UNIVERSITA' DEGLI STUDI DI PADOVA

DIPARTIMENTO DI SCIENZE ECONOMICHE ED AZIENDALI "M.FANNO"

CORSO DI LAUREA MAGISTRALE IN ECONOMICS AND FINANCE

TESI DI LAUREA

"THE MACROECONOMIC IMPACT OF EUROPE'S CARBON PRICING"

RELATORE:

CH.MO PROF. LORENZO FORNI

LAUREANDO: ANTONIO RELLA

MATRICOLA N. 1175104

ANNO ACCADEMICO 2020 –2021

Il candidato dichiara che il presente lavoro è originale e non è già stato sottoposto, in tutto o in parte, per il conseguimento di un titolo accademico in altre Università italiane o straniere.
Il candidato dichiara altresì che tutti i materiali utilizzati durante la preparazione dell'elaborato sono stati indicati nel testo e nella sezione "Riferimenti bibliografici" e che le eventuali citazioni testuali sono individuabili attraverso l'esplicito richiamo alla pubblicazione originale.

The candidate declares that the present work is original and has not already been submitted, totally or in part, for the purposes of attaining an academic degree in other Italian or foreign universities. The candidate also declares that all the materials used during the preparation of the thesis have been explicitly indicated in the text and in the section "Bibliographical references" and that any textual citations can be identified through an explicit reference to the original publication.

Firma dello studente

_____

INDEX

INTRODUCTION

During the years pollution has been argued by several studies, that have concentrated their discussion on causes and consequences that this problem can lead to. Humans influence the climate and the earth's temperature with several actions. The amount of emissions in the atmosphere cause an increase of the greenhouse effect. Many of these emissions occur naturally, but human activity is increasing the concentrations of some of them in the atmosphere. Burning fossil fuels, deforestation, increasing industrial production, are only a small fraction of causes that contribute to this diffusion. All these phenomenas spread in the air the greenhouse gases (GHG), which principal components are given by carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), that are responsible for 64%, 17% and 6% of emission in the air, respectively.

Europe has been the first continent to take actions to fight climate change, but policies and regulations cannot be enough to tackle this challenge. Climate actions represent an opportunity to improve our life under a different point of view and everyone must contribute to find solutions.

The current global average temperature is 0.85ºC higher than it was in the last century. Reduce GHGs emissions and become the first climate-neutral continent by 2050 is the primary objectives of the European Union (EU). The current climate target is to achieve for 2030 at least 40% of this reduction, with an increase of the targets period by period. In fact, the objectives for 2050 is to achieve a reduction of emission of at least 80% with the possibility to go towards 95%.

The overall goal given by scientist is to maintain global temperature at a level below 2°C as at pre-industrial level, the threshold beyond which there is a much higher risk that dangerous and possibly catastrophic changes in the global environment might occur.

The consequences are strict correlated to each other because causes ripple effects as for example, melting ices generate rising seas that flood and erode coastal and low-lying areas, or extreme weather that shift rainfall, and causes waves, or forest fires and droughts, that causes several damages to property and infrastructure that imposes heavy costs on society and the economy. Also, sectors that are strongly correlated with certain temperatures and precipitation levels as agriculture, forestry, energy and tourism are particularly affected, and the effect to the ecosystem are not calculated by raising risk of extinction.

Contrasting this consequence required important effort by the EU with the introduction of different measures.

The script will start with an overview of different measures adopted at global and European level during these years since 1990. These policies are considered as a springboard toward short and long-run measures that have been implemented by 2030 first, and by 2050. Afterwards, it will explain in detail the carbon pricing measures adopted by Europe to contain the increase of emissions. It will focus the attention on fifteen EU countries. The purpose of this chapter is to give some context and to understand the decision of imposing different taxes.

Then, it will analyze the effects of the carbon measures among the countries taken in consideration and will focus on the effect on GDP, and the influence on the level of CO_2. It will test also the relationship between the carbon price and the set of variables that could influenced its level.

At the end, it will illustrate the different uses of revenues arise by the carbon measures, and the different investment financing instruments that Europe will apply for the next years, with the implementation of increasing private insvestment, encouraged by the introduction of Green Bonds issue.

CHAPTER 1

1.1 History

Fighting climate change requires several actions from all countries across the world. The EU in this way is operating to become the first continent to promote climate neutrality at the end of 2050. All parties of EU are working to promote the ambitious aim through different actions and to give the necessary support to the countries that could suffer from this challenge. The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty managed by 154 states at the United Nations Conference on Environment and Development held in Rio de Janeiro in 1992. It was the first commitment held for the stabilization of the greenhouse gases (GHG) concentrations in the atmosphere. It is considered the first step toward changing. The first extension of UNFCCC was Kyoto Protocol, which was signed in 1997. It entered in force in 2005 and implemented the previous objective of reducing emissions to fight global warming. Since every country has different ability to face climate change based on their historical reputation about level of pollution, Kyoto Protocol enforced the obligation to reduce emission. To meet its targets, Kyoto Protocol defined three mechanisms that ware adopted by all countries:

- International Emission Trading (IET),
- Clean Development Mechanism (CDM),
- Joint Implementation (JI).

IET is based on a set quantitative restriction of emissions, instead CDM and JI are going hand in hand to encourage production emissions reductions among all countries. First commitment period was from 2008-2012, in which 37 industrialized countries and 15 European Union countries (at the time of the treaty) applied targets to the four principal GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6) and two groups of gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs). They are translated into tonnes of CO_2 equivalents to determine the reduction in emissions. However, the principal emitters were not part of protocol in the first period and for this, the reduction was an average of only 5% respect to 1990 levels, because it covered only 18% of total global emissions. Europe instead, was able to reduce by 8% its emission, thanks also to the fact that the protocol allowed groups of countries to meet their target jointly.
The second period commitment was agreed in 2012 and ended in 2020. In this period the EU and other European countries like Iceland have agreed to meet a 20% of reduction, respect to 1990s, and after eight years they reached this objective.

Separate instrument under UNFCCC was the Paris Agreement, which entered in force in 2016. It was stipulated by 195 countries with the aim to reduce the level of emissions and try to maintain the global temperature below 2°C and to avoid that the level will rise above 4°C at the end of this century, respect to pre-industrial period. All countries governments are meeting every five years to evaluate progress towards long-term goals and to report on how to implement the needed climate action. However, reinforcing the capability of society to face the impacts of climate change, provide to enhance support for weak countries and recognise the importance of losses associated with the effects of climate change are also other important section of the Agreement. The EU will continue to support climate action with important financial support and targeted investments. Paris Agreement alone is not sufficient, because it is expected that the rise of temperature could be contained at most 3°C at the end of this century. In support countries, cities, businesses and civil society members are taking action to accelerate cooperative climate action. The EU in this way has been the first continent to put several efforts to fight climate change.

The Intergovernmental Panel on Climate Change (IPCC) states that to avoid the risk of a bad future, the temperature rise must be at most 1.5°C. For this reason, the Agreement specify that EU's countries have agreed to submit the Intended Nationally Determined Contributions (INDC) to satisfy the long-term emission reduction. All countries that signed the UNFCCC were asked to publish the Intended Nationally Determined Contributions (INDC) and under Paris Agreement it became the first contribution made at national levels. Every country proposed their agreements based on their capabilities and what support they needed to reduce emissions.

Furthermore, every year the annual Conference of the Parties (COP) take place, which is represent by all States Members of UNFCCC. The objective of this annual review is to reassess the national communications and emission inventories submitted by all Members. It assesses the progress made by countries and implements the news one. The first was held in Berlin in 1995, and over the years other twenty-five Conferences waere held, with the last one held in Madrid in 2019. The last Conference that was held in Glasgow on November 2020, was postponed in 2021 for the world pandemic causes by COVID-19. The recent Conference held in 2018 in Katowice contains detailed procedures and guidelines for the Paris Agreement. To meet this ambitious plan, the EU works closely with other countries to face a foreign policy agenda on climate plans through diplomacy and cooperation with non-EU countries. The aims are to ensure the effectiveness of cooperation and support partner countries. The intervention area includes cooperation on climate policy and implementation under UNFCCC, sharing expertise, support the transformation in technologies and help

research collaboration, financing to support the countries with low capability and development the cooperation on issues that could arise over the years. The EU collaborates with partners of all the world with bilateral settlement as: Organization for Economic Cooperation and Development (OECD) with US, Canada, Japan, and Australia; with emerging economies such as Brazil, India, South Africa and so on. Financial resources are also important to implement the agreement reached in Paris, especially in developing countries. The transition to a clean and healthy planet is the greatest challenge for the European Union. To achieve this objective, all economic agents must act in support regions and rural areas, to keep up with the transformations of our world. It is not easy and for this the use of a cohesion funds plays an important role.

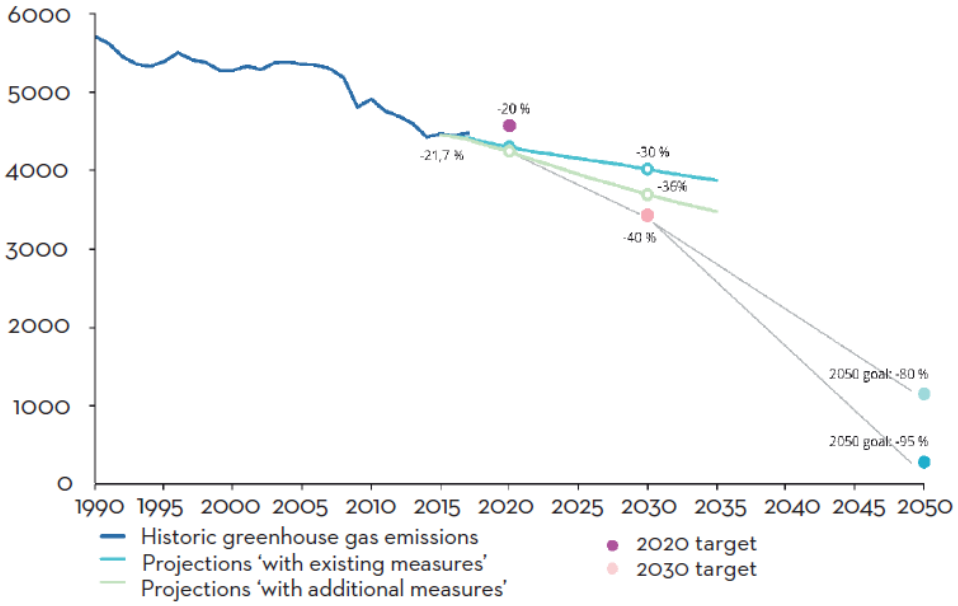
1.2 Different plans

Becoming the first climate neutrality continent is the primary aim of EU's political strategy. It sets itself targets to progressively reduce its GHG emission by 2050. These targets are established first in the 2020 climate and energy package, later in 2030 climate and energy framework and finally in 2050 long-term strategy. They have been defined by EU and have been proposed under the Climate Law. In December 2019, the Commission also presented a clear agenda, to make Europe the first climate neutral continent in the world by 2050. The intervention areas are:

- energy efficiency,
- development of renewables,
- clean and connected mobility system,
- competitive industry and circular economy,
- connected high-standard infrastructures,
- use of carbon capture and storage.

The Commission also presented and provided a range of new opportunities jobs and contributions to economic growth, especially after pandemic crisis of 2020 caused by COVID-19. Across all these areas joint actions are required, combinations of technological innovation and investment. These policies should benefit not only the climate purposes, but also the economy ones.

Figure 1.1 EU GHGs emissions pathways



Source: Prometeia discussion note n.13, THE EU GREEN DEAL POST COVID-19, July 2020

The figure shows trends of GHGs emission reductions for the EU, from 1990 to projections of 2050. These are based on measures introduced during the pathway and addition measures planned at country level. The figure displays the needed of implement other measures to reach the 2030 target of 40% in reductions. Let us now consider the plan and what are the short and long-term policies adopted in order to achieve the 2030 and 2050 target.

1.2.1 2020 climate & energy package

The targets and the measures needed for the EU have already been put in place by all Member States, thanks to the 2020 climate & energy package. It is a set of laws that European Commission undertook in 2007 to reach the 20% targets of reduce GHG emissions, implementing renewable energy and improving energy system.

The first package is a set of laws useful to ensure climate and energy targets for the end of 2020. These targets consist in cutting 20% of GHGs emission respect to 1990 levels, having 20% of renewable energy and improving 20% in energy efficiency. Each of them is covered by specific and adequate tools. In support of them the European Commission introduced in 2005 the European Trading System (ETS) as a key tool to cut greenhouse gas emission. It is

part of carbon pricing mechanism tool and it covers 40% of total EU emissions. The target for the end of 2020 was to ensure emissions to be 20% lower than in 2005. Obviously, targets vary across the nations and are based on national wealth; each of them has taken on binding annual targets until the end of 2020. Progress is monitored by the Commission every year and also includes sectors that are not covered by ETS. This together with other instruments has contributed the EU to become the continent with the strongest and most efficient reduction measures in the world.

Share of renewable energy in the energy consumption is another target that vary among the countries and reflect the different starting point of every nations. Renewable energy plays a key role to fight GHG emissions and tackle climate change. The true evolution will be on the sector in which renewables are not spread or deployed as in transport, heating, industry, etc. Development of sustainable renewable energy requires a coordinated approach between nations and local system, to fully exploit not only the competence, but also technological and economies of scale in all Europe. Under Renewable Energy Directive of 2009 the overall objective is to guarantee that renewable energy contributes to the achievement of climate neutrality with first step of 20% of the energy consumed within the European Union until 2020. Each Member States were obliged to prepare a National Renewable Action Plan, a plan in which each nation provided guidelines on how reach the object of the share of energy provided by renewable sources by 2020.

Energy Efficiency Directive of 2012 instead, set out the measures for increasing energy efficiency among EUs, that are required to use energy more efficiently at all stages of the process (including energy generation, transmission, distribution, and end-use consumption). Several measures have been adopted such as: energy savings of 1,5% in national energy sales, mandatory energy efficient certificates for sales or rental of buildings, or large companies conduct energy audits every four years, etc. Achieving all these goals should reduce the impact on imported energy by other non-EU states and should create jobs with a prospective of green growth for Europe.

The EU is on track to meet its target. In fact, between 1990 and 2019 period GHG gases emissions were reduced by 24%, more thanexpected, without damaging the economic growth, that in the same period grew of 60%. The worst decline was in sectors covered by ETS, instead the other sector faced a slightly decrease. The goal for next decade is to reduce more than the previous years.

1.2.2 2030 climate & energy framework

In September 2020, the Commission proposed to increase the goals of the previous 2020 energy package and started the implementation of legislative proposal by June 2021. The 2030 climate and energy framework include targets and policy objectives for the period from 2021 to 2030. It looked at the same actions made by the previous one and tried to improve the aims with an ambitious step. The EU's nationally determined contribution under Paris Agreement is to reduce the level of GHG emission of at least 40% respect to 1990 levels. This target is implemented by ETS, Effort Sharing Regulation and LULUCF. In this way all sectors will contribute to the achievement of this target by both reducing emissions and increasing removals. In September 2020, European Commission stipulated the Climate Target Plan. The plan is more ambitious than the previous one, because it includes a reduction of gas emissions by at least 55% by 2030, compared to the existing target upwards from the previous target of at least 40%. The objectives are essentially the same, except for an increased effort to limit the rise in global temperature from 2°C, to 1,5°C. Rising of ambition has been made year by year, because each year is different from the previous one. The new proposal delivers on the commitment made on the European Green Deal is in line with the Paris Agreement objectives. The EU also has adopted a measure to ensure right reporting and monitoring process towards 2030, followed by a better regulation principle in which the governments make consultations with citizens and stakeholders.

In December 2018 new Renewable Energy Directive was enforced as a part of Clean energy for all European package and sets new target for 2030 to reach at least 32% share for renewable energy, with possible revision by 2023. EU requires a National Energy and Climate Plan for the next decade in which drawing up how they will meet the new 2030 target. To achieve the new proposal, renewables energy will play an important role, together eith the entire energy system. About this, other aim of EU's will be to improve energy efficiency of 32,5% respect to 1990 levels. Projections indicate that, without the new proposal, if the current policies are fully implemented by all countries, in 2030 the level of reduction would be around 45% compared to 1990, and 47% including land use.

1.2.3 2050 long-term strategy

An economy with net-zero emission is the ambitious and most important objective of European Union for 2050. Different plan issued during the years and measures that will apply in the next year are on the basis of the unique objective: making the EU the first climate

neutral continent in history. Society and economic sector will play an important role towards this transition, thanks also to policies strategies of the governments. The European Commission can lead the way by investing into realistic technological solutions and aligning action in strategic areas as industrial policy, finance, and research. In accordance with Paris Agreement, the EC proposes also a strategic long-term strategy for a climate neutrality by 2050 and submitted it to the **UNFCCC** at the beginning of 2020. It required also that each Member States develop national long-term strategies on how they plan to achieve the reduction emissions needed. EU countries provide information about specific emission reduction for each sector, CO_2 gross domestic production and research and development plans that are related to environmental national policies. Obviously, the Commission will support each Member States for the preparation of these strategies. It will supervise and control their work and the how try to achieve their targets. Moreover, they should develop their strategies in efficient and transparent manner. All sector of our economy should act in different way and should include different support to every subject. Investing in technologies, support industries, decarbonize energy sector and work with other international partners are the main purposes that these plans intend to reach in the next years. The EU will also provide a financial support to help the transition toward green economy. Adequate instruments and investments are needed to enable toward mitigations. Using those strategies in the right way, can cause a positive consequence in different point of views. Obviously, the most evident impacts is related to environment: reduction of GHG emission and replace fossil fuel with renewable sources. The EU has a positive and growing trade balance for renewables, for wind turbine, heating technologies, solar thermal and hydropower. The economic growth is also related to the creation of new jobs with consequent positive effect on employment rate. Now we do not ensure that this result will happen in 2050 but need to change is important especially for the developing countries that are most affected by pollution. It is important to try to prevent the disaster that will happen if the temperature rise above 2°C or the GHG emission in the air exceed a certain threshold. Unfortunately, these are not short-term consequences, but we will look at them in the next year. Only the coordination with both, short-term and long-term strategy will ensure the primary objective.

1.3 European Green Deal

New European Commission headed by Ursula von der Leyen into political guidelines for 2019-2024, proposed a European Green Deal (EGD). EGD is the first and concrete plan made

by European Commission in December 2019. The plan consists of increasing the 2030 GHG reduction target from 40% to at least 50% towards 55% compared with 1990 levels and will bring Europe to become the first climate-neutral continent by 2050.
In December 2019, the European Council together with European Commission approved the European Green Deal, in line with the objective of Paris Agreement. The principal aim will lead to have an economy with zero-net greenhouse gas emissions and to have a climate-neutral society. All parts of society and economic sectors, from the power sector to industry, transport, buildings and agriculture and forestry, will play an important role towards the final purpose; the main objectives are to enhance energy security, create new jobs and try to not sterilize the economy growth. As part of the European Green Deal, the Commission proposed three initiatives:

1. European Climate Law,
2. European Climate Pact,
3. 2030 Climate Target Plan to reduce net GHG emission by at least 55%.

The EU is tackling climate change through these policies. Not only, it is increasing its ambition and operates under all kind sectors to cover as much as possible this serious problem.

1. Under Climate Law the principal aim is to ensure that all EU policies contribute to reach cutting emissions on all sectors of economy and try to mitigate as much as possible in green technologies. First, it must ensure that the transition to climate neutrality will be irreversible, in this way all policies must cooperate to provide stability to investor and industry. Later, creation of monitoring system that guarantee progress and take decision whenever the necessity rises and set a long-term directive that led to meet the climate goals in a socially fair and cost-efficient manner. Progress will be reviewed every five years, according to the timing of Paris Agreement and in line with National's Energy and Climate Plans of every Member State.

2. The European Climate Pact is an EU-wide initiative that invites people and organizations to participate in climate action. It focuses on different areas that cover greener urbanization, transport, buildings, skills. These are correlated to each other to account a mitigation target. The importance of green urban area, for example, allows not only mitigation in the building technologies, but also in the behavior of citizens that must change towards low-carbon lifestyle. Transport plays an important role

because it gives the major impact on carbon footprint. Primary object is implemented innovative and digital solutions for public transport and others type of clean mobility. Transformation has already started, in fact many European cities are implementing healthier and cheaper solutions to fossil fuel vehicles, with the introduction of electric sharing and green buses and trains.

3. Commission suggests necessity to cut greenhouse gases emissions by at least 55% by 2030 under new proposal. Through Climate Target Plan, the Commission proposed to increase the EU ambition for the next 10 years and showed to increase the ambition in all sectors. Thanks to this short-run targets, it intends to stimulate the creation of green jobs and try to not reduce the level of employment. Moreover, it is in line with limiting the rise of global temperature above 2°C.

Let us now consider the principal steps, in which these three initiatives identify themselves as the foundations to base the achievement of European Green Deal goals. The target imposed by Paris Agreement in 2015 was emission reduction of 40% by 2030. The ambition now is to scale up this target, in order to bring a reduction of at least 50% with maximum of 55% respect to the level of 1990. European Commission act on interest of this primary goal and for this is important to invest in innovation and research for our industrial economy. The introduction of **Carbon Border Tax** (tax introduced at national level) to avoid carbon leakage is crucial because every pollutant will pay for its damage. It is also important because this taxation will be invested in green projects. In addition, Commission introduced an extension of the pre-existing **Emission Trading System**, to cover sectors that are not included in the original plan such as: maritime, transportation and construction industries.
EC put forward a strategy for green financing and introduce Sustainable Europe Investment Plan that will consist of support on €1 trillion of investment in green project over the next decade around all EU countries. The principal objectives are to increase public and sustainable investment through the **EU budget**. The next long-term EU budget will run for seven years from 2021 to 2027 and will invest substantially 25% in climate and environment goals. It will provide €503 billion to the European Green Deal Investment Plan and will trigger additional national investment of around €114 billion over the same period. The EU budget alone cannot be enough to tackle climate change or to meet the global investment needs. The European Investment Banks (EIB) plays an important role in the contribution to the European Green Deal Investment Plan, that is expected to give an amount to €250 billion of investments through the EU budget.

The Invest EU program was proposed in June 2018 as part of the future long-term EU budget. It will leverage around €279 billion of private and public climate and environment related investments over the period 2021-2030. It will provide a EU budget guaranteed to allow the EIB and other implemented partners to invest in more and higher-risk projects. The EIB will contribute to a public sector loan facility to support national and regional authorities with low-interest loans. With the contribution from the EU budget of €1.5 billion and the EIB lending of €10 billion at its own risk, the public sector loan facility could mobilize between €25 and €30 billion of public investments over the period 2021-2027. It will be used for investments in energy and transport infrastructure, district heating networks, renovation and insolation of buildings, among others.

In addition, part of the Sustainable Investment Plan will be used for the Just Transition Mechanism that will mobilize at least €100 billion in the first seven years and around €150 billion over ten years in investment to support citizens and workers most impacted by the transition.

The transformation in a green world depends also by citizens. Change in lifestyle it is important and must take part of our education. This transition shall be controlled by regional and local administration. The introduction of **Just Transition Fund** will help change towards neutrality and would put up the money for rural areas that depends on brown sources. The Just Transition Mechanism will focus on the social and economic costs of the transition in the most impacted regions and finance projects ranging from creation of new workplaces through support to companies, but also renovation of buildings and investments in renewable energy and sustainable transport. All European states share the same ambition, but some may need more support than others to get there. Low-income households for example can be affected by climate policies, or small businesses can face difficulties in keeping up with the new green policies. In this way, Europe together with private investments tries to support people and regions.

Moreover, to decarbonize energy sectors, the Commission has introduced the **New Circular Economy Action Plan** for developing European countries to increase the use of sustainable resource, especially in resource-intensive and high-impact sectors such as textiles and construction. To preserve Europe's natural environment,the **Biodiversity Strategy** has been introduced, in which Europe will work with its global partners to limit biodiversity loss within the next five years. All those plans have different field of competence and have different impact. The common economic objective is to preserve the work of our industries, and stimulate innovation, competitiveness, and creation of new jobs.

The projects financed under the EGD plan will contribute to reaching the goals of new and clean energy and circular economy industries and it would create high quality jobs for a competitive European economy. Invest EU or Just Transition Fund will provide to finance a several range of projects. Both support small projects as individual household energy renovation and larger ones as installation of a network of electric vehicle charging stations. The investment support will be adjusted to the level of risk of these projects. The risk is also associated to the fact that there will be no high quality on the projects financed. A specific support program will provide technical support to the Member States. For example, under invest EU program the Commission will ensure the support to public administration and under Just Transition Mechanism it will assist each countries and regions to prepare the plan. The achievement of climate targets will be supported by an efficient reporting and monitoring system. In fact, every year the Commission will meet with all stakeholders in order to take control of the progress on all points of the European Green Deal Investment Plan. Not all countries or regions start from the same point. Certain regions will be more affected than others by the transition, especially the regions where jobs depend on fossil fuels. Transforming these regions will be important to reaching carbon-neutrality, as the green transition must put people, industries, and workers on the same levels. Just Transition Mechanism will go in this way. Member States will complement their Just Transition Fund allocation from their resources under the European Regional Development Fund and European Social Fund+ through a transfer mechanism. They will also provide national resources in line with cohesion policy rules.

CHAPTER 2

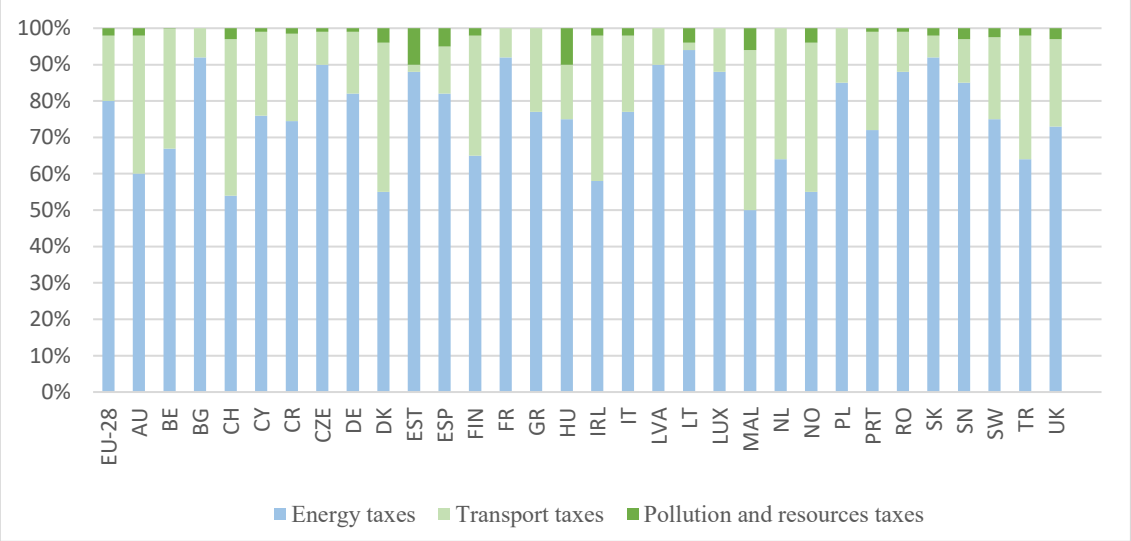
In the last years, many economists have conducted different kinds of works related to the fact that putting a price on carbon emission is the most important tool to reduce pollution. The control of pollution, especially in the last three decades, is one of the most objective that European Union has followed. During the years, many economic instruments and important policies have been issued. In fact, countries use different tools to price carbon emission and in most cases combine them together. To address environmental problems, behavioural changes are needed, some of which involve substantial economic costs and affecting labour, product and capital markets. Environmental policy aims to reach environmental and sustainable development goals. Economic instruments for pollution control and natural resource management are thus an increasingly important part of environmental policy in EU and OECD countries. The range of instruments includes the tax on environmental pollution and carbon pricing mechanism that are included at national level with the Carbon tax and super-national level with EU-ETS system. These instruments provide flexible and cost-effective means and for reaching environmental policy objectives. Let us describe what are the main areas in which these policies occur, and what was contribution of these measures during this year was.

2.1 Environmental Taxes

Environmental taxes are used to discourage behaviour that is potentially damaging for the environment and can provide incentives to reduce the burden on the environment and to preserve it. An environmental tax is a levy with Tax Base which has a specific negative impact on the environment. To identify environmental taxes, a list of tax bases was established. All taxes levied on these tax bases are considered environmental taxes. In some cases, the tax base is the measured or estimated amount of emissions, but often it is difficult and expensive to measure emissions directly, so many taxes are based on proxies for emissions, for example the use of fuel oil. The tax bases are grouped by four main categories and include a set of taxation rate on different sector. In Europe there are different kind of environmental taxes based on the sector for which they are applied: energy, transport, pollution and resources sectors. In general, energy taxes represent more than three quarter of environmental taxes. The taxes applied on energy refers to energy product used for transport as excise on petrol and diesel, for stationary purpose such as light and heavy fuel oil, natural

gas, coal and immediate heat consumption and for the quantity of GHGs emission by carbon content fuels. Transport taxes that represent the second taxation sectors, include taxes related to the ownership of motor vehicles, congestion charges, flights and flights tickets, vehicles insurance (exclude fuel for transport). Pollution and resources cover taxes on the extraction of raw material, measured or estimated emission air and water of effluents to water, waste management, landscape changes and felling trees.

Figure 2.1 Tax category for Europe's country



Source: Eurostat

- **ENERGY TAXES**

  This category includes taxes on energy production and on energy products used for both transport (petrol and diesel) and stationary purposes (fuel oils, natural gas, coal and electricity). It includes also taxes on biofuels and on any other form of energy from renewable sources, and taxes on stocks of energy products. Carbon dioxide (CO_2) taxes are also included rather than under pollution taxes. Often, they are partly introduced as a substitute for other energy taxes and the revenue from these taxes can be very large compared to the revenue from pollution taxes. This means that including CO_2 taxes with pollution taxes rather than energy taxes would distort both the time series at national level and international comparisons. GHGs should also be included in this category. The most important scheme is the EU Emissions Trading Scheme (EU-ETS) related to emissions of greenhouse gases.

- **TRANSPORT TAXES**

  This category mainly includes taxes related to the ownership and use of motor vehicles. Taxes on other transport equipment such as planes, ships or railway stocks, and transport services are also included there. Taxes on vehicle insurance should also be included, instead taxes on petrol, diesel and other transport fuels which are included under energy taxes. In several countries, taxes on the specific CO_2 emissions of vehicles have been introduced. These taxes are not related to the actual use of the vehicles or to the actual emissions generated. The tax base is a technical property of the vehicle such as the average CO_2 emissions per 100 km or the average fuel consumption per 100 km, often combined with other similar technical properties such as vehicle weight or engine power. These taxes are to be considered as transport taxes and not as energy taxes. Some cities have introduced charges for access to the city centre. If a city charge is treated as a tax in the national accounts, then it should be included as a transport tax.

- **POLLUTION TAXES**

  This category includes taxes on measured or estimated emissions to air and water, management of solid waste and noise. Taxes on lubricating oils (it is not used for energetic purposes). Major environmental impacts can include soil or water pollution if lubricating oil is spilled. However, where lubricating oils are included in the mineral oil tax it may not be possible to identify the tax revenue related to lubricating oils.

- **RESOURCE TAXES**

  This category includes taxes linked to the extraction or to the use of natural resources, such as water, forests, wild flora and fauna, etc., as these activities deplete natural resources. All taxes designed to capture the resource rent from the extraction of natural resources should be excluded.

In environmental tax statistics, the main ways to present data on environmental taxes are according to these four categories and according to the statistical classification of economic activities in the European Community (NACE). It is the subject of legislation at the European Union level, which imposes the use of the classification within all Member States. This classification provides the framework for collecting and presenting a range of statistical data according to economic activity in the fields of economic statistics (e.g. production, employment, national and environmental accounts) and in other statistical domains.

In the last years, EU collected environmental tax revenue for a huge amount as for example in 2018, where the revenues amounted for €324,6 billion with the value that represented 2.4 % of the EU gross domestic product (GDP) and 6.0 % of the EU total government revenue from taxes and social contributions. Data show that the biggest portion of tax revenue comes from energy taxes (around 80%), followed by transport taxes (19%), while the share of taxes on pollution and resources is still very small (1%). Over the time the distribution has continued the same trend, with no changes in the share of every sector. In 2009 probably due to the economic recession and as a result of the financial crisis, there was a slight decrease in the tax revenue, but after that, it remained relatively stable. For 2020, we expect a decrease in different sectors due to pandemic crisis.

Energy taxes increased their level from 2002 to 2018, but in the same period the ratio between energy tax revenue-to-GDP dropped by 5%. This decrease is caused by faster grew of GDP respect to tax revenue, especially in the period from 2003 to 2008. The ratio between the revenue from energy taxes and final energy consumption gives the implicit tax rate (ITR), following the same trend of energy taxes. The ITR on energy among European country increase between 2002 and 2018, and it differs across the EU countries.

Thanks to these taxes and an increase in the use of renewable energy¸ the consumption of solid fossil fuel has fallen during the time, respect to pre-industrial level. An important annotation to make concerns the contribution made by resident households and companies. In fact, they contribution in the energy tax revenue is equal. Households paid almost 51% of all energy tax revenue collected by the government in 2017, the contribution for the companies is almost the same; households pay also for transport with large share of 67% of the EU transport taxes, because they are the main payer of the motor vehicle tax revenue; for pollution and resource taxes household pay a bit more than half of the tax revenue because they are generated from taxes on waste, plastic bags etc.

2.2 Carbon pricing

In the process of decarbonizing Europe, an important role is played by carbon pricing and its interaction with policies. Carbon pricing is another way to reduce emissions and help countries to steer their economies towards carbon neutral growth path. Carbon pricing maximize the amount of emission reduction for each Euro invested in decarbonization and encourages consumers to avoid carbon intensive activities (EUR per tonne of CO_2). In 2013 OECD finds that putting a price on carbon is the lowest policy on emission reduction. It

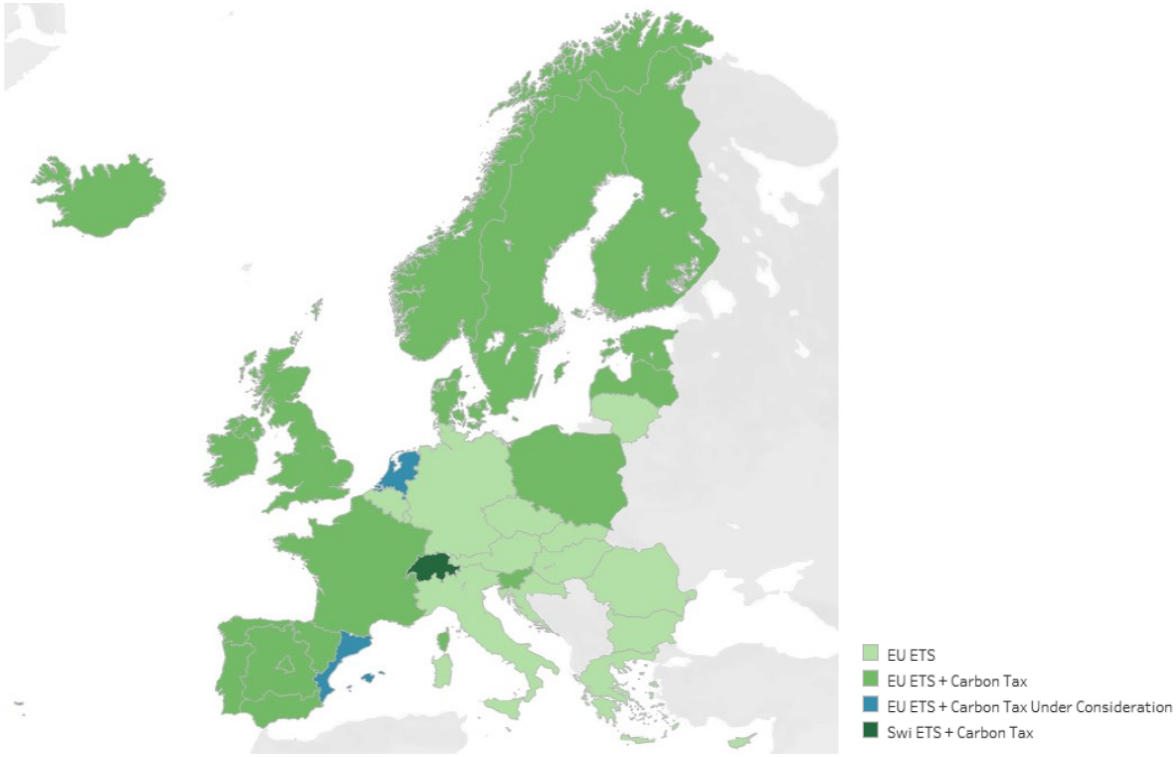
provides a cost-effective measure in order to pursue decarbonization. If the carbon emission continues to be underpriced, it is difficult complete the short and long run goals that will bring Europe to become the first carbon neutral continent in the world in 2050. Green tax framework focuses its policy on carbon pricing. It would provide change in investment and consumption in the future. Strong carbon pricing in the future increases the benefit of carbon-neutral technologies and the changing towards greener world. The change is hand in hand with innovation policy and specific technology support given by the government.
Different EU countries set different kind of policies and different price measures. They add flexibility to fiscal policy and support innovation in order to accelerate the transition towards carbon neutrality. A carbon price with well-designed rates, tax base and revenue use is a good climate and fiscal policy. Research and development are the most important sectors that can help this mitigation. In line with Paris agreement goals, the High-Level Commission on Carbon Prices estimates that in 2030 carbon prices should reach on average of 50-100 EUR/per tonne of CO_2 to go towards full decarbonization. The success of Paris Agreement depends on effort that every country is pledged with. To induce changing to achieve temperature goals it is not easy, because nations could be reluctant if it is the only one to scale up ambition. In fact, the current mitigation pledges are not expressed using a common measure for all countries, and for example if the cost of the energy increase, this will cause lack of competitiveness by the firms. The introduction of International carbon price floor for high-emitting countries, could help to pursue Paris Agreement and might address obstacles that can arise.
The solutions that may be brought are:

- International approach against losses in competitiveness, in which countries can support robust floor prices as this reduce the emissions of other participants,
- Introduction of common minimum emission price that can improve activity of the countries, and can cut emission at the lowest cost possible,
- Provide advanced economies to enhance financial or technological support to emerging economies, in order to help achievement of targets,
- Give the possibility to countries to exceed the floor to meet Paris pledges, when they need,
- It can be designed to accommodate other strategies for mitigation as: ETS, subsidies, regulation, etc.

There are two tools that can be used to set carbon prices: Carbon tax on fossil fuels and EU-ETS (European Trading System). Figure 2.2 shows both carbon pricing instruments in Europe, and what are the countries that introduced them. They are applied at different rate for

producers and users. This figure includes European countries that from 1990 apply Carbon tax plus Iceland, Norway and Switzerland and the countries that make part of ETS.

Figure 2.2 Carbon pricing initiatives



Source: Prometeia discussion note n.12, THE EUROPEAN ROADMAP TO CARBON NEUTRALITY, December 2019

2.2.1 Carbon tax on fossil fuel

Carbon tax is based on carbon content of each country and levied on supply of fossil fuel. It is implemented at country level by each Green tax reform. The main purpose is to put a price on the emission in order to decrease the consumption derived by pollution factors and reduce their amount in the atmosphere. Carbon tax has widespread in Europe, and it is also supported by the European Commission. It is the first continent, among the world, to adopt different policies against climate change and air pollution as Carbon tax ones.

A European carbon tax impact directly or indirectly among all industrial sectors because it affects EU importers that pay this tax, and those sector that are affected on imported inputs. The impact is influenced by two factors: carbon intensity and trade intensity. It is obvious that the contribution of different countries to the pollution is different like for example the impact of USA respect to Liechtenstein. Carbon intensity is calculated as metric ton of GHGs emissions divided by metric tons of production among the sectors. Essentially, it calculates

how much industrial sector contributed to GHG emissions.
Trade intensity instead measures the degree to which goods are traded and how much carbon tax would have to absorb when buyers switch to a European-sourced product. Forty-four sectors are directly interested in the evaluation of these two factors and they have the priority for the new carbon measures that EU must adopt. The impact of this measure would modify competitiveness in the firms that are in carbon-intensive industries; ability to quickly adjust their carbon footprint are the major challenges that they can afford and could bring risk to market losses.
Carbon tax has a recent history, and it can be analyzed only from the last thirty years. Together with ETS are the most single powerful and efficient tools to reduce domestic fossil fuel emissions. Predicting price and encouraging investment is the highest challenge that governments face. Moreover, we also consider benefit that come from taxation as for example through exploiting the revenue arise and reinvesting them through cuts in other taxes or exploiting as additional investment and improving economic efficiency.
Only fifteen European countries have imposed carbon taxes during these years. The first countries were Scandinavian regions with: Finland, Poland, Norway, Sweden, Denmark introduced it in the early of 1990s; later on Eastern Europe countries like: Slovenia, Estonia, Latvia; the others were introduced in the last decade as: Switzerland, Ireland, Iceland, UK, Spain, France, Portugal. These nations are also part of ETS, and together with carbon emission will try to reach Paris Agreement objectives.
In general Carbon taxes increase the reduction of emission regularly during the time and are expected to be more efficient than ETS, which encourage emission reduction to the point of the cap. In addition, it is also easy to manage for the government that can intervene to regulate whenever they want. The benefit comes also from revenues, as we can say, and can be used for many purposes.
Let us now consider the countries in Europe that applied carbon tax in the last year. We consider chronological event that happened by 1990. Prices in general, are not comparable between carbon price policies, for a lot of differences among countries. Every country is applying carbon tax in different ways and in different sectors and modifying it during the years, due to dynamic approach that brings nations to improve the data. Let us base our explanation on OECD and World Bank Carbon Pricing Dashboard sources.

- **Finland:** it was the first nation to apply carbon tax in 1990, adopted during the time of tax reform. At the beginning Finland tax was $1,40 per ton of CO_2 included typically carbon content as: gasoline, diesel, jet fuel, light fuel, coal and natural gas. Later

modified it in order to include 60% of carbon content and 40% of energy content. The transport has a higher rate respect to electricity and heating fuels. Now carbon tax is around $70 per ton of CO_2. During these years Finland followed a series of political reform. Increasing the carbon tax rate and lowering social contributions puts Finland in a good position to achieve the mitigation by 2030. Tax revenues are not used for a specific purpose but reduce the income tax rates into government budget.

- **Poland:** Poland did not have a specific carbon tax. It enacted in 1990 and priced 83% of carbon emission from energy use and large share of these emission was from road transport. Most emissions are not covered by carbon tax as: industry, residential and commercial sector. The share of GHG emission covered are less than 5% with price below $10/t.

- **Norway:** in 1991 Norway applied measures that are adopted to restore the income tax reform. The tax covers fuel, oil and natural gas. The sectors with the highest tax coverage are transport and electricity and cover 62% of CO_2 emission from energy use. Norway increased the full rate of carbon tax in 2019 about $60/t, but in 2020 with the pandemic crisis the government has decided to give permission for natural gas and liquefied petroleum and for fuels used on fishing vessels in order to facilitate this sector.

- **Sweden:** it enacted in 1991 as a part of a broader tax reform. Initially it was applied to transport and heating fuels with $45 per metric ton CO_2, while other sectors paid lower proportion than the two ones. Between 1990 and 2006 the Swedish Ministry of the Environment estimated that GHG emission fell about 9%, while in 2008 decreased around 40% respect the level of 1970, thanks also the introduction of ETS system. Now it has the highest price for emission of all Europe around $138 per metric ton of CO_2 .

- **Denmark:** it is another country that implemented carbon tax as a part of tax reform in 1992. It covers fuel, gasoline, natural gas especially in the transport and industrial sectors. The Danish carbon tax was introduced gradually as part of a larger program including energy and sulphur taxes and subsidies for green investments. Denmark primary energy intensity declined by 26% from 1990 to 2010 and CO_2 emissions were

reduced by 25% per produced unit from 1993 to 2000. At the beginning, the price was around $24/t, and after an increase on average of $32/t, instead in 2019 price was around $25 per metric ton of CO_2 and now cover 40% of GHG emission. Denmark has one of the most ambitious climate change targets in the world, aiming to reduce its emissions by 70% by 2030 and become completely climate neutral no later than in 2050.

- **Slovenia:** it was the first country of Eastern-Europe to apply carbon tax. Slovenia priced 82% of carbon emission from energy use. The most priced sector is road transportation. A substantial share of unpriced emission was from the combustion of biomass in all sector, that decrease the percentage of emission covered. Price is around $30/t.

- **Estonia:** the first country to implement carbon tax at the beginning of new century was Estonia. It has a modest carbon tax that principally levied fuels on road sector, followed by industry and residential and commercial sector.

- **Latvia:** Carbon tax priced 55% of carbon emission from energy use, with most of these emissions comes from road, industry sectors. At the beginning of the introduction in 2003 the price was particularly low ($0,96/t), but it increased during the years until 2019 when the price is around $10/t.

- **Switzerland:** it was implemented in 2008 as specific taxes on energy use and covered the 87% of carbon emission from energy use, with large share of emissions that rise from road, residential and commercial sectors. From 2013 to 2014 the price increase from $37/t to $67/t, with a huge increase in 2018 at $101/t. In 2019 the Swiss Parliament approved the agreement to adopt EU ETS, in order to cover also other sectors that were not covered. **Liechtenstein**, also applied in 2008 the carbon tax rate, but it is not included in the evaluation because it has the same environmental laws as in Switzerland and the data are not relevant for empirical analysis.

- **Ireland:** in 2010 carbon tax was introduced in Ireland with levied on gasoline, fuel oil, liquid petroleum gas and natural gas. The 89% of carbon emission are priced and come from energy use. On average, 65% of industry sector is subject to both pricing

instruments: Carbon tax and ETS. Price was around $25 per metric ton CO_2 along all the period and considered principally transport fuels.

- **Iceland:** following the financial crisis in 2010, Iceland enacted carbon tax on mineral oils and natural gas, while coal and other fossil fuels were not covered. In fact, coal and other solids fossil fuels used in the industry sector are not taxed with geothermal energy that is not taxed. Energy use is exempted because it is integrated in EU ETS and diesel is taxed unless the use is already subject to the EU ETS. In 2019 the carbon tax rate increased approximately to $30/t. This increase will help to eliminate fossil fuel in the transport sector by 2040. Furthermore, Iceland has already increased the changing in transport sector with purchasing of electric vehicle that are tripled respect to 2016.

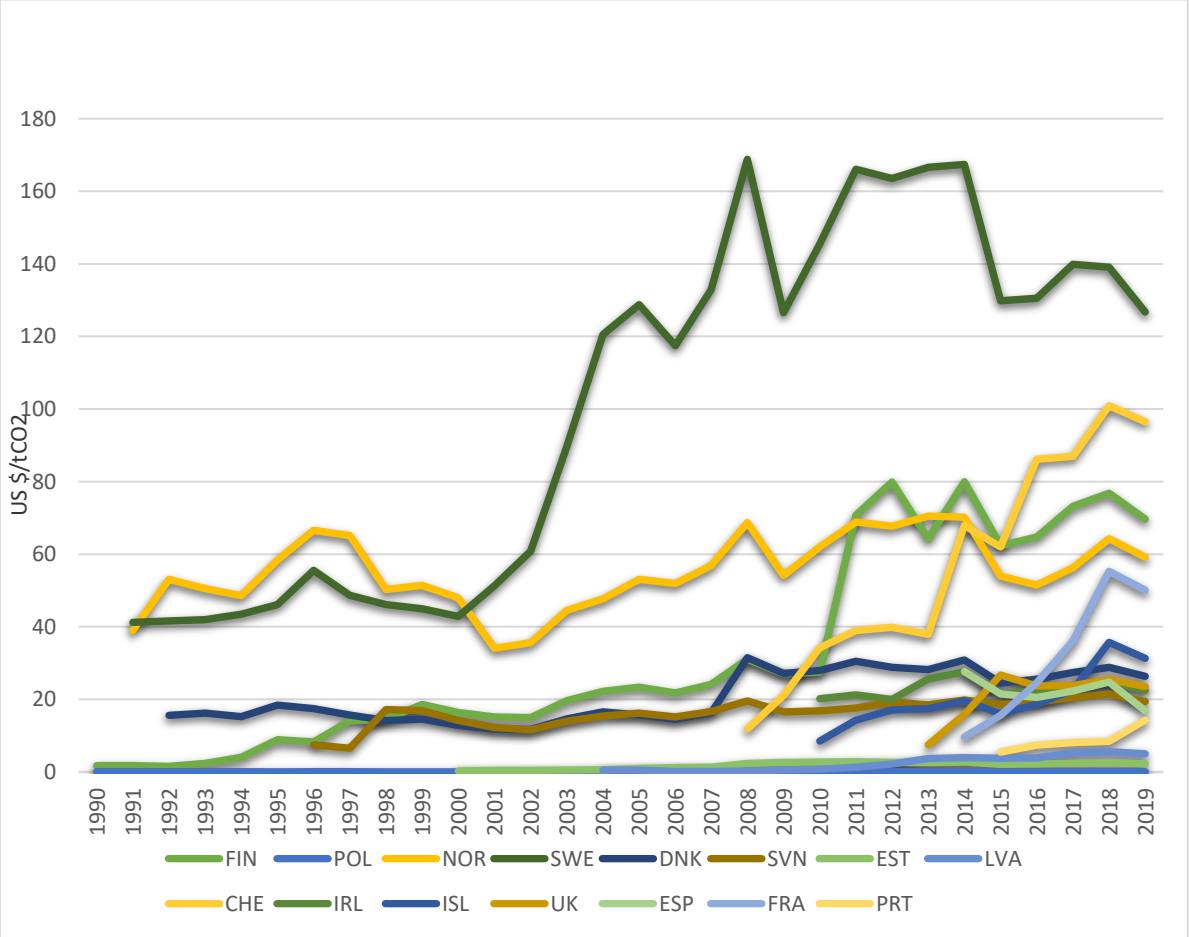
- **United Kingdom:** in 2013 the Carbon Price Floor (CPF) was introduced to support EU-ETS. The CPF is applied on power sector at rate that initially was very low $7/t and later is setting to increase as happened in 2019 at around $22/t. Since 2001, UK also applies Climate Change Levy that is not a true Carbon tax because it applies different rate per ton of carbon dioxide to different fuels. In 2020, the UK published its approach with the EU related to Brexit. The targets will not change, considering link between any future UK-ETS and the actual EU-ETS, that will bring to exchange allowances between both systems.

- **Spain:** it is pricing a portion of carbon emission since 2014, with on average of 30% of covered sectors at $27/t (on average). It was stipulated Carbon tax on transport fuels, heating and process purposes and for the electric sector. The sectors with the highest tax coverage are electricity and road transport, but in general Spain remain the EU member with the lowest percentage of environmental taxes. The goals for the next decade are to increase this percentage in order to achieve the EU low-carbon target.

- **France:** It was another country that implemented carbon tax in 2014. The tax is imposed on all fossil fuels according with their content, that are not covered in EU-ETS system. At the beginning the carbon price was $9/t, but its price increased during the years with currently around $53/t.

- **Portugal:** The main sector covered by carbon tax is road sector. The others like industry or electricity are not covered for the presence of ETS. It was implemented in 2015 with initial rate of $5/t, with a rate of $13/t in 2019. For 2021 forecast will bring to consider a rate of $26/t.

Figure 2.3 Carbon tax in Europe



Source: World Bank Carbon Pricing Dashboard database

2.2.2 European Trading System

Second tool used to set carbon price on emission producers is European Trading System. It is part of a large system that includes many areas of the world, but the EU area is the largest one. It counts 31 countries (EU countries plus Iceland, Liechtenstein, Norway) and covers 40% of GHG emissions and 4.2% of global GHG emissions. ETS is the key factor that EU add to national carbon tax to fight climate change and to reduce the GHG emissions in a cost-efficient way. It works based on cap-and-trade system, in which a cap is set on the total annual amount of GHG emission issued by all participants. It is important to note that the cap

of emission was set at national level through National Allocation Plan (NPA). This plan established the EU cap emission, where the sum of the allowances established the overall cap, and also sets the rules for the allocation of allowances for installations. Participants receive or buy emissions allowances, which they can trade with another one that needed them, with a combination of auction and free allocation. After each year participants must have enough allowances that cover their emissions, otherwise it must pay fines. The cap is reducing over time in order to decrease total emission year by year. If the participants reduce their emissions in less than one year, it will keep a certain stock of allowances in reserve to cover the future needs or to sell to another company.
The principal sectors covering by ETS are energy sector that include heavy energy, energy-intensive industries and transport sector with attention to airlines category. Each allowance gives the holder the right to emit carbon dioxide (CO_2), nitrous oxide (N_2O) (from production of nitric, adipic, glyoxal acids) and perfluorocarbons (PFCs from aluminium production).

2.2.2.1 Different phases

The EU ETS Directive was adopted in 2003, but the system became effective in 2005. Let us consider three phase that has spread during these years. Phase one regards a 3-year pilot from 2005 to 2007 to plan for phase 2 which occurred from 2008 to 2012. Phase three covered the period from 2013 to 2020 and phase 4 will cover from 2021 to 2030.

1. Given that caps were based on the estimates made by specialist, **in phase one**, the total amount of allowances gave exceeded emission. Probably also due that all allowances were gives for free at companies and covered only CO_2 emissions from power generators and energy-intensive industries. Trading volumes of allowances was 321 million at the beginning, then increased at 1,1 billion in 2006, 2,1 billion in 2007.
2. **Phase two** is slightly different from the previous one. The number of allowances available exceeded the demand for allowances, and there was a surplus of allowances accumulated during this period, which resulted in lower prices for emission allowances and limited the incentive to invest in clean, low-carbon technologies. The free proportion of allocation fell about 10%, and cap was 6,5% lower compared to 2005. The penalty for non-compliance of target, in the phase one, was around $49 per tonne of CO_2 (€40/t), instead in the phase two was increase at $120 per tonne of (€100/t). During this phase there were several countries that kept auctions for the

allowances of emissions. However, the economic crisis of 2008 allowed to increase a surplus of allowances because there was a decrease in production during that period. Trading volume in 2008 was 3,1 billion, with a huge jump in 2009 around 6,1 billion of allowances. At the end of that phase, 7,9 billion were traded. From 2013, the cap decreases by a linear reduction of 1,74% per year, respect to the average quantity issued annually during the period 2008-2012. The target considers the reduction of free allocation year by year, replacing it with auction.

3. **From 2013 to 2020**, it was expected that 57% of total trading will be auctioned and the remaining was given for free. In fact, power sector was covering by auction emission allowances totally, but only 15% of the aviation sector is auctioned, whilst the remaining is given for free. Several allowances originally planned to be allocated through auctioning between 2014 and 2016 (corresponding to 900 million allowances in total) were not allocated. As a result of so-called 'backloading' measure, the overall number of allowances available to operators has declined considerably. In 2017 and 2018 the supply of allowances and verified emissions were the same. In 2019, the supply of allowances decreased compared to the previous year and this decrease of around 20% is mainly due to the suspension of British auctions in 2019 and the fact that the Market Stability Reserve (MSR) started to withdraw allowances in 2019. During the last years of the phase, overall EU-ETS emissions decreased by 9%, where emissions from combustion plants (mainly power plants) were down 13%, while emissions from industrial installations decreased by 2%. The sectors cover by EU-ETS system by 2030 must reduce their emissions by 43% compared to the beginning level in 2005. This target imposes a revision in the plan of EU Commission.
4. **In phase four**, the cap on emission will reduce of 2,2% respect to previous phase. The system of free allocation will be extended until 2030 for the highest risk sector that suffer carbon leakage. This sector will receive 100% of their allocation for free, compared to the sector that are less exposed to this problem. For this, the free allocation will be slowly eliminated from a maximum of 30 % until the end of this decade.

EU will install more flexible rules in order to line up the level of free allocation with productions level. In fact, allocation to individual installations may be adjusted annually to reflect relevant increases and decreases in production, with the list of allocation that will be updated every 5 years. It will expect 6 billion of allowances to be allocated for free from 2021 to 2030. A huge number of free allocations will be maintained as reserve for new installations.

The calculation of these allocation is based on allowances that were not allocated from the total amount available for free allocation and 200 million allowances from the Market Stability Reserve (MSR).

Market Stability Reserve is the mechanism established by the EU to reduce the surplus of emission allowances in the carbon market. It began operating in 2019. Since 2009, due to economic crisis, this surplus has created an exceed of supply with consequences of decrease in carbon price. At the beginning of phase three the surplus was around 2 billion allowances. Through an amendment to the EU-ETS Auctioning Regulation, in 2014, the Commission delayed the auctioning of 900 million and allowances will be transferred to the reserve rather than auctioned until 2019-2020. In this way European Commission will be limited the number of allowances held in reserve, based on the level of auction volume of the previous year. This fact does not reduce the number of allowances during phase three, but the distribution of the volume during the years. In fact, the auction volume is reduced by 400 million in 2014, 300 million in 2015 and 200 million in 2016. From January to August 2020, another 265 million allowances are due to be placed in the reserve. Thanks to regulation, supply and demand is balancing and price volatility is reducing, without impacts on competitiveness. The reserve manages the surplus of allowances and improves the system whenever a shock occurs in order to adjust supply of allowances to be auctioned. European Commission made also important changes in the mechanism of MSR. From 2021 to 2025, the number of allowances put in reserve will determine the percentage of the total number of allowances in circulation. Furthermore, from 2023 if allowances held in MSR overcome the volume of auction of the previous year, it will not be valid.

So, allowances can be allocated for free or placed in MSR or auctioning. The latter method is the clearest and most efficient method. During phase three the percentage of allowance auctioned was above the 50%; in phase four this share will remain the same. Among the sectors, the share of allowances changed and the transition to auctioning method takes place at different times. For example, at the beginning of phase three, manufacturing industry received 80% of its allowances for free, but this percentage decreased for 30% over time until 2020. The goal is to reduce, at the end of this decade, to 0 level. In general, allowances are distributed among EU countries based on the share of their emissions. For phase four 90% of allowances will be distributed and 10% will be allocated to poorer countries.

Free allocation is important a measure because it contemporaneously try to reduce the emissions and protect the industrial sector from carbon leakage. This policy will continue also in phase four with different regulation and list of sectors that could be suffer this risk.

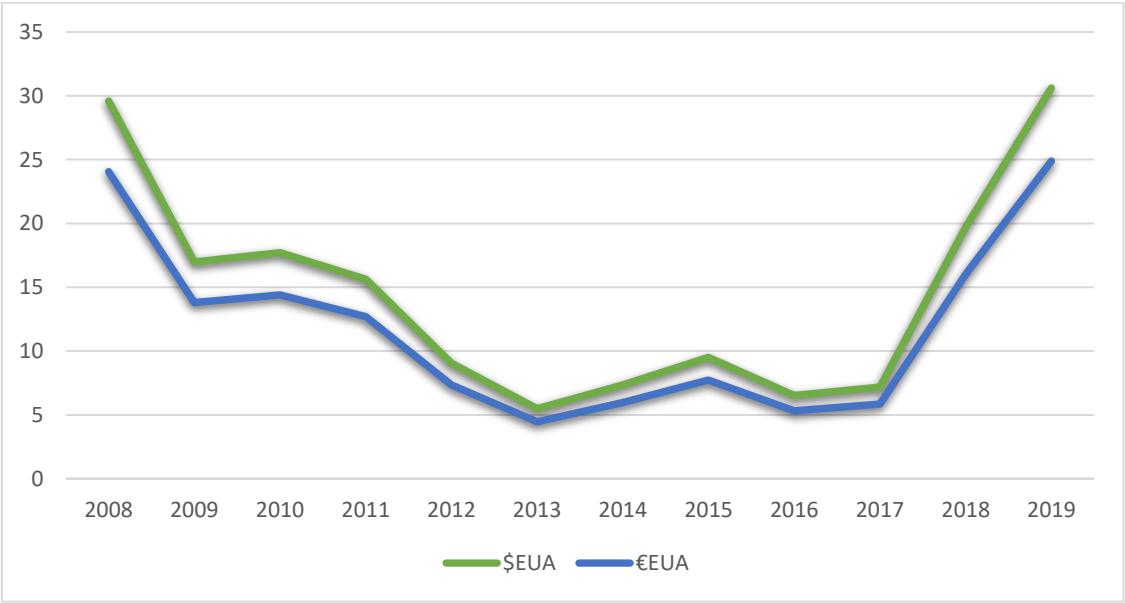
Figure 2.3 Emissions, allowances, surplus and price in the EU-ETS, 2005-2019

Note: The cumulative surplus represents the difference between allowances allocated for free, auctioned or sold plus international credits surrendered or exchanged from 2008 to date minus the cumulative emissions. It also accounts for net demand from aviation during the same time period.

Sources: Point Carbon, (2012); EEA (2020b), EEX (2020), ICE (2020)

Source: Trends and projections in the EU ETS in 2020, The EU Emissions Trading System in numbers, EIONET report - ETC/CME 3/2020 - December 2020

Figure 2.4 Emission price allowances 2008-2019, in Europe



Source: EMBER climate database

CHAPTER 3

The process towards climate-neutrality is influenced by the role that carbon tax played in the previous years and will play for the next. Among several studies there is a general opinion according to which the carbon price process is the most cost-effective tool to reduce carbon emission. Increasing the cost of CO_2 emissions and inducing consumers and businesses to choose an efficient way to reduce the level of energy production and to switch to greener sources are the principal aim of Europe.

In the medium/long term the quantity of reductions should keep the rise of temperature constant and lead the development of the more efficient energy production, thanks also to the use of renewable sources. So, a consistent rise of price should also encourage the technological innovation and accelerate the diffusion of carbon-efficient goods and services. However, the share of GHG emission covered by carbon price is still low at world level. More efforts will be faced by governments of all the world if they want to change drastically. On the other hand, Europe is the main continent with accurate policy for the future and during the past it tried to make more than others. Prevent carbon leakage and protect competitiveness are also the great challenge that countries will face.

Moreover, to maximize the fairness and political viability of a rising carbon tax, all the revenue should be returned in the governments budgets even if it is difficult to evaluate, and they are not always returned. The efficiency of all entire system should ensure that all economic factors should benefits from the introduction of policies also the categories that are most vulnerable than other as workers.

The difficulty of carbon pricing consistsd in the evaluation of economic impact of the policies adopted by the governments and the consequences of them. How to assess the economics cost of different policy and how this cost will affect the economy in the future are the principal arguments addressed by several studies.

3.1 The theory

During the years, many studies have gone through the expansion of GHGs accumulation on global average temperature, and a broad consensus about the effects of additional GHG emissions has emerged. Their accumulation in the atmosphere intensifies their effect, leading to an increase in the level of temperature. This, in turn, bears adverse environmental effects and induces economic costs. This implies that any tonne of CO_2 emitted in the atmosphere

implies a marginal damage. Avoiding excessive emissions and the reduce the economic cost is the main rationale behind the reduction of GHG emissions.
As previously discussed, the two most simple ways to apply price are Carbon tax and cap and trade system. The externality associated with the release of GHG into the atmosphere is the same regardless of its source or type of use. Therefore, the price signal associated with GHG emissions should be the same across the economy and cover all emissions.
Recent experience with carbon pricing policies suggests that their implementation has rarely followed theoretical prescriptions. Most of the policies had low coverage at the time of introduction, in fact careful observation of policy developments shows no consistency between the environmental goals and carbon prices.
The share of emission covered by carbon tax and EU-ETS is increasing and changing over time. Carbon taxes are applied to the carbon content of fossil fuels and on the level of CO_2 emission, ETS cover multiple gases and try to integrate what carbon tax does not make. Furthermore, the price of these two policies varies mainly along time (for the difference in the implementation) and country. Countries that have introduced Carbon tax policy have experimented with different strengths of the price signal. This varies across countries and could introduce distortions in the analysis. Instead, for the Emissions Trading schemes price signal is the same across all countries.

3.2 Data

For the analysis, 15 European countries that introduce Carbon tax are considered. The time range in which it operates goes through thirty years from 1990 to 2019. The countries are Denmark, Estonia, Finland, France, Iceland, Ireland, Latvia, Norway, Poland, Portugal, Slovenia, Spain, Sweden Switzerland, and United Kingdom.
Our data on carbon tax rates and GDP are in nominal way and comes from the World Bank Group. It is transformed in real way to capture the real economic values of the data: dividing the nominal carbon tax for the GDP deflator (home country currency) and converting it to US dollars. Carbon tax captures the emissions derived by combustion of fossil fuels that emits principally. For this reason, the average price of European Allowances (EUA) from 2008 by EMBER database for all countries that differ over the time (it is excluded data from 2005-2008) is considered equal. One EUA gives the holder the right to emit one tonne of carbon dioxide, or the equivalent amount of two more powerful greenhouse gases (other gases). The

level of CO_2 emissions from fossil fuels come from IEA World Energy Balances 2020 database, measured in thousand tonne.
For the calculation of Weighted Carbon Price (WCP) that takes into account the price of both carbon tax and emission allowance weighted for their share of emission covered, the total level of GHG emissions taken by Eurostat database is used, instead of the share of emission covered thanks to the contribution of different OECDs of every single country.
For the second part of our analysis, we test the relationship between the carbon price and the set of variables that could influence it. All data comes from The World Bank database.

The choice of panel econometric approach

Typically, multiple regressions are based on cross-section or time series database. Despite these two cases are more frequent, jointing them allow to create pooled or panel data. Pooled analysis refers to different statistical unit in each period that does not remain the same as time varies. Instead, panel data are defined as the observations obtained by sampling the same statistical unit in different time periods. The choice to carry out the analysis using panel data allows to work with more information than simpler datasets, including more variability across the data. Consequently, the parameters are estimated more efficiently and precisely. Furthermore, they allow to study the dynamics of data variation. For this reason, different methods of panel data analysis have been developed, such as the pooled OLS model, the Fixed Effects model (FE) and the Random Effects model (RE). The pooled OLS model uses the estimator of Ordinary Least Squares (OLS). In most cases it is unlikely to be adequate, but it offers a guideline for one comparison. Later, it is conducting a standard panel regression used FE and RE. In most of cases each model gives the same results, therefore in this situation we omit the RE. Let us consider the possible distortion caused by financial crisis of 2008; in this case we include dummy variable that assume 0 value if the Year<2008, and 1 if the Year>2008.

3.2.1 The choice of data

Before proceeding with the estimation, we organize the data description of our explanatory variables and try to explain the choice of these variables and how it could influence the dependent variable. Our empirical investigation shall consist principally in the standard panel regression with different dependent variable: real GDP and level of CO_2 emissions from fossil

fuels. Once make it, it will examine the drivers as: the level of industry, percentage of trade based on GDP, the total energy use and energy use derived by fossil fuel, electricity production from oil, gas and coal sources, and the share of renewable energy consumption of all fifteen countries, on the level of Carbon tax.
In the choice of data, we try to be as coherent as possible with the major factors that should impact on the level of the carbon price. It is obvious that there are several others historical and economic components that influenced it.
It is analyzing only the economic factors taking both countries and year fixed effect, and later with the introduction of temporal dummy try to include also the historical fact as financial crisis. Also, the fact of evaluate both GDP and Carbon tax in real way, is due to embed inflation-adjusted measure over the time for each country (expressed in base-year prices).

For what concerns the introduction of Weighted Carbon Price, arisen for the necessity to reflect the price of carbon price adjusted for its share of emission covered, because the price alone does not reflect the intensity of carbon pricing scheme. The price is an emissions-weighted average of all carbon price signals present in an economy at a point in time, that weights Carbon tax and Price Emission Allowances together with its coverage. The weights are the quantity of emissions covered at each price as a share total GHG emission; the exact coverage is difficult to evaluate, for this we try to do the best, thanks also the contribution of different OECDs of every single country. The calculation is based on the data available by 1990 for carbon tax and by 2008 for EUA, and by the contribution made by G.G. Dolphin at all (2016). It is clear that the heaviest contribution given by carbon tax that in the most countries have been introduced before 2008 and have already been established in the first 90s decade. Countries that have introduced carbon pricing policies have experimented different level of the price because it varies mainly along time, across and within countries, and by the sector. However, distortions introduced by the Emissions Trading system between covered and non-covered sectors (since the price signal is the same across all covered sectors) whereas a carbon tax scheme also introduces distortions among covered sectors. The carbon price does not vary much across fuels. In other words, most tax schemes apply the same tax rate to all fossil fuels. Our data of carbon price are related to the number of tax rate applied to fossil fuels, and for simplicity we assume that they are comparable between carbon pricing initiatives among also in the number of sectors covered. The main difference between ETS and carbon taxes is that: the former often covers multiple gases, whereas the latter only applies to the carbon content of fossil fuels.

The choice of data for the second part

For the second part of the analysis, I will try to consider what are the element that can affect the level of tax rate imposes by single nations and what are their impact on it. The contribution made by G.G. Dolphin (2016) gives an important help to the analysis.

- It is considering the total energy use (kg of oil equivalent per capita) of primary energy before the transformation to other end-use fuels such as electricity and refined petroleum products. It includes energy from combustible renewables and waste (solid biomass and animal products, gas and liquid from biomass, and industrial waste). From regression, a positive impact on the carbon tax is expected because it implies that a higher level of production in the countries, will increase the consumption of oil. It is calculated as the differences between domestic production and imports, exports and fuels supplied to ships and aircraft in international transport. However, in the developing economies growth, energy use is closely related to growth in the modern sectors such as industry, motorized transport, and urban areas. Energy use also reflects climatic, geographic, and economic factors and has been growing rapidly in low- and middle-income economies, but high-income economies still use almost five times as much energy on a per capita basis. Governments in many countries are increasing the attention on this problem with the necessity to make better use of the world's energy resources. Improved energy efficiency is often the most economic and readily available means of improving energy security and reducing greenhouse gas emissions.

- The uses of fossil fuels from energy consumption are expressed as share of total energy consumption and comprise coal, oil, petroleum, and natural gases products. As in the previous case the possibility to induce a positive effect could be consistent with the estimation, although it should consider the possibility that it does not necessarily react in the same way, for the correlation with other policies that do not contribute in the same way: as for example free emission allowance in the early period of enacted.

- Electricity sector is the area in which any form of carbon pricing that includes the power sector imposes the highest costs on electricity producers from fossil fuels. In this case the electricity production from oil, gas, and coal sources as a share of total electricity production is examine. Sources of electricity refer to the inputs used to generate electricity. Oil refers to crude oil and petroleum products, gas refers to

natural gas but excludes natural gas liquids and coal refers to all coal and brown coal, both primary and derived fuels. In this case, there will be an ambiguous result, because the larger will be the share of electricity produced from fossil fuel, the higher will be the potential capital losses and less politically feasible carbon pricing regulation will be. It is not easier for the firms embedded the potential increase of the price, and this price will reflect on the consumers, but if the firms are unable to transfer the cost, the change in market price will not reflect the increase in cost and this could be negative for the profit of the firms; on the other hand with the introduction of other policies as said before, could induce the possibility of not reduce the share of production of electricity from fossil fuels and at the same time the cost will still remain higher on consumers and the firms will make a profit.

- With the introduction of industry added value (net output), we consider the sectors covered by the classification of International Standard Industrial Classification of All Economic Activities (ISIC). It comprises value added in mining, manufacturing, construction, electricity, water, and gas. The introduction of this variables is driven by the necessity of introducing other energy-intensive sectors in the evaluation of regression. The probably negative effect could be associated by the risk that these sectors have respect to fewer stringent policies of international partner. The carbon intensity depends on the size and on the importance that these sectors have in the trade. For this it is also introduced the value of trade as the sum of exports and imports of goods and services measured as a share of gross domestic product. It is expected that it will give the same result as industry, although countries that are open to trade may be more sensitive to the carbon policy and also for the effect given by carbon leakage; for this also in this case the result could be ambiguous.

- Finally, let us also consider the share of renewable energy consumption in total final energy consumption. What we expect is the negative effect that an increase in the share of consumption should have on carbon price rate. In fact, the introduction of renewable sources gives another possible solution to this problem. The effect of these sources should smooth the long-run effect of carbon tax. The governments in this way must incentive the use of these sources not only with financing support, but also changing the mentality and behaviour of the population; this latter solution should depend also on the level of civilization.

3.3 Econometric Approach

Let us proceed with the first part of our analysis, with the examination of different impact of carbon pricing on macroeconomic variables. All regression is created using Gretl econometric software.

The level of Real GDP

Starting from the assumption that consider the logarithm of the variables to standardize them and have similar descriptive statistics data. Consider as dependent variable the logarithm of real GDP. It is difficult to identify the dynamic causal effect of a carbon tax on GDP, for the possibility to ignore a several other factor that could influenced and happened during the year on different countries. We omit the random effect estimated because it gives the same result of fixed effect.

Table 1: Different regressions

Dependent variable: l_realGDP	Pool OLS	Fixed effect	Fixed effect (with dummy)	Random effect (with dummy)
constant	25,6727*** (0,6790)	25,6554*** (0,1253)	25,6520*** (0,1261)	25,8226*** (0,3950)
ln_realcbrtax	0,143529 (0,1819)	0,15064** (0,0515)	0,08997* (0,0495)	0,0910* (0,0485)

For what concerns Pool estimation, it is found that the variable is not significant (decision to set the significance level at 0.1). With the introduction of Fixed Effect, the variable changes and a significant level of the parameters estimated with low p-value is noticed. With dummy variable for fixed and random effect the value of coefficient decreases but remains significant. What we expect is that in this case the effect that the tax should have is negative. Contrary, the results' effect is positive. This probably could arise from the use of carbon tax revenue made by each country, to improve the overall efficiency of the tax system. In fact, even if there is limited data on how countries use this revenue, many of the early countries as Scandinavian countries, Switzerland and Portugal established carbon taxes as part of Green

Tax Reform in order to reduce the income taxes on the population. Another possibility is that countries with a long experience with the carbon tax have a different response than countries with less experience. The fact that there is considerable variation in tax rates, or the length of time the carbon tax has been in effect, or the fact that we take into account the initial intention that can mitigate during the years, or the true way in which these revenues are used, can make revenue recycling difficult to estimate, and for this we limit to explain the theory in which our positive coefficient could be based.
This is in line with the analysis made by Metcalf and Stock (2020), that analyses the impact of Carbon tax in the short and long period. Their results do not suggest particularly large positive impacts of tax on GDP and they do not support a claim of large adverse impacts.

The second estimation takes into account the possible effect that Emission Price Allowance gives on the level of real GDP. Also, in this case the logarithm of the variables are taken.

Table 2: Different regressions

Dependent variable: l_realGDP	Pool OLS	Fixed effect	Fixed effect (with dummy)	Random effect (with dummy)
constant	26,2193*** (0,4274)	26,2193*** (0,0332)	26,6294*** (0,0524)	26,6294*** (0,4067)
ln_EUA	0,04721*** (0,0132)	0,04721*** (0,0131)	−0,08297*** (0,0165)	−0,08297*** (0,0165)

What we notice is that the Pool and FE estimation gives the same results. This is related to the fact that our result of prices allowances is from 2008, and for this reason the two methods are not acceptable by economic way, although the result gives the efficient coefficient.
The Chow test questions if there is a structural break in the data on Pool OLS. To do this, the regression is modified by inserting a dummy variable. In this way we want to verify if in 2008 the estimated parameters of the model had significant changes. If the test value is greater than 2, a structural change has occurred. The p-value below 0.05 therefore implies a structural break.

Test Chow structural difference respect to dummy variable

Null hypothesis: no structural differences

Test Statistics: F(2, 176) = 284,666 con p-value <0,00001

The test says that there are structural differences. In fact, if we consider the FE and RE with dummy variable the coefficient becomes negative. This is coherent with data, first because we have the data from 2008 and second because consider the fact that for one restriction emission allowance emits, the impact on GDP is negative for the restriction imposes by the EU in equal way for each country. Respect to Carbon tax, the EUA are not managed at country level. For this reason, the price permission is paid by each country and inevitably effects on GDP negatively.

The last step is to evaluate the effect of our Weighted Carbon Price on GDP. Even in this case the logarithm of data available is used.

Table 3: Different regressions

Dependent variable: l_realGDP	Pool OLS	Fixed effect	Fixed effect (with dummy)	Random effect (with dummy)
constant	26,2193*** (0,3548)	26,1593*** (0,00396)	25,9731*** (0,0155)	26,6294*** (0,4137)
ln_WCP	0,007915 (0,00913)	0,00213** (0,00092)	0,00151*** (0,00013)	0,00151*** (0,00013)

The data evidence that even in this case the Pool estimation are not consistent. The data show a slightly positive effect of WCP on real GDP. This is coherent with what we expect because the WCP takes into consideration the share of emission covered by different policies and the differences in time of emission. With the introduction of dummy the difference is even smaller than without dummy, and this coincides with the introduction of ETS system. The same assumption made with carbon tax could be remade for WCP, but the evidence shows that the slightly effect are influenced by EUA that compensate the effect of carbon tax alone. Now we will consider the three element of this previous estimation and evaluate the effect on the real GDP. First, we make a preliminary analysis based on cross-correlation, to look whether there is correlation among regression and in case eliminate it when making the evaluation. This ensures that the assumptions for statistical inference are satisfied.

Coefficient of correlation, using the observation 1:19 - 15:30

(missing value are skipped)

Critic value at 5% = 0,0944 for n = 432

Table 4: Cross-correlation matrix

	lnrealcbrtax	lnEUA	lnWFC
lnrealcbrtax	1,0000	-0,0260	0,2002
lnEUA		1,0000	0,0899
lnWFC			1,0000

A rapid check of the cross-correlation matrix between the various variable reveals that there is no correlation between the parameters. Now, we will proceed with the estimation with all different method.

Table 5: Different regressions

Dependent variable: l_realGDP	Pool OLS	Fixed effect	Fixed effect (with dummy)	Random effect (with dummy)
Constant	25,7796*** (0,5230)	25,9174*** (0,06462)	26,3352*** (0,2360)	26,4851*** (0,3762)
ln_realcbrtax	−0,2380** (0,1097)	0,0648*** (0,0222)	0,04699** (0,0205)	0,05564* (0,0284)
ln_EUA	−0,2599 (0,2034)	0,0624*** (0,0173)	−0,0641 (0,0708)	−0,0657 (0,1003)
ln_WCP	0,3158*** (0,0700)	−0,0244290** (0,0115)	−0,0168 (0,0115)	−0,01132 (0,0159)

From an econometric point of view, computing on the Pool estimation, the White test to verify the presence of homoskedasticity. In the case of the fixed effects model, it is exploiting the non-parametric Wald test (for the random effect model the econometric software does not provide tests on heteroskedasticity). The first has as a null hypothesis the non-presence of heteroskedasticity, and the second has as a null hypothesis that the units have in common the

variance of the error (homoskedasticity). Therefore, both tests are structured in the hypotheses to provide the same methodology for interpreting the results: where the p-value of the test statistic is lower than the critical level 0.05, H0 is rejected

White test for heteroskedasticity -
Null hypothesis: not present heteroskedasticity
Statistica test: LM = 80,2691
with p-value = P(Chi-quadro(9) > 80,2691) = 1,42896e-013

Non-parametric Wald test for heteroskedasticity -
Null hypothesis: the units have in common the variance of the error
Asymptotic test statistics: Chi-quadro(15) = 217,133
with p-value = 6,8634e-038

However, we conduct the F-test for fixed effects. It tests the null hypothesis that the fixed effects α (the part of the error dependent on the observed unit and independent of time, including the effect of all unobservable variables) are the same in all units. Rejecting this hypothesis means that the fixed effects are non-zero. Therefore, in case the null hypothesis is rejected, it can be concluded that there is a significant fixed effect or a significant increase in the goodness of fit of the model in the fixed effects model, and the FE model is better than the model pooled OLS.

Test statistic: F(14, 132) = 2127,75
with p-value = P(F(3, 132) > 2127,75) = 5,32568e-148
(a low p-value counts against the null hypothesis that the pooled OLS is adequate, in favor of the alternative model with fixed effects)

The joint regressors test is an F-test that evaluates whether all the coefficients in the model are different from 0. In this case it gives a very low p-value, thus indicating that the coefficients are different from 0.
This confirm our expectations that FE are efficient, and we take it into consideration. Models with dummy are not good for the fact that they consider a strict amount of data.
In line for what Metcalf and Stock (2020) papers give, there is no evidence to support that European carbon taxes have had impact on GDP. Low coefficients support this theory.

From an economic point of view the only different assumption is that now we have a different change in the sign of EUA and WCP. This is due probably to the fact that they are in the same regression at the same time and the coefficients are influenced by each other (even if there is no correlation). The negative effect on the GDP made by WCP is given by the presence of variables that influenced the direction of regression, and by the fact that in the WCP are embedded the double effect made by both Carbon tax and EUA and take all time patterns. While the positive effect of EUA should be given by a small fraction contribution of that price only the last twelve years respect to thirty overalls. Infect, dummy models (that consider only the last twelve years) confirm this theory and give change in the sign, coherent also with the previous assumption.
The low level of coefficient, even in this case support the theory of Metcalf and Stock (2020) that found no evidence, either positive or negative, to support that these taxes have had impact on the level of GDP.

The Level of CO_2 emissions

We focus now on the effect of the carbon tax, EUA and WCP on the level of CO_2 fossil fuel. A basic assumption is that tax could help to reduce the curve of emission and the other measure in this way helped tax countries to reach this purpose. On the other hand, the possibility of different scenario should be gives by EUA with free permission allowances gives on the first of their implementation and for the possibility to exchange this permission each other. Let directly analyze the impact of the three dimensions across different models. Also, in this case we will take the logarithm of the three dimensions, to standardize the variables. Instead, given that the level of CO_2 fossil fuel is express with thousand tonne and thanks to descriptive analysis, we will look that they have a different data respect to the three variables, even in this case take the logarithm.

Table 6: Different regressions

Dependent variable: l_levelofCO2	Pool OLS	Fixed effect	Fixed effect (with dummy)	Random effect (with dummy)
Constant	10,9630***	10,6261***	11,0709***	11,2889***
	(0,5020)	(0,0632)	(0,1971)	(0,3091)
ln_realcbrtax	−0,3789***	−0,007669*	0,01355	0,0107
	(0,1053)	(0,0218)	(0,0171)	(0,0211)
ln_EUA	−0,18713	−0,034951*	−0,2058***	−0,2058***
	(0,1952)	(0,0169)	(0,0591)	(0,0735)
ln_WCP	0,1947***	−0,0391***	−0,006516	−0,007439
	(0,0672)	(0,0113)	(0,0095)	(0,0118)

Based on the data the more realistic assumption are gives by FE. From econometric point of view the coefficients are significant. The Wald test leads us to reject the null hypothesis and show the presence of heteroskedasticity.

Non-parametric Wald test for heteroskedasticity -
Null hypothesis: the units have in common the variance of the error
Asymptotic test statistics: Chi-quadro(15) = 1392,77
with p-value = 5,94468e-288

The F-test confirm our expectations that FE model is better than Pool OLS.

Test statistic: F(14, 132) = 2049,55
with p-value = P(F(3, 132) > 2049,55) = 6,22919e-147
(a low p-value counts against the null hypothesis that the pooled OLS is adequate, in favor of the alternative model with fixed effects)

Even if the dummy models are efficient estimation, we do not take into consideration for it gives no economic sense to our approach. In fact, it is reasonable that the restriction imposed by government and by EU gives negative impact on the level of emissions. This implies that during the year the implementation of policies gave the desired effect. For what concern the support gives by each polices, we notice that the coefficient of carbon tax is lower than the price allowances, probably due to the increase in the level of emission in the last year respect

to the first decade of 90s. The double effect gives more results, especially when they are weighted with their share of emissions. The combination of both policies given by WPC confirms what we explain and what the nation's first, and EU-commission's later is doing to tackle the mitigation climate policy towards climate neutrality by 2050.
However, we do not consider the low-level of the taxes imposed in some countries as for example Latvia or Poland. Countries with a higher level of prices, contributed in more efficient way to the reduction. To understand why our coefficient contributed with a low coefficients value, it should be better put to an equal level of taxes for all countries considered. In this way the contribution made by Metcalf and Stock (2020), gives an important result, which imposed a $40 Carbon tax per ton of CO_2 for each country, gives for the first 6 years by implementation 6,5% reduction in the level of emissions. This is a huge increase compared to our results.

3.3.1 Second part of analysis

Before proceeding with the estimation, we perform preliminary tests on the data to ensure that the assumptions required for statistical inference are satisfied. First, a rapid check of the cross-correlation matrix. The use the logarithm on all variable in order to ensure the standardization of the variables and have similar values. The table of statistic description can help to understand this.

Coefficient of correlation, using the observation 1:19 - 15:30
(missing value are skipped)
Critic value at 5% = 0,0925 for n = 450

Table 7: Cross-correlation matrix

	l_Energyuse	l_tradeofgdp	l_fossilfuel	l_renewable	l_industry	l_Electricity	l_GDP percapita
l_Energyuse	1,0000	-0,0742	-0,7262	**0,4068**	0,0258	-0,7639	**0,5754**
l_tradeofgdp		1,0000	-0,0609	0,0906	0,2075	0,0012	-0,0292
l_fossilfuel			1,0000	-0,4524	0,2904	**0,6692**	-0,1837
l_renewable				1,0000	-0,0761	-0,6266	0,2070
l_industry					1,0000	0,0320	-0,0395
l_Electricity						1,0000	-0,4905
l_GDPcapita							1,0000

Here correlation between the variables: energy use with GDP per capita and renewable, electricity and fossil fuel are used. In order to avoid multicollinearity issues, we shall therefore not include them in the same regression models.

To give sense to the data, a logarithm in order to have similar descriptive statistics is applied. The lack in the number of observations in the Carbon tax variable are due to different introduction of rate during the year.

Table 8: Descriptive statistics for all variables

Variable	Mean	St. Deviation	Min	Max	Missing observation
l_Carbontax	2,4312	2,1814	-2,9742	5,2299	190
l_Energyuse	8,2379	0,46686	7,3892	9,8080	0
l_tradeofgdp	4,4027	0,37263	3,5689	5,4774	0
l_fossilfuel	4,0307	0,49740	2,3278	4,5903	0
l_renewable	2,8079	1,0229	-0,49715	4,3681	0
l_industry	3,2169	0,17668	2,8376	3,6962	0
l_Electricity	2,5121	2,2067	-4,4550	4,5926	0
l_GDPpercapita	10,384	0,69361	8,6737	12,468	0

The models

In this second step, our empirical model aims at testing the relationship between the Carbon tax rate of different countries and the set of different variables introduced before. We use a Pool OLS estimation and panel analysis with Fixed and Random effects. For each of them we evaluate the possible alternative and try to give explanation on our results.

1- POOL OLS RESULTS

Table 9: Regression with ln_Carbontax as dependent variable

Pool OLS	**(1)**	**(2)**	**(3)**	**(4)**
l_Energyuse	4,3283***	1,7571***		
	(0,4032)	(0,3878)		
l_tradeofgdp	1,4728***	0,3855	0,1612	0,1245
	(0,3745)	(0,3609)	(0,2051)	(0,2107)
l_fossilfuel	2,0475***			−0,1349
	(0,3490)			(0,1703)
l_renewable			0,6793***	0,4024***
			(0,1445)	(0,1408)
l_industry	−3,5825***	−1,3783**	−0,9289	−0,8990**
	(0,6809)	(0,6129)	(0,3567)	(0,3767)
l_Electricity		−0,1955**	0,1059**	
		(0,0785)	(0,0481)	
l_GDPpercapita			2,4903***	2,4363***
			(0,1143)	(0,1127)

The results in most of cases do not give a consistent estimation of coefficient. Although in the first regression the coefficient is significant, they do not provide economic sense for the higher coefficient that produces exaggerate results and for the signs of the coefficients. This brings us to exclude our explanation on the results and does not take the Pool OLS as consistent estimation of parameters.

2- FIXED EFFECT RESULTS

Table 10: Regression with ln_Carbontax as dependent variable

Fixed Effect	(1)	(2)	(3)	(4)
Constant	−6,08211	−11,7034***	1,61144	−11,3411***
	(04,0769)	(4,1965)	(2,4784)	(1,7926)
l_Energyuse	1,5884***	1,8963***		
	(0,4790)	(0,5159)		
l_tradeofgdp	1,1647***	1,3821***	1,1655***	
	(0,2309)	(0,2137)	(0,3246)	
l_fossilfuel	−0,8544***		−0,9651***	
	(0,2945)		(0,3186)	
l_renewable			−0,4518**	−0,2366*
			(0,2067)	(0,1363)
l_industry	−2,0034***	−2,3042***	−1,8796***	
	(0,4267)	(0,4102)	(0,4134)	
l_Electricity		−0,1377*		−0,2752***
		(0,0745) *		(0,0781)
l_GDPpercapita			0,6665***	1,4549***
			(0,1898)	(0,1787)

From econometric point of view all regression give a higher significative estimation of coefficient. The F-test on all these four regressions gives a low p-value level that bring us to accept that there is significant increase in the goodness of fit of the model in the fixed effects model rather than in Pool OLS. The Wald test confirm the presence of heteroskedasticity. Start by analyzing the influence of the energy mix. According to our forecast, primary energy use (kg of oil equivalent per capita) increases the determination in the level of carbon tax as the countries level of trade and real GDP per capita. The log-log regression system, suggest that 1% of variation in the level of independent variable, determines an % variation of the coefficients in the dependent variables. Such that, an increase of 1% in the energy use, indicate an increase of 1,6% in the price level (first specification). We make the same assumption for trade (contrary for what we expect) and for GDP per capita. The latter is a measure of economic activity and is also used as a proxy for the development in a country's material living standards. For this the interpretation is that an increase in its level, induce an increase in the carbon rate. The assumption gives economic sense to our model because a

higher level of GDP supposes a higher purchasing power, and other economic factor related to them should induce an increase in the level of pollution, with consequences increase in carbon price. By analyzing the influence of electricity sector and fossil fuel from energy consumption, noticed that they reduce the stringency of a carbon pricing mechanism. This effect also is related to that of the share of industry value added in GDP. A larger industrial sector will, on average, decrease the stringency of carbon pricing policies. A 1% increase in the share of industry value added in GDP is associated with on average of 2% decrease in the carbon price, which suggests that countries with intensive emission of CO_2 in industrial sectors will decrease the level of the price tag associated with a tonne of CO_2 emissions. This is could be associated with the carbon leakage effect that occurs when there is an increase in GHG emissions in one country as a result of an emissions reduction in a second country with a more stringent policy.

Infact, carbon leakage may occur: when the emissions policy raises local costs then another country with a more relaxed policy, so this country may have a trading advantage and also when the demand for some goods remains the same, production may move offshore to the cheaper country with lower standards policies; when environmental policies in one country add a premium to certain fuels or commodities, then the demand may decline, and their price may fall, and countries that do not place a premium on those items may then take up the demand and use the same supply.

All these results are in line with the G.G. Dolphin at all (2016) papers. Other technical assumptions made in the previous section still remain valid. Also, the negative effect of renewable energy consumption is still valid because try to explain the double importance that this sector could give, because the increase in the energy consumption derived to renewable sources induce decrease in the price level and on the same time reduce the level of air pollution.

3- RANDOM EFFECT

Table 11: Regression with ln_Carbontax as dependent variable

Random Effect	(1)	(2)	(3)	(4)
Constant	−5,32868	−9,9771***	1,43376	−12,4503***
	(0,1657)	(3,669)	(2,3712)	(1,7060)
l_Energyuse	1,4051***	1,6751***		
	(0,4261)	(0,4390)		
l_tradeofgdp	1,2046***	1,3772***	0,7455**	
	(0,2261)	(0,2094)	(0,2944)	
l_fossilfuel	−0,6864**		−0,7064**	
	(0,2810)		(0,2901)	
l_renewable			−0,24309	−0,2068
			(0,19252)	(0,13214)
l_industry	−2,0317***	−2,2831***	−1,8590***	
	(0,4234)	(0,4026)	(0,4054)	
l_Electricity		−0,1156*		−0,2209***
		(0,06745)		(0,06595)
l_GDPpercapita			0,9588***	1,5456***
			(0,1793)	(0,1646)

For what concerns the econometric approach the Breusch-Pagan tests, evaluate the null hypothesis that the variance of αi is zero. If the null hypothesis is rejected, it can be concluded that there is a significant random effect in the dataset and that the RE model is better than the Pooled OLS model. For all four regression we have a low value of p-value (close to 0) that refuse the null hypothesis and for this we say that RE is better than Pool OLS. The Hausman test instead check that the individual effects are not correlated with any regressor in the model. If the null hypothesis is rejected, it can be concluded that the individual effects αi are significantly correlated with at least one regressor in the model and that therefore the random effects model is problematic. Therefore, it will be preferring fixed effects model. For the first two regression we accept the null hypothesis that RE estimates are consistent respect to FE, for the last two we reject it. This does not cause any problem for our economic assumption, because in this way the first two regression give almost the same effect and coefficient value of FE effects.

Hausman test –
Null hypothesis: GLS estimates are consistent
Asymptotic test statistics: Chi-quadro(4) = 6,09698
with p-value = 0,192022

Hausman test –
Null hypothesis: GLS estimates are consistent
Asymptotic test statistics: Chi-quadro(4) = 1,68715
with p-value = 0,79305

Hausman test –
Null hypothesis: GLS estimates are consistent
Asymptotic test statistics: Chi-quadro(5) = 20,2895
with p-value = 0,00110263

Hausman test –
Null hypothesis: GLS estimates are consistent
Asymptotic test statistics: Chi-quadro(3) = 10,7108
with p-value = 0,0133973

Additionals footnotes

The results presented above support the relevance of several factors that could be happened during these years. For example, the role made by EU during these years are not take in consideration as well as the political economy events that characterized every country during the last thirty years as the period in which each of them took part in the European Union. Infect, most countries that we analyze were not part of EU at time of implementation of carbon tax, and the role that could be played are not embedded in the model.
The time for which we evaluate the estimation is also important. The level of price is related to fact that in a given period it could be fall, because there would be the implementation of different policies across the country and also across the EU. For this is important understand that for certain sector the price should not reflect at all their emission for the fact that it could be taxable in another supplementary policies as EU-ETS. There is trade-off between carbon tax rate and other climate change mitigation policies.

Moreover, carbon pricing policies face their own internal trade-off between the increase in the price signal in covered sectors and the increase in field of application including other sectors that have not been covered yet.

So, the role of revenue recycling in the political acceptability of carbon pricing policies is difficult to introduce due to the heterogeneity of schemes and policies. However, it is to be noted that most of the carbon pricing schemes mentioned in the paper were introduced with some form of revenue recycling such as: Denmark, Sweden, Norway, Finland, Switzerland, and Portugal that partially or fully used carbon tax revenue to lower existing income tax rates. Further analysis of their development could provide additional insights into the political economy dynamics leading to carbon pricing: the design and scope of each of those schemes differ and it is likely that those differences are the consequence of different economic structures of the countries in which they are implemented.

CHAPTER 4

4.1 Fiscal policies

The role of policy makers has been important for the reduction of pollution and will be crucial towards climate neutrality transformation.

Most strategies include objectives for both mitigation and adaptation. The role of fiscal policies is important for implementing climate strategies using an efficient political tool.

On mitigation, this tool shows that carbon taxes can be attractive to tackle different area of interest as: emission reduction, fiscal problem, domestic environmental, and economic impact. Revenues might be used for lowering taxes or funding public investment. Fiscal instruments could also reduce other emissions derived by other interest area such as forestry or international transport.

Many countries would need high carbon prices to meet their obligation, and fiscal policies play an important role in this way. Research and development (R&D), infrastructure investment, and financial market policies can enhance the effectiveness of carbon mitigation. At international level, a carbon price could reinforce the Paris Agreement and address the high divergence in prices among countries.

National strategies should cover risk associated to diversification across a range of fiscal and financial instruments in order to make sustainable macro-fiscal framework that allows climate investments targeting.

The government have a key role in integrating carbon taxes and allocate carbon pricing revenues; it also should be able to integrate climate and financial risks into macro-fiscal frameworks and to coordinate strategies across political system.

Countries analysis of policy options can help move carbon pricing and other mitigation policies forward. They may have incentives to act unilaterally when the role of carbon pricing generates substantial domestic environmental benefits, mobilizes domestic revenues, and leverages external finance. Mitigation policies has brought a proliferate policy during the years. For example, many countries now have energy efficiency and renewable policies and many national or sub-national governments have implemented pricing through carbon taxes or ETS (not only in Europe).

To enhance the acceptability of the political strategies, the governments should keep in consideration the importance of a broad strategy that includes items on how revenues are to be used and help households and firms that could be suffer this policy.

However, carbon pricing may also need to be part of a broader fiscal and regulatory reform.

Fiscal instruments which are less efficient than carbon pricing could be another solution that could avoid increases in energy prices or regulations for emission standards for vehicles, power generation etc.

4.1.1 The use of revenues derived by carbon pricing

There are two effect that the correlation between carbon taxes and the broader fiscal system bring.

First is the potential economic efficiency gain from 'revenue recycling'. This could reflect gains from using revenues to reduce broader taxes that distort the economy by discouraging investment and the participation of labor force and could create a bias towards tax-preferred spending like housing etc. There is an efficiency gains from using revenues to fund public investment or reduce fiscal deficits.

The second effect is associated on loss of efficiency caused by taxes that could act as implicit taxes on labor, with consequences of increase in the level of unemployment and could reduce the investment. In every case, the first effect can dominate the second effect.

The problem can arise if carbon pricing revenues are not used to increase economic efficiency. In this case pricing can be substantially less cost-effective than regulatory or similar policies like emissions standards for power generators, vehicles, and electricity-using products.

Carbon pricing supply much needed revenues to fund other measures to complete the strategy make with the implementation of its. We can identify what are the potential objectives that can be reached by using carbon pricing and the reasons for which the countries used them. Principal aim of imposition the carbon taxes is to reduce the critical climate level that our world could reach at the end of this century. The revenues arise from them could be used for other fact, how we can see, but from policy perspective point of view we can identify different goals that can be achieved from use of them.

We take a look for the people category that can affected most by carbon taxes, especially the household with low-income and the political stringency imposes on middle firms. The governments can use the revenues for offset the burden that carbon pricing impose by these categories or can funding investment for the same purposes (green investment) or funding other public policy that could not be necessary related to climate changing.

4.1.2 Revenues among our country's analysis

It is difficult understand the potential that carbon revenues can bring and how they can fit into broader fiscal policy strategy. The political guidance on how to determine the best use of revenues is the main challenge that policy makers can afford in order to integrated them in the efficient way.

Carbon taxes generate revenue based on the size of the tax base and the price set by policy makers, while ETS revenues are raised through auctioning of emissions allowances.

An estimate shows that revenues from carbon pricing reached US$ 44,6 billion in 2018, a 30% increase respect to 2017, and on average of US$ 50 billion in 2019. With the introduction of other measures as EU-ETS, revenues associated from existing initiatives increased and contributing most of the increase in revenues following an increase in the EU allowance price. The EU-ETS remains the largest source of carbon pricing revenues due to its size. As in France and Sweden the EU-ETS already collects the largest carbon revenues due to the size of the covered market, and its level will continue to increase.

The change in the level of price could cause large impact on the size of revenues raised year to year. Variations tend to be greater under an ETS than under a carbon tax, where rates are set explicitly. The price of ETS react to changes in market demand, because is driven by interactions between economic and firm factors.

It is obvious that the level of free allocations under an ETS and any form of tax exemptions permitted in a carbon tax affect the revenues. They are also affected by the characteristics of markets. If there is not a substantial change in quantity demanded when another economic factor changes (inelastic markets) will have relatively more stability in demand, and therefore more stable revenues.

Moreover, other important role is played by taxes that already place an implicit price on carbon, such as electricity and transport fuel taxes. These together are used by governments as potential useful tool for raising government revenue. To make the most effective use of carbon revenues, governments should develop appropriate governance arrangements.

Placing a price on carbon emissions causes negative impact on firms, consumers, and investors that internalize this effect. Typically, are concentrated in certain sectors or among certain consumers, and the role of revenue in this way could be used to offset these impacts.

It is important to look the aims governments may pursue through fiscal policy, as these can inform decisions regarding the use of carbon revenues. Understand what the aims are, is important to know the pattern that the governments would give with its policy. One of the

standard fiscal policy aims is to maximize efficiency, by better allocating public and private resources to their most efficient social use. This aim can be achieved through policies that:

- internalize external benefits of certain activities through subsidies to increase their supply to a socially more beneficial level, for instance through spending on health, education, infrastructure, or environmental preservation as in this case.
- internalize negative externalities using taxes or pricing mechanisms to reduce their scale to a socially more beneficial level, for instance through taxes on air or water pollution.
- reduce distortions, by replacing taxes that change production decisions (such as income taxes) with taxes that internalize external costs (such as congestion charging) or those that are less distortionary and result in small relative changes in production decisions (such as taxes on "inelastic" goods like transport fuels or broad-based consumption taxes)
- Reduce administrative costs, for instance by replacing more complex tax, which may have larger costs associated with their collection, for simpler ones.

Support the long-run growth is another fiscal policy objective. This may include policies to:

- smooth the economic cycle; these spending and taxation systems smooth the economy if it is growing too fast or stimulate economic activity when growth slows.
- increase innovation and productivity growth, that include investments in new productive capital or support for technology innovation and diffusion, for instance through support for education or research, development, and deployment.
- could ensure sustainable levels of debt, that will stimulate investment and control future consumption.

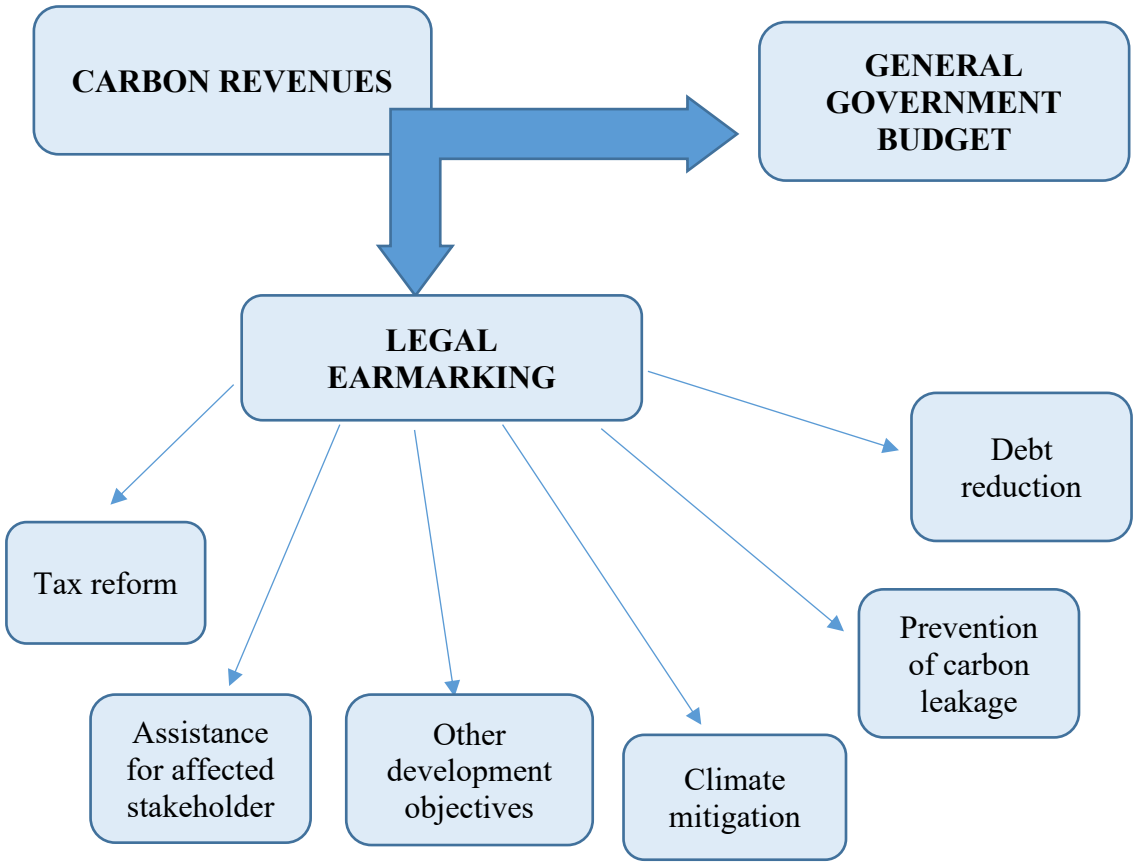
4.1.2.1 Countries at work

The use of carbon revenues can be a good instrument for pursuing environmental, economic, and social objectives. Countries have used their carbon revenues to achieve generally six categories:

1. Tax reform, to target higher economic growth with lower pollution.
2. Climate mitigation, such as investment in low carbon technologies.
3. Pursuit of other development objectives, such as in education and health.
4. Prevention of carbon leakage, to achieve carbon pricing's environmental and economic objectives.
5. Assistance for individuals, households, or businesses affected by higher carbon costs, through transfers or social programs.
6. Debt reduction, to reduce the debt burden on future generations.

In general, the use of revenues goes in general budget, but there are several reasons to use revenues for specific purposes, how we say before. This fact could lead to offset the negative impact that arise on different area and covering the public and private sector. Figure sets out the main potential uses of carbon revenue.

Figure 4.1



Let now try to look what are the use of revenues made during the year by each country of our analysis.

- **Finland**: Since 1990 carbon revenues have been approximately $750 million, but in 2018 registered $1,5 billion. Carbon tax revenue represents around 42% of total energy tax revenue. They are used for tax policy change purposes. As part of the 2011 tax reform, there was an increase in taxes in energy use, that offset the abolishment of the national pension contribution paid by employers. In addition, there is also the revenue raised by Excise tax on motor gasoline, on gasoline and on other petroleum products. Furthermore, it did not provide reported revenue use estimate of auction proceeds, but in 2016 spend 100% of the financial value of auction revenue on renewable energy program.

- **Poland**: tax revenues are on average of $1 million annually and are destinated for environmental projects. Not much information about the uses, but a high fraction of carbon tax and auction revenue flow to the National Fund for Environmental Protection and Water Management, the remain to provincial environmental funds. The revenues from excise taxes on electricity consumption and from the increase in the fuel surcharge are meant for social spending purposes.

- **Norway**: The taxes go into general revenue with taxes on energy that represented 55% of total tax revenue and are used for different purpose as: increase pension fund or for technology innovation. The revenues generated from the CO_2 tax paid by the petroleum sector together with the rest of the State's net cash flow from the petroleum industry, are transferred into the Government Pension Fund Global, which is a part of the Norwegian fiscal framework. The fiscal rules specifies that the transfers back from the fund to the central government budget shall over time equal the expected real return on the fund; in this way the revenue not earmarked to specific spending. The tax program demonstrates a clear transition toward green. In 2017, the budget indicates that the increase in the revenues from environmental taxes back to taxpayers in the form of sectoral reductions in taxes and compensate the side of expenditure of budget.

- **Sweden**: Revenue from carbon tax was steady for one decade but increased later around $3,65 billion in 2007. Almost 90% of tax revenue comes from the transport sector and goes directly into general government budget. The carbon tax is part of a broader fiscal reform and its increase in the level of taxation have been combined with the tax cuts in order to prevent the payment of other taxation; it also encourages job growth and address negative distributional effects. As a part of 1990-1991 tax reform, carbon tax was used to finance reduced in taxes on labor. The tax reform of 2001-2006 led to further cuts in income taxes, with a measure for low-income households. From 2016 all energy tax revenues flow to the general budget.

- **Denmark**: the focus of the tax reform was to lower taxation of workers and transfer income while increasing indirect taxation. The reform gradually shifted the tax base from labor to green taxes, that also include energy taxes. In 1996 Green Tax Reform

recycled revenues from energy taxes as reduction on the pay-roll tax, reduction on pension contributions paid by employers and to finance the fund for small business. Since 1998 the revenues have been used to lower the income tax rates and for fiscal consolidation. In 2008 the revenues were $905 million, for which 40% is used for environmental subsidies and the other for industry. In addition, $33 million of auction revenue was spent for developing countries. From 2009 the increase in the tax revenues is returned to households in the form of green check (higher personal deductions and lower taxes at work) that compensate household for the increased burden of taxation in energy and environmental. For 2017, Denmark reports the use of 100% of an equivalent to the revenues in financial value, with $25 million spend on Energy Technology Development and Demonstrations Program, which provide grants to low-carbon and green technologies R&D.

- **Slovenia**: carbon tax collects different levy on air emission of CO_2 such as: liquid fuels, gaseous fuels, solid fuels and combustible organic. From 2005 and for three years revenues were used to finance carbon reduction projects and subsidies for industries. All auction revenues are fully earmarked and goes to the budgetary Climate Change Fund. They are used for climate change, in particular to improve the energy efficiency of residential buildings (around 30%), to encourage the use of public transport (about 10%) and to promote the use of renewable sources of energy (60%).

- **Estonia**: Tax revenues go into general revenues and it is difficult understand for which it is used. Not much information about the use of carbon tax revenues. Auctioned revenues instead, earmarked for 50% for climate policy objectives. Most of it are used for improving energy efficiency and the use of renewable energy in public sector buildings. Between 2015-2017 the revenues are used for contribution of social and employment policy and on building used for child and elderly. It also continues to invest in developing countries towards clear shifts, promoting the use of alternative transport fuels and the implementation of flood related risk management plans.

- **Latvia**: lack of information due to the difficult to disaggregate the revenues from carbon tax and the revenues from Natural Resource Tax. The 90% of auction

proceeds are used to finance investment projects and initiatives, other 5% are used for R&D and technology projects, the remaining for covering administration expenses. EU-ETS covered over a quarter of emissions in industry sector and electricity sector for two-thirds. and tax revenues goes directly into general revenues.

- **Switzerland**: the collect revenues arise from carbon tax are earmarked for energy efficiency in buildings, for reduce the social security contributions for business and for household; the rest is redistributed uniformly to all Swiss residents via lower health insurance premiums, regardless of their income or consumption. The levy rate is linked to compliance with mitigation targets that if CO_2 emissions in a given year exceed the annual target, the levy rate is raised. All auction revenues remain in the federal government budget. Other taxes such as Mineral Oil Surcharge and Mineral Oil Tax on road fuels are earmarked for road and airport infrastructure funding and maintenance.

- **Ireland**: carbon tax designed to raise revenues for the general budget implemented in 2010. Some revenues (€50 million) are used for energy efficiency measures and to help household at risk of fuel poverty and to provide support to rural transport. Ireland's carbon tax revenues have risen steadily over time. Since the 2008 financial crisis, carbon tax revenues have been used to maintain or reduce payroll taxes; in general, all revenues are used to make changes to tax policy. Between 2010-2012, the Irish government received financial aid from the European Commission and the carbon tax contributed for 20/25% of the bailout plan required by EC. Ireland's carbon tax complements the EU-ETS by targeting residential and commercial uses of oil, natural gas, and solid fossil fuels that the EU ETS does not cover. In 2016 was allocated $31 million of auction revenues to afforestation program and $15 million for Energy program to finance news projects. In 2019 increased in revenues for $98 million.

- **Iceland**: after one year from implementation the estimated amount of revenue was $8 billion, with an increase of 2% every year. Not much information about earmarking of carbon tax and auctions revenues; in general, are used as payment for a particular service. Infect, revenues raised by Excise Duties on petroleum, Oil Tax and Special Excise Tax on gasoline are earmarked for road construction and to cover the costs associated with collecting and charging the fee for the government.

- **United Kingdom**: it has Carbon Price Floor and other measures as: Carbon Change Levy (CCL) and Excise Duty. They are introduced to cover the revenues losses from rate cuts on National Insurance Contributions paid by employers and to fund Carbon Trust (no-profit association, with capital invested by a guarantor, established in 2001 to help reduce carbon footprint of industries). The purposes of these policies, in particular CCL is to support changes to tax policy. The half-reported revenues from ETS system, are used for the Renewable Heat Incentive, that help the purchase of renewable technologies among households, communities, and business.

- **Spain**: poor information about carbon tax revenues for Spain; from 2013 and in subsequent year, 90% of auction revenues (capped at $540 million) finance the costs associated with promoting renewable energies in the electricity sector. Additionally, 10% of revenues (capped at $60 million) are earmarked to fund climate change mitigation programmes, which promotes the protection and conservation of forests, land and biodiversity. In addition, revenues generated from on the Excise Tax on Hydrocarbons and the Special Excise Tax on Coal gives to local communities and cities 58% of their revenues. In general, tax revenues were used as inter-governmental transfers. Taxes on energy represented 85% of total environmentally related tax revenue, that enters directly as a part of total general revenue.

- **France**: total revenues from the CO_2 tax funded a tax credit for businesses until 2016. Starting in 2017, $2 billion of revenues is earmarked to a special energy transition account which largely compensates industries for the higher costs associated with using renewable energies for electricity generation. For the revenues auctioned are earmarked to the "Habiter Mieux" programme managed by the National Housing Agency; this program is aimed at renovating the homes of low-income households to improve energy performance. The cost of this program amounted to $420 million, hence earmarked auction revenues represent 70% of its spending, albeit represented half of its total income from earmarked taxes. In 2013–2015, carbon revenues made up 39% of the program's total budget, with annual revenues averaging $300 million. However, in 2017 this revenue cap was met, and the remaining $335 million was allocated to the government's general budget to be used for other purposes. In addition, there are other measures as: The Consumption Tax on Energy Products and the Consumption Tax on Natural Gas and the Consumption Tax on Solid Fuels. Revenues generated from these policies are earmarked to the Transport Infrastructure

Financing Agency. Also, the additional revenues generated from the increase of the rate applied to diesel consumption are used to lower the tax burden on low-income households and pensioners, as well as to increase the premium granted when replacing old diesel vehicles. As part of the 2017 tax reform, tax reductions on corporate income and on the property wealth tax are compensated by increases in taxes on energy (including on CO_2 emissions). Initially revenue from the tax was allocated to finance green projects, but over time the share has declined in favour of increased in total general revenues in the balance of payment.

- **Portugal**: carbon tax took part of the Green Fiscal Reform in 2015. Revenues are used to reduce income taxes for households. The 11% of CO_2 Tax revenues are also earmarked for electric and public transport and for conservation and climate mitigation programmes. All auction revenues flow to the Portuguese Carbon Fund and are earmarked to offset the extra cost of generating electricity from renewable energies. In 2016, two third of revenues was allocated for the Wind-Float project, which supports the development of a pre-commercial floating offshore wind. In addition, total revenues from Excises Taxes on Petroleum and Energy Products gasoline, diesel, fuel oil, gases and kerosene are earmarked as a Contribution to Road Service for road construction and maintenance. Revenues are also earmarked to the Forest Fund. In 2018, the revenues generated from the taxation of solid fuels for electricity generation flow for 50% in the Environmental Fund and 50% in National Electricity System for tariff reduction purposes.

4.2 Green investment

To meet all different policies from Paris Agreement to European Green Deal, Europe will need a huge amount of investment. This investment should arise from public sector. But the public sector alone is not sufficiently. Private sector will play a key role to help the public towards transition climate change. The EU and European Investment Bank gives their support on its. A sustainable finance has played a key role in mobilising the capital used for the policy objectives under the European Green Deal. It generally refers to the process that consider environmental, social and governance considerations when making investment decisions in the financial sector. It led to increase longer-term investments into sustainable economic activities.

In addition, to support the carbon price signal, the EU also introduced two low-carbon funding mechanisms to support for low-carbon investments:

- The Modernization Fund to support investments in energy efficiency and renovation of the energy sector in lower-income Member States,
- The Innovation Fund to provide financial support for projects in the areas of renewable energy and carbon capture and storage utilization.

This mix of policy instruments will help the EU meet its targets that have been set to tackle the climate change.

4.2.1 The Modernisation Funds

The Modernization Fund is a program to support 10 lower-income EU Member States in their transition to climate neutrality by helping to renovate their energy systems and improve energy efficiency. The Member States are Bulgaria, Croatia, Czechia, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, and Slovakia. The Fund will support investments in:

- Generation and use of energy from renewable sources,
- Energy efficiency,
- Energy storage,
- Modernisation of energy networks, including district heating, pipelines, and grids,
- Transition in carbon-dependent regions: redeployment, re-skilling and upskilling of workers, education, job-seeking initiatives, and start-ups.

The Modernisation Fund is acknowledged in the European Green Deal Plan as one of the key funding instruments contributing to their objectives. It is funded from:

- revenues from the auctioning of 2% of the total allowances for 2021-30 under the EU-ETS
- additional allowances transferred to the Modernisation Fund by Member States (five Members adopted to do so: Croatia, Czechia, Lithuania, Romania, and Slovakia).

As of 2025, additional allowances may be added to the fund, depending on how much is needed for the free allocation to industry.
The objectives that this fund will reach are related to help the Members to meet the 2030 climate and energy targets. These countries generally are obsolete on its energy sources

system, and the object is also to enhance and to help the transition toward energy efficiency that reward the renewable sources.
The responsibility of the beneficiary Member States, who will work in close cooperation with the EIB is a fundamental key to reach what this fund will do. To finance the process there are main key comply steps that countries must do. First, they select the investments that wish to do and propose them to EIB, EC and Committee. The EIB verify if the investment is in line with the objective and look if it corresponds to the priority. The Commission take a decision whether finance this investment. The last step rewards the EIB that transfers the resources to the beneficiary in accordance with the disbursement decision within 30 days.
On the other hand, the beneficiaries are responsible for:

- selecting the investment proposals who they would like to support,
- submitting an indicative overview of their planned investments to the Commission, EIB and the Investment Committee,
- submitting the investment proposals for confirmation by the EIB and providing the information needed for their assessment,
- monitoring and submitting annual reports on the implementation of investments,
- auditing the project proponents or scheme managing authorities and submitting the results of these audits to the EIB and the Commission.

The Modernisation Fund leaves the beneficiary Member States the freedom to decide on the form of support. They can use grants, premium, guarantee instruments, loans or capital injections. The finance measures from private sector are also possible, as long as countries aid rules are respected and the same costs are not already funded by another Union or national instrument (no double funding). Member States could draw on existing national funds or European instruments, how we can see: Invest EU, Just Transition Fund etc.

4.2.2 The Innovation Funds

The Innovation Fund will provide about €10 billion of support in euro area from the next decade. It is the largest program of all the world in contribution of common target of climate neutrality. The aim of this fund is to support the businesses in transition policy of innovative low-carbon technologies. The main goal is to invest in clean energy and to increase the economic growth. The aim is also to create future jobs and to reinforce European technologies. Several projects are activated to make this. For example, enhance the processes

of energy-intensive industries and include the efficiency in the production system, and substitute them with renewable sources.
The fund supports cross-cutting projects on innovative low-carbon solutions that lead to emission reductions in multiple sectors.
Each country will be calls new proposals during the time of Fund. They should express their interest**,** and list the different effectiveness, innovation, maturity level and cost-efficiency of the project. Project could be applying by submitting, when there is an open call for proposals, via the EU Funding and Tenders portal. The EIB is responsible for the provision and management of the Project Development Assistance (PDA) support. The EIB will also oversee the monetization of the Innovation Fund allowances and the management of the revenues that will rise and will report regularly to the Commission. The European Commission and EIB help to assess the project, but the final responsibility for the selection of projects will be to the Commission.
The Commission is assisted by the Innovation Fund Expert group. It grants can be combined with funding from other support programs, for example: Horizon 2020, Invest EU, Just Transition Fund, etc.
The Fund is not considered to be State aid. To cover the remaining costs, a project applicant can combinng with public support by a Member State. The amount of public support for a project will depend on the cumulation thresholds of the applicable State aid rules.
The EU-ETS system is providing the revenues from the auctioning of 450 million allowances from 2020 to 2030. In parallel, the EU-ETS provides the main long-term incentive for technologies to be deployed. In this way the Innovation Fund will become a key funding instrument for delivering the EU's economy-wide commitments under the Paris Agreement and European Green Deal.

4.3 Green Bonds

The transition to a sustainable global economy requires to increase the financing of investments that provide environmental and social benefits. The capital market through Green Bonds can play an essential role in attracting capital to finance these requirements. Some countries have issued sovereign green bonds to implement and to intensify the transition towards climate change. The objective is to earmark the revenues arise from the green bonds for greener projects. The public sector could promote the private green investment by making more attractive for household and for financial institutions.

Under the European Green Deal arise the needed for long-term signals to direct financial and capital flows to green investments.
On June 2019 the Commission creates a voluntary EU Green Bond Standard to enhance the effectiveness, transparency, comparability and credibility of the green bond market and to encourage the market participants to issue and invest in EU green bonds. However, there is no uniform green bond standard within the EU. It is designed to be relevant and accessible to issuers located in and outside EU. It builds on market best practices such as the Green Bond Principles (GBP), developed by the International Capital Market Association (ICMA). The model sets out four main components:

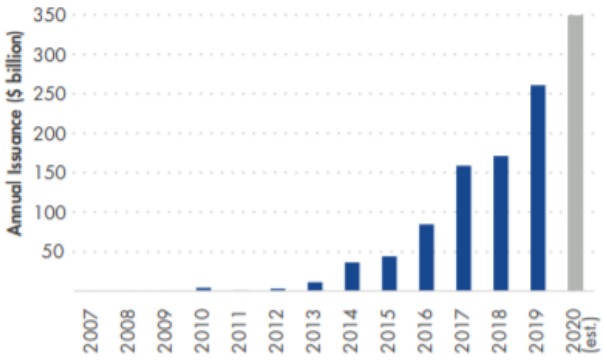
1. The alignment of the use-of-proceeds with the EU Taxonomy,
2. The content of a Green Bond Framework to be produced by the issuer,
3. The required Allocation and Impact Reporting,
4. The requirements for external verification by an approved verifier.

The EU Green bonds represent a still limited but growing share of the total bond market. The EU is a leader for issue green bonds and the market will growth further.

When starting?

The green bond market starting in 2007 with the triple A rated issuance from multilateral institutions European Investment Bank (EIB) and World Bank. From 2014 the market starting to take off with $37 (€30) billion of bonds issued. In 2018 the issuance reached $167 (€140) billion, a huge increase respect to 2014 and around $305 (€255) billion in 2019.
At the beginning of the last year, green bond issuers went slow for the pandemic crisis caused by COVID-19 that spread around the world, but the confidence increased in the third quarterly of 2020 that resulted the most prolific of all 2020. On September 2020, European Commission also confirmed EU plans to issue €225 ($270) billion in green bonds over the next few years. This could give an important mitigation into green bonds by both issuers and investors. Issuers will be inclined to align themselves with these developments by transforming their entities into climate compatible operations, and investors will be encouraged to commit funds to green investment strategies. The contribution comes from the financial institutions and by public sector, but also non-financial corporate goes in the same direction.

Figure 4.2: Green Bond issue (US$)



Source: Green Bonds and the Pathway to Sustainability, A Guide to Green Bonds: A look at the role of green bonds in the climate challenge and within a fixed income portfolio, September 2020

Figure 4.3: Green Bond issue (EUR€)

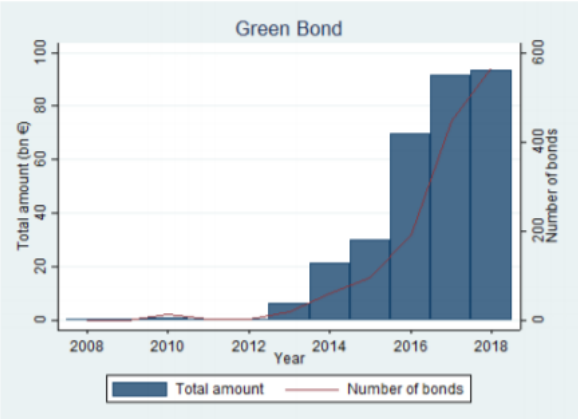


Figure 1 The Green Bond Market. The figure reports the total amount of Green Bonds issued (blue bars) yearly, billions of Euros. The red line represents the number of green bonds issued from 2007 until end of December 2018. The data source is Dealogic DCM.

Source: The pricing of green bonds: are financial institutions special?, JRC technical reports, European Commission, JRC Working Papers in Economics and Finance 2019/7, European Union, 2019

Sectors coverage

In Europe, a considerable part of green bond proceeds is destinated to the energy sector, but also the amounts of revenues invested in buildings and transport have risen. These are the most area in which the revenues are destinated. Energy sector issuers account for over 60% of energy allocations and the rest comes from: local government, sovereigns, and financial institutions. Energy sector issuers use about 90% of bond proceeds for energy investment, but also allocate funds to buildings, water and waste management.
Property sector issuers have contributed about 30% of buildings use of proceeds, with the rest coming from aggregators. It earmarked about 90% of bond proceeds towards buildings, but also for renewable energy used for buildings. Transport issuers earmarked about 70% of bond revenues towards investment in the electric vehicles and adding electric vehicle charging stations.
Rapid check across European countries noticed that:

- **France** is the largest green bond market in Europe, and it is the third country ranking in the world with €20,4 billion of bond issued in 2017. Allocations to buildings is around 32%, against the 18% for energy, remaining for transport sector. The allocations to other sectors remain very limited.

- In **Germany**, the energy dominates the use of proceeds: 80% of cumulative proceeds went to renewable energy, buildings accounted for 14%, followed by water (3%). The remainder was allocated to waste management, transport, energy-intensive industry.

- The **Netherlands** proceeds are used for energy sector for almost half the allocations, applied to different renewable assets such as onshore and offshore wind farms, solar projects, and electricity transmission. Transport account for 20%.

- **Belgium** was the second largest sovereign green bond issued (€4,5 billion in 2017) with the revenues allocated to clean transport. The target emissions reduction is around 35% by 2030.

- The only green bond issued by a **Luxembourg** trains corporate (20-year, €250 million) was raised to refinance debt associated with the acquisition of electric trains.

- The **Italian** green bond market was launched in 2014. The number of green bond issuers has grown over the time. Energy sector corporates dominate the market with 77% of total issuance, with 73% of issuance comes from energy companies. Enel is the largest issuer with €2,5 billion. In 2017, Intesa Sanpaolo became the first Italian bank to enter the market with a €500 million green bond earmarked for renewable energy and green building loans. The first public sector was "Ferrovie dello Stato Italiane" a railway company that issued €600 million of bond.

- For the **Spanish** bond, energy sector represents 94% of issuer with revenues allocated solely to renewable energy. The rest was for transport. In 2017 emit €5,2 billion.

- **Nordics** countries (Finland, Sweden, Norway, Denmark, Iceland) has issued green bond for €7,3 billion in 2017 with the most revenues earmarked to energy sector, buildings, and transport.

- **Central** and **Eastern Europe** countries (Estonia, Poland, Lithuania, Latvia and Slovenia) with small portions of issuances. The revenues are most allocated in the energy sectors, followed by building and transport. Poland became the first sovereign issuer worldwide.

- The **UK** green bond market emerged in 2014 with Unilever's issued, earmarked for energy and water efficiency improvements in production. Revenues are allocated mainly to low carbon infrastructure and water is the largest sectors for use of proceeds with for 29% of them.

- Issuance made by **Ireland** is very low but is expected to growth during the time. Moreover, the government has proposed an initial €7,6 billion of public funds to be invested in climate change mitigation projects from 2018 to 2027.

- **Austria** and **Switzerland** give low contributions but rapidly growing in the green bond over the time.

CONCLUSIONS

The process that brings a critical value of emission has already began many years ago. Climate warming goes faster than what expected and countries of all the world need to react quickly. Without introduction of relevant measures, for the end of this century the temperature will rise above 4°C respect to the pre-industrial level. The policies that already exist are not sufficient to tackle the climate changing.

On this way EU is the most continent that has already applied targeted policies during this year and will enforce in the next ages. The EU is pledged to cutting GHGs emission by 40% by 2030, and to engage in several investment toward greener energy, thanks also the support of European Green Deal.

The aim of EGD is to help the existing international measures as EU-ETS (applies to all the EU28 countries) by increasing the sector coverage and support the national measures as Carbon tax of the countries that has already introduced (15 countries so far). These kinds of measures are cost-efficient tool used for restricting the use of fossil fuels (the main component of air pollution) and to raise the price of carbon.

In particular, the introduction of Carbon tax seems to be the quickest and most efficient way to achieve the mitigation objectives. The uncertainty that has driven this measure during the years, especially for the effect on the level of GDP, has been denied. In fact, using variation in the use of carbon taxes in European coutries, that are also part of EU-ETS, we find no evidence to support that the taxes would impact GDP growth since their implementation. The slight result is driven for the fact that a Carbon tax has been introduced into national tax system, thanks the use of carbon revenues that every country has been used for different purposes. Also, this policy allows the price adjustment whenever there is necessity (how it has been made over the last thirty years), in line with the characteristic of single nation and with its mitigation targets.

However, we find modest evidence for emission reduction arising from the taxes, but the results are still low compared with the increasing in the level of CO_2 emission. Measures alone not give an important result, and the combination of both, how it is expected, gives more contribution. In this way, it is easy to understand that the measures alone are not sufficiently and that there is the necessity to implement them.

Moreover, the contribution of single economic factors is important because coul lead to understand the level of price signal. The drivers considered, gives different results, as for

example the degree of energy use and electricy from fossil fuels induced high level, as GDP per capita due to increase in the purchasing power.
On the contrary the degree of industry of single countries decreases the price signal for the effect of carbon leakage and the level of renewable sources that inevitably reduce its.
The policy maker play an important role in this transition mechanism, not only for ensure the right enforcement of the measures, but also for assist the subjects that major affect these restringent policies as industry and low-income households.
Using the revenues from carbon pricing would seem to be insufficient, even because not all countries destined the used of them with this specific purposes. The EU together with national governments, will provide a different kind of sustainable investment throught the introduction of Modernization and Innovation Funds. The aim of these funds is to support low-income Member States in their transition towards greener energy system and to support the business towards innovative technologies. Research and Deveolpment wil play an important role and should be necessary support with investment. The public sector, however, must create the right market conditions to give the possibility of introduction of private investment in order to help the mitigation policies. Thanks also with the introduction of a new financial instrument as Green bonds, sovereigns and financial institutions are be able to finance sustainable projects.
To fight the climate changing and the consequences that lead, must ensure that all economic agents work together to brings a real changing. Not only, behaviour of the people must also change, with simple action of every day that together will contribute in massive way. Only in this way it will be changing, and Europe will become the first climate neutrality continent of the whole world.

BIBLIOGRAPHY AND SITOGRAPHY:

Aylor B., Gilbert M., Lang N., McAdoo M., Öberg J., Pieper C., Sudmeijer B., Voigt N. *How an EU Carbon Border Tax Could Jolt World Trade,* BCG, June 30, 2020

Bird L., Smith H., Sumner J. *Carbon Taxes: A Review of Experience and Policy Design Considerations,* National Renewable Energy Laboratory, Technical Report NREL/TP-6A2-47312, 1617 Cole Boulevard, Golden, Colorado December 2009,

Catalano M., Pezzolla E. *The EU Green Deal post COVID-19,* Prometeia discussion note n.13, July 2020

Climate bonds initiative. *The green bond market in Europe,* Sponsored by White & Case, 2018

Cossaro L., Passeri S., Pezzolla E. *The European Roadmap to Carbon Neutrality,* Prometeia discussion note n.12, December 2019

European Commission, *Communication from The Commission to the European Parliament, The European Council, The Council, The European Economic And Social Committee And The Committee Of The Regions, The European Green Deal,* EC publication COM(2019) 640 final, Brussels, 11/12/2019,

European Commission. *Regulation of the European Parliament and of the Council on establishing the framework for achieving climate neutrality and amending,* European Climate Law, Regulation (EU) 2018/1999, EC publication COM(2020) 563 final, Brussels, 17/09/2020

European Commission. *The European Green Deal Investment Plan and Just Transition Mechanism Explained,* Brussels, 14 January 2020

European Commission. *The promotion of the use of energy from renewable sources*, Revision of Directive (EU) 2018/2001, Ref.Ares(2020)4087053 - 03/08/2020

European Investment Bank. *EIB Group Climate Bank Roadmap 2021-2025,* EIB publication, Position paper, 15 June 2020

European Investment Bank. *EIB energy lending policy, Supporting the energy transformation,* Final version adopted by The EIB's Board Of Directors On 14 November 2019

Eurostat. *Environmental taxes a statistical guide*, Luxembourg: Publications Office of the European Union, 2013 edition

Eurostat. *Environmental tax statistics, detailed analysis,* Eurostat publication, May 2020

EU Technical Expert Group on sustainable finance, financing a sustainable European economy. *Usability guide EU Green Bond Standard*, EC publication, March 2020

Fatica Serena, Panzica Roberto, Rancan Michela, *The pricing of green bonds: are financial institutions special?*, JRC technical reports, European Commission, JRC Working Papers in Economics and Finance 2019/7, European Union, 2019

Flues Florens, Van Dender Kurt. *Carbon pricing design: Effectiveness, efficiency and feasibility: An investment perspective,* OECD Taxation Working Papers No. 48, 2020

G.G. Dolphin, M.G. Pollitt, and D.G. Newbery. *The political economy of carbon pricing: a panel analysis*, EPRG Working Paper, Cambridge Working Paper in Economics, October 31, 2016

Gilbert E. Metcalf James H. Stock. *The macroeconomic impact of Europe's carbon taxes,* National Bureau of economic research, 1050 Massachusetts Avenue, Cambridge, July 2020, NBER Working Paper No. 27488

International Monetary Fund. *Fiscal monitor, How to mitigate Climate Change,* International Monetary Fund, Washington DC, October 2019

International Monetary Fund. *Fiscal policies for Paris Climate Strategies—From Principle to Practice,* International Monetary Fund, Washington DC, May 2019

International Monetary Fund. *Policy for the Recovery,* International Monetary Fund, Washington DC, October 2020

Marten Melanie, Van Dender Kurt. *The use of revenues from carbon pricing*, OECD Taxation Working Papers No. 43, https://doi.org/10.1787/3cb265e4-en, 2019

Nissen Christian, Cludius Johanna, Graichen Verena, Graichen Jakob, Gores Sabine (Öko Institut). *Trends and projections in the EU ETS in 2020, The EU Emissions Trading System in numbers*, European Environment Agency, European Topic Centre on Climate change mitigation and energy (2020), EIONET report - ETC/CME 3/2020 - December 2020

The Wall Street Journal. *Economists' Statement on Carbon Dividends,* Climate Leadership Council, Thursday January 17, 2019

Ursula von der Leyen. *Political Guidelines for The Next European Commission 2019-2024, My agenda for Europe*, By candidate for President of the European Commission, 2019

Van Eck Securities Corporation, Distributor. *Green Bonds and the Pathway to Sustainability, A Guide to Green Bonds: A look at the role of green bonds in the climate challenge and within a fixed income portfolio*, 666 Third Avenue | New York, NY 10017, September 2020

World bank group. *State and Trends of Carbon Pricing 2019,* International Bank for Reconstruction and Development / The World Bank, Washington DC, June 2019

World bank group. *State and Trends of Carbon Pricing 2020,* International Bank for Reconstruction and Development / The World Bank, Washington DC, May 2020

World bank group. *Using Carbon Revenues*, Partnership for market readiness, Technical note 16, International Bank for Reconstruction and Development / The World Bank, Washington DC, August 2019,

https://ec.europa.eu/clima/policies/innovation-fund_en

https://ec.europa.eu/clima/policies/strategies_en

https://ec.europa.eu/clima/policies/ets_en

https://ec.europa.eu/clima/policies/adaptation/international_en

https://ec.europa.eu/clima/policies/international/negotiations_en

https://ec.europa.eu/clima/policies/international/finance_en

https://ec.europa.eu/clima/policies/eccp_en

https://ec.europa.eu/clima/policies/budget/modernisation-fund_en

https://ec.europa.eu/clima/policies/eu-climate-action_en

https://ec.europa.eu/clima/change/causes_en

https://ec.europa.eu/clima/change/consequences_en

https://www.climatebonds.net/market/explaining-green-bonds

http://oe.cd/emissionsdata, access to 02/12/20

https://carbonpricingdashboard.worldbank.org/, access to 15/11/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 02/12/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 05/12/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 10/12/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 29/11/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 29/11/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 05/12/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 15/12/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 12/12/20

https://databank.worldbank.org/reports.aspx?source=2&series=AG.LND.IRIG.AG.ZS&country=, access to 05/12/20

https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_air_gge&lang=en, access to 12/12/20

https://ember-climate.org/data/carbon-price-viewer/, access to 15/12/20

https://www.iea.org/reports/co2-emissions-from-fuel-combustion-overview#data-service, access to 02/12/20