emissions, differentiated by the type of fuel, are shown in Table 2 and Figure 7.

	Tax rate (S/CO2 ton)				
	20S	35S	80S	120S	150S
Energy source	Percentage change in carbon dioxide emissions				
General level	−6.906	−10.951	−20.003	−25.865	−29.465
Coal	−14.111	−21.635	−36.566	−44.937	−49.623
Oil	−11.321	−17.682	−30.958	−38.804	−43.326
Natural gas	−6.129	−10.182	−20.233	−27.231	−31.626
Petroleum products	−2.887	−4.9	−10.284	−14.41	−17.187

Table 2: Percent change in predicted carbon emissions under different levels of taxation, both general and separated by sector (Khastar et al., 2020).

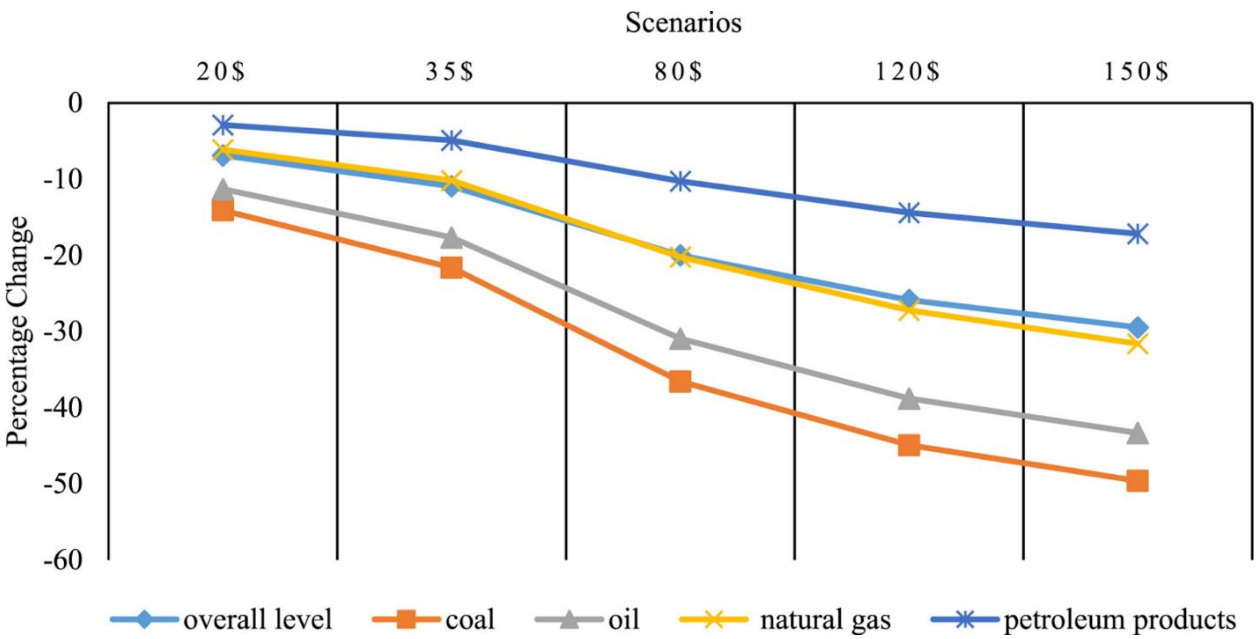

Figure 7: Graphical representation of the percent change in predicted carbon emissions under different levels of taxation (Khastar et al., 2020).

The predicted changes in emissions reduction under various tax levels, according to Khastar et al., makes it clear that higher carbon taxes would lead to decreased overall levels of emissions. Under a tax of $150 per tonne of carbon dioxide, carbon emissions from coal are predicted to be reduced by almost 50% (Khastar et al., 2020). Given that coal is one of the most significant polluters in Finland, this number indicates a significant gain from carbon taxes. Under the most recent levels of carbon taxes in 2021, which are between $69.00 and $73.46/t-Co2, emission reduction is between 11% and 20% as compared to a scenario without carbon taxes (Khastar et al., 2020).

The important distinction to make regarding the graph above and empirical data from Elbaum's study is that Figure 8 indicates an emission reduction rate lower than Elbaum's various carbon tax rates. While Table 1 indicates that a $150/t-Co2 tax would decrease emissions by 29.465% overall, Elbaum's study maintains that emissions reduced by over 28% by 2005 under tax rates that were significantly lower than $150/t-Co2. One explanation for this difference is that Finland's ETS had a significant effect on emission reduction that was not realized by Elbaum. The other possible explanation is that the estimated reduction in Figure 8 is an underestimation. These possibilities imply that a carbon tax needs to be implemented alongside other methods of emission reduction in order to achieve maximum effectiveness.

The impacts of a carbon tax, however, need to be assessed beyond their effect on the reduction of greenhouse gas emissions. In Finland, the carbon tax had serious effects on welfare within Finland's economy. Khastar et al. (2020) studied the effects of the same levels of carbon taxes on welfare, as measured by the difference between available welfare before and after the implementation of a carbon tax in Finland, in millions of dollars and in dollars per capita. The results are depicted in Table 4 and Figure 8.

Table 2. Welfare changes due to the implementation of carbon taxes in Finland.

Scenarios	20$	35$	80$	120$	150$
Overall (Mill $)	−412.965	−748.254	−1808.62	−2775.41	−3501.82
Per capita ($)	−75.0845	−136.046	−328.84	−504.62	−636.695

Table 3: Effects of different levels of carbon taxes on welfare, with overall effects reported in millions of dollars and per capita changes reported in dollars (Khastar et al., 2020).

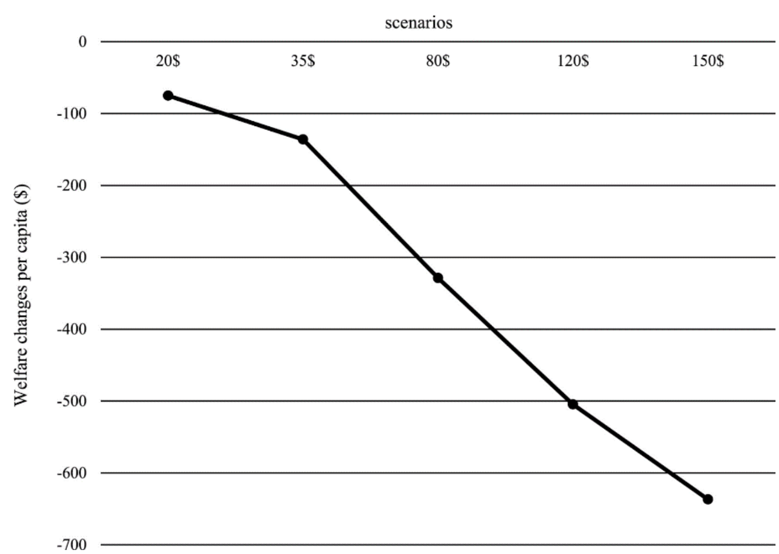

Figure 8: Overall welfare changes per capita as a result of different levels of carbon taxes (Khastar et al., 2020).

Despite the tax-shifting package implemented by the Finnish government to offset the negative effects of carbon taxes, the overall effects of the tax on welfare are negative. Consumers end up paying a higher price for goods, and the reduction in their income taxes does not cover the gap between their increased prices and their previous amount of wealth (Khastar et al., 2020). A carbon tax rate of $150 per tonne of carbon dioxide emitted will result in a decline in welfare of $3.5 billion. The closest data point to Finland's current carbon tax rate, $80 per tonne of carbon dioxide, indicates a welfare loss of around $1.8 billion (Khastar et al., 2020).

The effects of Finland's carbon tax, therefore, are mixed. Some of the biggest challenges with understanding the true effect of a carbon tax lie in the numerous changes in policy over time and the difficulty of measuring different variables as they relate to policy changes. Finland's carbon tax policy underwent major shifts in 1994 and 1997, making it difficult to gain data for long-term analysis. In addition, though the tax may be beneficial in reducing greenhouse gas emissions over time, it also reduces welfare and welfare per capita. Further research is needed to assess whether this increase in welfare inequality is greater than the increase in welfare inequality directly from climate change. Energy consumption may decrease in certain areas of the economy, but in cases of necessities in household consumption, changes in emissions were minor or nonexistent.

Finland's carbon tax policies, first implemented in 1990, paved the way for other countries around the world to implement and enforce taxes that would effectively and efficiently reduce greenhouse gas emissions. Though the first few countries were Scandinavian, other countries in Europe quickly followed suit. The popularity of carbon taxes spread across the globe and, in 2012, Japan became the first Asian country to implement a carbon tax. Japan based its discussions on carbon taxes off the structure of the tax in Finland, though the final tax showed major differences. These differences are discussed in Chapter 6.

Chapter 6

Japan

Japan is the world's third largest economy and the seventh largest emitter of greenhouse gases in the world (Timperley, 2018). It is the world's fifth largest oil consumer, fourth largest crude oil importer, largest natural gas importer, and the third largest coal importer (Gokhale, 2021). Its energy usage, by percentage, is shown in Table 5.

Energy Source	**Percentage of Use**
Petroleum and other liquids	40%
Coal	26%
Natural gas	21%
Nuclear power	3%
Hydropower	4%
Other renewables	6%

Table 4: Breakdown of Japan's energy usage by percentage, separated by source of energy (Gokhale, 2021).

In 2018, Japan experienced a heat wave with its highest summer temperatures, which killed 1000 people (Gokhale, 2021). In addition, Japan has seen a 20% increase between 1981 and 2021 in typhoons. Because of these extreme natural disasters, Japan needs to cut its emissions and reduce the effects of climate change quickly. In order to combat some of the negative impacts of climate change and reduce their carbon emissions, Japan passed a carbon tax of JPY 2,89/t-Co2 in 2012 (Gokhale, 2021).

Japan announced its intention to become carbon neutral by 2050, along with several specific goals regarding its overall energy usage by power source by fiscal year (FY) 2030. The hope is to reduce the use of oil and coal to 3% and 26% of total fuel use respectively, and to increase the use of natural gas, nuclear power, and renewable energy in order to compensate for energy demands. These goals are represented in Table 6.

Energy Source	**Percentage of Use**
Oil	3%
Coal	26%
Natural gas	27%
Nuclear power	22-20%
Renewable energy	22-24%

Table 5: Japanese goals for overall energy usage by FY 2030, by energy source (Gokhale, 2021).

Tax Rates and Evolution

Despite the fact that the Japanese carbon tax was not implemented until 2012, discussions about potential carbon taxes began in 1995, following the first European countries which had implemented the tax. As was the case with such countries, Japan’s primary goal was to use the tax to create a revenue-generating effect for the government, followed by a price effect on consumers and firms (Gokhale, 2021). This means that the key focus was to create an additional source of income for the government before increasing the price of emissions on firms and households.

The economic slowdown in Japan during the 1990s, along with the political concerns surrounding it, resulted in an overall low carbon tax rate. However, new potential carbon tax policies were brought back into discussion starting in 2001through the Expert Committee on Tax System to Combat Climate Change (Gokhale, 2021). Throughout the discussion phase of the Japanese carbon tax, four separate plans with a variety of goals, types of taxation, and other policies were generated by experts. Because Japan was modeling its policies after Finland and other European countries which had already passed a carbon tax policy, the four plans featured relatively high tax rates.

Debates among experts within the Expert Committee included those on upstream versus downstream taxation, the economic and political impacts of a potential tax, and the “greening” of the tax system. By 2005, Japan was considering the implementation of an environmental tax equivalent to JPY 2400/t-Co2, or $21.80 (Gokhale, 2021). This tax would apply to all types of fossil fuels but include exemptions for coal used in manufacturing, as well as temporary exemptions for gasoline, light oil, and jet fuel due to rising oil prices in the early 2000s and concerns about the international competitiveness of Japanese firms. However, this tax policy did not pass.

In 2010, the Global Warming Tax Consideration revisited the implementation of a carbon tax through the creation of a Climate and Energy Roadmap for Japan. By 2011, the main goal of the Japanese carbon tax shifted to ensuring a price effect instead of generating revenue because analyses from the Global Warming Tax Consideration revealed that the marginal cost of abatement of pollution was higher in Japan than it was in European countries or in the United States. Further analyses led to the conclusion that the positive effects of a carbon tax would compensate for the negatives through the use of revenue for subsidies for green energy and the reduction of other taxes. The carbon tax finally passed in 2012 (Gokhale, 2021).

Japan has two different environmental taxes: a vehicle tax and an energy tax. The carbon tax, initially adopted in 2012, falls within the energy tax and has been implemented with the aim of reducing greenhouse gas emissions by 80% by 2050 (Gokhale, 2021). Japan’s carbon tax applies to several fossil fuels, including petroleum, oil products, natural gas, and coal. However, the tax rate differs based on the carbon emissions content of each product and was levied in addition to the existing Petroleum and Coal tax (Gokhale, 2021). The idea was to create a revenue-neutral tax with a rate that increased gradually over the 3.5 years following its implementation (Gokhale, 2021). The primary reason to increase the tax rate over 3.5 years was to increase the rate of emission reduction. The Japanese government's primary reason for keeping low tax rates was to maintain international competitiveness and prevent potential negative economic impacts. Japanese carbon tax rate increases between 2012 and 2016 are highlighted in Table 7.

Taxed products	Tax rate before Oct 2012	Carbon tax		
		Oct 1, 2012	April 2014	April 2016
Crude Oil and Petroleum (per kl)	JPY 2040	JPY 250 (Total: JPY 2290)	JPY 250 (Total: JPY 2540)	JPY 260 (Total: JPY 2800)
Gaseous Hydrocarbon (per ton)	JPY 1080	JPY 260 (Total: JPY 1340)	JPY 260 (Total: JPY 1600)	JPY 260 (Total: JPY 1860)
Coal (per ton)	JPY 700	JPY 220 (Total: JPY 9,20)	JPY 220 (Total: JPY 1140)	JPY 230 (Total: JPY 1370)

Table 6: Japan's phased carbon-tax increase between 2012 and 2016 (Gokhale, 2021).

The carbon tax rate in Japan has stayed constant since 2016. The initial plan for the carbon tax did not explicitly define increases in this rate beyond FY 2016, and industry protests have pushed back against hikes in the tax rate. Financial ministries in Japan are actively trying to increase carbon tax rates in order to significantly decrease carbon emissions and to meet their eventual goal of cutting emissions by 46% of 2013 levels by 2030 (Takeo and Ito, 2022). However, the willingness of the Japanese public to trust the government and support environmental regulation will likely hold the key to effective carbon tax policies.

Implementation

Political Trust and Corruption Perception

Though Japan has higher levels of corruption perception and lower levels of political trust than Finland, both of these indicators are still above average. As of 2017, 51% of the public in Japan stated that it somewhat trusted the national government to do what is right for the country (Stokes, 2017). Six percent of the public states that it has a lot of trust in the government to do what is right. Both of these indicators prove that the Japanese public, for the most part, trusts the government to support their best interests. The implementation of the carbon tax in 2012 and the fact that it is still in place exemplifies this trust in the government.

Japan’s global ranking on the Corruption Perception Index, as of 2021, was 18 out of 180 countries. Its overall score was 73/100 (Japan, 2021). Finland’s score on these metrics is significantly higher than Japan’s, but Japan’s corruption perception is still extremely low relative to the rest of the world. The combination of this low corruption perception with its medium-to-high levels of trust in the government allow for carbon tax policies, which may be harmful to individuals who need to use fossil fuels for their necessities, to exist.

Both corruption perception and trust in the government in Japan are significantly lower than that in Finland. This indicates a possible explanation for why Finland’s carbon tax rates are much higher than those in Japan. In addition, Finland’s carbon tax policies have undergone several changes over the last thirty years. Japan’s policies may have been more permanent because of the relative lack of trust in the government. In a “perfect" situation, the public would trust the government completely and allow all changes in policy with the belief that such changes will have benefits. But in this situation, with lower levels of trust than Finland, the government must work harder to prove that any implemented changes will have a positive overall effect on the public.

World Views

Japan is known for its history of environmental catastrophes, especially regarding the protection of surrounding waters even though it is an island hotspot for biodiversity. For example, Minamata disease originated in Japan when Chisso, a Japanese company, used mercury as a catalyst in reaction chambers and dumped the resulting methylmercury into the sea. Fish and shellfish in surrounding areas of the ocean absorbed the chemical, making the consumption of seafood in Japan increasingly dangerous (Hachiya, 2006). On the other hand, the Japanese government has been known for its insensitive policies regarding whale hunting and exploitation of exotic timber wood in the past (Ecology and Religion, 2022).

Despite these issues, however, Japan has some of the most stringent policies against pollution in the world. For example, Japan's countermeasures against exhaust gases and sulfur dioxide and nitrogen emissions are amongst the strictest in the world (Ecology and Religion, 2022). Japan has also earned the designation of "green archipelago" because of its extensive forest preservation methods. The Shinto religion plays a significant role in Japanese views about nature and the environment as well. Often, beliefs and forms of worship were directed towards natural objects like trees, rocks, and mountains (Ecology and Religion, 2022). Concern for the environment clearly exists in some elements of Japanese culture, even if it is lacking in others.

A culture based on the worship of nature, to an extent, will likely prioritize environmental protection. Also, much like Finland was known for pioneering the field of carbon emission policies and international environmental agreements, Japan's history of strict pollution regulation indicates that the environment has remained a priority for decades prior and has influenced its perspective on emission reduction. Its previously-existing vehicle tax provided a baseline for the following carbon tax policy.

Effects and Limitations

Though there are justifications for the low carbon tax rate in Japan, the price of carbon is not high enough to limit emissions at the recommended level. A 26% reduction in emissions between 2019 and 2030 would require a carbon tax rate between $35/t-Co2 and $70/t-Co2. Japan's carbon tax is set at the low rate of JPY 2,89/t-Co2.

Japan's carbon tax resulted in a 0.5% curb in emissions in 2020, when compared with its emission levels in 1990. However, other countries have been able to accomplish this in significantly less amounts of time. Several northern European countries, including Denmark, Sweden, and Norway, reduced their carbon emissions between 0.5% and 1.7% between 1981 and 2008 (Gokhale, 2021). Finland was able to reduce its emissions by 10% in the same time frame. Evidently, carbon taxes, along with other measures to curb emissions, have had limited effectiveness in Japan. Part of the reason for this is that Japan's current tax policy includes exemptions for energy-intensive industries. When combined with its subsidies for the fossil fuel industry, Japan's policies lose even more effectiveness.

Energy prices in Japan have been on the rise in recent years. Households have become increasingly dependent on electricity as their share of electricity has increased from 15.7% of total energy consumption in 1989 to 25.0% in 2014 (Inoue et al., 2020). Much like the rest of the world, higher carbon tax rates in Japan, if Japan were to increase its rates, would impact different regions and households differently. For example, rural households in colder regions of Japan would feel heightened burdens on their income if the energy tax is increased based on carbon content because of the use of kerosene for heating purposes (Inoue et al., 2020).

The age of the heads of households would also influence the extent to which increased carbon tax rates affect incomes. Households with heads of age 29 or younger use, on average, 5245 MJ of energy, while those of ages between 50 and 59 use about 7437 MJ (Inoue et al., 2020). As a result, carbon tax increases would affect older heads of households more than younger ones.

Japan's carbon tax has also had a small, positive effect on its overall economic growth. This effect could be increased, however, with a double dividend effect where tax rates are increased in order to generate more revenue, which in turn can be recycled to reduce income or consumption taxes (Gokhale, 2021). The result would be a bigger economy and less inequality amongst individuals if the policy distributes the additional revenue depending on household income levels. Nevertheless, doing so would require Japan to increase its carbon tax rates by a high enough amount to effectively reduce emissions, while also correctly calculating its effect on consumers' incomes to create a system of tax-shifting packages.

Japan's Ministry of Environment (MOE) and its Ministry of Economy, Trade and Industry (METI) advise the government on policy decisions regarding the environment. METI advocates for lower tax rates in order to maintain economic growth and industry competitiveness in the international market. Meanwhile, MOE is more ecologically concerned and is in favor of higher prices to encourage emission abatement and technological development, both of which could bolster economic growth (Siripala, 2021).

The EU has suggested introducing a carbon border adjustment mechanism in 2023, which could hurt Japanese exports into the region and lock its products out of the market. The border adjustment tax would act as an additional tariff on imported goods based on the emissions resulting from the production of the goods. Japanese exports, as a result, would become more expensive to other countries, which in turn would hinder the Japanese economy's growth. This puts pressure on Japanese officials to decide quickly on a carbon tax that will not prevent economic growth, but one that will ensure emission reduction through abatement despite the EU's border adjustment program (Siripala, 2021).

Chapter 7

Conclusion

The need to reduce carbon emissions is growing quickly and the evidence for this exists in the atmosphere, oceans, and in climate change. Though greenhouse gas emissions overall are in need of reduction, carbon dioxide is one of the most significant contributors to climate change. However, this reduction cannot occur without appropriate methods to measure carbon emissions and its impacts. Carbon footprints, measured in CO_2e, and monetary valuation are used to calculate the impacts of emissions and to create policy solutions to reduce emissions. Though both strategies often result in an underestimation of environmental damage, they are the most commonly utilized strategies.

Several policies have addressed climate change in the past, including command-and-control policies and market-based policies. While the effects of command-and-control policies are mixed, market-based policies are quickly gaining traction globally as increasing numbers of countries adopt ETS and carbon taxes. Market-based policies rely on incentive-based structures, making them more appealing to open economies. In order to prevent the planet's average temperature from increasing by 2°C, the IMF recommends a carbon tax level of between $35/t-Co2 and $70/t-Co2, while the UNFCCC maintains that an emission reduction of 26% between 2019 and 2030 is needed to prevent this temperature increase.

The main idea behind a carbon tax is that the tax makes a firm's cost increase enough that pollution abatement is cheaper than paying the tax. Political trust, corruption perception, and preexisting world views influence the willingness of a country or region to implement and maintain the success of carbon tax policies. Meanwhile, the effects of a carbon tax policy can be addressed through an assessment of its effect on emission reduction and its effect on the economy and welfare inequality. Emission reduction and inequality were the primary metric used in the analyses of Finland’s and Japan’s carbon tax policies.

In Finland, carbon taxes were effective at reducing emissions quickly because of the high taxation rate. The public’s trust in the government helped the government, along with a high level of concern for the environment overall, helped the government pass a carbon tax policy and continue to increase the tax rates throughout the last few decades. The reduction in greenhouse gas emissions was slow in the beginning, but the rate of reduction increased after around 10 years of policy implementation. However, Finland experienced significant negative impacts on its welfare, both in general and per capita. These consequences of the Finnish carbon tax policy must be considered and addressed when changing the structure of the policy.

Meanwhile, Japan also experienced emission reduction of greenhouse gases as a result of the carbon tax, but the rate at which these reductions occurred was far slower than Finland and other European countries. The most plausible reason for this is that Japan’s tax rate is significantly lower than that of other nations, meaning that its firms may consider the cost of pollution to be lower than the cost of abatement. Japan, like Finland, boasts a relatively high level of political trust, along with a history of environmental concern in most regards. Both of these factors enable the government to pass carbon tax laws. However, the Japanese government has experienced much pushback from industries which, combined with a lack of long-term planning when the policy was implemented, reduces the likelihood of a significant increase in the carbon tax rate.

These are just two of many countries which have implemented the carbon tax policy. Many others have policies that are structured differently and have differing effects. Studying those countries in addition to Finland and Japan will provide valuable insights into the effectiveness of carbon taxes. Future research into the long-term effects of a carbon tax will likely get easier with time as well. The earliest carbon tax in Finland was implemented only 32 years ago, so studying the impacts of carbon taxes in different regions and cultures around the world will require time for these effects to develop. In addition, this thesis only addresses the implementation and impacts of carbon taxes on a national level. Other levels of analysis could include cities, provinces or states, or regions.

Overall, carbon taxes seem to be effective at reducing emissions but not in an equitable manner in terms of cost. The implementation of a carbon tax is likely related to political and social factors which influence the general public's world views and perceptions of the government. Whether future policy changes can address these issues, both within carbon tax policies and beyond them, will become evident as more countries adopt the policy.

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ACADEMIC VITA

EDUCATION

Master of International Affairs **Expected Graduation: May 2022**
Pennsylvania State University, University Park, PA

- Concentration: Environmental Economics
- Relevant Coursework: International Economics, Multi-Sector and Quantitative Analysis, Forest Economics, International Agricultural Development, Climate Communication
- Integrated Undergraduate-Graduate Program to receive a bachelor's degree and a master's degree concurrently

B.A. in International Politics **Expected Graduation: May 2022**
Pennsylvania State University, University Park, PA
Concentration: International Political Economy

- Schreyer Honors College, Paterno Fellow
- Minor in French and Francophone Studies
- Relevant Coursework: Political Ecology, Extractive Industries in Africa, Quantitative Political Analysis, Political Economy, Environmental Economics

Awards and Scholarships
Pennsylvania State University, University Park, PA

- Dean's List, all semesters to date
- Provost Scholarship for undergraduate students

EXPERIENCE

Citizens' Climate Lobby, State College, PA
Climate Advocacy Intern, May 2021 – December 2021

- Connecting with people in the area to promote the goals of the organization
- Submitting letters to the editor and op-eds to spread awareness about carbon emission policy
- Helping write blog posts to enhance the organization's social media presence

Penn State Residence Life, University Park, PA
Resident Assistant, August 2020 — Present

- Building a community through community builders, bulletin boards, and regular check-ins with residents
- Counseling and advising students on academic and personal matters
- Maintaining a safe environment for students during a pandemic

Penn State Public Speaking Center, University Park, PA
Student Mentor, January 2020 — Present

- Helping students with different aspects of speeches including content development, delivery, and visuals
- Completing several presentations and workshops about the process of speechwriting

- Training for the position through a Communication Arts and Sciences course on mentoring and public speaking

Penn State Department of Economics, University Park, PA
Undergraduate Grader, September 2019 — May 2020
- Assisting the professor in grading assignments including homework, quizzes, and midterms for Microeconomics
- Grading between 75 and 150 assignments when necessary
- Collaborating with other graders in distributing and collecting assignments efficiently

State College Area High School, State College, PA
Tutor, January 2019 — May 2019
- Tutoring for high school students in English and French to help them improve their skills and proficiency in both literature and language
- Learning how to work with various students' learning styles and adjusting mentoring approaches accordingly

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ACTIVITIES

Penn State Alternative Breaks Service Trip, Asheville, NC
Service Trip Member, March 2020
- Working with Asheville Greenworks, an organization based on local sustainability, to help clean regional waste and enhancing knowledge of native plant species
- Understanding and reflecting on environmental justice issues that affect communities around the country

Penn State International Affairs and Debate Association (PSIADA), University Park, PA
Conference Staffer, September 2018 — May 2020
- Staffing PHUNC, the Model UN conference held by Penn State for high school students
- Attending smaller simulations of crises to provide and receive feedback on necessary adjustments

Penn State Speech and Debate Society, University Park, PA
Speech Team Member, September 2019 — December 2019
- Conducting research and delivering an informative speech about the costs and benefits of sustainable cities
- Finding, splicing, and reorganizing poems to create and deliver a poetry program on the impacts of war

Penn State Mock Trial Association, University Park, PA
Mock Attorney, September 2018 — February 2019
- Developing opening and closing statements and working with mock witnesses in case trials
- Competing as an attorney for one witness in the fall, becoming captain of the team and playing attorney for two witnesses in the winter

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SKILLS
- Computer: R, Word, PowerPoint, Excel, ArcGIS, Google Suite
- Language: English (native fluency), French (intermediate), Hindi (fluent)