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The effect of Carbon tax on EU Member States

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Contents

1 Introduction

Since the Paris Agreement of 2015, the need to reduce greenhouse gas (GHG)[1] emissions gained importance in policy-making decisions. The objective of the Paris Climate Agreement is *'to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels'* (UNFCCC, 2024). As graphed in Fig 1, the concentration of GHG in the atmosphere reached 472 parts per million CO_2 equivalents in 2021[2]. We can say with a 67% confidence interval that this level of concentration cannot allow us to achieve the 1.5°C target.

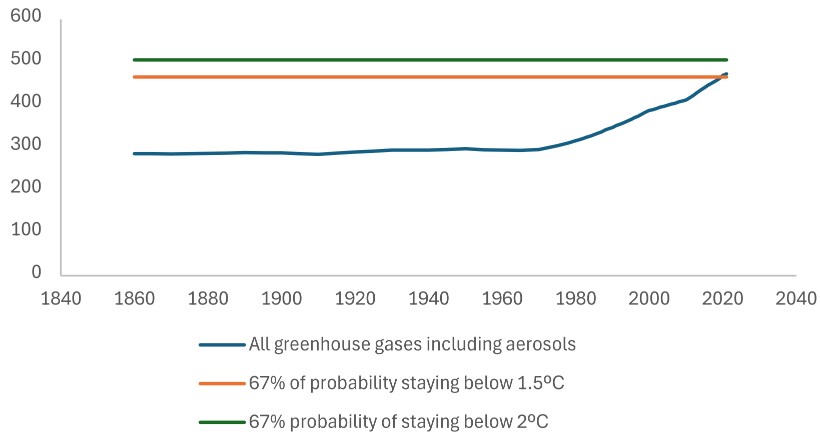


Figure 1: *Combined global atmospheric concentration of all greenhouse gases and forcing agents (European Environmental Agency, 2024)*

Furthermore, the emissions of carbon dioxide, the main GHG in the atmosphere, are increasing, especially with the rise of world powers such as China and India. The CO_2 emission per capita became a measure of the wealth of nations, with low levels reflecting low income[3]. Figure 2 gives us an overview of the higher level per capita. The graph shows us that the EU and the USA are starting to take action to reduce their carbon footprint, while China and India are continuing to increase their carbon footprint.

[1]**Greenhouse gases** (GHGs) are atmospheric gases that trap heat from the sun, preventing it from escaping back into space and thus warming the Earth's surface. Major greenhouse gases include carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These gases are produced by both natural processes and human activities, such as burning fossil fuels, deforestation, industrial processes, and agricultural practices.

[2]CO_2 **equivalent** (CO_2e) is a measure that expresses the impact of different greenhouse gases in terms of the amount of CO_2 that would have the same effect on global warming. This allows for a standardized way to compare the effects of various gases, with that of carbon dioxide.

[3]CO_2 per capita is often considered a measure of the wealth of nations because higher economic activity typically involves greater energy consumption, which, in turn, results in higher CO_2 emissions. Wealthier countries generally have more industrial activity, transportation, and energy use, all of which contribute to higher emissions. Conversely, lower-income countries tend to have lower emissions due to less industrialization and energy consumption.

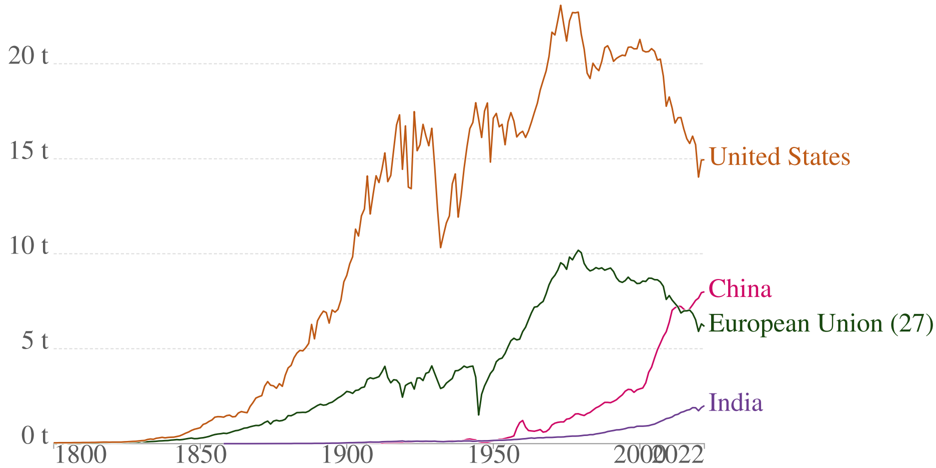


Figure 2: *Per capita CO_2 emissions in USA, EU, India and China. Global Carbon Budget (2023); Population based on various sources (2023)*

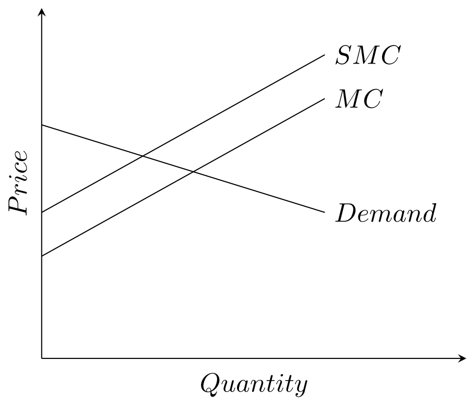
With the urge to act, we must find effective measures to decrease the level of GHG in the atmosphere. To achieve this, the goal should be to raise the cost of polluting while lowering the cost of clean alternatives (Metcalf, 2019).

In this thesis we focus on understanding the efficiency of the carbon tax for EU Member States. In Chapter 2 we have a closer look into the theoretical analysis, explaining possibility for climate policy and looking better at the current application of carbon tax. In Chapter 3 we explain the metholodogy used fro the empirical analysis were we replicated a previous study conducted by Metcalf and Stock. Chapter 4 provided the result from this research, focusing on the applicability of the initial study.

2 Theoretical Framework

2.1 Carbon Tax vs Cap-and-Trade

In this context, economists found two alternatives to decrease the level of GHG emissions: the direct taxation of emissions or the cap-and-trade system. The first one is built on the concept of "environmental eternality"[4], which needs to be internalised according to the Pigouvian view (Pigou, 1960).



Pigou theorised that the externality should be taxed at the Social Marginal Damage[5], being the social marginal harm for the emission. This taxation shifts the MC for producing up by the carbon tax ($\tau_{t,CT}$). As explained in Metcalf and Weisbach (2009) this approach cannot hold in practice for the taxation of emissions due to the high uncertainty of effects and the strong change over time of the variable. Hence, in recent years, the view that the carbon tax should be adjusted to the pre-existing level of distortion in the economy is increasing. Metcalf (2019) reasons that an effective carbon tax should be calculated by dividing the marginal damage of pollution by the marginal cost of public funds. In other words, if there is a large tax distortion, the marginal cost of public funds increases, leading to a lower carbon tax. The cap-and-trade system, on the other hand, is based on the work of John Dales (1986) and Coase's theory of property rights. This policy provided a limited number of allowances for pollution (cap) and the possibility to trade them among businesses. The EU Emissions Trading System (EU-ETS), established in 2005, is one notable implementation of this approach within the European Union, aiming to reduce greenhouse gas emissions by setting caps on emissions and allowing companies to trade allowances. The measure covers major industrial sectors such as energy production, manufacturing, and aviation, which are significant contributors to greenhouse gas emissions in Europe.

Currently, the most common policy in this framework is the cap-and-trade, primarily for political reasons (Metcalf, 2019). One rationale is that the emission price is determined by the market, which reduces direct political interference. Another explanation is that allowances can be distributed strategically to industries and stakeholders,

[4] **Environmental externality** refers to the unintended or uncompensated impact of economic activity on the environment. When the costs or benefits of an activity are not fully reflected in the prices that individuals or businesses pay, externalities arise. Environmental externalities can include pollution, depletion of natural resources, or habitat destruction, affecting third parties or society at large without their consent or compensation.

[5] **Social Marginal Damage** refers to the additional harm caused by emitting one more unit of a pollutant, such as a GHG. This concept takes into account the negative externalities, or unintended side effects, that pollution imposes on society, including health problems, environmental degradation, and economic costs.

which helps to mitigate political opposition and gain broader support for the policy.

2.2 Design a Carbon Tax

While in theory, the carbon tax represents a viable response to climate change, in practice the design of the policy measure is more complex than it seems. Metcalf and Weisbach (2009) identify three main issues: the tax rate, the tax base and the international trade, which have later been expanded by Marron and Toder (2014).

2.2.1 Tax Rate

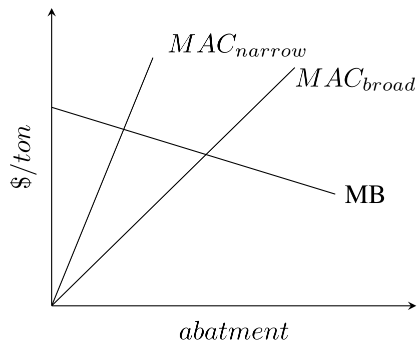
Firstly, as explained above, the tax rate should be set at the marginal harm from emission. However, the uncertainty of direct and indirect effects, the non-linear dependence on the stock of GHG, and unsure future economic development make it more complex to identify the tax rate properly. Marron and Toder (2014) argued that a possible solution could be the design to meet future environmental targets, which is a less demanding solution to achieve the goal. Furthermore, when designing the tax rate we need to discuss the progressivity over time. Since the social cost increases as GHG is built Marron and Toder (2014) consider a progressive tax rate more appropriate. This solution allows for the reduction of transition costs and the fostering of innovation.

2.2.2 Tax Base

The second aspect that Metcalf and Weisbach (2009) analysed is the tax base. In this context, the efficiency benefit of expanding the tax base needs to be balanced with the administrative saving of a narrow one. For this reason, we write the formula as Marginal Abatement Cost[6] equals to Marginal Benefit.

$$MAC = MB \tag{1}$$

Obviously the broader the tax base, the flatter the MAC, thanks to the spread of aggregate cost on a wider base. As shown in the graph below, a broad MAC increases the optimal abatement quantity, while a narrow MAC requires a higher $/ton tax rate. Another advantage of a broad tax base is the possibility of decreasing the tax rate, which leads to the reduction of political opposition to the measure. However, at the same time, it brings more special interest into play, making it more difficult to properly design the tax.



[6]**Marginal Abatement Cost** (MAC) refers to the cost incurred to reduce or mitigate one unit of pollution or emissions in the context of environmental economics. It represents the additional expenditure required to achieve a marginal decrease in pollution levels, often through the implementation of environmental policies, technologies, or practices. The concept of MAC is crucial in assessing the economic efficiency of environmental regulations and policies, as it helps policymakers and analysts evaluate the trade-offs between environmental benefits and the costs associated with achieving those benefits.

2.2.3 International Concerns

The last point considered in Metcalf and Weisbach (2009) is the international trade. Since the introduction of local carbon prices allows for carbon leakage[7], the discussion needs to focus on globalised considerations. The most popular solution (Metcalf and Weisbach, 2009 and Marron and Toder, 2014) is to tax the importation of products coming from countries without carbon prices. This solution is perfectly consistent with the free trade principle, since the no-carbon price is not in a true competitive advantage situation, due to the externality. This price is simply not considering a part of the production cost, which is the emission. This tax will serve as a substitute for the lack of accounting for this additional cost in the production chain.

2.2.4 Use of revenue

Lastly, since carbon tax is a regressive tax[8], and the cost of it is passed to consumers both through higher cost of energy and higher cost of goods and services (Mathur and Morris, 2012), it is also crucial to focus on the use of carbon revenue. Marron and Toder (2014) found that the largest efficiency benefit comes from the reduction of corporate tax rate. However, this measure does not affect the middle and lower classes of the population. Other possibilities that the two economists found compelling are the use for transitional assistance, environmental remediation, and the reduction of future deficits. In the next section we will look deeper into the use of revenue to reduce the burden of other taxes.

2.2.5 Double-Dividend Effect

It is commonly said that the carbon tax has a double-dividend effect, providing both environmental benefits and reducing the overall cost of the tax system. While there is common agreement on the positive effect on the environment, the reduction of cost is more debated. To reduce the impact, early literature suggested returning carbon tax revenue to the economy through lump-sum payments[9]. However, the focus has now shifted to reducing distortionary taxes[10].

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[7]**Carbon leakage** refers to the phenomenon where stringent climate policies, such as carbon pricing or emissions regulations, lead to the relocation of carbon-intensive industries to regions with weaker or absent regulations. This relocation can occur due to competitive disadvantages faced by industries in regions with stricter climate policies, potentially resulting in an overall increase in global GHG emissions rather than a reduction.

[8]**Regressive tax** is a type of tax that takes a larger percentage of income from low-income earners than from high-income earners. This means that as income decreases, the proportion of income needed to pay the tax increases, placing a heavier financial burden on those with lower incomes.

[9]**Lump-sum fashion** refers to a method of distributing or collecting funds where each recipient or payer receives or pays a fixed amount, regardless of their circumstances. This approach does not take into account the individual's income, consumption, or other economic factors, making it a straightforward but often less equitable method of fiscal policy. For example, in the context of carbon tax revenues, a lump-sum distribution would mean returning the same amount of money to every citizen, irrespective of their carbon footprint or financial situation.

[10]**Distortionary tax** is a tax that alters economic behaviour and resource allocation by changing the relative prices of goods, services, or factors of production. Common examples of distortionary taxes include income taxes, which influence work effort; sales taxes, which can affect consumer spending patterns; and corporate taxes, which can impact investment decisions and business activities. Distortionary taxes are considered more ethical and fair since they consider individuals' ability to pay.

Goulder (1995) identifies and discusses three key claims regarding this effect, exploring each claim in depth to understand their validity. The weaker form states that the cost-saving from the reduction of distortionary tax (ΔT_L) is greater than those from lump-sum fashion (Δt_x).

$$C(t_e; \Delta t_x) < C(t_e; \Delta T_L) \tag{2}$$

This form is easy to prove since the fact that swapping from lump-sum to distortionary creates welfare efficiency is in the definition of the latter.

The stronger forms are harder to prove. They state that the switching from a distortionary tax to an environmental one results in a negative overall gross cost.

$$C(t_e; \Delta t_x) < 0 \tag{3}$$

This means that *ceteris paribus*, the costs associated with an environmental tax are lower than those of distortionary ones. The intermediate claims state that this applies to at least one of the distortionary taxes, while the stronger one states that this applies to an average distortionary tax. In the intermediate claim, if we have a particularly expensive tax we should replace it with any other less expensive tax, even without a carbon tax, because this tax is harmful for the tax system. Bovenberg and de Mooij (1992, 1994a) studied the stronger claim and rejected the strong form of the double-dividend proposition. However, Goulder (1995) argued that tax base erosion in these studies limited the benefits and increased the overall cost[11].

2.3 Carbon Tax in Europe

Looking at the situation in Europe, Table 1 shows us that 17 countries under the EU-ETS already implemented the carbon tax in their climate policy[12]. Sweden, as one of the pioneers, continues to lead with one of the highest carbon tax rates globally, currently set at approximately \$130 per ton of CO2e. The revenue from Sweden's carbon tax is used for the "general budget", however, it may fund specific purposes linked to the carbon tax (Regeringskansliet, 2018).

Similarly, Finland, another early adopter, maintains a high tax rate of around \$100 per ton. France has also implemented a carbon tax, although at a more modest rate of €47.94 per ton, with efforts to balance environmental goals and public acceptance following the "Yellow Vest" protests. In contrast, countries like Estonia have been more cautious, leading to lower or less comprehensive carbon tax schemes.

Interestingly, it is noted that Spain has one of the lowest carbon taxes in Europe. Even if the country has a longstanding history of carbon pricing, the tax rate decreased over time. This can be attributed to the increase in dependence on the importation of energy sources from countries such as Morocco. Those countries are not affected by Spanish carbon tax, thus making even less competitive local energy (Climate Scorecard, 2020). This concept is explored in Section 2.2.3.

[11] In Bovenberg and de Mooij (1992, 1994a) the tax base does not cover all the final good, thus incentivising the household to substitute the goods subject to this tax with other could that does not fall under this taxation.

[12] Switzerland is not part of the EU-ETS, and it has its own cap-and-trade policy. However, since 2020 the two measures have been linked to improve efficiency. Since that year the two ETSs have adopted the same benchmark, for some sectors, to avoid carbon leakage (ICAP, 2020).

Country	Year of Enactment	Rate in 2023 (USD/tCO2e)	Share of Emissions in 2023 Covered by Tax	Revenue in 2023 (USD Millions)
Denmark	1992	28.21	0.48	468
Estonia	2000	2.15	0.10	2
Finland	1990	99.99	0.45	1734
France	2014	47.94	0.40	8400
Hungary	2023	38.70	0.32	NA
Iceland	2010	36.51	0.36	55
Ireland	2010	60.19	0.34	874
Latvia	2004	16.12	0.02	8
Liechtenstein	2008	132.12	0.72	5
Luxemburg	2021	49.91	0.72	287
Netherland	2021	71.48	0.45	0
Norway	1991	107.78	0.65	2157
Poland	1990	NA	0.24	7
Portugal	2015	NA	0.40	495
Slovenia	1996	18.60	0.46	85
Spain	2014	16.12	0.02	77
Sweden	1991	127.26	0.40	2342
Switzerland	2008	132.12	0.35	1617

Table 1: *List of countries under the EU-ETS which have a carbon tax.*

On the other hand, various countries still do not have implemented the carbon tax in their climate policy. For example Italy and the Czech Republic argue that EU-ETS already imposes significant costs on their economies and prefer to focus on gradual transitions, investments in renewable energy, and other measures to meet climate goals.

Austria is starting to implement an ambitious carbon price system (Federal Ministry of Finance, 2022). This process started in 2022 with an experimental phase which will last until 2025 and mixed the concept of a carbon tax with the cap-and-trade system allowing for the sale and selling of carbon credits at a specific price set by the Ministry of Finance. This measure will cover all the sectors not affected by the EU-ETS.

2.4 Sweden Case Study

Sweden is one of the pioneers of carbon tax with its first implementation in 1991. As shown in Figure 9 and in Table 1 the country also has one of the highest tax rates in the world and the highest among Scandinavian countries.

Important aspects need to be analysed when looking at the Swedish carbon tax. First of all, since Sweden is an acceding country of the EU-ETS, sectors already covered by that measure do not fall under this tax base. Secondly, given that the country was one of the early adopters, the concern for international competitiveness and carbon leakage was high. Those issues have been solved with lower rate differentials for specific sectors such

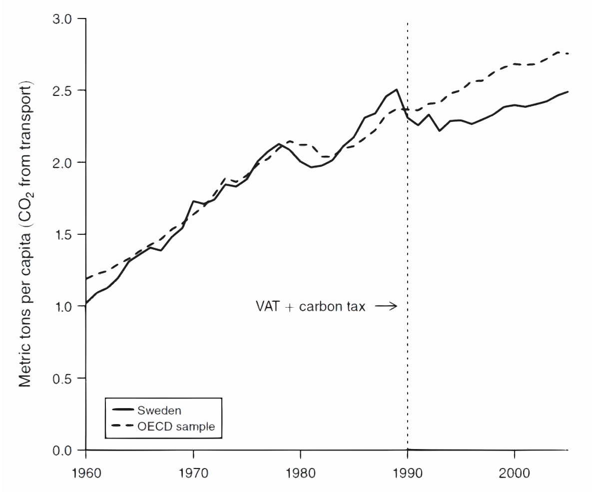

Figure 3: *Per Capita CO_2 emission from the transportation sector in the period 1960-2005, Sweden versus 14 OECD Countries*

as industry and agriculture. Those carbon rate differentials have been progressively narrowed until a complete elimination in 2018 (Metcalf, 2019). One of the few sectors that has not been affected by this differentiation is transportation, which accounts for 90% of the total revenue coming from the measure (Andersson, 2019). Thirdly, before the application of the carbon tax in 1991, the Swedish government expanded the value-added tax (VAT) to include gasoline and diesel at a 25% rate. This measure is applied to all components at a retail level. This means that while in 1989 the price of gasoline was only given by the retail price plus the energy tax ($p_g + \tau_{t,energy}$) in 1991, only two years later, it added to the previous price the carbon tax ($\tau_{t,CT}$) and multiplied the result by the VAT.

$$p_g^* = (p_g + \tau_{t,energy} + \tau_{t,CT})VAT_g \tag{4}$$

Different studies have been conducted to understand the effectiveness of this measure and it has been shown that between 1990 and 2004 the emissions fell by 10% while the manufacturing output improved by 35% with carbon tax playing a significant role in this improvement (Brännlund, 2014). Furthermore, the Swedish GDP has grown by 80% since the 1990s, alongside an emission reduction of 1/4 in the same period (Metcalf, 2019).

Lastly, Andersson (2019) focuses on the effect of the carbon tax on the transportation sector. Figure 3 related the trend in emission in Sweden with other 14 OECD countries. The result found in the paper shows that emissions declined by 11% in an average year from the 1990s. However, thanks to an empirical analysis done by Andersson (2019)[13] it has been found that 6% of the decrease can be attributed to the carbon tax alone.

In conclusion, Sweden's pioneering carbon tax policy demonstrates a successful approach to reducing GHG emissions while maintaining economic growth. The country carefully addressed international competitiveness and carbon leakage concerns through sector-specific rate differentials. Sweden has shown that environmental and economic objectives can be aligned. The significant reduction in emissions, and the simultaneous growth in GDP and manufacturing output underscore the effectiveness of the carbon tax. The Swedish experience provides valuable insights and a robust case study for other nations considering similar measures to combat climate change.

[13] In this empirical analysis Andersson questions the effect of the carbon tax on the transportation sector by decomposing the Swedish retail price of gasoline into oil price and excise tax.

3 Methodology

After having seen the theoretical aspect of the carbon tax, we aim to analyse the effect of this measure on the economy. Es explained in Section 3.1, there is a widespread belief that carbon price harms the economy. In this chapter, we look deeper into the methodology used for the empirical analysis of the effect of carbon tax on EU Member States and address the issues encountered by doing so.

3.1 Metcalf and Stock (2020) Analysis

This research is built on the previous study conducted by Metcalf and Stock (2020). To address the widespread public concern that a carbon tax could hurt the economy[14], Metcalf and Stock examined its impact on key macroeconomic variables, including GDP and employment. As explained in Section 3.2, by expanding on this work, the present research aims to further investigate these effects across different sectors and time periods, especially after macroeconomic shocks that impacted the economy.

3.1.1 Econometric Model

The authors applied the Local Projection (LP) Model (Jorda, 2005) to build an Ordinary Least Squared (OLS) econometric model[15] to estimate a sequence of panel data regression. The Local Projection method is used to estimate the Impulse Response Function (IRF)[16] of a variable affected by a shock, this function is characterized by dynamicity since each regression is estimated separately for each time horizon. Thanks to this, more complex temporal patterns can be analysed. This can be particularly useful in a panel data context such as ours since the fixed effect allows us to control for unobserved heterogeneity across countries and time. Another important advantage of the LP model is its robustness. This model is less sensitive than other Vector Autoregression models to misspecification.

In the original paper, the authors combine the LP model with the Structural Vector Autoregression (SVAR) to have a better overview of the results. However, since the results were almost identical and we expected the same from our analysis, we kept the result only with the LP estimation for simplicity.

Equation 5 relates the carbon tax rate for the country i at time t (τ_{it}), the effect of unexpected changes in the

[14]There is a common perception that a carbon tax can harm the economy by increasing costs for businesses and consumers, leading to higher prices and reduced economic growth (The Globe and Mail, 2021; Competitive Enterprise Institute, 2018). Critics argue that this could result in a competitive disadvantage for industries and spur a political backlash against the policy. This idea is also supported by standard public finance theories, which suggest a relation between the level of the tax and the level of GDP. Over a given period, an adjustment of GDP from a no-tax to a tax path entails a shift in the level, that is, an effect on the growth rate.

[15]**Ordinary Least Squares** (OLS) model for panel data is a statistical method used to estimate the relationships between variables across multiple observations over time for the same entities (in this case countries). The OLS method minimizes the sum of squared residuals to provide the best linear unbiased estimates of the coefficients. This approach assumes, among others no perfect collinearity, exogeneity, and no heteroskedasticity.

[16]**Impulse Response Function** (IRF) is a tool used in econometrics to analyze how a dynamic system, responds over time to external shocks. It traces the effect of a one-time change in an exogenous variable on the endogenous variables in the model, providing insight into the temporal dynamics and the magnitude of the response. IRFs are commonly used to understand the impact of policy changes, economic events, or other shocks on the variables of interest.

carbon tax rate, and the annual GDP growth. $\theta_h \tau_{it}$ is the measure of the immediate effect of the carbon tax on GDP growth. This is the primary coefficient of interest for policy evaluation.

$$100\Delta ln(GDP_{it+h}) = \alpha_i + \theta_h \tau_{it} + \beta(L)\tau_{it-1} + \delta(L)\Delta ln(GDP_{it-1}) + \gamma_t + u_{it} \tag{5}$$

This model includes a country (α_i) and year (γ_t) fixed effect[17] allowing us to account for the higher probability of countries with higher mean growth to increase their carbon tax[18]. Although the exogeneity assumption[19] of the model suggests that a year-fixed effect is not necessary, it has been included. This inclusion accounts for common political pressures across countries that could act as confounders, even if they are exogenous. Additionally, adding the year-fixed effect reduces the standard error in our regression. It could be argued that the result appears to be different from the one without this effect, however, Metcalf and Stock (2023) tested for dropping this variable and showed that the result is unchanged. Therefore, we kept the fixed effect in our analysis as provided in Metcalf and Stock (2020).

3.1.2 Dataset

Continuing our analysis on Metcalf and Stock (2020), the dataset used for the paper considered only countries subject to the EU-ETS[20]. It is important to note that this policy already covered some of the main carbon-intensive industries such as the electricity sector. For this reason, the carbon tax already existing in some countries does not include those sectors in their tax base. To ensure continuity with the original study, we maintained consistency with the sources used in Metcalf and Stock (2020) while updating the dataset with the most recent available information. Table 2 provides a detailed compilation of the specific data sources used in this study, offering transparency and clarity regarding the data underpinning our analysis.

As will be explained in Section 3.3, certain data are not publicly available. To overcome this issue we kept the original files available in the replication package.

[17] **Country and year fixed effects** are used to account for unobserved heterogeneity across countries and time periods, respectively. Country fixed effects capture differences between countries that are constant over time, such as cultural factors or institutional differences. Year fixed effects capture common shocks or trends affecting all countries in a particular year, such as global economic conditions or policy changes. Including these fixed effects in the model allows for controlling these unobserved factors and focuses estimation on the variation within countries over time, providing more robust and unbiased estimates of the effects of explanatory variables on the dependent variable.

[18] The increase in the tax rate could be due to higher economic growth. This unobserved factor introduces bias in our analysis, as it creates structural differences between countries with higher economic growth and those with lower growth. These structural differences can lead to inaccurate estimations because countries with stronger economies might naturally be more inclined to raise their carbon taxes. By including country and year fixed effects, we control for these differences, ensuring that our estimates accurately reflect the impact of the carbon tax itself rather than being influenced by underlying economic growth disparities.

[19] **Exogeneity** in panel data refers to the assumption that the explanatory variables are uncorrelated with the error term in the model. This implies that the explanatory variables are determined outside the model and are not influenced by the dependent variable, ensuring that any observed relationships are not biased by omitted variable bias or reverse causality. In practical terms, this assumption allows for consistent and unbiased estimation of the coefficients in panel data regression models.

[20] In this measure are included countries members of the EU plus Iceland, Norway and Switzerland. Of these countries, 17 have a carbon tax that covers some sectors of the economy not covered by the EU-ETS. As explained above the participation of Switzerland in this measure is marginal, however, we decided to consider it in our analysis.

Type of Data	Source
Real GDP	World Bank Group
Carbon tax rates	World Bank Group
Employment	EU Eurostat database
Energy price and tax	International Energy Agency
Share of Emission covered	World Bank Group

Table 2: *Sources used in data collection*

Once the data had been collected, we followed the same procedure used in the original study to build the final dataset. Those procedures can be found in the replication package. The main function of the procedure was to drop data for countries that we do not aim to consider in our analysis, meaning outside the EU-ETS, and to clean variables that we are not interested in, such as employment of some specific sector. This allowed us to have a clean dataset which contains only the relevant information. Figure 4 shows the variables contained in the final dataset with their explanation.

Variable name	Storage type	Display format	Value label	Variable label
country	str66	%66s		name
ID	str8	%9s		LOCATION
year	int	%10.0g		Year
EU2	float	%9.0g		EU plus Iceland, Norway, Switzerland
IntRevRec	double	%10.0g		Fraction of carbon tax revenues initially earmarked for tax reduction
SCA	float	%9.0g		Norway, Sweden, Denmark, Finland
ctaxever	float	%9.0g		carbon tax in any year
ctaxyear	float	%9.0g		First year of carbon tax (else missing)
dlemission_ct~s	float	%9.0g		CO2 from fuel consumption in road transport, commercial and institutional sector
dlempman	float	%9.0g		Manufacturing employment annual growth rate (percent)
dlemptot	float	%9.0g		Total employment annual growth rate (percent)
dlrgdp	float	%9.0g		Real GDP annual growth rate (percent)
dlrgdppc	float	%9.0g		Real GDPPC annual growth rate (percent)
ecp_ghg_ta~2018	float	%9.0g		Emissions (2013 GHG) weighted carbon tax, 2018 USD
emission_ctse~s	float	%9.0g		CO2 from fuel combustion in road transport, commercial, institutional, household
lemission_cts~s	float	%9.0g		log(emission_ctsectors)
lempman	float	%9.0g		log(manufactoring employment)
lemptot	float	%9.0g		log(total employment)
lrgdp	float	%9.0g		log real gdp
lrgdppc	float	%9.0g		log real per capita gdp
pgdp	double	%10.0g		GDP deflator, local currency
rater_LCU_USD18	float	%9.0g		Carbon tax rate (real, LCU, 2018 USD @ PPP)
share23	float	%9.0g		share GHG emissions covered by tax in 2023

Sorted by: ID year
Note: Dataset has changed since last saved.

Figure 4: *Description of variables used in the dataset. As explained in Section 3.3 for* `rater_LCU_USD2018` *I kept the data provided by Metcalf and Stock since I was not able to find the updated version.*

3.2 Goal of the Research

This research pivots around two main goals. The first one is to look for possible variations of results since the last analysis. Since 2019, many macroeconomic changes have happened and our goal is to see if these had an impact on our analysis. Due to COVID-19 in 2020, we experienced a sharp fall in global emissions, especially due to the decline in energy demand. Since the beginning of "drastic measures" by the government worldwide, the industry-related energy consumption dropped by 30% within a couple of weeks. Furthermore, the emissions from the transportation sector were heavily impacted with -18.6% of emissions from ground transportation and -43.9% from aviation (Nguyena et al., 2021). Those last data are particularly interesting since the transportation sector is one of the main sectors affected by the carbon tax (Andersson, 2019). The other macroeconomic shock that affected the last five years was the war in Ukraine. It is proved that the war raised the price of gasoline for the countries that were strongly dependent on Russia's exportation (Meng and Yu, 2023). This was the case for Europe, which had imported the vast majority of its gasoline from Russia. Since the outbreak of the war, Europe started to differentiate the provision of this recourse, decreasing the effect on the price. However, it is too soon to study the impact of the war in Ukraine on GHG in the atmosphere. Given these shocks, especially COVID-19, strongly targeted sectors subject to the carbon tax, it is our interest to explore any variation in the result from the period before these variations, and if they had an impact on the effect of the carbon tax on GDP and employment.

The second goal is to prove the transparency of the original paper, verifying the replicability of the research conducted. In the last decade, the concern about transparency in academic research has increased, with the obligation for researcher to publish their replication files for the general public. Below you can find an extract of the Replication Guidelines for Data and Code of the American Economic Association. For these reasons, in our thesis, we kept the replication files used by Metcalf and Stock (2020) to check for consistency.

> Authors of papers that contain empirical work, simulations, or experimental work must provide information about the data, programs, and other details of the computations sufficient to permit replication, as well as information about access to data and programs. Data and programs must be archived in the AEA Data and Code Repository or another trusted repository by May 1.
> As part of the archive, authors must provide a README file listing all included files and documenting the purpose, format, and provenance of each file provided, as well as instructing a user on how replication can be conducted.
>
> *American Economic Association Replication Guidelines on Data and Code*

3.3 Issues Encountered

3.3.1 Unavailability of Data

The first issue encountered in the replication was the availability of data. As seen in Figure 5 the README file in the replication package of the paper stated that some of the data was personally provided by Geoffrey Dolphin and others by a World Bank staff member. For the first file, `ECP_tax_2013.csv`, I looked in Dolphin's web page for possible substitute of the file[21]. However, I have not found any. In the `WorldCarbonPricingDatabase` available on the website there were multiple data but none of them correspond to the initial file. To overcome this issue I used the original file, even if it was not the most updated available. It was also not possible to verify the validity of the data since I was not able to find similar estimations online. The second document that has been privately delivered was the `WB_CarbonTaxData.xlsx`. This file contained three Sheets, one for `rate_LCU` (being the carbon tax rate in local currency), one for carbon tax details and one for the share of emission covered

[21] At this link you can find Dolphin's web-page: `http://geoffroydolphin.eu/carbon-prices-data/`

by the carbon tax. In this file, I was able to find in the World Bank Carbon Pricing Dashboard the data to properly update the share of emissions and the details of the measure. In the missing Sheet, I had to use the previous data used in 2019.

I believe that this decision affected the final result, however, this variable was needed for our estimation and I could not drop it.

```
ECP_tax_2013.csv - emissions weighted carbon tax data from
    Geoffrey Dolphin in a personal communication.

WB_CarbonTaxData.xlsx - data on carbon tax rates provided by
    World Bank staff member as per documentation in paper
```

Figure 5: *Screenshots from the README file in the Replication Package of Metcalf and Stock (2020)*

3.3.2 Formatting of Dataset

Another main issue for the replication of the study was the formatting of the initial dataset. This was needed for the data to properly fit the code already written. Since 2019, when the last data were downloaded, various platforms changed their layout, thus providing different formatting of their Excel file. While for smaller Excel files, this problem was easily overcome, for bigger files such as `Total employment domestic_Thousand persons.xls` this issue was not easy to overcome. This file was characterized by 172 different sheets in it, with various cells that have been merged and the names of the states were written in the full form instead of in the two-digit format. To overcome this issue I wrote a Python script (Listing 1), that properly formatted the document. It firstly takes the file `Names_2digit_corrected.xlsx` to change the full name of the state with the two-digit format. The next steps of the code are to unmerge the cells and delete the useless columns that arose from the unmerge.

4 Results

4.1 GDP growth

Figure 6 compares the results obtained from my calculations with those from Metcalf and Stock (2020). We used an unrestricted estimation[22], allowing for a nonzero long-term effect in the LP regression, as explained in Section 3.1.1. The trend observed in our results shows a positive effect in the initial years, which diminishes in year four and then remains constant through years five and six. Notably, only the results for years one and four are significant at a 95% confidence level. For a more comprehensive analysis, we restricted the model, considering only Scandinavian counties [23] and we found a similar pattern. An initial increase in the GDP, followed by a decrease from the fourth year. It is interesting to note that the initial positive effect in Scandinavian countries is significant for years two and three even at a 95% confidence interval, while the decline that affects subsequent years is not significant even at a 67% confidence interval. The result from this analysis can be found in the Appendix (Figure 11).

Metcalf and Stock found similar results, with none of their regressions being significant at a 95% confidence interval. This lack of strong effects may be due to the potential accumulation of impacts in the long term, beyond six years. To prove this hypothesis we would need to expand the time frame of the regression. This will inevitably increase the standard error, making the results less reliable.

To validate this hypothesis, we examined countries that had already implemented the carbon tax. We observed similar trends: a progressive increase in GDP in the first years, followed by a subsequent decrease (Figure 10). However, the high volatility in this analysis, with some countries experiencing significant GDP decreases, can be attributed to multiple recent economic shocks. These shocks include the COVID-19 pandemic, which caused unprecedented disruptions to global supply chains and economic activities, and the war in Ukraine, which led to substantial fluctuations in energy prices and geopolitical uncertainties (Section 3.2). Additionally, variations in national policies, market responses, and external economic pressures contribute to this volatility.

In conclusion, our analysis of the carbon tax's effect on GDP is summarized in Table 3. This table presents the results of tests for the restriction that the long-run effect of the tax on GDP growth is zero. The LP regression does not reject the null hypothesis, with a test statistic of -0.27 and $p - value = 0.79$.

[22]**Unrestricted model** allows for the estimation of all parameters without imposing constraints, thereby permitting nonzero long-term effects. This contrasts with a restricted model, which imposes constraints such as setting certain parameters to zero, thereby not allowing for nonzero long-term effects. In this terms, the unrestricted model provides a more flexible framework that can capture more complex relationships in the data. For this reason in this analysis we mainly consider unrestricted regression.

[23]we chose to restrict the analysis considering only those countries since notably they are the pioneer of this measure, and are characterised by more comprehensive data.

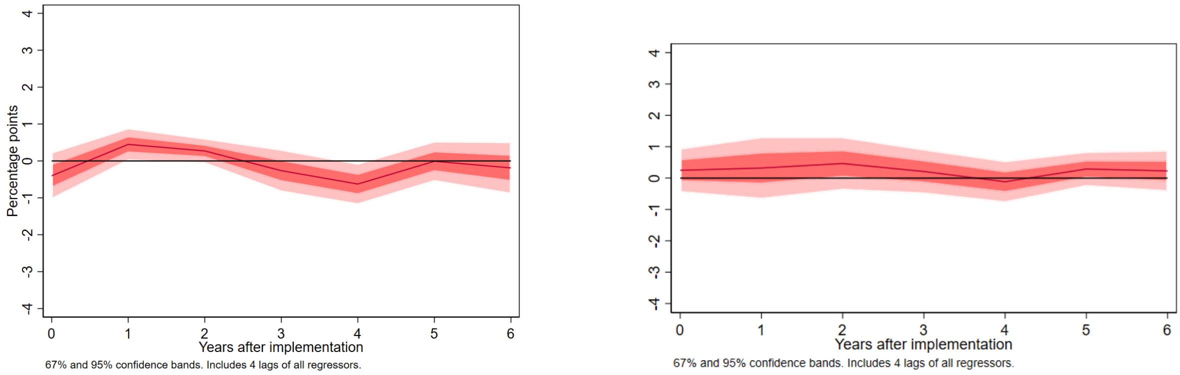

Figure 6: *GDP Growth with LP Regression, unrestricted. Panel a shows the result from my replication, with data until 2022. Panel b shows the same result published in the paper*

4.2 Employment

Our second macroeconomic variable of interest is total employment. In this case, we note an initial stagnation, with a modest improvement in years five and six. However, we could never reject the null hypothesis. Since we are considering an unrestricted model, allowing for nonzero long-term effects, we could expect to see different results in the longer term. Comparing our result with the one of Metcalf and Stock (2020), they found a modest improvement in the beginning, followed by stagnation in subsequent years. Both our research cannot reject the null hypothesis, nor claim a positive effect, nor for negative ones.

If we look at Table 3 the effect that LP has on total employment is slightly positive (0.17 for the full sample and 0.52 for the revenue recycling countries), however, those results are not significant neither at a 90% confidence level ($p - value = 0.87$).This lack of significance due to the high p-value found by our analysis as much as others, highlights the difficulty of isolating the effect of carbon tax on employment, which is affected by countless other variables. As for GDP growth, the recent macroeconomic shocks could play a role in this, however, the fact that Metcalf and Stock (2020) found a similar result in confidence intervals, suggests that the main issue arises due to the difficulty of properly isolating the effect of a carbon tax.

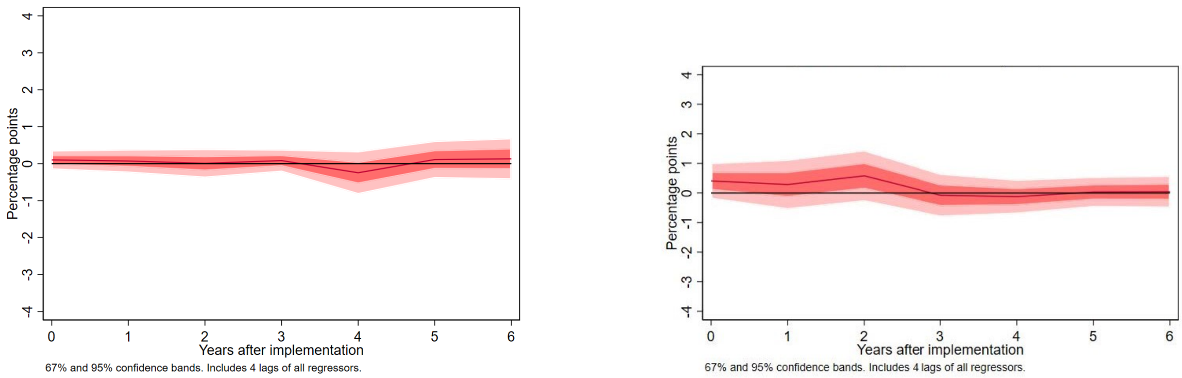

Figure 7: *Growth in total employment with LP Regression, unrestricted. Panel a shows the result from my replication, with data until 2022. Panel b shows the same result published in the paper*

4.3 Emission

Given the mixed results from the previous regressions, it is useful to study the emission reductions analyzed in Metcalf and Stock (2020). In their study, the authors focused on CO2 emissions in road transport and the commercial, institutional, and household sectors[24], ultimately rejecting the hypothesis of zero long-run change in the level of emissions. They found modest evidence of emission reductions with a $40/ton carbon tax.

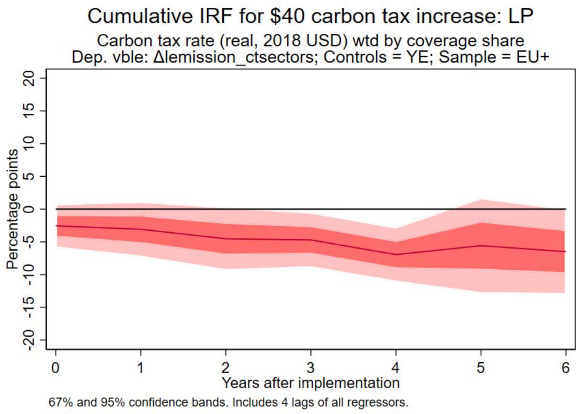

Figure 8: *Result from Metcalf and Stock (2020). Emission under LP method, unrestricted*

While these results might appear to be below expectations, it is important to note that the most carbon-intensive sectors of the economy are already regulated under the EU-ETS. Consequently, the observed reductions primarily reflect changes in less carbon-intensive sectors not covered by the EU-ETS, which may explain the modest impact. Nevertheless, this result highlights the first dividend of carbon tax explained in Section 2.2.5.

4.4 Isolation of Carbon Tax

Looking at the results, we note that most of the results are not significant. This issue is caused by the difficulty of properly isolating the effect of carbon tax rather than other variables not specified in the model. Could be proposed to add other variables in the regression to account for this. Adding variables such as a dummy parameter for the presence of macroeconomic shock in that specific year could be helpful to increase the reliability of our analysis and decrease the variance of the result[25]. Adding new variables to the model does not affect the unbiasedness[26] of our estimation. However, it could cause the over-specification of the model[27] and increase the variance of the estimator.

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[24]The choice of the sector was given by the fact that those sectors are the ones usually covered by carbon taxation in Europe, since they are the one not subject to EU-ETS.

[25]Adding new variables is a way to decrease the error variance. By doing this we can account for more sources of variation in the dependent variable, reducing the "noise" in the equation and helping us to properly estimate the partial effect of θ on y.

[26]**Unbiasedness** is the property of the model that states that the expected value of the coefficient of the estimator is equal to the true population parameters E$[\hat{\beta}] = \beta$. In other words, the estimator $\hat{\beta}$ is unbiased if, on average it estimates correctly the population β.

[27]**Overspecification** occurs when we add to the model variables that do not have a partial effect on the independent variable (which in our case is $ln(GDP_{it+h})$), meaning that the population coefficient is 0. Even in case of overspecification, the unbiasedness of the model holds since E$(\hat{\beta}) = 0$.

Another issue that we should consider if we want to add another variable is the multicollinearity. This problem arises when the variation in one independent variable can be explained by the other independent variable. Other things equal is better to have less correlation among the variables when estimating the parameters.

4.5 Replication

The second goal of this research was to stress the replicability of the original paper. As stated in Section 3.2 in the academic literature the importance of replicability of research is increasing and with our research, we stress this aspect. Section 3.3.1 pointed out that some data used in the analysis were not publicly available. This could have altered the results since I needed to use non-up-to-date information. Apart from that, the replication package was complete, providing all the necessary information to replicate the study.

The first part of the replication was the creation of the dataset starting from various Excel files. The `.do files` provided in Stata were detailed, explaining the relevant passage and their utility for the research. The most complex part of the replication process was the understanding of the code needed for the creation of the result. Since the techniques used for the analysis were beyond the competence acquired in my undergraduate curriculum, I struggled to understand the precise use of particular aspects of the code. However, the clarity of the replication package made it more clear, helping me to deliver higher-quality results.

5 Conclusion

This research studied the effects of the carbon tax on macroeconomic variables such as GDP and employment. It aims to analyse the impact considering recent economic shocks like the COVID-19 pandemic and the war in Ukraine. We achieved this by replicating the previous study conducted by Metcalf and Stock (2020). The replication allows us to compare the result of 2019 with the one of 2023, underlining small differences.

Our findings indicate mixed results regarding the impact of carbon tax on GDP. While there was a positive effect in the initial years, this effect decreased over time, however few time periods were statistically significant. This aligns with the findings of Metcalf and Stock, who also noted a lack of strong significant effects. In terms of total employment, our analysis revealed an initial stagnation followed by a modest improvement in later years. However, similar to the GDP results, we were unable to reject the null hypothesis, indicating no significant long-term impact of the carbon tax on employment levels. These findings verify those of Metcalf and Stock, who also observed no significant changes in employment due to the carbon tax.

The study also underscores the significance of replicability and transparency in academic research, as demonstrated by our use of replication files from Metcalf and Stock (2020) to verify our findings.

This thesis leaves for future research, focusing on the betterment of the econometrics model used, as much as the analysis on the longer term effects.

Looking at the practical application we show that there are no negative effects of the application of Carbon Tax on EU Member States. However, the set of a European Carbon Tax for domestic products is a complex step in the decision-making process of the European Commission. Nevertheless, the implementation of Carbon Border Adjustment Mechanism[28] is a strong measure considering the issue analysed in section 2.2.3 The taxation of imported goods based on the GHG produced puts European goods at the same level playing field as the one imported from countries that do not have this measure.

[28]**Carbon Border Adjustment Mechanism** (CBAM) is a tool used by the EU to ensure fair prices on carbon emission during the production of carbon-intensive goods that are entering the EU, and to encourage cleaner industrial production in non-EU countries. The CBAM will ensure the carbon price of imports is equivalent to the carbon price of domestic production. CBAM will apply in its definitive regime from 2026, while the current transitional phase lasts between 2023 and 2025. This gradual introduction of the CBAM is aligned with the phase-out of the allocation of free allowances under the EU Emissions Trading System (ETS) to support the decarbonisation of EU industry.

6 Appendix

```python
import openpyxl
wb_obj = openpyxl.load_workbook(filename)

def unmergeAllCells(sheetName):
    print(' - unmergeAllCells')
    sheet_obj=wb_obj[sheetName]
    for merge in list(sheet_obj.merged_cells):
        sheet_obj.unmerge_cells(range_string=str(merge))

def findCode(countryText,sigle):
    if countryText==None:
        return 'DELETE THIS'
    for element in sigle:
        if(element['text']==countryText):
            return element['code']
    return countryText

def removeCols(sheetName):
    print(' - removeCols')
    sheet_obj=wb_obj[sheetName]
    for i in range(100, 1,-1):
        countryText=sheet_obj.cell(row = headerRowIndex, column = i).value
        if countryText == 'DELETE THIS':
            sheet_obj.delete_cols(i)

if __name__ == "__main__":
    main()
```

Listing 1: *Part of the Python script used for formatting Excels. The first function unmerges the cells in all the files. The second one looks if there is the name of the country in the header row, and otherwise, it delates the column (this is because if it does not have the name of the country in the header it was one of the previously unmerged cells). The last code deletes all the columns with the text "DELATE THIS" that has been previously created.*

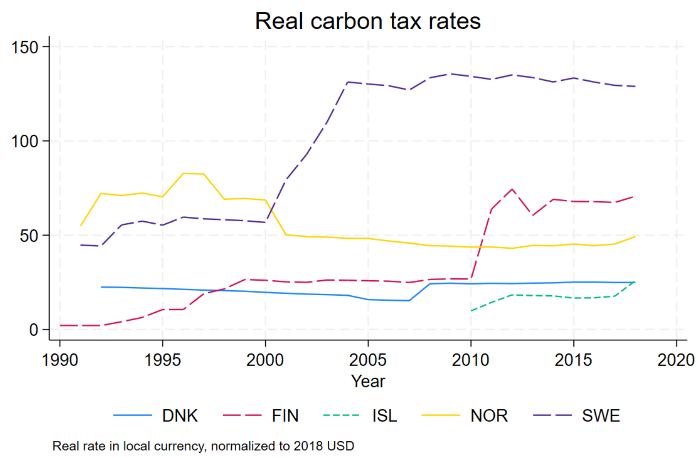

Figure 9: *Real Carbon Tax Rate in Scandinavian countries. We note that Sweden has the highest real tax rate*

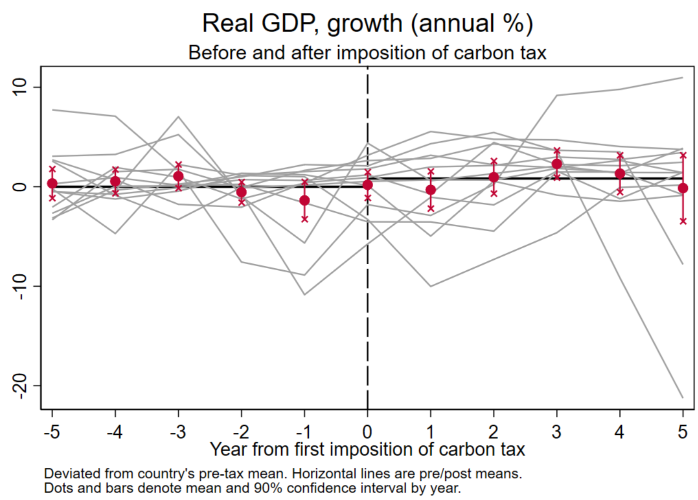

Figure 10: *Real GDP growth for countries that have already implemented the measure*

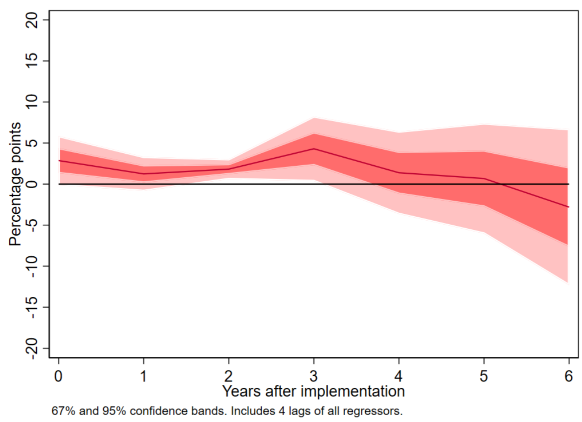

Figure 11: *GDP Growth rate restricted for Scandinavian Countries only. LP regression*

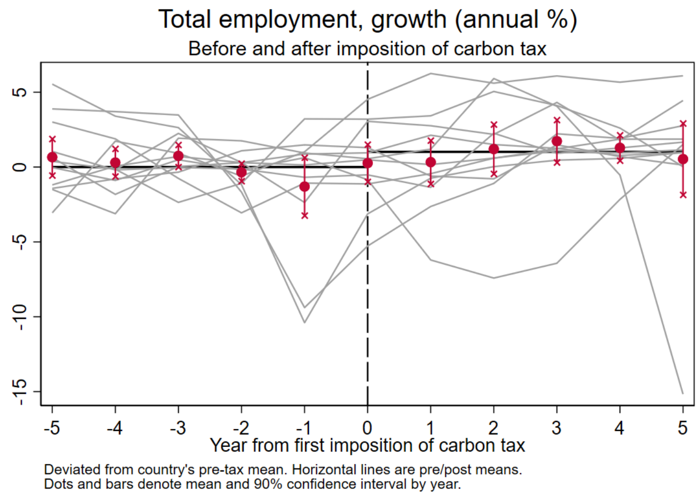

Figure 12: *Total Employment Growth for countries that have already implemented the measure*

	GDP	GDP per capita	Total Employment	Manufacturing Employment
Full Sample				
LP	−0.27	−0.35	0.17	-2.13
	0.79	0.73	0.87	0.03
Revenue Recycling Countries				
LP	−0.61	−0.48	0.52	-1.68
	0.54	0.63	0.60	0.09
Large Carbon Tax Countries				
LP	−0.23	0.33	0.39	-2.23
	0.82	0.74	0.70	0.03
Scandinavian Countries				
LP	−0.14	0.18	0.64	-1.31
	0.89	0.86	0.52	0.19

Table 3: *Table reports results of the test that there is no long-run change in the growth rate. Failure to reject the null supports the no long-run change hypothesis. The table reports the t-statistic for the test in the top row and its p-value in the second row.*

References

Andersson, J. J. (2019, 11). Carbon taxes and co2 emissions: Sweden as a case study. *American Economic Journal: Economic Policy*, *11*, 1-30.

Atmospheric greenhouse gas concentrations. (2024, 02). EEA. Retrieved 2024-07-01, from https://www.eea.europa.eu/en/analysis/indicators/atmospheric-greenhouse-gas-concentrations

Carbon border adjustment mechanism. (2023). Retrieved 2024-07-08, from https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en

Carbone, J. C., Rivers, N., Yamazaki, A., & Yonezawa, H. (2020, 07). Comparing applied general equilibrium and econometric estimates of the effect of an environmental policy shock. *Journal of the Association of Environmental and Resource Economists*, *7*, 687-719. doi: 10.1086/708734

A carbon tax would raise prices, harm economy and spur political backlash - competitive enterprise institute. (2021, 11). Retrieved 2024-07-03, from https://cei.org/news_releases/a-carbon-tax-would-raise-prices-harm-economy-and-spur-political-backlash/

The case for carbon taxation – imf fd — december 2019. (2019, 12). International Monetary Fund. Retrieved from https://www.imf.org/Publications/fandd/issues/2019/12/the-case-for-carbon-taxation-and-putting-a-price-on-pollution-parry

Five myths about carbon pricing. (202, 11). MIT Center for Energy and Environmental Policy Research. Retrieved 2023-09-09, from https://climate.mit.edu/posts/five-myths-about-carbon-pricing

Goulder, L. H. (1995, 08). Environmental taxation and the double dividend: A reader's guide. *International tax and public finance*, *2*, 157-183. Retrieved 2024-06-19, from https://link-springer-com.ezproxy.unibo.it/article/10.1007/BF00877495 doi: 10.1007/bf00877495

Green, J. F. (2021, 01). Does carbon pricing reduce emissions? a review of ex-post analyses. *Environmental Research Letters*, *16*. doi: 10.1088/1748-9326/abdae9

Greenhouse gas emissions by source sector. (2024). Eurostat. Retrieved 2024-06-16, from https://ec.europa.eu/eurostat/databrowser/view/env_air_gge__custom_11832025/default/table?lang=en

Initial information on the 2022 national emissions certificates trading law (nehg 2022). (2022). Federal Ministry of Finance. Retrieved 2024-07-06, from https://www.bmf.gv.at/en/topics/Climate-policy/initial_nehg_2022_en.html

Instrument detail. (2023, 10). World Bank. Retrieved 2024-06-12, from https://carbonpricingdashboard.worldbank.org/compliance/instrument-detail

Jordà, (2005, 02). Estimation and inference of impulse responses by local projections. *American Economic Review*, *95*, 161-182. doi: 10.1257/0002828053828518

Lavoie, C. (2024, 04). *A carbon tax will hurt the economy, but that doesn't mean it isn't the right policy.* The Globe and Mail. Retrieved 2024-07-03, from https://www.theglobeandmail.com/business/commentary/article-canada-carbon-tax-climate-change/

Marron, D. B., & Toder, E. J. (2014, 05). Tax policy issues in designing a carbon tax. *The American economic review*, *104*, 563-568. Retrieved 2024-06-26, from https://www.aeaweb.org/articles?id=10.1257/aer.104.5.563 doi: 10.1257/aer.104.5.563

Meng, X., & Yu, Y. (2023, 10). Does the russia-ukraine conflict affect gasoline prices? *Energy Economics*, *128*, 107113-107113. doi: 10.1016/j.eneco.2023.107113

Metcalf, G. E. (2019, 01). On the economics of a carbon tax for the united states. *Brookings papers on economic activity*, *2019*, 405-484. Retrieved 2024-06-19, from https://www.proquest.com/docview/2317599148/fulltextPDF?parentSessionId=8ISz4WfpuwGvHgp0mM4fiSegRrr6SzeyrZpUICh4K0g%3D&pq-origsite=primo&accountid=9652&sourcetype=Scholarly%20Journals doi: 10.1353/eca.2019.0005

Metcalf, G. E., & Stock, J. H. (2020a, 07). *The macroeconomic impact of europe's carbon taxes.* Retrieved 2023-12-13, from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3644097

Metcalf, G. E., & Stock, J. H. (2020b, 05). Measuring the macroeconomic impact of carbon taxes. *AEA Papers and Proceedings*, *110*, 101-106. doi: 10.1257/pandp.20201081

Metcalf, G. E., & Weisbach, D. (2009). The design of a carbon tax. *Harvard Environmental Law Review*, *33*, 499. Retrieved from https://heinonline.org/HOL/LandingPage?handle=hein.journals/helr33&div=20&id=&page=

National accounts. (2021, 09). Statistics Norway. Retrieved 2024-06-17, from https://www.ssb.no/en/statbank/table/09189/tableViewLayout1/

Newell, R. (2008, 12). *A u.s. innovation strategy for climate change mitigation.* Retrieved 2024-06-25, from https://dukespace.lib.duke.edu/items/63e7e35f-b813-4163-ac54-e0dee2b6c25b

Nguyen, X. P., Hoang, A. T., Ölçer, A. I., & Huynh, T. T. (2021, 01). Record decline in global co2 emissions prompted by covid-19 pandemic and its implications on future climate change policies. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1-4. doi: 10.1080/15567036.2021.1879969

Pettigrew, S. (2020, 03). *Spanish carbon pricing the lowest in the eu - climate scorecard.* Retrieved 2024-07-06, from https://www.climatescorecard.org/2020/03/spanish-carbon-pricing-the-lowest-in-the-eu/

Ritchie, H., Rosado, P., & Roser, M. (2023a, 12). *Co and greenhouse gas emissions.* Retrieved 2024-07-06, from https://ourworldindata.org/co2-and-greenhouse-gas-emissions

Ritchie, H., Rosado, P., & Roser, M. (2023b, 12). *Per capita, national, historical: how do countries compare on co2 metrics?* Retrieved 2024-07-06, from https://ourworldindata.org/co2-emissions-metrics

Stock, J. H., & Watson, M. W. (2003). *Introduction to econometrics*. Addison Wesley Publishing Company.

Sweden's carbon tax. (2018, 02). Government Offices of Sweden. Retrieved 2024-07-06, from https://www.government.se/government-policy/swedens-carbon-tax/swedens-carbon-tax/

Swiss ets — international carbon action partnership. (2020, 12). ICAP. Retrieved 2024-07-06, from https://icapcarbonaction.com/en/ets/swiss-ets

Weisbach, D. A., & Metcalf, G. E. (2009). The design of a carbon tax. *SSRN Electronic Journal*. doi: 10.2139/ssrn.1327260

What is the paris agreement? (2024). UNFCCC. Retrieved 2024-07-01, from `https://unfccc.int/process-and-meetings/the-paris-agreement`

Wooldridge, J. M. (2019). *Introductory econometrics: a modern approach.* (7th ed.). Cengage Learning.

World bank open data. (2024). World Bank. Retrieved 2024-06-17, from `https://data.worldbank.org/indicator/NY.GDP.DEFL.ZS`

World development indicators — databank. (2015). World Bank. Retrieved 2024-06-17, from `https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.KN&country=#`