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The Effectiveness of Carbon Taxes - An Analysis Across Multiple Countries

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ABSTRACT

With worldwide emissions of carbon dioxide contributing to global warming, countries are looking for ways to lower local emissions. One strategy for reducing carbon emissions is through national carbon taxes. These taxes vary both in terms of amount of the tax and industries included in the tax. With the first carbon taxes imposed thirty years ago, it is possible to assess effectiveness and challenges associated with carbon taxes.

Keywords: Carbon Tax, Emissions, Carbon Dioxide, Effectiveness

I. INTRODUCTION

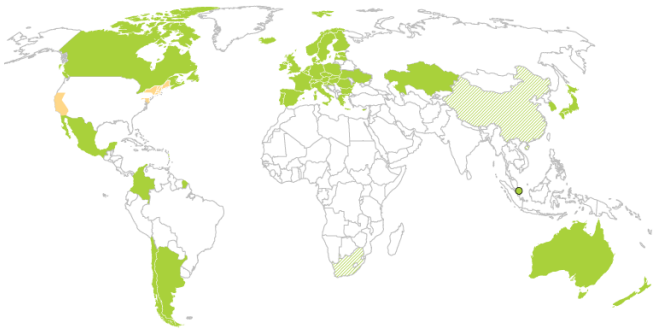
Carbon dioxide is the greatest contributor to global warming. With an intent to reduce carbon emissions, sixty-four countries have implemented taxes on carbon emissions. These taxes cover about twenty percent of carbon dioxide emissions worldwide (Farbstein & McCarthy, 2021). Carbon taxes vary in pricing structure, industries included in the taxation, income generated and reduction in carbon emissions. Several factors, including geographic location, per-capita income and resiliency to climate change are considered prior to implementing a carbon tax.

II. CASE STUDIES

To determine the effectiveness of carbon taxes, six countries were examined. Sweden, Canada, Ireland, Japan, Chile and China were selected as they represent a variety of tax rates, geographic locations and initial levels of carbon emissions.

A. Case Study — Sweden

In 1991 Sweden was one of the first countries to introduce a carbon tax. The price of Sweden's carbon tax started at $24 per ton and has risen to the highest in the world at $137 per ton. The Swedish carbon tax is designed to regulate motor and heating fuel production. As little fossil fuel is produced in Sweden, taxes are levied on fossil fuels at the time of import. Over the thirty years of Sweden's carbon tax, emissions have dropped from 0.25% to 0.11% of the global carbon dioxide emissions. (Jonsson, Ydstedt & Asen, 2020)



1. Countries with carbon taxes are shown above in solid green. Countries with pending carbon taxes are shown in green dashes and those with regional carbon taxes are in yellow.

Sweden's carbon tax raised $2.3 billion in 2019, approximately one percent of the country's total tax revenue. Several concerns exist within Sweden with regard to the carbon tax. A primary concern is the cap placed on taxation. Once a given amount of tax is reached, no further tax is placed on a company. The concern is that this may eliminate a company's desire to reduce émissions and leave potential for companies to produce more carbon dioxide than prior to implementation of the carbon tax. Further, large producers of carbon dioxide, including the steel and concrete industries are exempt from carbon taxes. The Swedish steel industry has been exempt from the carbon tax because the government demanded the industry be able to compete with foreign competitors. Further, the high cost of the carbon tax creates a benefit for companies to report reduced emissions. There is a cost associated with the Swedish government's need to provide oversight to this program and ensure accuracy (Jonsson, Ydstedt & Asen, 2020).

In the thirty years of Sweden's carbon tax, the per capita carbon dioxide emissions from industry, including steel production, have not declined (Ritchie, Roser & Rosado, Sweden, 2020).

B. Case Study — Canada

Canada's carbon tax was implemented in 2007. Canada's tax is primarily focused on carbon dioxide emissions from oil, coal and gas, These are taxed at a rate of $38 per ton (Plumer & Ponovich, 2019). Canada exempts most users within the steel and chemical industries from the carbon tax. However, the dirtiest companies within each sector are taxed.

In an attempt to focus impact on companies and limit the impact on households, revenue from Canada's carbon tax is provided to consumers. This creates a revenue-neutral carbon tax. The structure of Canada's carbon tax raises energy bills for those consuming energy from oil, coal or gas and while lowering energy bills for all other consumers.

In the province of British Columbia, the government directs income from the carbon tax to the two lowest income tax brackets. As a result, those with the lowest incomes in the area receive the greatest financial support (Revenue-neutral Carbon Tax, n.d.).

C. Case Study — Ireland

The Irish government initially considered a carbon tax in 2004. It was rejected based upon the potential impact on low income households. Despite the concern, the Irish government introduced a carbon tax in 2010. The initial tax of €20 ($21.60) per ton cost low income families less than €3 per week (Callan, Lyons, Scott, Toj & Verde, 2009).

The tax initially covered liquid fuels and gaseous fuels. It now extends to solid fuels. In 2020, the Irish government committed to increasing the tax by $8 per ton annually until 2030 (Callan, Lyons, Scott, Toj & Verde, 2009).

Since the implementation of a carbon tax in 2010, Ireland's share of global carbon dioxide emissions have decreased from 0.13% to 0.1%. It is estimated that Ireland will experience a reduction of 7% of their carbon dioxide emissions annually between 2021 and 2030 (Ritchie, Roser & Rosado, Ireland ,2020).

D. Case Study — Japan

Japan, vulnerable to climate change due to its geographic position within the Pacific Ocean, became one of the first Asian nations to implement a carbon tax. In 2012, at a time when their economy was declining in the financial crash, Japan chose to introduce a carbon tax.

Japan's carbon tax levy started at $2.65 per ton and increased $1.70 every two years (Gokhale, 2021). While the tax appears relatively low, Japanese emissions are taxed at two stages - first when the energy is produced or imported and later the consumer is taxed at the time of use.

The success of Japan's carbon tax is reflected in Japan's share of global carbon dioxide emissions decreasing from 3.73% in 2012 to 2.96% in 2020 (Ritchie, Roser & Rosado, Japan, 2020).

E. Case Study — Chile

In 2014 the Chilean government introduced a carbon tax on the power sector. The tax was set at $5 per ton of carbon dioxide emissions. In a country that is considered an average producer of greenhouse emissions, this number was considered by many to be low. In Chile's National Energy Policy Strategy Plan, the carbon tax for 2030 is projected at $35 per ton.

Since implementation of the tax, Chile's carbon emissions have increased by 7.8 million tons (Chile sets stage, 2022).

F. Case Study — China

China, the world's largest emitter of carbon dioxide, is yet to implement a carbon tax. China is currently trialing a cap and trade program in seven cities with intent to implement this program nationwide (Plumer & Popovich, 2019).

Through the cap and trade program, the government allocates each company carbon credits. Companies pay a tax for all emissions over the allocation. Companies have the option of trading unused credits with other companies.

China's cap and trade system has not yet had a noticeable impact on their carbon dioxide emissions. This is likely due to the limited scale of the test and the lesser effectiveness of a cap and trade system in comparison to a carbon tax.

III. ANALYSIS OF CASE STUDIES

Between 1991 and 2021, global carbon emissions have increased by 13.88 billion tons. Finland was the first country to attempt to address the issue of carbon dioxide emissions through the implementation of a carbon tax in 1990. Since this time, sixty-four countries have introduced carbon taxes.

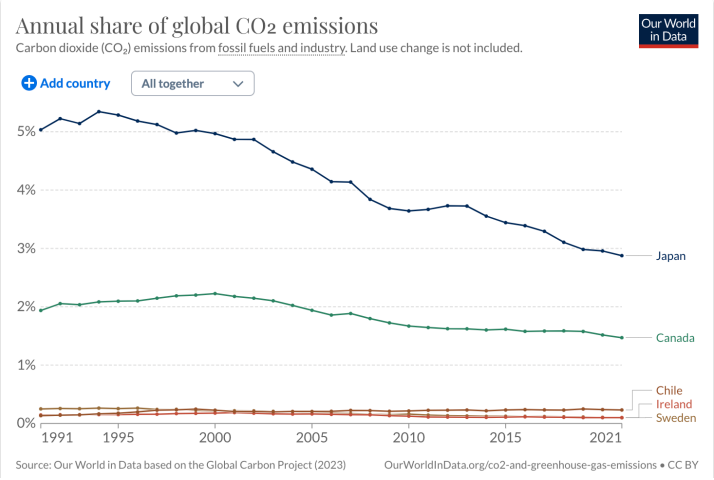
The carbon taxes have been structured in a variety of formats. Sweden taxes specific industries while Canada levies a lesser tax on low income households.

Both the structure of the carbon taxes and the results have been significantly varied across countries. As seen in Tab. 1, Chile saw an increase in carbon emissions following implementation of a carbon tax. In contrast, Sweden, Canada, Ireland have seen decreases of 0.7, 3.0 and 0.4 million tons per year respectively. The most significant reduction in carbon dioxide emissions is seen in Japan.

Japan demonstrated an average annual reduction in their carbon dioxide production by 27 million tons. At nearly severn times that of the combined reduction of Sweden, Canada and Ireland, this initially seems significant. However, further examining Japan's carbon emissions, before and after the implementation of the carbon tax, see Fig. 2, there is no noticeable change. The amount of carbon dioxide production in Japan was falling prior to the carbon tax and continues to fall. At a similar rate following the tax.

When looking at sources by fuel, see Fig.3, there is a noticeable shift around 2012 when Japan introduced their carbon tax. At this time the amount of carbon dioxide from burning oil drops in Japan from over 500 million tons to less than 400 million. Similar to Japan's overall carbon dioxide production, this trend was already shown prior to the carbon tax.

The question becomes one of whether these changes have an impact. Collectively, Sweden, Canada and Ireland reduced their carbon emissions by approximately four million tons per



2. Annual share of global carbon dioxide emissions for Japan, Canada, Chile, Ireland and Sweden since 1991.

year since the onset of their carbon taxes. This is more than off-set by the 7.8 million ton increase seen in Chile.

Further examination of overall carbon dioxide production of ten additional countries show varied results. Countries including Denmark, Mexico, Norway, South Korea and Ukraine show carbon taxes having no discernable impact on carbon emissions. Meanwhile, Columbia, Kazakhstan, Pakistan and Singapore have increased their carbon dioxide emissions since levying carbon taxes.

The differential between the carbon produced in these countries is put into perspective when one examines the carbon dioxide emission of China. In the last year, China alone increased their carbon emissions by 510 million tons. There is little value in dissecting the components of country-specific carbon taxes when those producing the largest amounts of carbon dioxide have the option to avoid the issue.

1. Selected countries start date of carbon tax, change in emissions with carbon tax, and percent change in carbon dioxide emissions during the period of time when they have a carbon tax

Country	Japan	Sweden	Canada	Ireland	Chile
Year of onset of carbon tax	2012	1991	2007	2010	2014
Total change in annual carbon dioxide emissions since onset of tax (million tons)	-240	-22	-48	-5	8
Average change in emissions per year since onset of tax (million tons)	-27	-0.7	-3	-0.4	1.1

IV. Limitation

This research is limited by the number of countries included in the analysis. While an attempt was made to include a variety of countries, both geographically and in terms of current trends in carbon dioxide emissions, inclusion of a greater number of data points would increase the accuracy of this work.

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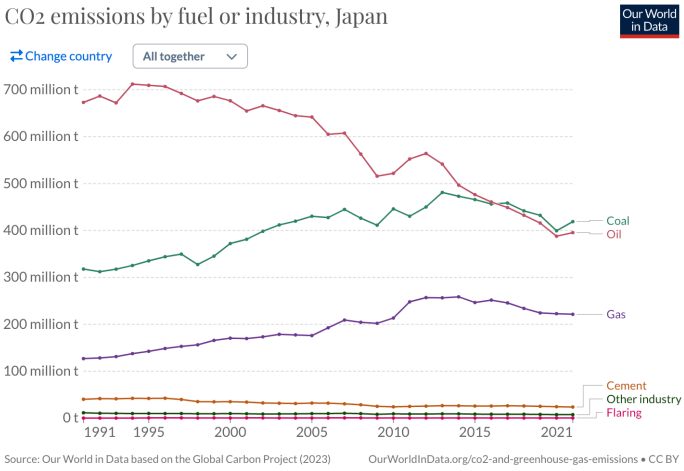
V. Future Work

In the coming years I intend to develop an analysis of worldwide carbon taxes from the time of introduction to the present. I will investigate both country-specific factors and worldwide information that may have influenced reductions in carbon emissions.

References

A brief history of the Canadian carbon tax. (2016, December 21). Energy Now. Retrieved May 20, 2023, from https://energynow.ca/2016/12/brief-history-canadian-carbon-tax/

Callan, T., Lyons, S., Scott, S., Tol, R. S.j., & Verde, S. (2009). The distributional implications of a carbon tax in ireland. *Energy Policy*, *37*(2), 407-412. https://doi.org/10.1016/j.enpol.2008.08.034



3. Carbon dioxide emissions by fuel for `Japan since 1991

Chile sets stage for new carbon tax as part of broader reform package. (2022, May 5). Bnamericas. Retrieved May 21, 2023, from https://www.bnamericas.com/en/news/chile-sets-stage-for-new-carbon-tax-as-partof-broaderreformpackage#:~:text=Chile%20sets%20stage%20for%20new%20carbon%20tax%20as%20part%20of%20broader%20reform%20package,-Bnamericas%20Published%3A%20Thursday&text=Chile's%20energy%20and%20environment%20ministries,part%20of%20a%20reform%20package.

A credible carbon tax trajectory for Ireland. (n.d.). Organisation for Economic Co-operation and Development. https://www.oecd.org/climate-action/ipac/practices/a-credible-carbon-tax-trajectory-for-ireland-a39128a3/

Farbstein, E., & McCarthy, T. (2021, September). *Global carbon pricing & COP26: a primer*. Normative. Retrieved May 20, 2023, from https://normative.io/insight/global-carbon-pricing-cop26/#:~:text=These%20carbon%20pricing%20programs%20cover,net%20zero%20emissions%20by%202050.

Fouché, G. (2008, April 29). *Sweden's carbon-tax solution to climate change puts it top of the green lis*. The Guardian. Retrieved May 21, 2023, from https://www.theguardian.com/environment/2008/apr/29/climatechange.carbonemissions

Gokhale, H. (2021). Japan's carbon tax policy: Limitations and policy suggestions. *Current Research in Environmental Sustainability*, *3*, 100082. https://doi.org/10.1016/j.crsust.2021.100082

How the climate crisis impacts Japan. (2019, August). The Climate Reality Project. Retrieved May 21, 2023, from https://www.climaterealityproject.org/blog/how-climate-crisis-impacts-japan

How the climate crisis impacts Japan. (2019, August). The Climate Reality Project. Retrieved May 20, 2023, from https://www.climaterealityproject.org/blog/how-climate-crisis-impacts-japan

Jonsson, S., Ydstedt, A., & Elke, Asen. (2020, September 23). *Looking back on 30 years of carbon taxes in Sweden*. Tax Foundation. Retrieved May 20, 2023, from https://taxfoundation.org/sweden-carbon-tax-revenue-greenhouse-gas-emissions/

Konradt, M., & Weder di mauro, B. (2023). Carbon taxation and greenflation: Evidence from europe and canada. *Journal of the European Economic Association*. https://doi.org/10.1093/jeea/jvad020

Plumer, B., & Popovich, N. (2019, April 2). *These countries have prices on carbon. Are they working?* The New York Times. Retrieved May 20, 2023, from https://www.nytimes.com/interactive/2019/04/02/climate/pricing-carbon-emissions.html

Prasad, M. (2022). Hidden benefits and dangers of carbon tax. *PLOS Climate*, *1*(7), e0000052. https://doi.org/10.1371/journal.pclm.0000052

Revenue-neutral carbon tax | Canada. (n.d.). United Nations Climate Change. Retrieved May 20, 2023, from https://unfccc.int/climate-action/momentum-for-change/financing-for-climate-friendly/revenue-neutral-carbon-tax

Ritchie, H., Roser, M., & Rosado, P. (2020). *Canada: CO2 country profile*. Our World in Data. https://ourworldindata.org/co2/country/canada

Ritchie, H., Roser, M., & Rosado, P. (2020). *Japan: CO2 country profile*. Our World in Data. https://ourworldindata.org/co2/country/japan

Ritchie, H., Roser, M., & Rosado, P. (2020). Ireland: CO2 country profile. Our World in Data. https://ourworldindata.org/co2/country/ireland

Ritchie, H., Roser, M., & Rosado, P. (2020). *Sweden: CO2 country profile*. Our World in Data. https://ourworldindata.org/co2/country/sweden

Ritchie, H., Roser, M., & Rosado, P. (2020). *CO2 emissions*. Our World in Data. Retrieved May 20, 2023, from https://ourworldindata.org/co2-emissions