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The Role of Carbon Taxes in Reducing Greenhouse Gas Emissions

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ABSTRACT

An abnormal rise in greenhouse gases in the atmosphere has triggered a range of environmental problems the foremost of which is global warming. CO2 is among the gases most responsible for the greenhouse effect. That is why, after the 1990s, new tax regimes, also known as energy-carbon taxes, were put in place in an attempt to lower emissions. There is still an ongoing discussion as to whether tax regimes are working in practice. Certain studies have indicated that carbon taxes are effective or partially effective in preventing CO_2 emissions. However, others assert that there is no causal relationship between carbon taxes and the lowering of greenhouse gas emissions. In this study, the annual data of 36 OECD countries in the period of 1990-2018 were used. To detect whether a carbon tax is effective in reducing greenhouse gas emissions, the panel data analysis method was employed. The results of the analysis revealed that carbon taxes have no effect on greenhouse gas emissions.

Keywords: Carbon Taxes, Greenhouse Gas Emissions, Energy Taxes, Externalities
JEL Classifications: P2, O13, H23

1. INTRODUCTION

In the 21st century, an era already characterized by an increasing global population and a rising consumption culture, there is a corresponding rise in the demand for technology and energy. As a result, our world is currently facing a myriad of global problems, the first of which is environmental pollution. One of the most serious issues is the disproportional increase in the volume of greenhouse gases which has initiated temperature rise and climate change. CO_2 is among the gases most responsible for the greenhouse effect. These gases filter harmful rays emitted by the sun (conductivity characteristic) and allow others to reach the earth's surface. Atmospheric greenhouse gases prevent heat from escaping the earth's atmosphere; thus, the required temperature conditions for life can be achieved on earth. However, a problem arises from the disproportional growth of atmospheric greenhouse gases (CO_2 emissions in particular) due to fossil fuel use by humans (Bates, 1990; Solnes, 2018). A rapid rise in the ratio of these gases is the reason for this problem known as global warming, resulting in a change in climate and the pollution of nature. As a result of global warming, the ecological balance has broken down; there are more frequent droughts and floods, rising sea-levels, depletion of the ozone layer, and more frequent hurricane and similar natural events. Thus, it has become imperative to limit greenhouse gas emissions and carbon dioxide, as a first step. To stop or at least slow down this emergent problem, modern states are motivated to form international cooperation agreements (Bennett, 2016).

To tackle the global warming problem on a global level, the agreement of the United Nations Climate Change Framework Convention was signed in 1992, the first intergovernmental convention on the environment. At the end of these attempts, in 1997, the Kyoto Protocol was signed in Kyoto, Japan, and began to be implemented as of 2005. 191 countries and the EU agreed on Kyoto Protocol, not including the United States. The main goal of the Protocol was to lower the use of pollutant gases in developed countries, mostly CO_2, that are the main causes of the greenhouse effect. Another element of this Protocol was the suggestion that well-designed environmental taxes would be effective tools in solving the problem. The signatories to the Paris Treaty (Paris Climate Agreement to lower greenhouse gas emission) and members of international organizations like the IMF also hold the belief that well-designed tax policies(carbon tax) are potentially effective tools for solving the climate problem (Gayer and Horowitz, 2006; Metcalf, 2019).

The primary reason for the imposition of a carbon tax was to stop global warming by reducing global-scale greenhouse gas emissions in an attempt to make the world a better place to live in. It was suggested that the enforcement of this tax enforcement diminish global climate change, inspire humans to choose more environmentalist energy sources (sun, wind, hydroelectric), boost energy efficiency, and decelerate consumption and the production of fossil fuels. However, it was also reported that carbon taxes, in general serve, to meet another aim in addition to their primary mission, the provision of additional revenue to national budgets. Thus, the question of whether these taxes are truly effective in reducing greenhouse gas emissions becomes controversial. This research examines whether or not carbon taxes have been effective in reducing the greenhouse gas emissions of 36 OECD countries in the period of 1990-2018. To that end, in the first part of this study, literature review on research topic was presented; in the second part, information on the material and method of the research was shared. In the third part, the compiled data was analyzed. In the final part of the study, findings discussed.

2. LITERATURE REVIEW

Environmental taxes are quite important in environmental economics (Cropper and Oates, 1992). In fact, the very first idea of issuing environmental taxes was published in 1920s by English economist Arthur C. Pigou. To manage the smoke problem in London, Pigou proposed environment-friendly or green taxes and thus avoid the societal costs that were due to pollution from carbon (Daugbjerg and Svendsen, 2001). It was also aimed that the personal costs that emerged from pollution would be stopped before they turned into societal costs. In other words, the negative externality that surfaced would be internalized so that those who polluted nature would personally pay the price (Cherry et al, 2008). Within that scope, methods of preventing environmental pollution can be grouped into three categories, traditional command and control tools, regulations, and market-based approaches. (i) Traditional command and control tools, that is to say, prohibition and auditing mechanisms fall into this category. "Command" refers to the borders of an area in which an industry or activity can be sustained are designated, and, thus, what makes a deed illegal is directly regulated by legislation. For instance, quality standards issued by state authority and threshold values in pollution can be examined within this context (Baldwin et al, 2013; McManus, 2009). "Control" refers to specifying the illegitimate acts and the sanctions to be imposed against such acts (Abbot, 2009). It is suggested that, unlike costly methods like taxation, traditional command-control mechanisms could be effective in controlling pollution without paying a high cost. (ii) With regulations, environmental externalities are internalized. Here, it is assumed that individuals or enterprises would be willing to perform more environment-friendly activities. Indeed, traditional command and control tools and regulatory policies make up a whole. These two policies can be grouped under a single title as regulatory and auditory foundations. (iii) Market-based approaches are among the most salient tools in solving environmental issues. Subsidies and marketable permit tax practices are solution methods analyzed within that context (Hussen, 2005; Markandya et al, 2002; Plastics Europe, 2014).

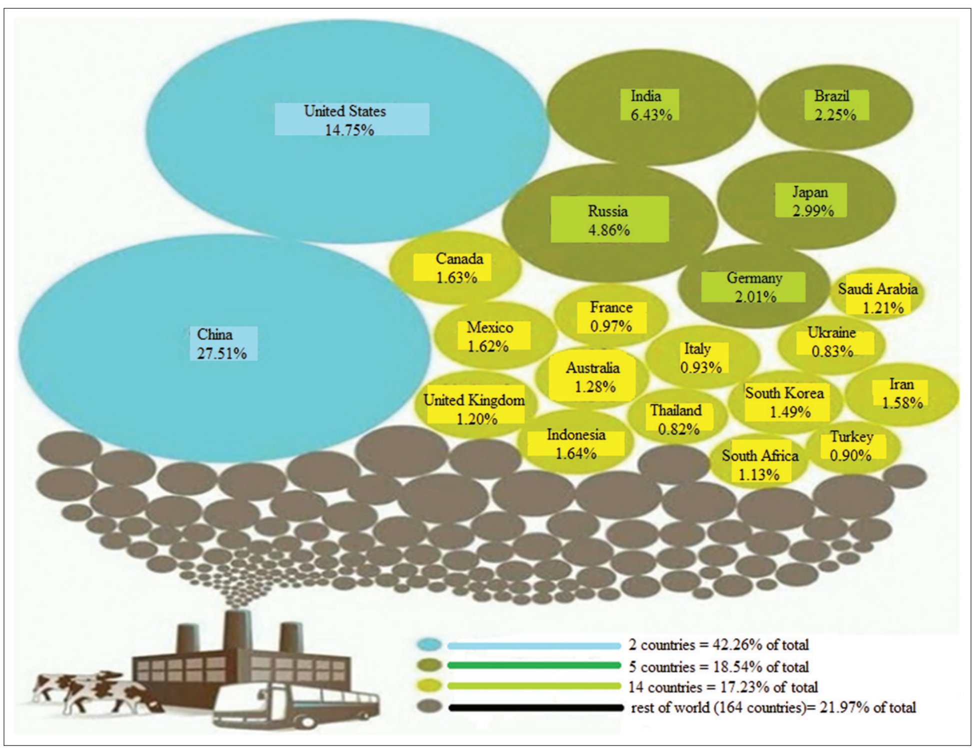
Yet, in practice, command and control tools (prohibition and auditing) may be inadequate. In fact, negligent governments, financial worries, and resource shortages are the kind of problems that push ecocide forward. Indeed, at the end of audits**,** punitive sanctions are enforced as administrative fines while liberty-limiting punishments are rarely imposed. In this situation, it becomes even harder to solve the problem. The effect of global scale prohibitions and audits, mostly by United Nations, is remarkably limited because current audit and sanction mechanisms are under the pressure of multinational corporations and governments. As asserted by Dr. Theo Colborn, "States are no longer run by themselves but rather controlled by multinational corporations." Thus, damaging activities like excessive hunting, improper disposing of nuclear waste, damage to the oceans and the ozone layer, deforestation, deterioration in ecosystems, and similar pressure and disruption in global public goods have escalated with each new day (CFR, 2013; Nar, 2019).

Removing environmental externalities via regulations is be feasible in every situation because the regulatory authority (the state) may prioritize company interests at the expense of social gains in the process of setting standards for regulated industries. There is an abundance of relevant examples in literature. For instance, regulatory foundations formed to manage water pollution in the USA may cater to corporate interests instead of preventing environmental damage caused by the company. It is true that efficiency standards issued by the U.S Department of Energy have set standards for energy-saving machinery, thus aiming to lower cost, to lower carbon dioxide emissions, and to stop environmental pollution by decreasing fossil-fuel consumption in electricity production. Nonetheless, due to the domination of interest and pressure groups in U.S Congress and power of lobbyists, there has been constant delay in developing standards. Because of that and similar causes, just as may be seen in command and control tools, it is likely that regulatory policies would also be ineffective in stopping environmental pollution (Nar & Nar, 2019.). It is therefore clear that market-based approaches, specifically taxes, take the lead in preventing environmental pollution because taxes orient financial and social policies in matters of investment incentives, redistribution of wealth, securing economic stability, and stopping unwanted financial activities (Gruber, 2015). For instance, the taxing of plastic bags and the enforcement of this tax achieved the lowering of plastic bag consumption by a ratio of 70% in just a few months.

As the power of tax on economic activities is examined, environmental taxes are discussed under four categories energy taxes, transport taxes, pollution taxes, and resource taxes. The Energy taxes category includes taxes imposed both on transport and energy products consumed for fixed objectives. Energy products consumed for transport requirements relate to petrol goods such as gasoline and diesel. Energy products consumed for constant use are fuel oil or diesel oil, natural gas, coal, and electricity. Energy taxes are collected from all energy components. Carbon dioxide taxes, on the other hand, place energy taxes below rather than instead of pollution taxes. Although there are several reasons for this categorization, it is, before anything else, related to the link of carbon dioxide tax to energy consumption. Carbon taxes, unlike energy taxes, are taken only from the carbon ratio of fossil fuels (coal, petrol, petrol products, and natural gas). The biggest portion in energy taxes lies with the carbon tax. Transport taxes are basically related to taxes on the ownership and use of motorized vehicles and include transportation services provided via airplane, boat, train, and similar transportation vehicles. Pollution taxes category includes taxes imposed on air and water emissions and taxes on solid waste and noise. Resource taxes, on the other hand, address issues of use pf water resources or the depletion of forests. Income from this tax is particularly aimed at securing the sustainability of natural life such as forests and wild flora and fauna (European Commission, 2013; Milne, 2008; OECD, 2001; OECD, 2019).

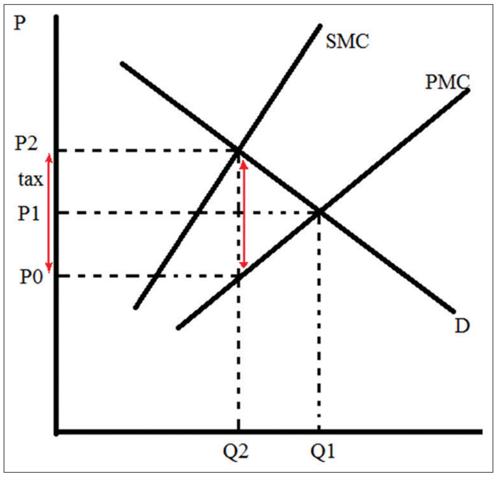
Greenhouse gas emissions vary from country to country (Figure 1); however, global climate change is a shared concern for the whole world. The common goal is the lowering of greenhouse gas emissions via taxation regulations, the first of which is the carbon tax. The carbon tax initially became a matter of discussion in England in the 1970s and in 1990. This tax was first put into practice in Finland, and Holland followed suit. In 1991, Norway and Sweden, and, in 1992, Denmark joined the other countries in imposing this tax. A carbon tax is a personal tax levied on the basis of fossil fuel (petrol, coal, natural gas) consumption that trigger carbon dioxide emission while the same tax is also computed and collected on the basis of the carbon content of fossil fuels. For each 1000 units of BTU, coal emits 25.1 g of carbon, petrol emits 20.3 g of carbon, and natural gas emits 14.5 g of carbon. Tax is collected according to the specific concentration. The most common practice is to fix the tax rate equal to the estimated benefit of reducing GHG emissions by 1 ton CO_2, the so-called social cost of carbon. Carbon tax is imposed most heavily on coal, second most heavily on petrol, and third most heavily on natural gas. The Kyoto Protocol advocates for a higher rate of energy tax (carbon tax) to be levied by countries that consume a high level of fuel and thus produce a high level of carbon. The system of carbon taxation is clearly illustrated in Figure 2 where the vertical axis symbolizes the price of produced goods, the horizontal axis stands for the quantity of produced goods, SMC stands for the social cost of produced goods, and PMC symbolizes the personal cost of produced goods. D represents the total demand curve. P1 stands for market price, and yet, this price disregards the resulting social costs placed upon society due to pollution. Thus, it is suggested that a carbon tax of P2-P0 would raise the price to P2 and cause a more socially efficient level of output. Carbon taxes internalize emergent communal or social costs. To illustrate, the personal cost (PMC) of a flight for

Figure 1: Global greenhouse gas emissions



Source: http://www.climaloop.com and https://iklim.csb.gov.tr/turkiye-ve-diger-ulkelerin-sera-gazi-emisyonlarinin-karsilastirilmasi-i-4410. The data have been compiled by us. (2020). The U.S and China cumulatively account for over 40% of global greenhouse gas emission and thus are the two countries that are the worst polluters in the world. Five other countries cause almost 20% of greenhouse gas formation. 14 countries contribute to greenhouse gasses over a range of 0.80% to 1.6%. All of the remaining 164 countries account for a total of 21%, each individual country contributing only a tiny portion to global greenhouse gas emissions.

Figure 2: Energy-carbon tax organization



one individual is 300 $. However, the external or societal cost (SMC) due to pollution from air travelling is 100 $. When 100$ carbon tax is added for each flight, plane ticket then would be 400 $, and this price would high enough to dissuade some people from plane travel. Due to decrease in air travel, production would go down from Q1 to Q2, and CO_2 emission would also fall. In the end, as a result of adding a carbon tax to the price of one good, prices would escalate, and the higher prices may, in turn, lead to a fall in consumption. Once consumption or demand goes down, a corresponding decrease is observed in the production curve. Hence, CO2 ratios, the primary source of greenhouse gas formation, can be lowered to acceptable levels because, whenever humans can ensure a social cost in goods or services, more effective consumption and production levels normally result (Economics, 2020; Gayer and Horowitz, 2006; Haites, 2018; Kovancılar, 2001; Metcalf, 2019).

However, literature studies question whether carbon-energy taxes operate as an effective mechanism in lowering greenhouse gas emissions and the practical efficacy of such tax regimes is still controversial. Some studies indicate that in stopping CO_2 emission, carbon taxes are effective or partially effective; however, others indicate that no causal relationship exists between carbon taxes and lowering of greenhouse gas emissions (Bruvoll and Larsen, 2004).

Manne and Richels (1990) reported that a carbon tax has an effect on CO_2 emissions. Pearce (1991) claimed that energy-carbon taxes could offer double benefits, by boosting social welfare by stimulating clean energy in place of dirty energy and by decreasing the tax load on employee compensation. Symons et al. (1994) noted that carbon taxes in England increased the price of fossil fuels, and, due to rising prices, consumers chose to lower their CO_2 emissions. According to Bovenberg and Mooij (1997), the carbon tax results in diminished production and employment levels. Goto (1995) focused on the random effects of energy taxes on greenhouse gas emission ns. Studies conducted across Finland, Sweden, and Norway pointed out that carbon taxes have generally been imposed. That being the case, as an effect of a decrease in greenhouse gas emissions, there was a corresponding increase in general budget incomes. Enevoldsen et al. (2007), in a study based in Denmark, reported that carbon taxes were significantly effective in diminishing CO_2 emissions. Similarly, in Sweden, the carbon tax per ton was 127 $. Since the year1995 when the imposition of the tax began, greenhouse gas emissions decreased by 25.5% whilst economy soared by 75% (IMF, 2019a). Nakata & Lamont (2001) claimed that carbon tax motivates consumers to choose clean-energy resources. Studies after the 2000s revealed that energy/carbon taxes catered to the funds that produced technologies that boosted energy efficiency. Parry (2019) stated that carbon tax incomes contributed substantially to clean industries because they elevated environmental subsidies and energy efficiency (Andersen, 2010; Bhattacharyya, 2019; Lin and Li, 2011; Milne, 2008; Schmalensee and Stavins, 2017).

Some other studies have drawn attention to the inadequacy of carbon taxes (Bohlin, 1998), Vermeendand van der Vaart (1998) claimed that, in Holland taxes, played an insignificant role in greenhouse gas emissions where exemption of electricity and gasoline consumption from the carbon tax was mostly related to social and political concerns. In some recent studies, Murray and Rivers (2015) and Komanoff and Gordon (2015) have argued that the carbon tax imposed in British Columbia had an insignificant effect on greenhouse gas emissions. In one study on Norway, Bruvoll and Larsen (2004) suggested that, although carbon taxes lead to a significant price rise for certain types of fuel, the tax still had an extremely restricted effect on lowering CO_2 emissions since the rate of decrease rate was merely 2%. In Denmark, the effect of the carbon tax on a decrease in emissions is controversial. Holland is among the European states with the maximum rate of environmental taxes (IEEP, 2013). However, since, in Holland, the government exempts big corporations from paying the carbon tax, there has been a much weaker effect on greenhouse gas emissions. Similarly, imposed taxes in Ireland are collected from fossil fuel industries, but the level of CO_2 emissions is still quite high there. This discrepancy is not due to inadequacy of the taxes but rather because of the exploiting taxes to provide income for the general budget. Levied in England in 2013, a carbon tax managed to significantly lower rates of coal use in many industry sectors. However, greenhouse gas emissions are still not at the desired low levels (Bhattacharyya, 2019; Lin and Li, 2011; Nadel, 2016; Rosenthal, 2012).

3. DATA SET AND METHODS

In this study, conducted to unravel the effect of the carbon tax on greenhouse gas emission, the greenhouse gas emissions (tons) of 36 OECD countries and the carbon tax's ratio (%) of the GNP (gross national product) was examined on the basis of data, collected yearly, from 1990-2018, and these data were compiled from the OECD database and the IEA (International Energy Agency). Since the data entailed both a horizontal section and a time dimension, panel data analysis was implemented in this study.

Prior to the analysis, first, logarithms of the data were taken. In the panel data analysis, the stability of the panel data was initially examined using the LLC panel unit root test. It was determined that data the from which logarithm was taken stayed stationary in level value. To see if the data that were stationary in level value and the ratio of carbon taxes by GNP had any effect on greenhouse gas emissions (tons), a panel data analysis was employed. In the panel data analysis, at the beginning, the Breusch Pagan LM test was administered to determine the type of personal effects and time effect and to discover if they were fixed or random. Next, the Hausman test was applied (Breusch and Pagan, 1979; Hausman, 1978). Since countries included in the study were located in geographically distant zones and maintained different economic development levels, it was estimated that the personal and time effects would be random. At the end of the LM test administered to check the validity of this hypothesis, it was determined that at least one of the personal or time effect was random. Next, the Hausman specification test was conducted to test the validity of the LM test findings, and it was concluded that the random model proved to be more effective. Via the random effects model available, the effect of the carbon tax ratio by GNP on greenhouse gas emission was examined.

4. FINDINGS

4.1. Panel Unit Root Tests

Of the 36 countries in this study, first, the logarithms of their greenhouse gas emission and carbon tax by GNP were calculated. Next, their stability level was investigated by applying one of the panel unit root tests, the LLC test.

Table 1 shows that variables employed in the study remain stationary in level value (P<0.05). It was thus revealed that, in the inspected period, shocks on the variable disappeared over time.

4.2. Panel Regression Analysis of the Effect of a Carbon Tax on Greenhouse Gas Emission

Prior to conducting the panel regression analysis to detect the carbon tax's effect on greenhouse gas emissions, it was necessary to check for the presence of horizontal section dependence and an interiority problem in the model selection.

4.2.1. Horizontal section dependence: The breusch-pagan LM test

In the panel data econometry, the horizontal section dependence between the series was analyzed due to their effect on the validity and reliability of the findings. Disregarding horizontal section dependence could make the results of the analysis distorted and inconsistent. Hence, before resuming the panel data analysis, it was first necessary to test horizontal section dependence in the series which can be examined via the Breusch Pagan LM test (Tatoğlu, 2018).

At this stage, the Breush Pagan LM test was administered to identify the type of personal effects and the time effect. Since the countries included in the study were located in geographically distant zones and maintained different economic development levels which resulted in different ratios of carbon taxes by GNP, it was estimated that the personal and time effects would be random. To check the validity of this hypothesis, the Breush-Pagan LM test was employed, and related findings from Breush Pagan LM test may be seen in Table 2.

Table 2 shows that the P value of the Breusch Pagan LM test was measured as 0.9959, higher than extreme value of 0.05. That means there was no horizontal section dependence between the units. The attained P > 0.05 at the end of this test indicates that at least one of the personal or time effects was random. In that case, the random effects model was used for estimations.

4.2.2. Hausman specification test

To determine whether an internality problem existed between the personal effects and explanatory variable, the Hausman specification test was utilized. The Hausman test is used when there is a need to make a choice between fixed effect and random effect models to decide which model tis o be used. In the Hausman test, the main hypothesis is that fixed effects are not valid (Baltagi, 2001; Greene, 2003). In reality, the test aims to determine whether or not there is a statistically significant difference between the fixed effects model's parameter estimators and the random effect model's parameter estimators (Cameron and Trivedi, 2005).

If the Chi-square statistics value obtained at the end of this analysis had a P value lower than 0.05, it would be argued that the model had an internality problem. In that case, a fixed effects model would be employed. If the p value for the Chi-square statistics value was higher than 0.05, it would be argued that there is no internality problem. If an internality problem is present, a fixed model would be used, and, in the absence of an internality problem, a random model would be utilized (Greene, 2003). In Table 3, the results of the Hausman specification test may be seen.

As may be seen in Table 3, the P value of the Hausman specification test was higher than the extreme value that equals 0.05 (P = 0.08870 > 0.05). Thus, it was clear that there was no internality problem in the model. The Hausman specification test is not an alternative for the LM test; rather, it is a verification of the LM test (Greene, 2003). That being the case, the LM test finding in favor of using the random effects model was verified by the Hausman test. In that case, the analysis should be conducted using the random effects model.

4.2.3. Random effects model estimation

At the end of the Breusch Pagan LM test and the Hausman specification test, it was agreed to use the random effects model. Thus, in the panel regression analysis to measure the effect of a carbon tax on greenhouse gas emissions, a random effects model

Table 1: Panel unit root test

Levin, Lin, Chu (LLC)	$LogCO_2$	LogTax
T	−15,1811	−1,75083
P	0.000	0.040

Table 2: Breusch pagan LM test

Breusch-Pagan LM	
T	284,9794
P	0.9959

Table 3: Hausman specification test

Hausman test	
Chi-squared	0.020194
P	0.8870

was activated in which weighted statistical values were utilized. Findings from the random effects model implemented to measure the effect of a carbon tax on greenhouse gas emissions may be seen in Table 4.

It may be seen in Table 4 that the random effects model used to measure the effect of carbon taxes on greenhouse gas emissions fails to be a significant model as a whole ($P = 0.910191 > 0.05$); neither is the log tax variable statistically significant ($F = 0.012734$; $P = 0.9118 > 0.05$). The Durbin Watson value related to the model is much closer to critical value 2, and it is desired to keep this value between 1.5 and 2.5 (Srivastava and Rego, 2016). The fact that the Durbin Watson value stayed within the range of limit values showed that there was no autocorrelation in the model. Thus, this analysis indicates that carbon taxes have no effect on greenhouse gas emissions.

In this regard, here are some of the proofs that verify econometric analysis:

To begin with, although fuel excise and carbon taxes are simple and cost-effective tools, it is difficult to apply the taxes in the required ratios due to political and economic concerns. In fact, while around 50 countries have issued plans to implement a carbon tax, due to political and economic concerns, it has been difficult to impose fuel consumption tax and carbon taxes in the required ratios. On a global scale, a carbon tax of two dollars per ton is far below the price demanded by the world. As stated in the Paris treaty, to ensure that a rise in global temperature can be kept at 2°C or below by 2030, the carbon price, which is currently two dollars per ton, must be redefined as 75 dollars per ton in China, the USA, and India (IMF, 2019a; OECD, 2019). However, it is easier said than done.

The IMF also claims that, in limiting the release of carbon dioxide into the atmosphere, carbon taxes can be valued as the most powerful and efficient tool, but tax policies should be applied in tandem with another effective method, the emissions trading system. What is meant by emission trading is that wealthy countries or sectors purchase emissions from the countries or sectors that cause less pollution, in other words, a trade in pollution rights (IMF, 2019a; Eurekalert, 2019).As seen in the Holland model, carbon tax exemption applied by governments for energy dense sectors or the giving of subsidies to some sectors via a tax discount as seen in Sweden mean that the expected benefit from tax is below expected level (World Bank, 2015).

Currently, many countries assert that carbon taxes are preventive mechanisms in reducing greenhouse gas emissions. In most developing countries, carbon taxes are implemented under the title of "urgent political measures" due to economic and environmental causes. Since the carbon tax is computed and collected with little expense, it is viewed as a cost-effective tax. However, when we take a closer look at its 30 year history, it is evident that carbon taxes are mostly used in ways that are incompatible with their designed objectives (Table 5). In particular, the main objectives of carbon taxes are the increasing of general budget incomes, the financing of public investments, the reduction of taxes on labor. Overall, a minuscule portion (3%) of the income from the collected tax is expended in favor of the environment. Furthermore, the issue of which sectors are to be taxed or what is to be taxed is a political as well as an economic concern. Since tax ratios applied in various countries tend to vary, there is a corresponding variation in the areas for which tax incomes are used. In a carbon market that is dominated by uncertainties, carbon taxes can only be effective in lowering CO2 emissions on a superficial level (Bird, 2017; Gayer and Horowitz, 2006; Nordhaus, 2008; Parry, 2019).

In reality, if carbon taxes are be utilized in line with their main objective, it is possible to achieve sustainable economic development with low carbon ratios**.** It is suggested that carbon taxes should be to limit the growing demand for energy, to boost the improvement in green industry and employment, and to promote production of environmentally friendly vehicles. For instance, it is viable to manufacture environmentally friendly vehicles that use natural gas and make use of clean energy resources such as wind turbine and geothermal energy. Likewise, carbon taxes could be transferred to low income continents like Asia, Africa, and Latin America to eradicate income equality in a global level (IMF, 2019b; OECD, 2001).

Finally, a closer look at Figure 1 reveals the countries that are the most responsible for greenhouse gas emissions. Sweden, Norway, and Finland do not appear on this list, so it could be argued that these countries, all of whom mandate high carbon taxes, have low levels of greenhouse gas emissions. However, this is a potentially misleading argument. Table 1 also shows that Sweden is a country that mandates the maximum carbon tax ratio. Like Sweden, Norway and Finland also utilize carbon taxes to finance the general government budget. In that case, how is it possible that, although carbon taxes are used to finance the general budget, there is a significantly low level of greenhouse gas emissions? The answer to this question lies within the specific conditions that exist in the Nordic states where energy saving and using low carbon technologies are distinctively important. In the region, 37% and even higher levels of energy consumption originates from renewable resources, and 54% of energy consumption is from

Table 4: Random effects model for the effect of a carbon tax on greenhouse gas emissions

Variable	Coefficient		SE	T	P
Constant term	11,75679		0.101285	116,0763	0.0000
LogTax	−0.018037		0.162676	−0.110874	0.9118
R^2		0.000021	Number of observations		618
Modified R^2		−0.001603	Average of Dependent Variable		11,74812
Standard Error of Estimate		1,573134	SD of the Dependent Variable		1,57187
Error sum of squares		1524,446	Durbin-Watson		1,68139
F		0.012734			
P		0.910191			

Table 5: Carbon tax revenue use, by jurisdiction/tax rates

Jurisdiction	Use of carbon tax revenue	Tax rate (US$/t$CO_2$e)
British Columbia (2008)	Income tax reductions and credits. Property tax reductions and credits	22
Chile (2014)	General budget, intended for spending on education and health	5
Costa Rica (1997)	Environmental Services. Sustainable development. Forest conservation	3.5
Denmark (1992)	Reduced taxes on labor. Energy efficiency and environmental programs Reduced industry contributions to government programs	31
Finland (1990)	General budget Income tax reductions. Decreased employer social security payments	48-83
France (2014)	Reduced corporate income taxes. Reduced labor taxes Energy assistance for low-income households	24
Iceland (2010)	General budget	10
India (2010)	Clean energy and environment	6
Ireland (2010)	General budget/deficit reduction/debt payments	28
Japan (2012)	Clean energy technology. Energy efficiency	3
Mexico (2012)	General budget	1-4
Netherlands (1990)	General budget. Reduced labor taxes. Income tax reductions. Reduced corporate income taxes	74
Norway (1991)	General budget. Reduced labor taxes. Decreased capital income taxes Pension plan for low-income individuals	4-69
Portugal (2015)	Income tax reductions for low-income households. General budget	5
South Africa (2016)	Electricity levy reduction. Energy Efficiency. Solar tax credit. Renewable energy. Energy services for low-income individuals. Public transport. Rail freight transport	8.50
Sweden (1991)	General budget. Reduced labor and corporate taxes	127
Switzerland (2008)	Reduced health insurance premiums. Decreased social security contributions Building energy Efficiency. Technology development	87
United Kingdom (2000)	General budget Besides, the U.K.'s carbon price floor (CPF) is a tax on fossil fuels used to generate electricity. It came into effect in April 2013	16

(IMF, 2019b; OECD, 2019; World Bank, 2017)

sources other than fossil fuels. Likewise, according to the 2013-2018 environmental action plan issued by the Nordic Council of Ministers, all Nordic states aim to have lowered their greenhouse gas emissions around 50-80% by the year 2050. To achieve that objective, these states diligently focus on their attempts to make the best use of a wide range of renewable energy sources such as hydroelectricity, wind energy, geothermal energy, and biomass energy. Furthermore, research and development activities are promoted that choose energy saving technologies and clean energy resources **(**Bird, 2017; Metcalf, 2019; World Bank, 2017**).**

5. CONCLUSION

To cope with environmental problems caused by greenhouse gases, a great number of countries have put carbon taxes into practice. Despite that initiative, there are ongoing discussions as to whether carbon taxes really work in practice. In this study, data from 36 OECD countries from 1990 to 2018 were used in order to determine whether a carbon tax is effective in reducing greenhouse gas emissions. The results of the analysis indicated that carbon taxes have no effect on greenhouse gas emission. This statement holds true merely for OECD countries. However, since developed countries are also OECD member states, results of the analysis can be generalized.

Studies to date suggest that effects of carbon taxes have been limited. It is highly improbable that carbon taxes can bring solutions to the climate change problem (Nadel, 2016) because tax incomes have evolved into a tool to fund general budgets. Even in countries where taxes are imposed at a level of around 40% and above, greenhouse gas emissions have still not reached the desired low levels (Bruvoll and Larsen, 2004).Therefore, carbon taxes should be used according to appropriate goals, a fixed-rate tax should be imposed according to carbon content, and the tax should be applied homogenously in every country. Tax ratio should also not be so high as to dissuade CO_2 emissions or not too low to cause carbon leakage. Accordingly, the tax should be levied on all sectors that emit greenhouse gases and should be assessed in tandem with other preventive methods such as the emission trading system. In short, taxes must be effective and politically applicable.

Carbon taxes can diminish energy use by increasing fossil fuel (petrol, coal, natural gas) prices and by elevating consumption and production costs. In addition, taxes can orient consumers and manufacturers toward environmentally friendly (solar energy, wind), low carbon energy resources. Nevertheless, taxes can equally be harmful. In the sectors that benefit from tax discounts and exemptions in the economy, those who fail to benefit from these financial benefits are pushed towards a disadvantageous position, and, thereby, a situation of unfair competition emerges. Excessive taxation can also cause carbon leakage. Financial growth ratios could slow down, or taxes could evolve into a tool that state authorities frequently resort to under all circumstances on account of budget necessity.

On the other hand, climate change also causes a decrease in biological diversity, faltering ecosystems, lowered yield in basic foods such as corn or wheat, increasing numbers of poverty-stricken nations every day. Income deficits and extreme debt force desperately poor countries or regions to deplete all of their resources. For instance, rainforests that are the biggest resource for absorbing CO_2 gas are being demolished in Brazil to achieve commercial gains while in Indonesia tropical forests are burnt down for palm oil production. Thus, it is vital that funds collected from carbon taxes be spent to conserve habitats. These funds can be transferred to undeveloped or developing countries or regions in the form of direct income support and aid. Above all, the world's biggest polluter states like China, the USA, and India should agree to sign an international cooperation agreement to reduce greenhouse gas emissions. Otherwise, as stated by environmental activist Paul Watson, "Nature solves its problem by itself. If we are the problem, it will perceive us as a problem and solve us as well. Being an environmentalist is protecting nature and ourselves. We are in fact trying to protect ourselves. If we don't learn how to live in the ecosystem, nothing will happen to the world, we will be the ones that vanish off the face of the earth" (Nar, 2019).

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