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# The Impact of a Carbon Tax on Emissions

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# The Impact of a Carbon Tax on Emissions in Selected Countries

An Honors Thesis submitted in partial fulfillment of the requirements for Honors Studies in Industrial Engineering


By

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## Abstract

A carbon tax is an economic policy that aims to reduce various emissions to serve the protection of the environment. Versions of this policy have been implemented in multiple countries across the world to introduce a cost for contributing to environmental damage. Since climate change is prevalent in today's world, finding an effective method to reduce emissions is essential. However, many countries hesitate to utilize a carbon tax for two reasons. First, they are unsure if the carbon tax is effective at reducing emissions. Second, there is a concern that the implementation of such a tax will be detrimental to the economy.

The aim of this study is to run a linear regression model to analyze the relationship between these different carbon tax plans with the production of various emissions as well as the GDP of each country. Then, each of the analyzed carbon tax plans will be defined as effective or not effective. Effective is defined as meeting the following two criteria. First, the tax must have a significant effect resulting in the reduction of at least one of the given emissions with no positive effect amongst the remaining emissions. Second, the carbon tax must hold no significant impact on GDP. A significant increase in GDP is also accepted as a success if the other requirement is met but this was not expected. Therefore, a positive relationship or no relationship between the tax and GDP is a success.

Twelve countries were analyzed in terms of emissions, while eleven of these twelve were also analyzed in terms of GDP. These countries, including Finland, Mexico, Japan, and Sweden, have varying carbon tax plans, so they were assessed individually. The results show that the implementation of a carbon tax plan in six of the eleven fully analyzed countries were considered effective.

## Introduction

Climate change has been an ongoing concern across the globe since CO2 readings were connected to the global warming theory in the late 1950s [1]. Many key greenhouse gases, such as carbon dioxide, methane, and nitrous oxide have become increasingly abundant in the earth's atmosphere due to human activities [2]. The increase in these emissions has been linked to the rising temperatures of the earth's surface risking damage to the environment, human health, and the economy [3]. Rapidly reducing emissions across the globe is critical to avoid severe weather events, inundation of coastal cities, spread of diseases, loss of forests, failure of agriculture and water supply, infrastructure destruction, and more [4].

Many countries have been responding to this issue in various ways. This could include capping the allotted allowance for emission production, using low-emission energy sources such as solar or wind power, signing adaptation policies to make cities less vulnerable to natural disasters resulting from climate change, and implementing a carbon tax [5].

A carbon tax is a seemingly powerful incentive to reduce the production of carbon emissions. It has been implemented by many countries across the globe including Sweden, Poland, Denmark, and Japan. The tax varies from country to country, but the primary goal is to tax different fuels based on their carbon content to incentivize using more environmentally friendly sources of transportation, power, and product designs [4]. However, a primary concern of this carbon tax implementation is the theorized principle that a carbon tax could have negative effects on a country's economy [6]. Therefore, it is necessary to analyze whether a carbon tax would be an effective method of reducing emissions as well as to explore the effect it may hold on the economy.

A Linear Regression Model describes the relationship between a response variable and one or more explanatory variables. It is heavily used for predictive modeling, but it can also be used to analyze the strength of a relationship between two variables. In this case, it could prove to be useful in determining if there is a relationship between the implementation of a carbon tax with the production of emissions, analyzing existing data of countries with an ongoing carbon tax plan. It could also provide some insight into whether these tax plans negatively affected the respective country's GDP, an important measurement of the size and performance of an existing economy.

## Literature Review

Carbon taxes and their effect on various economies have been widely studied due to the prevalence of global warming and the debate on whether this implementation is effective. Liu, Huang C., Huang G, Baetz, and Pittendrigh conducted a case study regarding the carbon tax effects on a province in Canada [8]. For this study, a computable General Equilibrium model was used to analyze the economic impacts of this policy since the tax increases the price of things with CO2 production. The result of this study shows that a carbon tax in this province will reduce greenhouse gas emissions while contracting the economy. For my study, I did not wish to use a similar CGE model since it does not properly reflect the impacts of a carbon tax during an application process over time. I also wished to analyze multiple countries rather than focus on one, so the speed of producing linear regression models was preferable.

A study with a similar idea was conducted by Hajek, Zimmermannova, Helman, and Rozensky. This study analyzed the efficiency of a carbon tax in selected EU countries using a multiple-panel regression method. They used multiple control variables such as emission allowance price, household final consumption expenditure, corporate investments, etc. to focus on the effects of the tax. The results of this show that by raising the carbon tax by one euro per tonne, annual per capita emissions will be reduced by 11.58kg [9]. My study takes this in a different direction by focusing on the economic effects of a carbon tax that is capable of reducing emissions. I also wished to focus on countries inside and outside of the EU to gain a variety of carbon tax plans.

There have been many other studies that put into question if carbon taxes work at reducing greenhouse gas emissions [10, 11] as well as the impact a carbon tax had on a country's economy [11, 12, 13]. Most of the articles that I found that included a linear regression analysis focused on predictive modeling as compared to a direct analysis of the relationship between factors [14, 15]. In addition to this, these papers focus primarily on CO2 emissions which led to my decision to include multiple emissions throughout my study.

## Methodology

To start, data was pulled from the "World Report General Data" dataset that was collected and utilized in the World Inequality Report [16]. This combines several published datasets to create a comprehensive set of greenhouse gas emission pathways for every country as well as Kyoto gas throughout history up to 2019. Then, the data was narrowed to a few countries that have implemented a carbon tax. There are 44 OECD countries that have implemented a carbon tax currently; the full list is found on the OECD website along with the rate of the tax [17]. My selection of countries with the tax was based first on whether they had an explicit carbon tax, rather than a similar fossil fuel tax or an implicit tax. Then, it was based on if the tax was still in place in 2019. For example, I excluded countries like New Zealand that only incorporated the tax from 2008-2012. After this, I looked at which years the remaining 35 countries' taxes were introduced since this thesis requires proper analysis of emissions before and after implementation. I then took the median of the implementation years for the remaining countries, 2014. The countries with implementations of that year and the years prior were kept, while the others were removed from the dataset. This gave me at least 5 years of data from every analyzed country after their tax was introduced as well as many years of data prior to implementation.

Since the primary argument against implementing a carbon tax is the belief that it would have negative impacts on GDP [8, 11, 12, 13], I pulled data from The World Bank regarding the GDP of countries each year dating back to 1961 [18]. I then removed any countries with severe gaps in data (primarily with the GDP). This resulted in 12 countries shown in Table 1. I did include Poland in this mix despite no GDP data being available for the necessary years since it was one of the first countries to implement a carbon tax, aiding in the spark of the movement for many of the other countries to make similar decisions. Poland is also very impressive in the emissions reduction that it made but cannot be fully analyzed as "effective" or not due to the lack of GDP data.

*Table 1*: Countries with an implemented carbon tax

| **Country** | **Abbreviation** | **Year of Carbon Tax Implementation** |
|---|---|---|
| Canada | CAN | 2007 |
| Chile | CHL | 2014 |
| Denmark | DEN | 1992 |
| England | GBR | 2013 |
| Finland | FIN | 1990 |
| Iceland | ISL | 2010 |
| Ireland | IRL | 2010 |
| Japan | JPN | 2012 |
| Mexico | MEX | 2014 |
| Norway | NOR | 1991 |
| Poland | POL | 1990 |
| Sweden | SWE | 1991 |

The next things I looked at to downsize this dataset were years of relevancy. I wanted to keep the most recent years of data (2019) but needed to decide how much historical data to keep in my analysis. This dataset is being utilized to consider emissions before and after the tax was implemented, so I based my decision on the country with the earliest date of implementation of the carbon tax. This was Poland with a carbon tax beginning in the year 1990. Since the years 1990-2019 provide 30 years of data from implementation to “the present”, I kept 30 years of data prior to implementation (1961). This also suited the availability of GDP data. I was then left with emissions data for 13 different entities for each country. To ensure there were no holes in the data, I narrowed this down to the 5 entities that had data available for each of these countries in these relevant years. These entities include:

- $CO_2$: Carbon Dioxide
- $CH_4$: Methane
- $N_2O$: Nitrous Oxide
- KYOTOGHG (SARGWP100): Greenhouse Gases under Kyoto Protocol according to Second Assessment Report
- KYOTOGHG (AR4GWP100): Greenhouse Gases under Kyoto Protocol according to Fourth Assessment Report

The initial goal of this project was to see if the carbon tax plans that were implemented in various countries have been “effective” at reducing emissions in the environment. In the scope of this project, a tax is considered effective if it meets two specific requirements:

- First, the tax must have a significant effect resulting in the reduction of at least one of the given emissions with no positive effect amongst the remaining emissions.
- Second, the carbon tax must hold no significant impact on GDP. A significant increase in GDP is also accepted as a success if the other requirement is met but this was not expected.

To analyze these impacts given the implementation of a carbon tax, it was clear that a linear regression approach was ideal. Linear regression models the relationships between one or more variables allowing for a reasonable prediction of one variable based on the known value of a separate variable. These models generally take the form shown in Equation 1.

$$y_i = \beta_0 + \sum_{k=0}^{K} \beta_k (X_{ik)} \,\forall\, i \; (i = 1, \dots n)$$

*Equation 1*: Linear regression model

The coefficient $\beta_k$ depicts the impact of a one-unit change in the explanatory variable $X_k$ on the response variable y given that all other variables are held constant [7]. For this project, all linear regression was performed utilizing the statistical software, Stata. Since these plans are targeted towards specifically reducing $CO_2$ emissions, I began the analysis utilizing the $CO_2$ entity data over time. I ran a linear regression of the $CO_2$ emissions over time against a binary variable that is 0 in years the country’s plan is not in place and is equal to 1 after it has been implemented. This regression also includes a lag variable to hold for any changes in $CO_2$ emissions over time to strictly focus on the tax’s effects on emissions. This lag variable is equivalent to the $CO_2$ emissions from the previous year. I also wanted to see if these tax plans specifically targeted $CO_2$ emissions, or if they could reduce other types of emissions as well. I ran the linear regression over the other four types of entities: $CH_4$, $N_2O$, KYOTOGHG (SARGWP100), and KYOTOGHG (AR4GWP100). I also ran the GDP of each country against the carbon tax binary variable, holding with a similar lag variable to account for any changes over time. For each of these linear regressions, the result is significant if the p-value is less than an alpha value of 0.05. If the p-value is less than 0.05 and the coefficient is negative, then the carbon tax implementation had a significant impact on the reduction of emissions or GDP. If the p-value is less than 0.05 and the coefficient is positive, then the carbon tax implementation had a significant impact on the increase in emissions or GDP. If the p-value is greater than 0.05, there is no significant reaction between the tax implementation and the emissions or GDP.

## Results

The first linear regression that was run consisted of solely $CO_2$ emissions, as that was the primary focus of this project. The results are shown in Table 2. The yellow highlight indicates the p-values that are less than the alpha value of 0.05 as well as having a negative coefficient. For the sake of understanding a crucial difference in the tax plans, I also included the year each plan was implemented for each country as well as the rate of the tax plan per ton of emissions.

*Table 2*: Linear regression results of $CO_2$ emissions against the respective carbon tax holding for natural changes over time:

| Country | P-Value | Coefficient | Year of Implementation | Rate per ton of CO2 emissions |
|---|---|---|---|---|
| Canada | 0.397 | 7540.55 | 2007 | $20 |
| Chile | 0.443 | 5933.99 | 2014 | $5 |
| Denmark | 0.027 | -2737.376 | 1992 | $26.62 |
| England | 0.104 | -19946.94 | 2013 | $23.65 |
| Finland | 0.005 | -5360.2 | 1990 | $85.10 |
| Iceland | 0.762 | -96.9916 | 2010 | $34.25 |
| Ireland | 0.178 | -1037.073 | 2010 | $45.31 |
| Japan | 0.175 | -19909.48 | 2012 | $1.97 |
| Mexico | 0.380 | 29669.06 | 2014 | $3.50 |
| Norway | 0.015 | -4343.681 | 1991 | $87.61 |
| Poland | 0.000 | -18587.36 | 1990 | $0.08 |
| Sweden | 0.572 | 3427.621 | 1991 | $129.89 |

It can be noticed that Sweden’s variable is not significant. This is shocking because Sweden has one of the strictest carbon tax plans in the world as well as some of the lowest emissions. After further research, I found that Sweden was concerned with carbon emissions much earlier than the tax was implemented. Sweden's Social Democratic Prime Minister declared during the Stockholm Conference in 1972 that "Our future is common" [19]. This sparked a declaration of 26 principles regarding the environment and a country's responsibilities toward protecting it. I would draw from this that their tax was not a necessity to reduce carbon emissions but may have been implemented as an additional incentive to maintain the low emission rates. I ran a linear regression for Sweden's CO2 emissions, holding for changes over time, but with the binary variable being 0 prior to these principles, and equal to 1 after. The results can be found in Table 3.

*Table 3*: Linear regression results of CO2 emissions against Swedish principles holding for natural changes over time:

| | P-Value | Coefficient | Year of Implementation |
|---|---|---|---|
| Sweden | 0.013 | -6778.322 | 1972 |

This linear regression process was replicated for the remaining four types of entities: CH4, N2O, KYOTOGHG (SARGWP100), and KYOTOGHG (AR4GWP100). This allowed me to analyze if the tax plan was targeting one or more of these other emissions. It is important to note the Kyoto-defined greenhouse gases include more than one gas. This entity is a sum of multiple greenhouse gases defined by the different assessment reports. I wanted to analyze this as one entity to see if the tax plan was targeting a group of emissions rather than an individual. These results are shown in Tables 4-7. The yellow indicates a p-value less than 0.05 with a negative coefficient while the red depicts a p-value less than 0.05 with a positive coefficient.

*Table 4*: Linear regression results of CH4 emissions against the respective carbon tax holding for natural changes over time:

| Country | P-Value | Coefficient | Year of Implementation | Rate per ton of CO2 emissions |
|---|---|---|---|---|
| Canada | 0.005 | -80.67226 | 2007 | $20 |
| Chile | 0.581 | 3.708153 | 2014 | $5 |
| Denmark | 0.932 | 0.1918452 | 1992 | $26.62 |
| England | 0.266 | 117.749 | 2013 | $23.65 |
| Finland | 0.089 | -3.310484 | 1990 | $85.10 |
| Iceland | 0.01 | -0.485616 | 2010 | $34.25 |
| Ireland | 0.172 | 6.430318 | 2010 | $45.31 |
| Japan | 0.571 | 14.49836 | 2012 | $1.97 |
| Mexico | 0.111 | 76.07658 | 2014 | $3.50 |
| Norway | 0.002 | -3.415352 | 1991 | $87.61 |
| Poland | 0.000 | -180.2198 | 1990 | $0.08 |
| Sweden | 0.044 | -3.345512 | 1991 | $129.89 |

*Table 5*: Linear regression results of $N_2O$ emissions against the respective carbon tax holding for natural changes over time:

| Country | P-Value | Coefficient | Year of Implementation | Rate per ton of $CO_2$ emissions |
|---|---|---|---|---|
| Canada | 0.856 | -0.3105707 | 2007 | $20 |
| Chile | 0.976 | -0.0145094 | 2014 | $5 |
| Denmark | 0.001 | -3.235507 | 1992 | $26.62 |
| England | 0.898 | 0.6130055 | 2013 | $23.65 |
| Finland | 0.000 | -1.834478 | 1990 | $85.10 |
| Iceland | 0.41 | -0.023094 | 2010 | $34.25 |
| Ireland | 0.88 | 0.0403852 | 2010 | $45.31 |
| Japan | 0.176 | -2.972377 | 2012 | $1.97 |
| Mexico | 0.029 | 3.64392 | 2014 | $3.50 |
| Norway | 0.224 | -0.5439174 | 1991 | $87.61 |
| Poland | 0.000 | -9.609587 | 1990 | $0.08 |
| Sweden | 0.01 | -1.13441 | 1991 | $129.89 |

*Table 6*: Linear regression results of KYOTOGHG (SARGWP100) emissions against the respective carbon tax holding for natural changes over time:

| Country | P-Value | Coefficient | Year of Implementation | Rate per ton of $CO_2$ emissions |
|---|---|---|---|---|
| Canada | 0.552 | 5435.447 | 2007 | $20 |
| Chile | 0.339 | 7435.127 | 2014 | $5 |
| Denmark | 0.015 | -3119.7 | 1992 | $26.62 |
| England | 0.413 | -11252.3 | 2013 | $23.65 |
| Finland | 0.003 | -5976.08 | 1990 | $85.10 |
| Iceland | 0.753 | -99.4133 | 2010 | $34.25 |
| Ireland | 0.325 | -807.485 | 2010 | $45.31 |
| Japan | 0.236 | -17867.9 | 2012 | $1.97 |
| Mexico | 0.199 | 44847.08 | 2014 | $3.50 |
| Norway | 0.006 | -5331.38 | 1991 | $87.61 |
| Poland | 0.000 | -24033.6 | 1990 | $0.08 |
| Sweden | 0.621 | 2954.91 | 1991 | $129.89 |

*Table 7*: Linear regression results of KYOTOGHG (AR4GWP100) emissions against the respective carbon tax holding for natural changes over time:

| Country | P-Value | Coefficient | Year of Implementation | Rate per ton of CO2 emissions |
|---|---|---|---|---|
| Canada | 0.58 | 5089.491 | 2007 | $20 |
| Chile | 0.327 | 7620.879 | 2014 | $5 |
| Denmark | 0.015 | -3103.96 | 1992 | $26.62 |
| England | 0.457 | -10386.1 | 2013 | $23.65 |
| Finland | 0.003 | -5994.83 | 1990 | $85.10 |
| Iceland | 0.754 | -99.0257 | 2010 | $34.25 |
| Ireland | 0.344 | -782.454 | 2010 | $45.31 |
| Japan | 0.238 | -17823.2 | 2012 | $1.97 |
| Mexico | 0.182 | 46891.41 | 2014 | $3.50 |
| Norway | 0.006 | -5316.29 | 1991 | $87.61 |
| Poland | 0.000 | -24565.7 | 1990 | $0.08 |
| Sweden | 0.619 | 2972.7 | 1991 | $129.89 |

Since the primary argument against implementing a carbon tax is the belief that it would have negative impacts on GDP, I analyzed the impact tax had on the GDP of each of these countries (excluding Poland in which GDP data was not available) holding for any changes over time. The results can be found in Table 9. There were no observations of a country having a p-value less than 0.05 with a positive coefficient. The red indicates a country having a p-value of less than 0.05 with a negative coefficient.

*Table 9*: Linear regression results of GDP against the respective carbon tax holding for natural changes over time:

| Country | P-Value (GDP) | Coefficient |
|---|---|---|
| Canada | 0.379 | -4.39E+10 |
| Chile | 0.002 | -2.20E+10 |
| Denmark | 0.299 | 8.75E+09 |
| England | 0.479 | -4.84E+10 |
| Finland | 0.614 | 3.61E+09 |
| Iceland | 0.08 | 1.18E+09 |
| Ireland | 0.962 | -3.29E+08 |
| Japan | 0.057 | -2.70E+11 |
| Mexico | 0.165 | -4.97E+10 |
| Norway | 0.13 | 1.73E+10 |
| Sweden | 0.622 | 7.22E+10 |

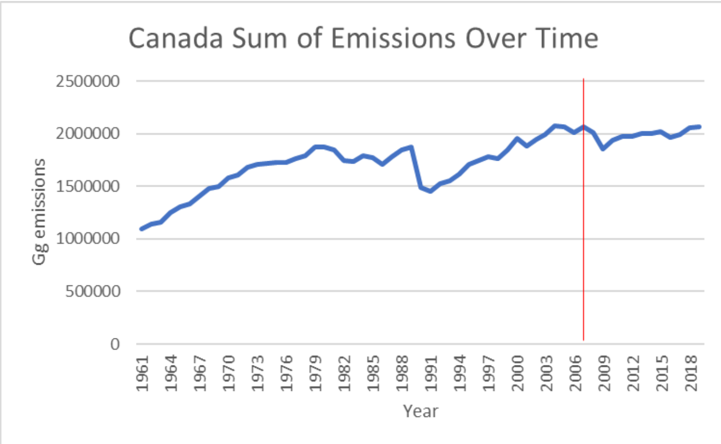
I found this result to be interesting because Chile's carbon tax showed to be ineffective at reducing emissions, but it ended up lowering their GDP. Based on the earlier definition of effective, this country seems to perform the worst of those analyzed. Comparatively, the other countries analyzed countries did not show an impact on GDP but did influence at least one of the emissions. The results of this linear regression process are summarized in Table 10.

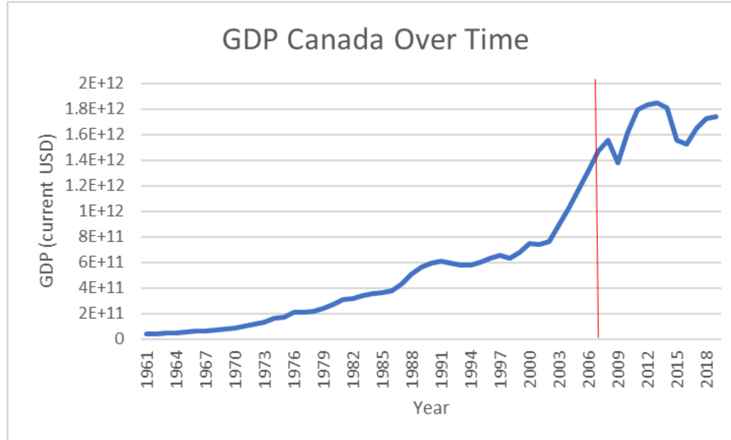
*Table 10*: Summarized results of linear regression models:

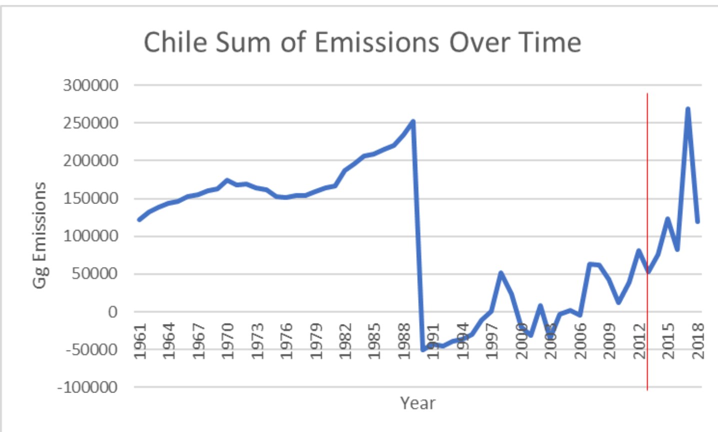
| Tax | Decreased GDP | No Effect on GDP |
|---|---|---|
| Increased at least one emission | | Mexico |
| No effect on any emissions | Chile | England<br>Ireland<br>Japan |
| Decreased at least one individual emission | | Canada<br>Denmark<br>Finland<br>Iceland<br>Norway<br>Sweden |

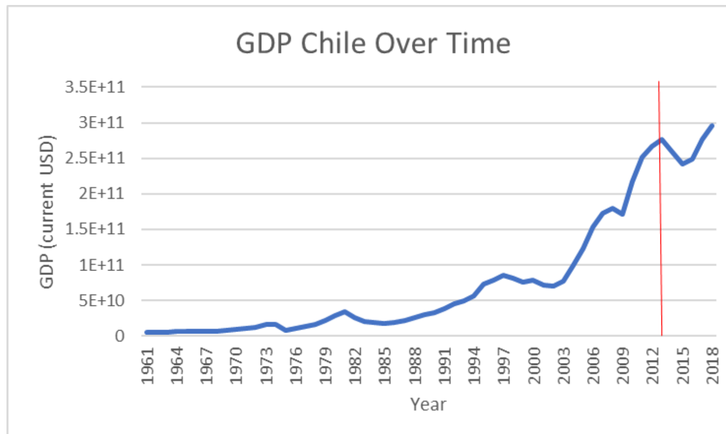
As mentioned earlier, success in this analysis is defined as two requirements being met. Emissions against the tax must have a p-value less than 0.05 with a negative coefficient for at least one emission, and GDP against the tax must either have a p-value greater than 0.05 or a p-value less than 0.05 with a positive coefficient. Based on these observations, six of the eleven carbon taxes fully analyzed were deemed “effective”.

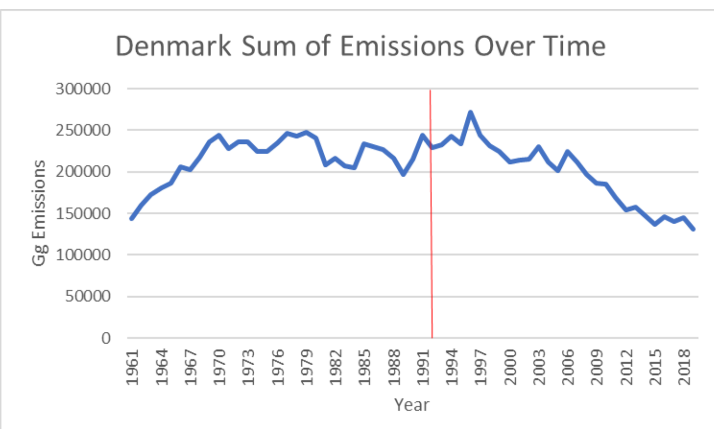
To better visualize these changes occurring over time, I graphed the total emissions in each country as well as the respective country’s GDP. The red line indicates the year of the tax implementation.

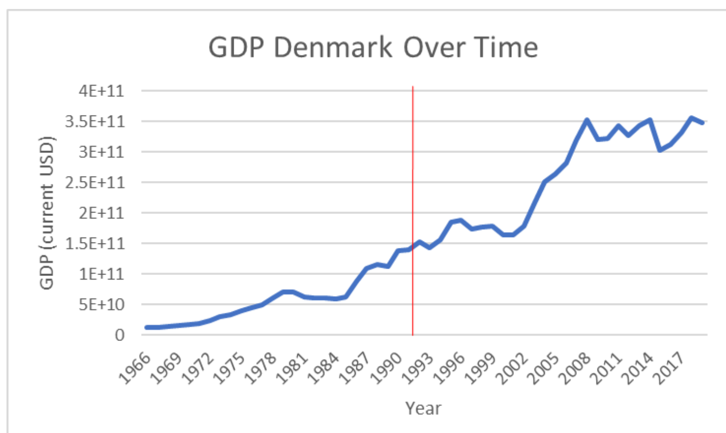

Canada Sum of Emissions Over Time
Gg emissions
2500000
2000000
1500000
1000000
500000
0
Year

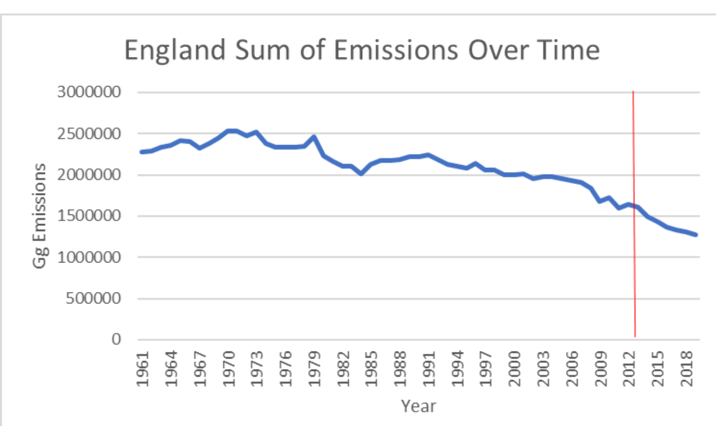

GDP Canada Over Time
GDP (current USD)
2E+12
1.8E+12
1.6E+12
1.4E+12
1.2E+12
1E+12
8E+11
6E+11
4E+11
2E+11
0
Year

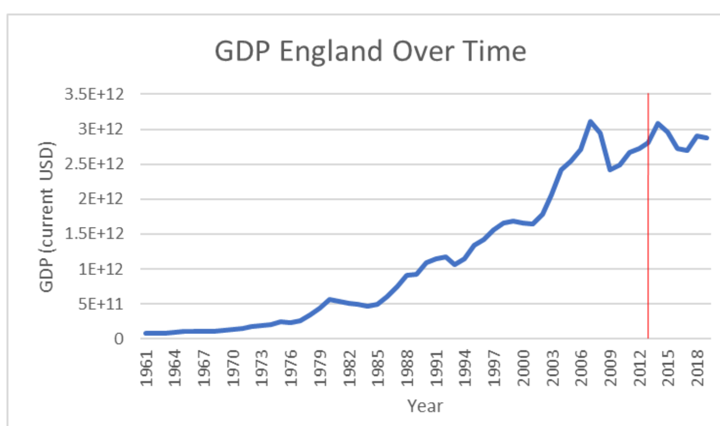

Chile Sum of Emissions Over Time
Gg Emissions
300000
250000
200000
150000
100000
50000
0
-50000
-100000
Year

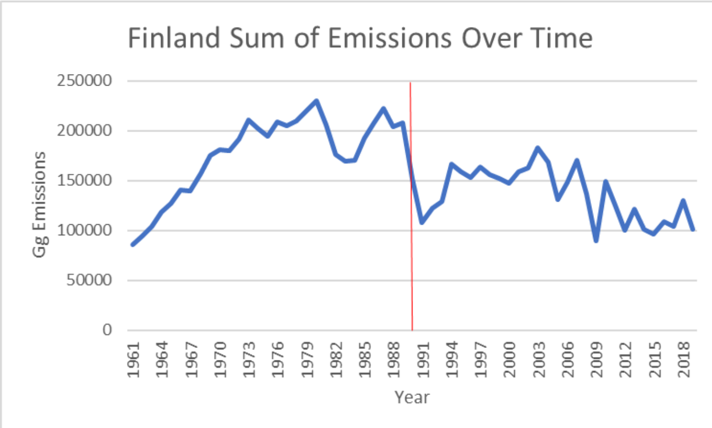

GDP Chile Over Time
GDP (current USD)
3.5E+11
3E+11
2.5E+11
2E+11
1.5E+11
1E+11
5E+10
0
Year


Denmark Sum of Emissions Over Time
Gg Emissions
300000
250000
200000
150000
100000
50000
0
Year

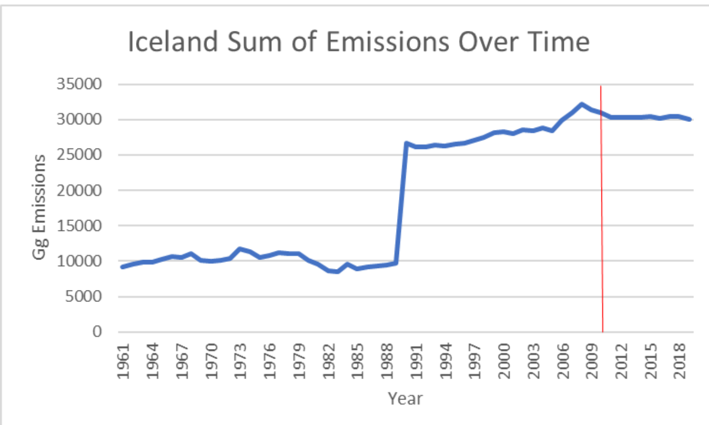

GDP Denmark Over Time
GDP (current USD)
4E+11
3.5E+11
3E+11
2.5E+11
2E+11
1.5E+11
1E+11
5E+10
0
Year


England Sum of Emissions Over Time
Gg Emissions
3000000
2500000
2000000
1500000
1000000
500000
0
Year

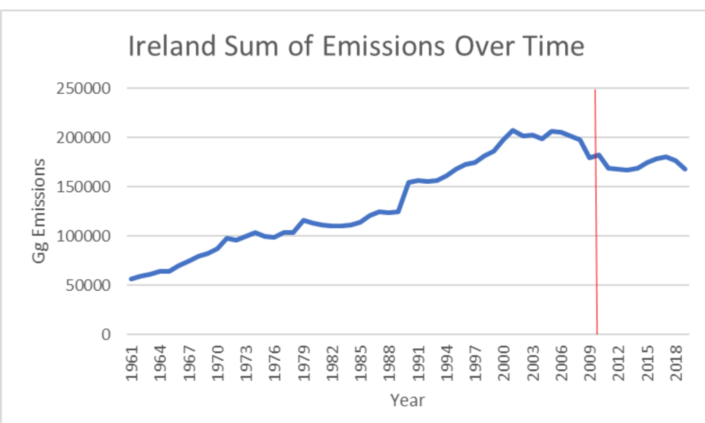

GDP England Over Time
GDP (current USD)
3.5E+12
3E+12
2.5E+12
2E+12
1.5E+12
1E+12
5E+11
0
Year

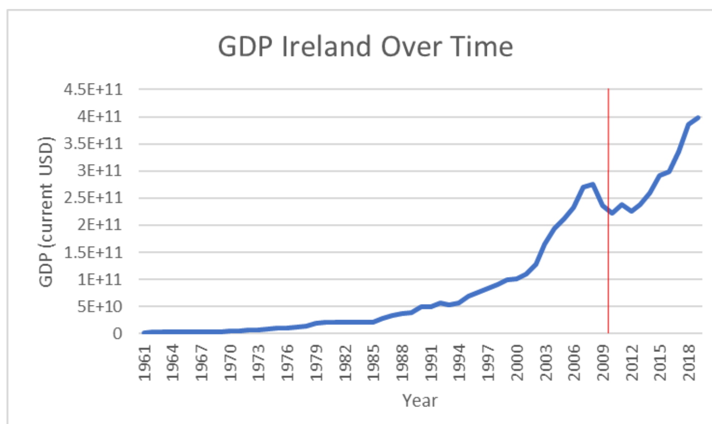

Finland Sum of Emissions Over Time
Gg Emissions
250000
200000
150000
100000
50000
0
Year

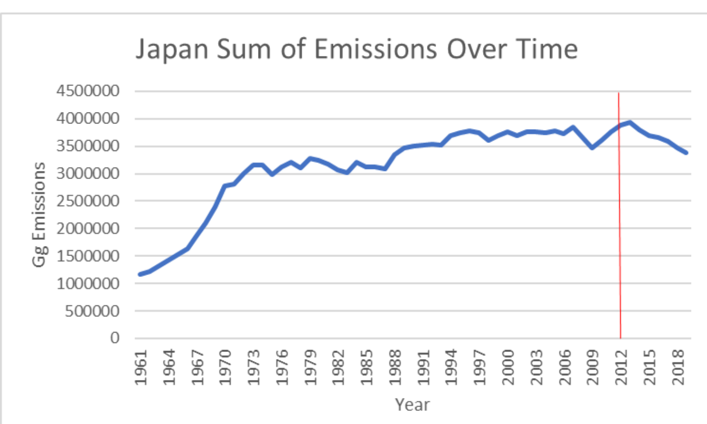

GDP Finland Over Time
GDP (current USD)
3.5E+11
3E+11
2.5E+11
2E+11
1.5E+11
1E+11
5E+10
0
Year

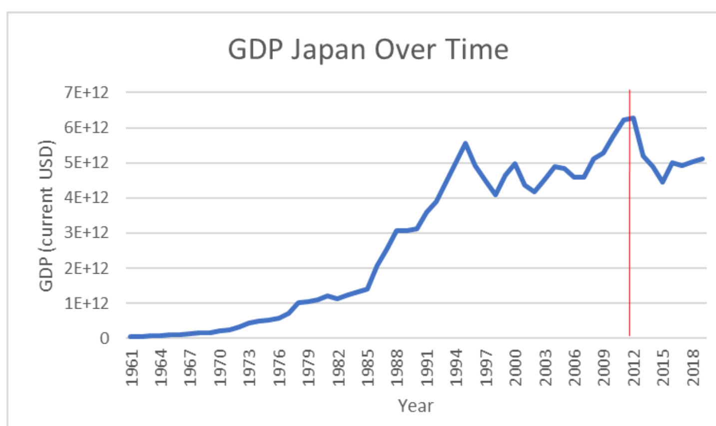

Iceland Sum of Emissions Over Time
Gg Emissions
35000
30000
25000
20000
15000
10000
5000
0
Year

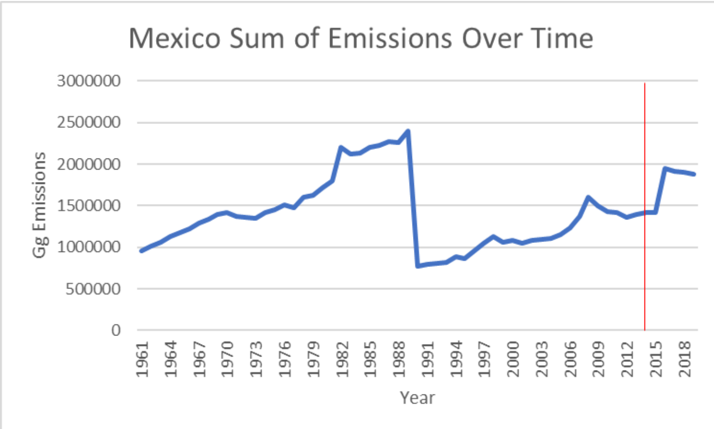

GDP Iceland Over Time
GDP (current USD)
3E+10
2.5E+10
2E+10
1.5E+10
1E+10
5E+09
0
Year


Ireland Sum of Emissions Over Time
Gg Emissions
250000
200000
150000
100000
50000
0
Year

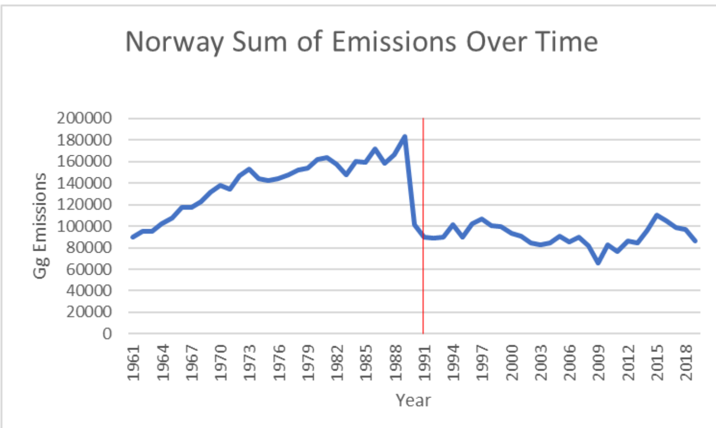

GDP Ireland Over Time
GDP (current USD)
4.5E+11
4E+11
3.5E+11
3E+11
2.5E+11
2E+11
1.5E+11
1E+11
5E+10
0
Year

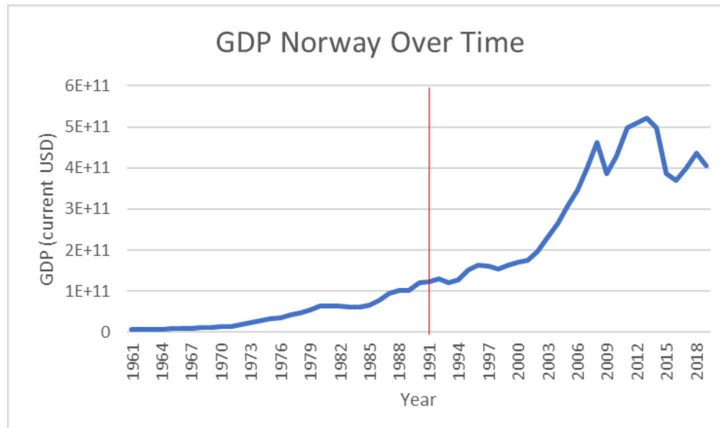

Japan Sum of Emissions Over Time
Gg Emissions
4500000
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
Year

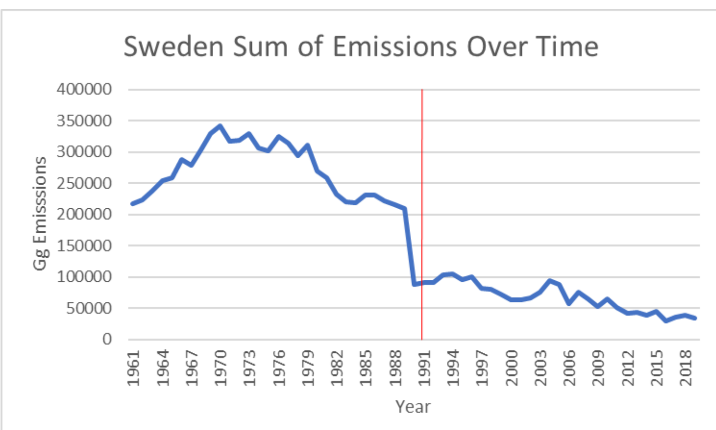

GDP Japan Over Time
GDP (current USD)
7E+12
6E+12
5E+12
4E+12
3E+12
2E+12
1E+12
0
Year

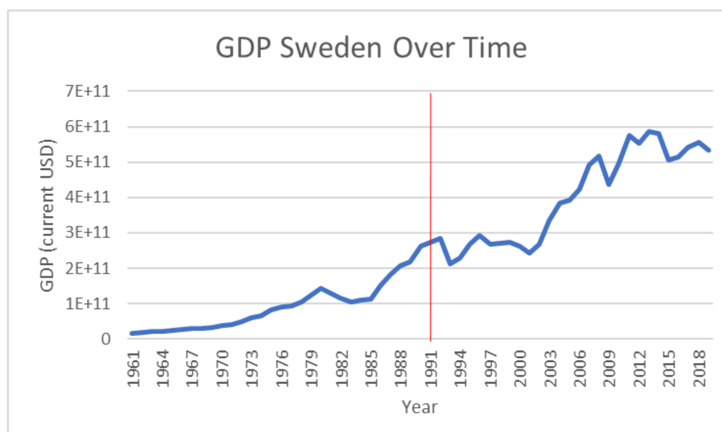

Mexico Sum of Emissions Over Time
Gg Emissions
3000000
2500000
2000000
1500000
1000000
500000
0
Year


GDP Mexico Over Time
GDP (current USD)
1.4E+12
1.2E+12
1E+12
8E+11
6E+11
4E+11
2E+11
0
Year


Norway Sum of Emissions Over Time
Gg Emissions
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Year


GDP Norway Over Time
GDP (current USD)
6E+11
5E+11
4E+11
3E+11
2E+11
1E+11
0
Year


Sweden Sum of Emissions Over Time
Gg Emisssions
400000
350000
300000
250000
200000
150000
100000
50000
0
Year


GDP Sweden Over Time
GDP (current USD)
7E+11
6E+11
5E+11
4E+11
3E+11
2E+11
1E+11
0
Year

## Conclusion

In this study, linear regression models were used to analyze the existence, or non-existence, of a relationship between the implementation of a carbon tax and the production of emissions in selected countries. The change in five different emissions across twelve countries was observed over time, with each of the twelve countries containing a carbon tax that was implemented prior to 2015. Furthermore, linear regression was also used to observe any change in the respective country's GDP as a result of the carbon tax to analyze if the implementation had affected the country's economy. Other factors that may affect emissions and GDP were held constant through a lag variable of time. Success, in this study, was defined as "effective" with a negative relationship between the carbon tax and at least one emission as well as no relationship between the carbon tax and GDP for each country.

It was found that of the eleven countries analyzed for both emissions and GDP, six were considered effective. What this indicates is that nine countries have a carbon tax in place that reduced emissions for their economy with no impact on their GDP.

## Future Work

There are some limitations I would like to address in future work. First, these models cannot deduce if these tax plans would be effective in any other circumstance. For example, implementing a tax in other countries that may be more dependent on fossil fuels or in a different country's economy. It can also be noted that there was no level of effectiveness defined in this paper. The plans were either deemed a success or a failure. Since climate change is such a prevalent issue, it could be worth the time to conduct further research into how effective these different carbon tax plans actually are. In addition to this, I would be very interested to look closer into the differences between each carbon tax plan to understand why some were more effective at reducing one emission compared to others.

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