The impact of the EU Emissions Trading System on the ESG performance score of European companies

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The impact of the EU Emissions Trading System on the ESG performance score of European Companies.

A STOXX Europe 600 Index most carbon-intensive super-sectors panel analysis between 2008 and 2021

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"Climate change has made ESG a force in investing."
- The Economist (December 7th 2019)

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1 | Introduction

Six months ago, the United Nations Climate Change Conference (COP28) took place in Dubai. All parties recognised the need to reduce the total amount of greenhouse gases (GHG) emissions released into the atmosphere by 43% in 2030, compared to 2019, in order to limit global warming increase to 1.5°C. The parties only confirmed what was already obvious to all scientists and the majority of governments in Paris at the COP21, already 8 years ago. Article 7 of the Paris Agreement stated that societies had to enhance adaptative capacity "*with a view to contributing to sustainable development and ensuring an adequate adaptation response*". The European Green Deal is another essential milestone in decarbonising the economy with a comprehensive set of proposals to reduce net greenhouse gases emissions by at least 55% by 2030, compared to 1990 levels. Furthermore, the ultimate goal is to become net neutral for 2050. These measures have been declined into several concrete measures, two of which are the subject of the present study, carbon pricing policies and ESG (Environmental, Social and Governance) ratings of companies.

The ESG rating of a company, which stands for Environmental, Social and Governance, is a marker of the willingness of a firm to measure its negative impact on the ecosystem and improve itself for society as a whole. This in term can lead to positive improvements in the fields subject to consistent and regular monitoring. These scores which can materialise in various forms and letters are the new gold standard in terms of sustainability even though they vary greatly across rating agencies. As such, they are relied on by sustainable investors in their quest for a greener finance and sustainable growth. Nevertheless, firms with better ESG scores are also sought out for their economic growth and financial stability. Overall, companies are now competing to improve such scores in order to become more attractive in the current change in investors' preferences. Indeed, the young investors are more inclined than before to invest in socially responsible investments then their old peers (SRI) (CNBC, 2020). As a matter of fact, despite marginal financial downsides, ESG investors can benefit from non-pecuniary benefits by investing in more responsible companies (Barber et al., 2121; Pastor et al., 2021).

On the other side of the economic spectrum, policy-makers seek out more and more ways for companies not only to improve their ESG scores, which is still not a perfect market indicator, but to diminish drastically their impact on the environment through a reduction in their greenhouse gas emissions. This is why the European Union put in place in 2005 the European Union Emission Trading System (EU ETS) to finally give a price to carbon emissions of certain industries within the European Union. This cap and trade systems, meaning that there is a yearly maximum amount of emissions permitted, the cap, and that companies who received or bought insufficient carbon allowances (EUA or permits to pollute) can trade with others which have an excess to balance their emissions with the amount they are allowed to emit. The EU already claims this system has already substantially reduced all carbon emissions within the Union. By putting a price on carbon, the goal was to incite as soon as possible the companies to shift towards a greener value chain. The mechanism was first an indication to companies that the shift will truly take place, with a low carbon price and high amount of free allowances. Then year by year reduction of the cap, the system should become more stringent. The system was not without some pitfall, with a too large amount of EUA allowed to be banked from one phase to the other thus pushing the price to a rock bottom, yet the EU showed a constant and statistically significant reduction of carbon emitted within the Union since 2005. Carbon market should be seen as being part of a broader policy framework to decrease GHG emissions by all means possible whether by pricing negative externalities, putting in place laws and regulations, encouraging and publicising scientific researches and overall making the problematic salient to the general public.

Our study aims to make a modest contribution to the study of the link between carbon pricing and ESG ratings of companies. One must acknowledge, this field of study is underdeveloped in Europe and North America but starts to take more and more importance in China. Indeed since 2013, the Chinese government has put in place a series of measures to promote the transition towards green technologies and implemented several carbon pricing policies throughout the country. The Chinese government estimates its economy's carbon emissions will peak in 2030 and turn carbon neutral for 2060. What sparked my interest was an article of three Chinese authors Yadu Zhang, Yiteng Zhang and Zuoren Sun published in 2023. These authors studied the impact of Carbon Emission Trading Policy on Chinese Enterprise ESG Performance which was yet not seen in Europe as sustainable finance literature puts the emphasis on financial benefits, risks and opportunities rather than carbon reduction. In their words *carbon emission trading policy can encourage enterprises to enhance their R&D investments and promote internal controls, ultimately enhancing their ESG performance.* (Zhang et al., 2023). The goal of this master thesis is to use a similar approach to test if their findings are robust within the European Union carbon trading scheme. For this purpose, we chose to study a representative panel of firms of the EU, which lead to the selection of the STOXX Europe 600 Index.

The green-shift promoted by the EU should mechanically improve the ESG scores of companies, but has the price of carbon really pushed the companies towards greener shores ? The goal of this study is to analyse the correlation between the price of carbon within the EU ETS framework and the evolution of the ESG score of various companies of the STOXX Europe 600 Index. For this purpose, we selected a set of the most polluting super-sectors within the index and in comparison a set of the top 40 companies outside these super-sectors as comparison variables. In terms of time-series, we are dependent of the fact ESG scores are quite new and are only updated once a year which means that the granularity of the data is not as fine as other financial informations. After analysing the informations extracted from Refinitiv Eikon Datasteam, we decided to study a panel of 108 companies from five of the most polluting super-sectors for a period going from 2008 to 2021. The end goal is to verify if the variations of the price of carbon provoked a variation in the ESG score of the selected firms, with the hypothesis that the ESG scores should improve. In order to add some granularity to the initial scientific question we also study two subsidiary questions on the environmental and managerial actions companies can take and how they can impact their ESG scores in a carbon-pricing environment.

This brings us to the main scientific question of this master thesis which is :

> "*Has the evolution of the price of carbon of the EU ETS influenced the ESG performance score of the companies from the most carbon-intensive super-sectors of the STOXX Europe 600 Index ?*"

The two other questions which aims to shed some more light on the mechanism are: *"Can carbon emission trading policies promote corporate ESG performance by pushing for environmental innovation investments ?"* and *"Can carbon emission trading policies promote corporate ESG performance by pushing for better management practices ?"*.

In terms of added value, we derive the conclusions of Zhand et al. (2023) to a still fairly unexplored link between ESG scores and carbon pricing within the EU. Furthermore, we add to the study two carbon prices - spot and future - in order to be as exhaustive as possible. Then, we consider different periods in order to analyse if companies adapt to the previous price of carbon in order to counter the possible increase in price. Lastly, we analyse more in detail the impact of environmental and managerial actions companies can take to improve their score in a carbon-pricing environment.

As for the plan of this master thesis, we begin in section II by a review of the literature brushing a clear view of carbon market, ESG scores and their implications. The next in section III, we focus on the description and hypothesis of the main research question and the subsidiary research questions. Afterwards, we describe in section IV the various endogenous and exogenous variables and data used and the way we retrieved them. Following, section V centres of the descriptive statistics and unconditional correlations between the variables. Section VI, is the core of the empirical work with a description of the methodology used, the econometric models and regressions employed as well as their results. Afterwards, section VII aims at pointing out the limitations of the study and directing attention to further areas of research. To end in section VIII with a general conclusions summarising our work.

2 | Literature review

We begin by a review of the literature starting by brushing a clearer view of what negative externalities are and how to price them, then analysing various carbon pricing policies. In a second time, we deep dive into the ESG scores, their meaning and measurement methods. To conclude by analyse the link between carbon pricing policies, carbon emissions and ESG scores.

2.1 Carbon pricing

Policy-makers opted for pricing carbon as it should mechanically increase the marginal cost of production which in term leads to a rethinking of the whole supply chain in order to minimise the overall cost. The constant decrease of available allowances enhances, permits to pollute, resulting in the contraction of the supply thus pushing for a higher price of carbon. This in time should lead to an increase in the viability of greener technologies which are cheaper on the long run. This view is the one we will follow in the footsteps of some of the most prominent neoclassical economists of the time (Wagner et al., 2015; Cramton et al., 2017; Nordhaus, 2013; Stiglitz et al., 2017).

These economists also argue that, following game theory results of non cooperative games (Fudenberg and Tirole, 1989), nations cannot agree on a given quantity of carbon emissions globally. This is due to the various interests and natures of their industrial mix and development in terms of economic maturity which will always push a nation to play by its rules. For example, member states of OPEC have on average between 1982 and 2009 produced 96% more petrol that what they agreed on (Colgan, 2014; Ghoddusi et al., 2017). This illustrates, that even when it is in their best economic interest, countries prefer to exceed their self-imposed quotas for short-term gains. With the European Commission's powers and the willingness marked by the populations to change, it has been possible to reach an agreement on a European level but the road is still long for a global price of carbon as advocated by many climate activists.

On this note, Cramton et al. (2017,p. 39 & 227) insist that price is intrinsically fairer than quantity in designing policies as it avoids the free-rider problem. In this configuration, everybody thinks he has the same probability as his neighbour to access the resource that everyone has to pay for. On the fairness note, the United Nations Framework Convention on Climate Change (UNFCCC) advocates the principle of "*common but differentiated responsibility*". This principle implies that developed countries must take more of the burden that developing countries as their population have, on average, more capabilities. Nobel price laureat Amartya Sen's capabilities refer to the real freedoms that people have to achieve their potential doings and beings (Sen, 1999). In terms of cap-and-trade system, this means a price differentiation reflecting the country's Health Development Index (Boroumand et al., 2022) which subsequently reflects its ability to pay for an increased marginal cost of goods and services. As a consequence, high income countries should pay higher price and lower income countries lower price, with a possibility to dial the price more granularly. This would result in a fairer sharing of the burden and shift competitiveness in favour of lower income countries, no wonders why such system is still wildly debated.

Authors from the report on Global Carbon Pricing (Cramton et al., 2017, p. 221-241) also insist on various complementary policies, which do not lay in the scope of this study, but must work in pair with carbon pricing policies as they are insufficient on their own to achieve carbon neutrality (Schmalensee and Stavins, 2017; Skelton and Allwood, 2017). These policies range from technology and innovation encouragements to broad regulatory interventions and social justice (Boroumand et al., 2022). Such holistic approach is also encouraged by the International Moneary Fund (IMF) in its publications (IMF, 2021) by stating that "*carbon pricing should be part of a comprehension mitigation strategy*". For example in Sweden, they implemented a reduction of the VAT on activities related to circular economy as they reduce indirectly carbon emissions. As stated by Mehling and Tvinnereim (2018) in their article: "*[...] policymakers need to be made aware of the limits to carbon pricing. For all its potentially beneficial effects, a price on carbon does not guarantee that emitting activities will cease within committed timelines of deep decarbonisation.*".

To conclude, we describe the FASTER principle for successful carbon pricing (OECD and World Bank, 2015, p. 10-11) developed by the Organisation for Economic Co-operation and Development (OECD) and the World Bank :

- Fairness: it should follow the principle of "polluter pays" which ensures that the one causing harm is the one carrying the burden. Nevertheless, they emphasis the share of the burden to not disproportionally put pressure on the most vulnerable households.

- Alignment of policies and objectives: carbon pricing should not be seen as a stand-alone policy but be embedded into a broader net of climate and non-climate related policies and legal frameworks working to achieve the given societal objectives.

- Stability and predictability: the changes to the carbon policy framework and the changes in carbon price should be consistent, credible and give the appropriate signals to encourage long term investment and foster new business opportunities.

- Transparency: the policymakers should communicate early, regularly and openly about the rationale, the outcome and benefits for the whole society in order to generate support thus avoiding frauds and leakages.

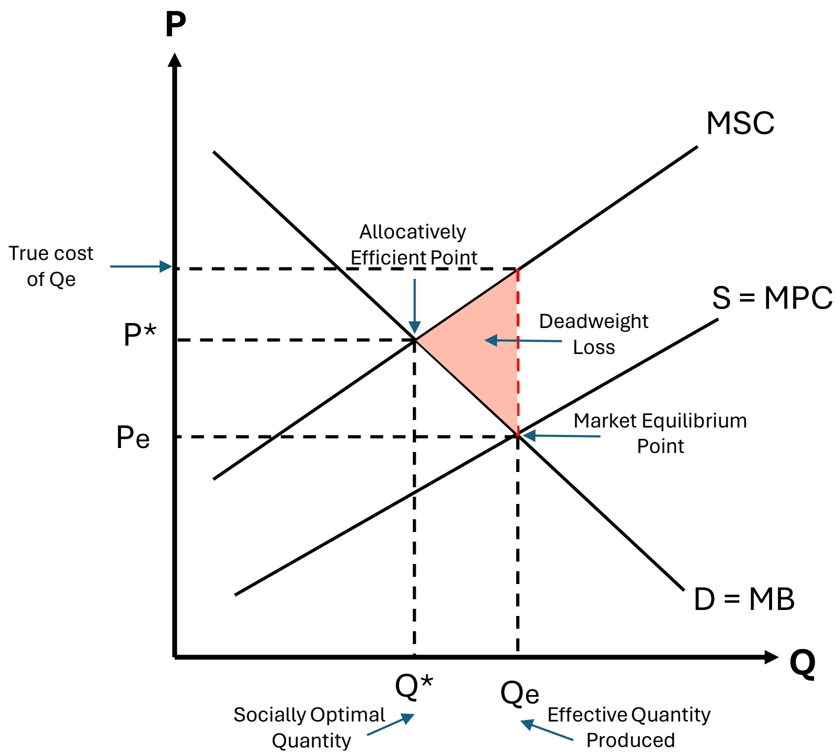
- Efficiency and cost-effectiveness: the pricing of carbon should improve economic efficiency by improving the allocation of resources and ensuring the revenues compensate for the damage to the environment. Administrative implementation should not impose a supplementary burden on the companies and a well tailored carbon market should yield some economic benefits, such as fiscal dividends.

- Reliability and environmental integrity: the coverage should be as comprehensive as possible covering all fuels, gases and sectors of the economy while being designed to improve environmental outcomes.

2.1.1 Pricing negative externalities

Carbon emission is a negative externality, which means that the emitter does not pay the full price for his emissions. In other words, the company makes a production decision only according to its costs and profits without considering the collateral cost of polluting. This results is a market failure as it brings the economy away from the general market equilibrium point. Indeed, as the negative externality is not priced, the cost of production is lower than the real cost of production thus pushing the supply curve downwards leading to an overproduction of goods and services. As a consequence, society as a whole must take over and pay for the damages resulting from the increase in carbon content of the atmosphere. This is illustrated in figure 2.2; the optimal social quantity (Q*) at the optimal price (P*) are satisfied at the allocatively efficient point, but as the price paid by the firm is not accounting for the total cost, the company's supply line shifts from the marginal social cost (MSC) to the marginal production cost (MPC) as the company pays a lower price (Pe). The aftermath is a higher quantity produced (Qe) at a lower price (Pe) thus a new market equilibrium point (Qe, Pe) away from the general efficient market equilibrium (Q*, P*). The deadweight loss created by this market inefficiency must be accounted for by society and is equal to the surface in red.

Figure 2.1: Negative externalities in production in a competitive market



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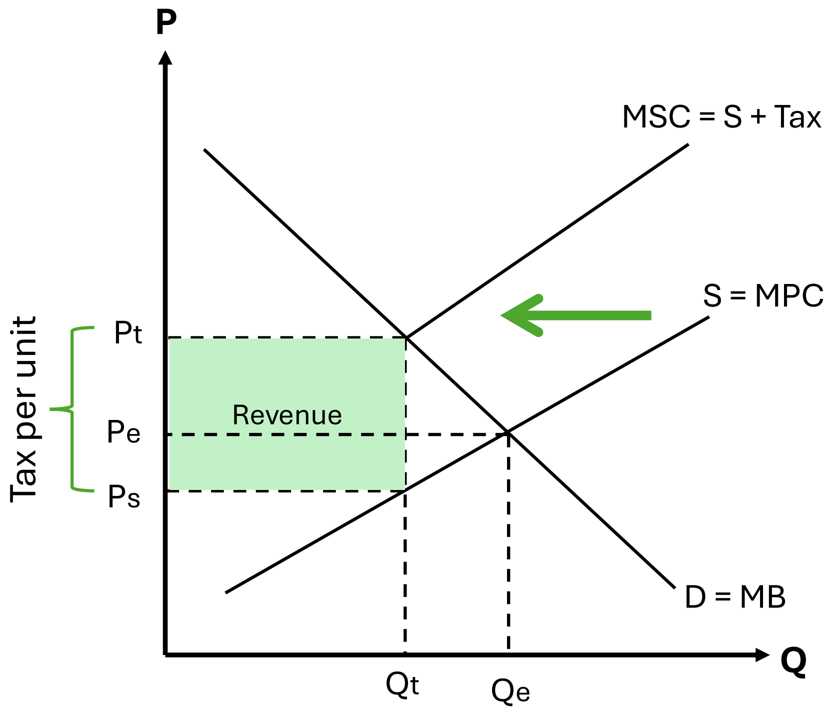
We will now describe three ways to price carbon, through a tax, a price floor or a quota. However, other possibilities exist such as regulation, mediation or partnership with all the parties involved with the goal to either limit such activities or compensate for their consequences, either voluntarily or by lawsuit.

2.1.1.1 Carbon tax

The first answer to address negative externalities is in the form of a tax. The government imposes to the firm to pay a fee for each unit produced in order to compensate for the marginal external cost of the externality, also called a Pigouvian tax after the English economist Arthur Cecil Pigou (Varian, 2014). The mechanism is illustrated in figure 2.3; the government imposes a unit tax to increase the marginal cost of production of goods and services with negative externalities. The increase in cost shifts the supply curve to the left thus reducing the quantity produced form the equilibrium (Qe) to a new one which accounts for the tax (Qt). The new price the consumer must pay is higher than previously (Pt) and the producer receives a lower price than before (Ps). The government extracts a revenue from this mechanism equal to the new quantity produced multiplied by the amount of the tax (Revenue = Qt x t). This revenue may be employed to compensate for the negative externalities imposed on society as a whole. The assumption in the case of a Pigouvian tax is that the amount received by the government is sufficient to compensate society for the harm done. This assumes the government has better means than the market to evaluate thoroughly the situation of thousands of companies and citizens thus inferring the right amount for the tax.

Figure 2.2: Effects of a Pigouvian tax in a competitive market



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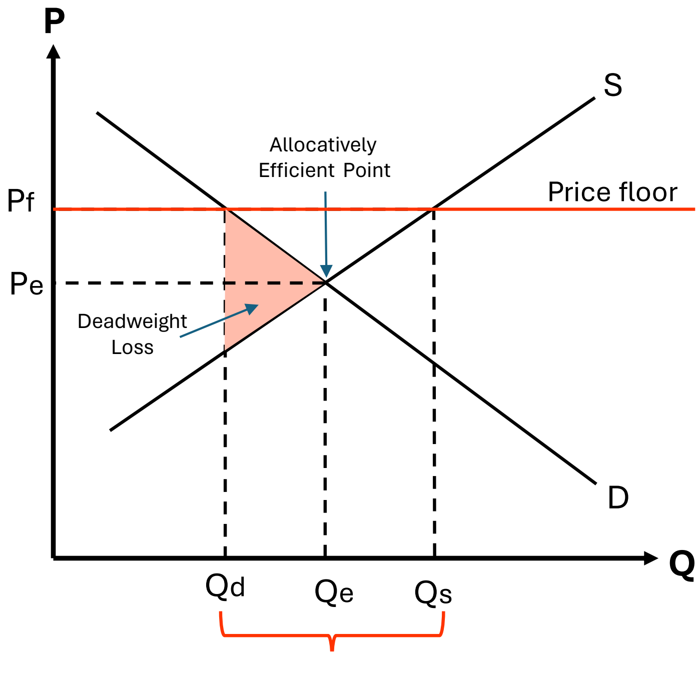
The disadvantage of a carbon tax is that is does not ensure a reduction in emissions but only a minimum price of carbon (Pizer, 2001, p. 99). Nevertheless, it ensures a revenue which the government can use to finance green projects. Even if recognised as less effective in terms of carbon emissions reduction, a carbon tax is deemed more favourable in terms of investment uncertainty than a cap and trade system or a price floor (Zakeri et al., 2015). This argument is also supported by Stiglitz et al. (2017) who argue that a tax system is easier to implement and enforce than any other mechanism as it can benefit from already existing taxation mechanisms.

2.1.1.2 Price floor of carbon

A floor price can be enforced by a government which wants to ensure a minimum price for a certain production of goods and services (Varian, 2014). The mechanism is illustrated in figure 2.4; initially the market is at a certain equilibrium (Qe, Pe), then the government fixes a floor price which means that theses goods or services must now be priced at a minimum price (Pf). The consequence is a shift in the production from an initial quantity (Qe) to a lower quantity (Qd). The result is a surplus as the firms are willing to produce a certain quantity (Qs) at this price, but the demand is lower (Qd). This leads in a deadweight loss divided between the consumer and the producer according to their relative price elasticity. In this case, this mechanism ensures a minimum cost of carbon so to ensure a certain reduction in its emissions.

Figure 2.3: Price floor mechanism in a competitive market



Source : Author

Literature about price floor mechanisms argues it is inherently a government-led policy as it has the total control over the mechanism. This argument is twofold, on the one hand it gives government the latitude to change the price of carbon accordingly to the microand macroeconomic circumstances as well as the ecological response of the market. On the other hand, it diminishes the uncertainty about the price of future allowances which stimulates companies investment decisions in greener infrastructures as it reduces carbon price volatility. Furthermore, the authors comparing Chinese policies conclude that compared to a lump-sum subsidy for investment, a price floor is still more performant as a subsidy does not reduce investment volatility (Zhang et al., 2023).

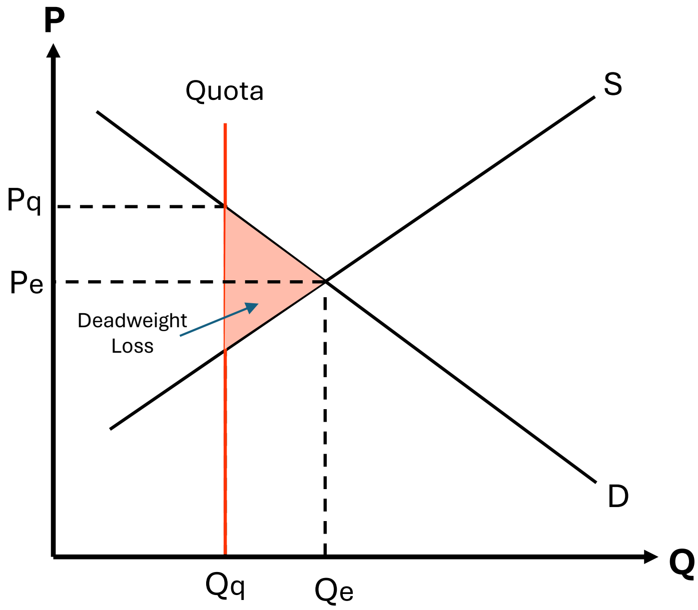
As of 2013, the United Kingdom has implemented a price floor, the carbon price support (CPS), mainly due to the low prices of carbon within the EU ETS. The goal was to top-off the price of European carbon allowances (EUA) with a minimum price rate in the electric power sector. The CPS rate was raised twice, in 2014 and 2016, and led to an average decrease per year of around 26% in carbon emissions for a total on 57% decrease in GHG emission of the sector (Leroutier, 2022). The first phase, from April to December 2013, was shown to have introduced a virtuous fuel switch as the subsequent tax jumps led to significantly lower decreases (Gugler et al., 2023). The three main takeaways from these authors is that the CPS led to the phasing out of coal in the power sector, from 40% of the 7% of the electricity produced. Second, the shift towards gas turbines led to reduction in the output of inefficient gas plants. Third, it increased the probability of closing power plants which were at the limit in terms of European air quality regulations.

Furthermore, the advocates of a carbon price floor argue for a single policy mechanism in order to provide a worldwide level playing field (Cramton et al., 2017; IMF, 2021). This would ensure an consistent price and avoid the increase in border adjustment mechanisms, such as the future European Carbon Border Adjustment Mechanism (CBAM). These border mechanisms aim to ensure every product is subject to the same carbon price burden. Despite these good intentions, it bumps up the regulatory burden and legal adjustment cost of companies while pushing countries exporting to Europe to engage in retaliatory measures leading to market inefficiencies. However, as stated previously, the authors insist of a differentiated price floor of carbon according to the ability of more fragile countries to handle the increase in marginal cost for their economy.

2.1.1.3 Carbon quota

A quota is an imposed maximum quantity that can be be traded or produced within a given area in a given period of time (Varian, 2014). The mechanism of quota is illustrated in figure 2.5; the government considers the equilibrium quantity (Qe) to be too high thus imposing a quota (Qd). The consequence is an increase in price from the initial price (Pe) to a higher price (Pq) which accounts for scarcity. The aftermath is a deadweight loss as the market is constrained to produce less than what is was able to. The increase in price is divided between the producer and the consumer depending on their respective price elasticity. The cap and trade system implemented within the EU is similar to a quota system with a cap, the maximum amount of EUA, but with the possibility to exchange your allowances (free or bought) with other according to your needs. The advantage of a combined cap and trade system over a fix quota per company is that it lets the market adjust the supply and demand of all goods and services in the EU market according to their need in carbon allowances. This would be impossible or too costly for a government to act as the intermediary between all companies but is possible to put in place a market which should lead to an optimal general equilibrium.

Figure 2.4: Quota mechanism in a competitive market



Source : Author

The idea behind the cap and trade system is to fix a global quota for the total amount of carbon allocations within a year then lets the market set the price in a general equilibrium model perspective by trading any excess allowances. These systems are viewed as superior to command-and-control approaches because of the increasing variability surrounding emission reduction costs. This minimises state intervention and trading costs both for society and firms. Economically, it lets the companies adjust their intertemporal budget constraint with the fluctuation of spot or future price of carbon thus adjusting their production to maximise their profit.

In their article form 2017, Schmalensee and Stavins analyse the design and performance of seven of the most important ETS markets implemented the last 30 years, six in the United States and the EU ETS. They find nine main takeaways for the design of a cap and trade system. First, free allowances can build strong political support and permit to ease the transition even if they are phased down. Second, auctioning allowances can be gradually implemented without diminishing the efficacy of the mechanism and generate revenue for government which can then be allocated to greener the economy. Third, transaction costs are sufficiently low to allow efficient trading and must not require prior regulatory approval of trades. Fourth, banking of allowances permits significant gains from trading but also allow to achieve compliance while letting firms adapt to unanticipated circumstances. Fifth, being able to bank from one phase to the other avoids price of allowances to drop to zero at the end of a phase thus rendering the mechanism useless. Sixth, it is essential to obtain accurate data of emissions prior to a new compliance period to avoid over- or underallocation thus price volatility. Seventh, high levels of monitoring and penalties are required to enforce properly the regulation. Eight, leakages can be avoided by including a maximum of neighbours into the system which avoids waterbed effect. However, even if free allowances limit the phenomenon, it cannot be avoided. Lastly, even if it was not completely implemented, the authors suggest using a price collar in order to avoid too low or too high of a price, both of which are detrimental to the economy. In addition, a price collar limits volatility which facilitates investment planning for companies.

A caveat to a capping system is finding the right amount of carbon emission allowed per country over a given period of time. This is feasible on a regional scale but is deemed impossible on a large scale as there always exist the temptation for a country to take more than its share (Weitzman *in* Cramton et al., 2017, p. 130). Furthermore, the authors argue that there is no such thing as a global fair distribution function for carbon allowances among all countries. On a last note, quantity-based policies lead to price uncertainty while price-based policies lead to quantity uncertainty (Pizer, 2020, p. 233). In the case of the EU ETS, the EU adjusts the quantity of carbon emissions on a yearly basis and from one phase to the others change the rules. In this case, economic agents face price uncertainty which results in a possible under investment by carbon-intensive companies, but more generally by all companies facing carbon price in their value chain. In order to limit volatility Mideksa and Weitzman (2019) propose to use both price- and quantity-based policies relative to the marginal cost and marginal benefit of the agent, which is similar to the empirical price collar defended by Schmalensee an Stavins (2017). Theoretically, this approach is more comprehensive but one must empirically and dynamically determine the marginal cost and benefit of each economic agent.

Moreover, the determination of a cap is intertwined with the precision of the *ex ante* initial estimation of the total amount of carbon emissions. Empirically such measures are often too high. The explanations are various (Tvinnereim, 2014), but the most salient explanation of these high estimates are to soften the initial effects of the policy, a deep correlation between emissions and production thus a high sensitivity to economic cycles, a relative fuel price movements which leads to a switch in sources of fuel for power generation, an unforeseen innovation in abatement methods due to conservative bias and, lastly, the complementary policies for emission reduction going in the same way as the cap and trade system leading to lower emissions that the estimated cap.

2.1.2 The EU carbon market: EU emissions trading system

The EU ETS was launched in 2005 with the aim to reduce greenhouse gas emissions, measured in CO2 equivalent tons of Co2, as to follow the objectives of the Kyoto Protocol which came into force the same year. It is applicable in to all EU Member States, the European Free Trade Association countries (EFTA) which are Iceland, Liechtenstein and Norway as well as Northern Ireland for electricity generation. It is a cap and trade system which means that the EU Commission allocates a certain amount of carbon allowances (EUA) to a country which then transfers them to its companies which can either buy more allowances to cover thier needs, trade them if it have too much or bank them for future times. The trading of allowances may be a reallocation within the company, traded via a broker or sold on the spot market. Each allowance permits to emit a ton of CO2 or a ton of CO2 equivalent of greenhouse gas which must be surrendered by the company at the end of the year, otherwise it must face a fine. The fine was of 100 euros with a base year of 2005 which accounts to roughly 160 euros in 2024 accounting for the correction to the consumer price index. Initially, only carbon dioxide was covered but as of 2013 the EU included nitrous oxide (NO2), with a coefficient of 300 tons of CO2 equivalent, and perfluorocarbons (PFCs) with an average coefficient of 10.000 tons of CO2 equivalent.

The sectors covered by the system are electricity and heat generation facilities, energy-intensive industries (oil refineries, steel works, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals), aviation within the European Economic Area and flights to Switzerland and the United Kingdom and maritime transports from 2024 with certain specifications. For each of those sectors, the participation in the emission scheme is mandatory with some thresholds in some cases or if the national government puts compensation measures in place.

The allocation mechanism is based on the principle of supply and demand with a steadily decreasing supply of freely allocated allowances. The total amount of allocation given to a member state is derived from its National Allocation Plan (NAP). Prior to the beginning of phases 1 and 2, the countries had to hand over to the European Commission the quantity of allowances they needed to sustain their economy while reaching the goal of reducing their emissions. The sum of all NAPs made up for the total cap of the Union. After some challenges by member states, the NAPs were phased out in the subsequent phases in favour of an EU-wide cap.

The first step towards the EU ETS was the legally-binding greenhouse gas emissions reduction targets of the Kyoto Agreement of 1997 followed by the 2000 "green paper" of the European Commission. Then came the 2003 EU ETS Directive which made the system a reality at the beginning of 2005. This starts the first phase, from January 2005 to December 2007, which was a learning-by-doing phase. Nearly 12.000 installations were part of the scheme for around 40% of all European Union CO2 emissions. The allowances were in majority given for free which led to an array of windfall profits because of the lack of reliable benchmarks and monitoring for carbon emissions (Carbon Market Watch, 2016). The situation led to a price of carbon of zero in 2007 as the Commission ruled out the possibility of banking allowances for the next phase. The result is a slight increase in emissions but the establishment of the necessary regulatory infrastructure (European Commission, 2024).

The second phase began in January 2008 and ended in December 2012. The cap was lowered by 6.5% and the amount of free allowances was reduced to 90% of the total amount thus enabling countries to host auctions for the remaining amount. This phase saw the inclusion of three countries form the EFTA as well as the intra European flights. The pitfall of the second phase was the 2008 economic crisis during which companies went bankrupt thus leading to an excess of allowances which downplayed the reduction efforts to a mere 3% according to the European Commission (2024).

The third phase, from January 2013 to December 2020, saw some major changes beginning with an overall EU-wide cap then allocated to member states. Auctioning is now the default method of allocation allowances but there is still the opportunity for member states to allocate free allowances. The banking of allowances is now limited from one phase to the other and the EU ETS scheme now includes some more sectors (aluminium, petrochemicals, non-ferrous and ferrous metals, ammonia and other various chemicals) as well as some gases according with their CO2 equivalence (No2 and PFCs). The decrease in allowances follows now a constant linear reduction of 1.74% per year. This third phase proved to be more efficient than the two others with a reduction of 43% tons of CO2 equivalent greenhouse gases from 2005 to 2020.

We are now in the fourth phase from January 2021 up to 2030 with the EU ETS at the spearhead of the European Commission's 55% net reduction versus 1990 in greenhouse gas emissions for the end of 2030. This phase sets a constant linear reduction factor of allowances to 2.2% per year. From 2021, around 57% of allowances are auctioned and the free allocations are given according to a benchmark of efficiency, historical levels of activity and risk of carbon leakage. There is also a fund for innovation and modernisation and a derogation for some countries with a GDP below the 60% EU average inside the Union.

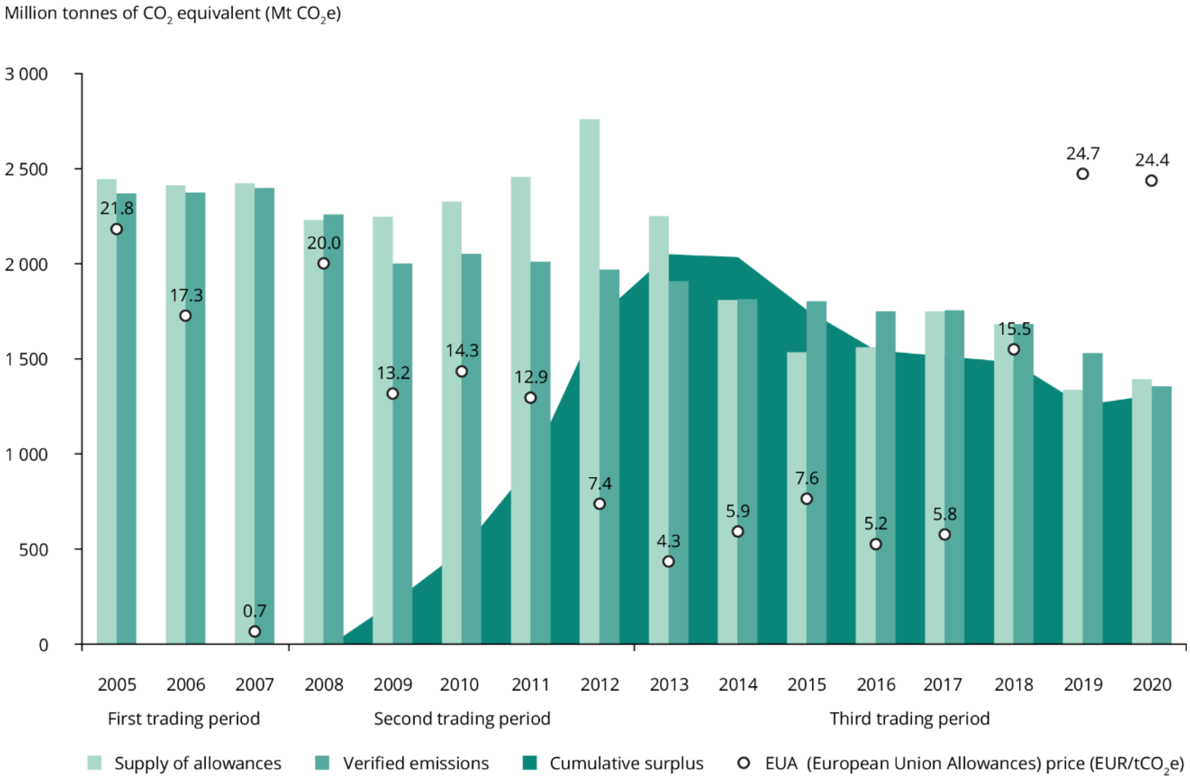
These reductions in CO2 equivalent emissions take only into account the stationary ETS emissions as the aviation allowances are free for 82% and 15% is auctioned as of 2021. The same reduction is applied as for the rest of the ETS. The maritime ETS enters in force in 2024 with some reserves and still remain to be amended to align with other sectors.

Figure 2.5 pictures the supply, verified emissions and cumulative surplus of EU allowances across the three first phases. The supply of allowances is above the amount of verified emissions for the two first phases, which led to a low decrease in greenhouse gas as stated previously. As of the third phase, the amount of allowances auctioned yearly is almost always below the amount of verified emissions which is possible because of the vast amount of cumulative surplus banked by the industries. However, the amount of cumulative surplus is slowly diminishing with the yearly decrease of the EU-wide cap. As for the price of the auctioned allowances, it is volatile with a sharp decrease in the first phase then a rebound at the beginning of the second phase followed by a steadily decreasing price during this phase. The third phases had quite a constant price around 6 euros per ton of CO2 equivalent allowance only to see an increase as of 2018 which culminated at a maximum over 100 euro in 2022. The fourth phase and its constant reduction of the cap should see the price of carbon be much higher than what we observed since the inception of the EU ETS.

2.1.3 Carbon pricing worldwide

The EU ETS is not the first nor the last greenhouse gases pricing initiative worldwide. According to the World Bank, there are 35 implemented ETS worldwide (see appendix A1) accounting for roughly 18% of global GHG emissions. The EU ETS is the most prominent ETS until 2020 with 2.7% of all carbon emissions until it was dethroned by the Chinese national ETS with nearly 9%. Other important carbon markets are the Korean ETS since 2015 (1%) and the Californian CaT since 2012 (0.5%). In total, the five biggest ETS only account for 13% of the global carbon emissions. Furthermore as showed in appendix A2, the prices of carbon ETS worldwide can be miles apart with, on the 31 of March 2023, a price of carbon in the EU of USD95 similar to the UK and Switzerland ETS. On the other side an average price of carbon in North America around USD35 and

Figure 2.5: Emissions, allowances, surplus and prices in the EU ETS, 2005-2020



Source : European Environmental Agency

in China less than USD10. Not surprisingly, carbon leakage is now becoming a great concern for carbon-pricing countries and unions.

In terms of taxation, there are 33 implemented greenhouse gases taxes worldwide (see appendix A3) accounting for roughly 5% of global GHG emissions. The most important tax is the Japanese carbon tax (1.7%) since 2012 then the South African carbon tax with 0.8% since 2019 to finish with the Mexico carbon tax (0.6%) since 2014. The top five carbon taxes count for less than 4% of all greenhouse gas emissions covered globally. In term of price, we observe the same discrepancies with a maximum of USD156 per ton of CO2 equivalent emissions and as low as USD2 for the Japanese carbon tax, with all possible prices in-between.

Lastly, despite their theoretical efficiency, price floor mechanism is only implemented in the United Kingdom through the CPF with an actual rate of USD22 which is increasing each year following a certain index.

2.2 ESG Scores

2.2.1 Defining sustainable investment

Investors and businesses use many terms to qualify stocks or companies following certain criteria seen as a pledge of good conduct. They could be ethical investment, socially responsible investment (SRI) or sustainable finance but these often lack a systematic definition. According to Sandberg (2009, p. 521) they refer to "*the integration of certain non-financial concerns, such as ethical, social or environmental, into the investment process*". This definition is still broad enough to encompass a large spectrum of companies which are far apart in terms of business practices. Meuer et al. (2020) performed a systematic literature review and found from the detailed analysis of more than 100 papers up to 33 different definitions of corporate sustainability. In a world were investors put more and more their money where their believes are, a more systematic definition should be made.

Sprakes (2002, p. 201) narrows the definition by including a reference to the market, stating that "*key distinguishing feature of socially responsible investment lies in its combination of social and environmental goals with the financial objective of achieving a return on investing capital approaching that of the market*". In financial terms, risk plays a central role which brings us to Eccle and Vivier (2011) who define SRI as "*investment practices that integrate a consideration of environmental, social and governance issues with the primary purpose of delivering higher-risk-adjusted financial returns*". This risk-adjusted precision is valuable as it emphasis the fact that they are still investments which must yield a monetary return rather than have only a virtuous impact on the world.

Let us now analyse how banks and investors define these types of investments. According to a 2016 BNP Paribas analysis SRI means "*considering "extra-financial" criteria when making investment choices: these include Environmental, Social and Governance (ESG) criteria.*". This explanation is not far from our first definition and does not help defining the scope or criteria. Deutsch Bank Wealth Management narrows the definition by saying that it is "*the principle that investors should consider the full range of benefits and harms that a business may cause for employees, customers and other members of society*". To end, HSBC defines SRI as "*an investment approach that aims to combine economic performance with social and environmental impact by financing companies that contribute to sustainable development in all business sectors*".

In a nutshell, these definitions both from academics and banks tend to follow the path taken by most investors which is to choose sustainable investments mainly for higher expected return or higher risk-adjusted-return incentives (Amel-Zadeh and Serafeim, 2018). This is not surprising as finance has at its core the efficient allocation of resources with regard to risk. Nevertheless, for this study we keep Lozano's definition of corporate sustainability (Meuer, 2020, p. 31) "*Corporate activities that proactively seek to contribute to sustainability equilibria, including the economic, environmental, and social dimensions of today, as well as their inter-relations within and throughout the time dimension while addressing the company's system (including Operations and production, Management and strategy, Organisational systems, Procurement and marketing, and Assessment and communication); and its stakeholders*". The definition puts the emphasis on a proactive approach to all ESG pillars and all share- and stakeholders while including intertwined time horizons embedded in each ESG action. This leads us to ask ourselves what does investing means according to ESG criteria and whether there are different types of sustainable investments.

2.2.1.1 Stages of sustainable finance

As defined by Levine (2005, p. 7), the financial system has five main functions :

- *Produce information ex ante about possible investment and allocate capital.*
- *Monitor investments and exert corporate governance after providing finance.*
- *Facilitate the trading, diversification, and management of risk.*
- *Mobilize and pool savings.*
- *Ease the exchange of goods and services.*

The three first functions a the most salient in regards to sustainable finance. First, financial investors play a key role in lending money to sectors and projects which can permit a more efficient green transition. They possess the power to pick out which project to fund and what constraints to apply to the borrower. Second, institutional investors more than others can influence, direct or even control the decisions taken by corporate boards. They also balance the interests of the various stakeholders and channel the impact of the company on the environment and society as a whole. Third, finance is good at pricing risk by sketching future scenarios according to all relevant variables. This is especially important at a time of growing uncertainty for companies. This brings us to the new financial paradigm which is embedded by the triple bottom line : people, planet, profit.

This new paradigm is reshaping the way finance sees itself and impacts society by changing its value creation objective. This is done by rethinking what should be optimized and under which horizon of time it should be done. The new sustainable finance (SF) typology developed by Schoenmaker and Schramade (2017, p. 20) divides finance into four different stages of evolution each balancing differently the financial,F, the environmental, E, and social, S, values of a given investment.

- Finance as usual is the baseline of reasoning. At this stage, financiers rank their material factors according to their value and maximise the combination of financial return (r_f) and risk, max(F|r_f). Even if shareholders should care about the medium to long term, short-termism is more prominent.
- Sustainable Finance 1.0 refines the type of companies it invests in by including an exclusion principle. This means avoiding sin-companies such as tobacco, alcohol or weapon manufacturers. This list can be broadened to extend the exclusion zone to other sectors regarded as adverse. With his pool of "virtuous" companies, the investor will now maximise, with some possible refinements, the combination of financial return and risk, max(F|S,E). Nonetheless, it often falls into the same pitfall of short-termism as prior.

- Sustainable Finance 2.0 includes explicitly negative externalities into their decision-making. Financial value is also attached to social and environmental impacts which makes up for a new integrated value of the financial instrument, I = F + S + E. The time horizon for valuating extra financial impacts is also taken into account which pushes the time horizon beyond short term goals. This time the maximisation process in not only (refined) shareholder value but a stakeholder value, max(I|r_p). The discount rate used, r_p, is also higher than previously as it is a private discount rate which accounts for uncertainty.

- Sustainable Finance 3.0 avoids the caveat of the previous methods by pushing to the second plane all financial aspects. Indeed, in sustainable finance 2.0, a very high financial gain can offset a mild decrease in social or environment value. This way of financing puts the emphasis on creating common good value by maximising social and environmental impacts over financial value, max(S + E|F). This forces the investor to look at the long term horizon as easy profit, especially risk-adjusted return, is less than likely.

2.2.1.2 Sustainable financial strategies

Following sustainable finance typology, we can now analyse different sustainable financial strategies. EUROSIF (European Sustainable Investment Forum) and GSIA (Global Sustainable Investment Alliance) identify seven possible sustainable financial strategies :

- Best-in-class consists of choosing the most virtuous companies according to their ESG score in a certain sector. This is at the limit between finance as usual and SF 1.0 as you may accept companies from sin-sectors.

- Exclusion strategy, similar to SF 1.0, is the most common strategy in Europe (Eurosif, 2018, p. 16) and the second largest in the world (GSIA, 2020, p. 11). Its success comes from the relative ease to implement and disclose to investors.

- Sustainability themed investment consists on focussing on a certain thematics in order to accelerate the change for instance green agriculture, diversity and inclusion or greener energy production.

- Norm-based screening consists for the investor to compare the possible investments with norms in place such as the OECD guidelines, UN Global Compact, UN Forum on Sustainability Standards or the EU taxonomy for sustainable activities.

- ESG integration, similar to SF 2.0, includes all systematic environmental, social and governance aspects in the investment strategy. It is the most important strategy in the world (GSIA, 2020, p. 11). The broad definition and unclear border make it easy to market without going too much into the details.

- Engagement and voting invites the investor to engage with the company and take actions into their hands. This strategy is the shareholder advocacy described by Schueth (2003) where the investor takes an active role in steering the company on a more favourable course on the long run. Stewardship is the third strategy used worldwide (GSIA, 2020, p. 11) and is promoted by the European Union through the Shareholder Rights Directive II.

- Impact investing, similar to SF 3.0, is aimed at tackling in a meaningful manner the social and environmental of society through "*demonstrating the intentionality of investor and underlying asset/investee, and demonstrating the investor's contribution*" (GSIA, 2018, p. 7). It can also take the form of community investing when the goal is to target a specific underserved group with the intention to improve its social or environmental condition.

Outside of the scope of finance stands philanthropy where the investor accepts partial or full loss of capital.

2.2.2 ESG ratings

As described in the last section, investors have a large range of financial strategies to implement their transition to sustainable finance. However, to be able to efficiently allocate their fund in accordance to their ESG tastes, they all rely on ESG ratings in order to weight the ESG-worthiness of a company or an investment. This makes ESG rating agencies a cornerstone of sustainable finance and increasingly enhances their influence. According to the UN Principles for Responsible Investment (UNPRI) in its 2022-2023 report, they reached more than 5000 signatories, either investors or service providers, accounting for more than $120 trillion in combined assets. These signatories commit to take into account ESG information into their investment strategies. This means a that all these trillions could be allocated to world were ESG really matters, only if these companies can rely on correct ratings.

However, according to PRI (2015, p. 27), ESG rating agencies "*evaluate a security issuer (either of bonds or equities) according to their exposure and performance relative to ESG factors and compared to their peers. They are quantitative indicators; they are usually compiled by third-party service providers (typically paid for by investors) and are unregulated products*". Which makes comparing ESG ratings hazardous and even raises questions about their reliability. This in term can lead to misallocation of resources and economic inefficiencies. Indeed, according to Billio et al. (2020, p. 12) "*[...] there is a lack of common metrics among rating agencies in the definition of ESG (characteristics, attributes and standards) and that heterogeneity in judgment can lead agencies to assign even opposite ratings to a given company.*". Even if each ESG rating agency base their analysis of the same three ESG factors, the different rating principles can lead to widely different score which can provide false indicators to investors.

Nevertheless, each agency has roughly the same methodology to obtain a final comprehensive ESG score. First, choosing the scope of each ESG criteria which means a set of attributes worth analysing. Second, deciding how to measure each attribute in the way it makes the more sense in order to extract the essence of the given factor. Third, ensuring the most meaningful way to aggregate the various measures into a single score, whether a letter or a number. This methodology evidently leaves of lot of leeway to a company's own decisions. According to Deloitte (2024), more than 600 rating agencies operate worldwide. To illustrate these discrepancies, we are analysing four prominent ESG rating agencies and they way of rating companies.

- MSCI (Morgan Stanley Capital International) ESG rating uses a rules-based approach to identify a company's exposure to ESG risks and opportunities which are material to the specific sector or sub-industry and their long term management ability relative to peers. The company uses artificial intelligence in order to research more efficiently informations on the company. A risk is material to a sector if it is likely to incur substantial costs while an opportunity is material if it is significant enough to generate profits.

- Morningstar Sustainalytics ESG Risk rating uses a risk-based approach to measure a company's exposure to industry-specific material ESG risks and how they handle them in comparison to their peers. Is material an issue which if not tackled would likely influence the value of a company thus the decision made by a rational investor.
- S&P Global rating uses a financial performance-based approach and a cross-sector analysis to measure the ESG strategy and ability of a company to cope with future risks and opportunities. The analysis is twofold, first the ESG profile of the company is drawn by identifying observable ESG risks and opportunities and how the company mitigates them. Second, assessing the preparedness, namely its long term ability to anticipate, adapt and capitalise on long term plausible disruptions (ESG, regulatory or any other relevant factor).
- LSEG Data & Analytics (former Refinitiv) ESG rating uses a data-driven approach to measure ESG performance based on company's reported informations and ESG controversies gathered from global media sources and treated both by employees and algorithms. The scores of these factors are measured relative to the company's sector for the environmental and social pillar and relative to the country of incorporation for the governance pillar.

Comparing the methodology these agencies use, we already observe some notable discrepancies in-between the different rating agencies. In addition, the sources from which they disclose to gather they data from vary as shown in the table below.

Table 2.1: Disclosed sources used by ESG rating companies

MSCI	**Sustainalytics**	**S&P Global**	**LSEG**
Disclosure from the companies	Disclosure from the companies	CSA Questionnaire	Annual Report
CSR Report	NGO sources	In-person meeting	CSR Reports
Government	Media sources	Public information	NGO sources
Data mining			Stocks exchange filings
			Media sources

Sources : MSCI, Sustainalytics, S&P Global and LSEG websites

A last element is the update of all data, which according to these four agencies is done at least yearly even if some update data weekly which also depends from the source the data originates.

2.2.2.1 Defining criteria

First of all, ESG rating agencies must choose criteria they find relevant in order to measure the specific pillar score (environmental, social or governance). Second, these ratings must encompass a broad range of variables and choosing is difficult in the absence of a global ESG rating taxonomy. Third, the same criteria is then divided into several, even hundred, key issues. However, the main themes dividing each pillar is roughly following the 17 UN sustainable development goals. The criteria presented in the following tables are the one disclosed by the rating companies, except for Sustainalytics which is a black box. Certain of these criteria are more short-term in their effect, meaning that their impact can be measured year-on-year basis such as waste management, while others have long lasting effects on the company, such as community inclusion. The ESG rating of a company possesses a forward-looking component for the investor. The combination of all these criteria and the higher granularity of the key issues make the difference between rating agencies. To conclude, one could say that in an ESG efficient market world, these scores could encompass all ESG informations of a firm in order for investors to optimally allocate their resources according to their sustainability tastes.

2.2.2.1.1 Environmental pillar score

The table below illustrates the main drivers of the environmental pillar score, we can observe that GHG emissions are high on the priority list followed by pollution and waste management then usage of natural resources. LESG has fewer criteria but puts innovation in third place. This resonates with the OECD and World Bank FASTER principles stating that carbon pricing should encourage long term investment which is exactly what innovation is striving for. Thus LSEG takes a more proactive approach to the environmental rating by pushing for innovation not only to measures prone to mitigation, even if both are not mutually exclusive.

Table 2.2: Disclosed themes used to assess the environmental pillar score

MSCI	**Sustainalytics**	**S&P Global**	**LSEG**
Climate change	*Not disclosed*	GHG emissions	GHG emissions
Pollution & waste		Pollution & waste	Resource used
Natural capital		Water use	Innovation
Environmental opportunities		Land use	

Sources : MSCI, Sustainalytics, S&P Global and LSEG websites

2.2.2.1.2 Social pillar score

The social pillar criteria are also similar with an emphasis on the workforce rights and safety and the liability of the products. The emphasis on the stakeholders opposition or communities are other proactive elements which are most material to companies in a growingly ESG aware world. Lastly, only LSEG states Human Rights as a criteria rather than a key issue.

Table 2.3: Disclosed themes used to assess the social pillar score

MSCI	**Sustainalytics**	**S&P Global**	**LSEG**
Human capital	*Not disclosed*	Workforce & diversity	Workforce
Product liability		Safety management	Human rights
Stakeholder opposition		Customer engagement	Product responsibility
Social opportunities		Communities	Community

Sources : MSCI, Sustainalytics, S&P Global and LSEG websites

2.2.2.1.3 Governance pillar score

The governance score is the most standard score, even if in appearance the criteria are different, as it is centred around good corporate governance and transparency. It could be summarised as such: are companies following best practices, are their reporting all necessary information and are shareholders heard whatever their number of shares are ?

Table 2.4: Disclosed themes used to assess the governance pillar score

MSCI	**Sustainalytics**	**S&P Global**	**LSEG**
Corporate governance	*Not disclosed*	Structure & oversight	Management
Corporate behaviour		Code & values	Shareholders
		Transparency & reporting	CSR strategy
		Financial & operational risks	

Sources : MSCI, Sustainalytics, S&P Global and LSEG websites

2.2.2.2 Rating scores

The rating of a company is based on the measure given to various key issues which are then gathered to a single criteria score which in term aggregated into a single pillar score. These pillar scores are then combined into an overall score. At each step the rating agencies can choose the way they aggregate these scores together. According to the disclosed informations, they combine these scores by mean of a weighted arithmetic mean. These weights vary across all agencies thus applying another layer of divergence. In the end, all four agencies provide a single ESG score as shown in the table below.

These scores taken as such are insufficient as they do not provide the same information. MSCI score comes in the form of a letter (even if they provide a quantitative

Table 2.5: ESG score ranges and grades across ESG rating agencies

MSCI		Sustainalytics		S&P Global		LSEG	
AAA	8.5 - 10	Negligible	10 - 0	Prepared	100	A+	91 - 100
AA	7.1 - 8.5	Low	20 - 10	Average	50	A	83 - 91
A	5.7 - 7.1	Medium	30 - 20	Unprepared	0	A-	75 - 83
BBB	4.2 - 5.7	High	40 - 30			B+	66 - 75
BB	2.8 - 4.2	Severe	40+			B	58 - 66
B	1.4 - 2.8					B-	50 - 58
CCC	0 - 1.4					C+	41 - 50
						C	33 - 41
						C-	25 - 33
						D+	16 - 25
						D	8 - 16
						D-	0 - 8

Sources : MSCI, Sustainalytics, S&P Global and LSEG websites

ladder) which measures the company's long term resilience to material risks and opportunities. Sustainalytics' overall score measure the residual risk resulting from a company's inability to cope with risks it is exposed to and how they could impact its value. S&P Global provides a score related to the company's preparedness to operate correctly in the future despite plausible long term disruptions. Finally, LSEG is designed to measure a company's transparency, ESG commitment and effectiveness.

However, for MSCI, the ESG score comes with an assessment of the ESG controversies which are assessed according to a specific framework following the three ESG pillars (23 in total with some possible extra). Each measure is based of the company's public profile and actual or alleged involvement in negative externalities activities as reported by media, NGOs or any other stakeholder. They are ranked from very severe to minor with the addition of a direct or indirect element and complement the overall ESG score with useful information.

For LSEG's, the overall ESG score is complemented by a ESG combined score (ESGc) which accounts for controversies. It is based on a fix number of 23 ESG controversy topics and if companies do not suffer any controversy the last fiscal year, they get a score of 100. Otherwise, they suffer a penalty reducing this score. The controversy function takes into account the market cap not to over-penalise big capitalisations and ensures no controversy is double counted. If a company has a controversy score above or equal to its ESG score, the ESGc score equals the ESG score; in the other case, the controversies score becomes the ESGc score in order to penalise for controversies in reducing the overall score. Controversies are generally viewed as bad for a firm but Xue et al. (2015) provide an academic insight into this common knowledge. Indeed, they find that reputation damage and controversies lead to corporate investment inefficiencies and decreased long term value. This is especially true for big capitalisations with more news coverage and a bigger pool of analysts scrutinising the company. They thus confirm another common knowledge that the more a company is monitored, the more virtuous it strives to become to avoid reputational penalty.

2.2.2.3 Scores divergence

According to Chatterji et al. (2016), 1 out of every 9 dollars in the United States and 1 out of every 6 euros in Europe is invested in SRI which makes ESG rating divergence a major factor of inefficiencies in global capital markets. Moreover, the lack of common ESG metric leads to irrelevant benchmarks or ESG indexes which disrupts passive investors, ETF's and stock selection for active portfolio managers. To illustrate how salient the lack of convergence in overall ESG scores of our four agencies is, we use the correlation matrix found in Berg et al. (2022, p. 8).

Table 2.6: Correlations between ESG ratings

	MSCI SUST	MSCI S&P	MSCI LSEG	SUST S&P	SUST LSEG	S&P LSEG	Average
ESG	0.46	0.38	0.38	0.67	0.67	0.62	0.53
E	0.37	0.29	0.23	0.66	0.64	0.70	0.48
S	0.27	0.26	0.27	0.55	0.55	0.65	0.42
G	0.16	0.11	0.07	0.51	0.49	0.76	0.35

Source : Berg et al. (2022, p. 8)

While the total ESG score is poorly correlated between some agencies, it has overall the best congruence. Analysing the correlation between MSCI with other rating agencies, it seems like their methodology is not in line with any other in any meaningful way. This raises questions about their methodology as the computed values provides MSCI with a below average correlation. On the other hand, S&P Global and LSEG seem to have the most in-line methodology or at least come with the most consistent score even if the aggregation of the ESG factors seems to be different. Unsurprisingly given the difficulty of the exercise, the governance score is the one with the least overall correlation with an average of 35%. Conversely, the environmental score is the most correlated which might be due to the higher degree of granularity which diversifies out idiosyncratic biases.

Different ESG scores comes from the three main aspects of methodology: scope, measurement and weight divergence (Berg et al., 2022). As stated prior, the first step is to define the right set of themes and attributes to estimate a company's ESG factor performance, this leads to "scope divergence". For example, an agency can measure governance performance by including employee satisfaction, while another might use labour practices. Second, the set of indicators used to measure the same attribute might differ. For instance, one might use employee turnover rather than employee court cases taken against the firm to measure a firm's labour practices. Third, the aggregation of all these measurement points into a single score is made by means of weighted linear combinations with each weight representing a relative importance given to the element. There might be multiple sets of weights as each indicator is weighted to make up an attribute which is then aggregated into a factor which finally is combined into a final score.

Quantitatively, scope divergence accounts for 56% of the divergence in scores while scope divergence contributes to 38% and weight divergence for a mere 6%. At last comes the rater or halo effect which is defined by Forgas and Laham (2016) as "*a tendency of judges to assume that once a person possesses some known good (or bad) characteristics, their other, unrelated and unknown characteristics are also likely to be consistent, that is, good or bad.*". The rater effect is substantial as it explains 15% of the variation of category scores.

There are two last important elements worth mentioning about the raters. First, Chatterji et al. (2016) alert on raters theorisation bias which means raters theorise ESG in a personal manner different from his peers which could lead to even more heterogeneity. Second, rating agencies may be inclined to distinguish themselves from the competition by adopting certain views on ESG topics in order to create a defined identity in the market (Negro et al., 2011).

Nevertheless, Berg et al. (2022) demonstrated that they were able to re-estimate ESG scores based on a common taxonomy which means convergence in ESG ratings is possible. However, this would require ESG rating companies to step down and agree whether by choice or by means of regulation on a given taxonomy and measurement method. To conclude on the topic, ESG ratings are usually updated yearly while risk managers and investors require timely data.

2.3 Carbon policies, ESG scores and carbon emissions

As described in the previous sections, the ESG score of a company is an aggregate between three different pillars, nevertheless it would be naïve to come to the conclusion that only the environmental pillar matters to carbon reduction. Following Tirole (1988), companies try to optimise their profits thus minimise their costs, losses and risks. Xue et al. (2015) come to the same conclusion empirically which emphasis the importance of the two other pillars in the implementation of policies within the company to reduce carbon emissions and green house gases in order to minimise their exposure to controversies and legal issues. This applies to other environmental matters such as water consumption and disposal, hazardous chemicals and waste management or use of natural resources. This explains why in the literature, it is the ESG score which is employed and not only the environmental score to measure the impact of environmental policies on companies.

This brings us to highlight the first mechanism by which ESG ratings are linked to carbon emissions. Indeed, in an environment where carbon emissions and high carbon intensity is seen as detrimental to a company on the long run, firms are willing to reduce their effective or perceived exposure to carbon thus their GHG emissions by all means possible. This means mechanically improving their ESG score by changing and improving their internal processes in a holistic way. This is highlighted by Shu and Tan (2023) who analysed a dataset of Chinese listed companies between 2010 and 2019. They find that carbon control policy risk tend to increase the probability of default of high emitting and carbon-intensive sector thus raising their interest rates and cost of borrowing. They also point out the link between the reduction of GHG emissions and the increased capital expenditures in green innovations which are positively correlated with an improvement of ESG score. Zhang and al. (2023) study a panel of companies from Shanghai and Shenzhen from 2011 to 2019 using Bloomberg ESG score data and find that carbon emission trading policy improve the ESG score of companies by improving the internal and external control and pushing for research and development in green innovations.

Indeed, green innovation are necessary in order to shift to a greener economy and quite intuitively, this should improve the ESG score but Wang et al. (2023) studied how the opposite is also true. They analysed a panel of 3301 listed Chinese companies between 2013 and 2019. Following the methodology of Lindman and Söderholm (2016), they measured the level of green innovation by measuring the number of green patent applications. To correct for green-washing, they defined a green patent quality variable ($GreenCite$) accounting for the number of times the patent was cited. They find that companies with higher than average ESG scores tend to invest more in green innovations, which is also consistent with the findings of Zhou et al. (2023). This phenomenon is emphasised for non-state owned companies and with less short-sighted investors. This is in line with the vision of the ESG score as a long term value creation indicator.

In conclusion, carbon emission policies can push ESG scores to improve by means of stimulating green investments, improving internal and external control and pushing for less GHG emissions. Furthermore, GHG reduction policies encourage high emitting and carbon-intensive companies to double down on reduction policies to decrease their risk. Indeed, carbon control policy risk materialise in a raise of borrowing rates leading to an increase in cost of equity thus lowering the value of the company.

3 | Research questions development

This master thesis is build around a central question as stated in the introduction. Nevertheless, in order to answer this question as completely as possible, it seems important to add two questions in order to provide the reader with a more holistic view. These questions are analysed along the main question in a quantitative manner before aggregating the results in a single general conclusion.

Main research question

"***Has the evolution of the price of carbon of the EU ETS influenced the ESG performance score of the companies from the most carbon-intensive supersectors of the STOXX Europe 600 Index ?***"

The literature review revealed that carbon emissions trading markets lead to a significant reduction in greenhouse gas emissions. This reduction is possible by the establishment and allocation of quotas which are reduced each year in order to mechanically diminish the overall emissions, such is the path the EU chose when establishing the EU ETS. Carbon credits allocated by the EU to the states then to the companies push for more reductions of GHG in order to lower their marginal cost of production while enabling companies to trade their surplus in carbon allowances if they are virtuous. These GHG emissions optimisation are only possible if companies take the necessary measures to reduce structurally their emissions which should in term improve their overall ESG score. The analysis will be on the ESG score as a whole but also on all pillar scores to illustrate the interconnectedness of carbon pricing policies on companies.

Hypothesis: carbon emissions trading scheme leads to improved overall ESG scores but also of all pillar scores.

Subsidiary research question 1

"***Can carbon emission trading policies promote corporate ESG performance by pushing for environmental innovation investments ?***"

ESG score is a trifold wallet where the environmental pillar is prominent in comparison to social and governance scores when looking at the aggregated ESG scores. Companies subject to carbon pricing policies innovate one the one hand to reduce their GHG emissions in order to lower their marginal cost of production and cost of equity and on the other hand to improve their overall ESG score to foster investors keen on sustainable investments. Besides green innovation, carbon policies push for the creation of dedicated internal environmental teams whose actions improve the ESG score of companies by implementing the environmental strategy of the firm.

Hypothesis: carbon emissions trading scheme leads to more environmental innovation investments which improve environmental pillar and ESG score, scores which are also boosted by the presence of dedicated environmental teams within the company.

Subsidiary research question 2

"***Can carbon emission trading policies promote corporate ESG performance by pushing for better management practices ?***"

Firms are the property of the shareholders but it is the management which is running the day to day business. As a working base, one could say that companies are less motivated by the reduction of GHG than avoiding environmental risks or controversies. The quality of the management and the internal audit department reporting within the company is thus a good indicator of the governance pillar score. Furthermore, the inclusion of independent directors should lead to better corporate governance.

Hypothesis: carbon emissions trading scheme leads better management, board practices, reporting and less controversies ; these practices explain part of the variation of the ESG and governance pillar scores.

A caveat to this study immediately arises as the social pillar is obviously left behind in this study, only to be relegated to an aggregated value in the overall score. This analysis will be left for further studies on the matter.

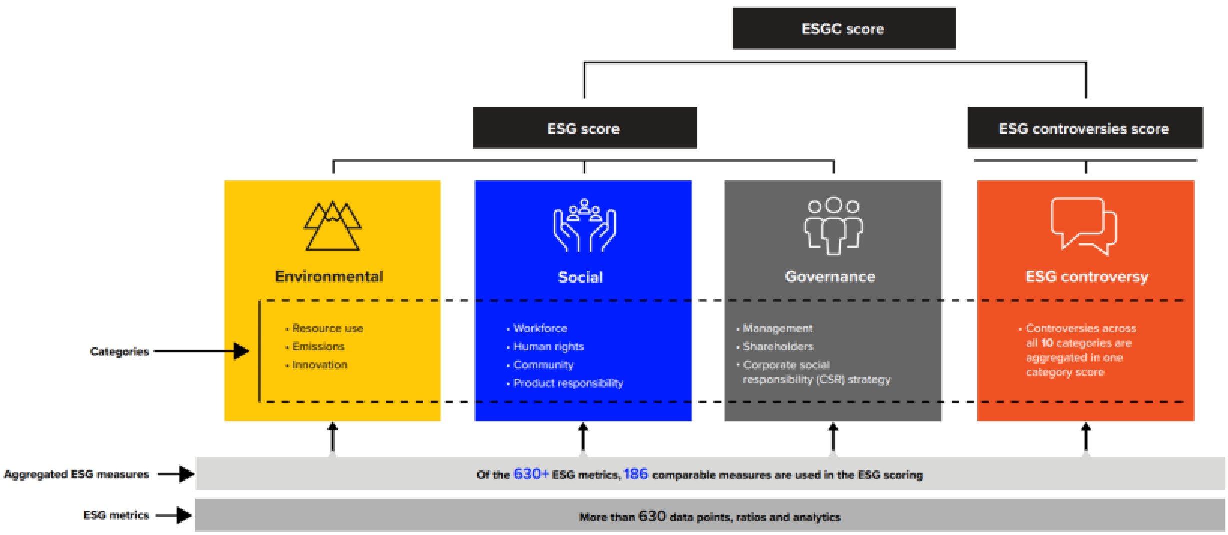
4 | Data collection

In this section, we describe what the literature review highlighted as the most salient endogenous and exogenous variables to answer the various research questions. The variables are divided into endogenous or dependent variables which are explained by the model and exogenous or independent variables which explain the studied phenomenon. In this section, we take the time to explain each variable to better understand what they encompass, how they are measured and what their caveats are.

4.1 Endogenous variables

LSEG Data & Analytics' framework to obtain an overall ESG score is described in figure 4.1. It collects publicly available informations which include annual reports, company websites, NGO websites, stock exchange filings, CSR reports and news sources then standardise it in order to obtain a consistent and exhaustive view of the company. All these more than 630 generic data points are then processed into industry-specific data points. Next, they are merged into themes (waste management, water consumption, structure of the board, etc.) which consist of the structure of each categories. These categories, between three and ten, make up the pillar score of a company. The last step is to aggregate these scores into a single ESG score. As showed previously, LSEG Data & Analytics provides also an ESG combined score which can downgrade the score of a company if it is subject to too many controversies.

Figure 4.1: LSEG Data & Analytics' ESG score methodology



Source : LSEG Data & Analytics report, December 2023

The dependent variables in this study are the overall ESG score, the ESGc and the three different pillars scores: environmental, social and governance. Table 4.1 provides a complete description of the endogenous variables. These data come from LSEG Data & Analytics' proprietary database called Refinitiv Eikon Datasteam.

Table 4.1: List and description of the endogenous variables

Variables	**Notes**
Environmental Score	Refinitiv's Environment Pillar Score is the weighted average relative rating of a company based on the reported environmental information and the resulting three environmental category scores.
Social Score	Refinitiv's Social Pillar Score is the weighted average relative rating of a company based on the reported social information and the resulting four social category scores.
Governance Score	Refinitiv's Governance Pillar Score is the weighted average relative rating of a company based on the reported governance information and the resulting three governance category scores.
Controversies Score	ESG controversies category score measures a company's exposure to environmental, social and governance controversies and negative events reflected in global media.
ESG Score	Refinitiv's ESG Score is an overall company score based on the self-reported information in the environmental, social and corporate governance pillars.
ESG Combined Score	Refinitiv's ESG Combined Score is an overall company score based on the reported information in the environmental, social and corporate governance pillars (ESG Score) with an ESG Controversies overlay.

Source : Refinitiv Eikon Datastream

4.2 Exogenous variables

The exogenous variables collected following the literature on the subject. They are composed of the carbon spot price and the carbon future price which are the main exogenous variables. They are complemented by economic control variables which account for the economic characteristics of the firm. These two sets are complemented by various environmental and management scores: innovation score, the presence of environmental management team, management score and board independent director score. Lastly, we add super-sector dummy variables stating the sector to which the company belongs to.

Table 4.2: Description of carbon prices

Variables	**Notes**
Carbon Spot price	Carbon Spot price is the average yearly spot price of carbon on the EU ETS for a lot of 1000 EUA.
Carbon Future price	Carbon Future price is the average yearly price of one ICE ECX EUA Future contract for a lot of 1000 EUA.

Source : Refinitiv Eikon Datastream

The data on the price of carbon is extracted from Refinitiv Eikon Datastream on a daily basis then the yearly average is computed. This methodology permits to have a high level of precision in the raw data in order to compute an average as close as possible to what the companies are confronted to. On the one side, spot price of carbon is the day to day price at which firms can buy carbon allowances to balance their carbon EUA needs (in tons of CO2) to their carbon emissions. On the other side, carbon future price is the price of future contracts that companies can buy in order to manage their coming expected consumption and balance their investment decisions. One EUA is for one ton of CO2 but they are grouped by 1000 per contract, this is why we will refer to kt of CO2 in the rest of the study.

The economic control variables, as listed in table 4.3, are standard literature economic control variables accounting for the size of the company, its assets and liabilities embodied by the leverage and the operating income. The return on asset is a profitability ratio describing how the company generates profits from its assets whereas the asset turnover describe the efficiency of a firm to extract revenues or sales from its assets.

Table 4.3: List and description of the economic exogenous variables

Variables	Notes
Market Value	Market Value of a security expressed in millions, calculated by multiplying the number of shares (NOSH) and security price (P).
Total Asset	Total Assets represent the sum of total current assets, long term receivables, investment in unconsolidated subsidiaries, other investments, net property plant and equipment and other assets.
Total Liabilities	Total Liabilities represent all short and long term obligations expected to be satisfied by the company (Current Liabilities, Long Term Debt, Provision for Risk and Charges, Deferred taxes, Deferred income and Other liabilities).
Leverage	Leverage represents the ratio of Total Assets toTotal Liabilities.
Operating Income	Operating Income represents the difference between Sales and Total Operating Expenses.
Return on Assets	Return on Assets represents the ratio of Net Profit to Total Assets.
Total Asset Turnover	Total Asset Turnover represents the ratio of Net Sales or Revenues to Total Assets.

Source : Refinitiv Eikon Datastream

Table 4.4: List and description of exogenous action variables

Variables	Notes
Env. Innovation Score	Environmental innovation category score reflects a company's capacity to reduce the environmental costs and burdens for its customers and creating enabling opportunities through new technologies and processes.
Env. Mgt. Team	An individual or team at any level composed of employees dedicated to environmental issues. Even if the name of the team is different, they perform the implementation of the environmental strategy. The members of the team includes employees of the company, who are operational on a day to day basis and are not the board committees.
Management Score	Carbon Management category score measures a company's commitment and effectiveness towards following best practice corporate governance principles.
Ind. Board Members	Percentage of independent board members as reported by the company.

Source : Refinitiv Eikon Datastream

The environmental action variables, listed in table 4.4, characterise the actions a company can take to actively improve its ESG score and minimise controversies. Considering the data available, only the environmental and governance pillar are considered. This materialises by the environmental innovation score (in percentage) which denotes the willingness of the company to actively engage into environmental actions and by the presence of an environmental management team (dummy variable, one for the presence zero otherwise) dedicated to environmental matters within the company and performing the implementation of the company environmental strategy.

The management action variables, listed in table 4.4, denote the quality of the governance of the firm by the management score (in percentage) which is a score of alignment to best practices in business governance and by a score reflecting the number of independent board members (in percentage of the Board). The two following variables are not listed as they do not provide any additional econometric information, for the selected companies and the time period considered : independent reporting score (dummy variable) representing the presence within the company of an independent reporting system and the board cultural diversity which is a percentage of board members that have a cultural background different from the location of the corporate headquarters.

4.3 Dataset: STOXX Europe 600 Index

After selecting the variables, we search for the most the appropriate set of data. We choose the STOXX Europe 600 Index as it is a comprehensive European country- and industry-diversified index. Indeed, this index covers 600 small, medium and large capitalisations among 17 countries in Europe and covers around 90% of underlying investible market (using free-float capitalisation weights). Furthermore, it is not limited to the Eurozone. All companies selected from the STOXX Europe 600 are listed in appendix 2 tables B.1 to B.3.

Furthermore, we selected six super-sectors which mimic the closest possible what the Intergovernmental Panel for Climate Change (IPCC, Climate Change 2023: Synthesis report, p. 5) evaluates to be the five most polluting sectors globally: energy, industry, transport and building. These six super-sectors are in bold in the table below constitute of automotive and parts, Chemicals, Construction and materials, oil and gas, real estate and utilities. These six super-sectors encompass 135 possible companies or 22.5% of the total number of companies in the index for a total weight of 22%. This makes for an evenly weighted set of companies in comparison to the index total weight.

Having extracted the maximum of variables possible on the largest timespan available from Refinitiv Eikon Datastream, it appeared to us that the optimal time period for this study in terms of data availability is from 2008 to 2021, which accounts for missing values. The end-data consist of 108 companies out of 135 possible which gives a relatively balanced panel with some occasional missing values for the two first years and for the last year.

As comparison variables, we selected the top 40 biggest capitalisations of the index which all come from sectors outside the already selected, see appendix A2 table B4.

Table 4.5: List of STOXX Europe 600 super-sectors

Super-sectors	Number of companies	Weight
Automobiles & Parts	16	3%
Banks	47	12%
Basic Resources	17	2%
Chemicals	26	5%
Construction & Materials	19	3%
Financial Services	31	2%
Food & Beverage	22	8%
Health Care	40	12%
Industrial Goods & Services	110	11%
Insurance	35	6%
Media	29	3%
Oil & Gas	22	5%
Personal & Household Goods	34	9%
Real Estate	26	2%
Retail	31	3%
Technology	22	4%
Telecommunications	23	5%
Travel & Leisure	24	2%
Utilities	26	4%
Total	600	100%

Source : Refinitiv Eikon Datastream

5 | Variables analysis

In this section, we detail and comment the principal variables of the econometric model developed to answer the research questions. First, we perform a descriptive statistical analysis of the variables then we compute and describe the unconditional correlation matrix of the variables.

5.1 Descriptive statistics

5.1.1 Endogenous variable

The table below summarises the main descriptive statistics for the dependent variables. The main takeaway from the results are the mean and median which are less than a standard deviation apart from one another which shows that the set of companies are homogeneously distributed. Second, we observe some minimum scores which are very low and maximum scores which are nearly to 100 across all variables which denotes a wide range of results. This is confirmed by the relatively high standard deviation around 20% across all variables.

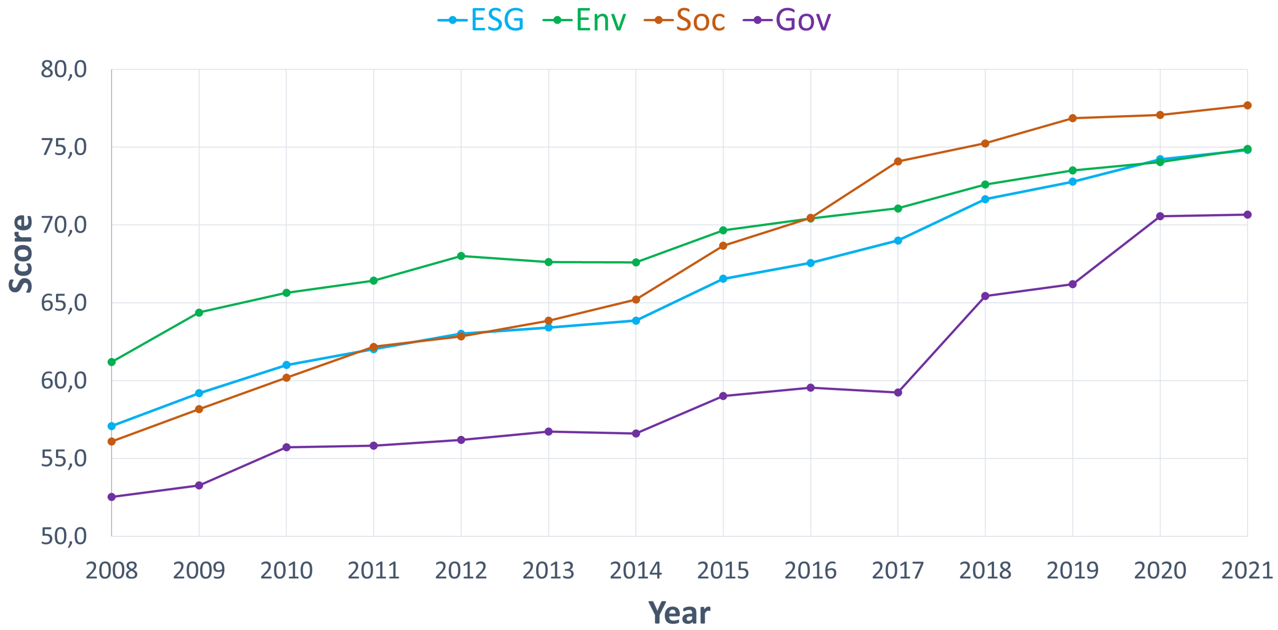
Table 5.1: Descriptive statistics of the endogenous variables of the selected companies of the STOXX Europe 600 Index from 2008 to 2021 (%)

	Mean	**Median**	**Std**	**Min**	**Max**
ESG Score	66,20	69,70	17,16	3,91	94,40
ESG Combined Score	61,49	63,58	16,79	3,91	93,16
Controversies	82,61	100,0	29,81	0,81	100,0
Environmental Score	69,12	74,13	21,60	0	98,88
Social Score	67,82	72,65	20,93	2,60	97,47
Governance Score	59,86	62,96	21,42	4,63	98,14

Source : Refinitiv Eikon Datastream

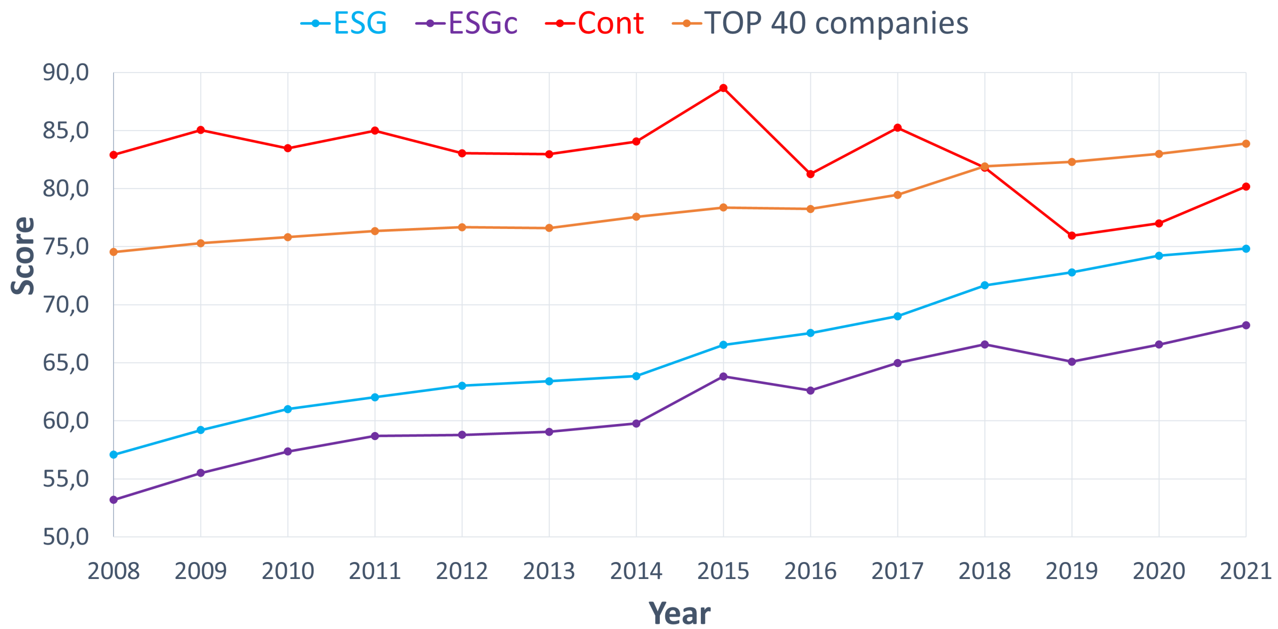
Figure 5.1 illustrates the governance pillar is the clear laggard of the three ESG pillars. Nevertheless, we observe a clear increasing trend for all scores and, as of 2016, the social pillar is better on average than the environmental pillar. One should keep in mind, that these scores are the result of discrete categories and are by no means an exhaustive depiction of reality. It only depicts that according to the selected categories, themes and measurement methods, companies as a whole improved what was necessary to increase their ESG scores.

Figure 5.1: Evolution of the average ESG and pillars scores of the selected companies of the STOXX Europe 600 Index from 2008 to 2021 (%)



Source : Refinitiv Eikon Datastream

Figure 5.2: Evolution of the average ESG, controversies and combined scores of the selected and top 40 companies of the STOXX Europe 600 Index from 2008 to 2021



Source : Refinitiv Eikon Datastream

As shown in figure 5.2, the controversies score is the only score which in average is not constantly increasing but dropped as of 2015 to go up again as of 2019. As a reminder, one must read the controversies score the other way around with 100 being the absence of controversies. The ESG combined score is also rising, which means that on average, companies have lower controversies on average. This is further confirmed by the median controversies of 100. Furthermore is included the average ESG score of the selected top 40 companies outside the already selected super-sectors. Their ESG score is significantly higher than the one of the most carbon-intensive sectors.

Table 5.2 shows the descriptive statistics of the ESG scores of the top 40 companies of the STOXX Europe 600 Index excluding the already selected super-sectors, see appendix 2 B.4. On the one hand, we observe a clear increase in the mean ESG score in comparison to carbon-intensive companies, 78,57 instead of 66,20, as well as in between all three pillar scores. On the other hand, the number of controversies increased with a mean ESG controversies score of 56,90 instead of 82,61. Nevertheless, the ESG combined score is still on average higher, 64,28 instead of 61,49. The type of sector is a plausible explanation but so is the size of the company which is, according to LSEG Data % Analytics, one of the main driver of controversies. Nevertheless, the ESG combined score should correct for the size which seems to be the case regarding the average ESGc computed.

It is also worth noting that the standard deviation is decreasing and that the median is more consistently matching the mean of the panel. The maxima are similar but the minima defer with a minimum ESG score of 3,91 in the studied panel instead of 43,07 in the top 40 companies. This trend is reflected in the three pillar scores minima which are much higher. In conclusion, the super-sectors selected have statistically significantly lower ESG scores than the top 40 companies from other super-sectors which is consistent with the goal of the constituted panel for this study which is to study the most carbon-intensive companies which should be the one with the lowest ESG scores.

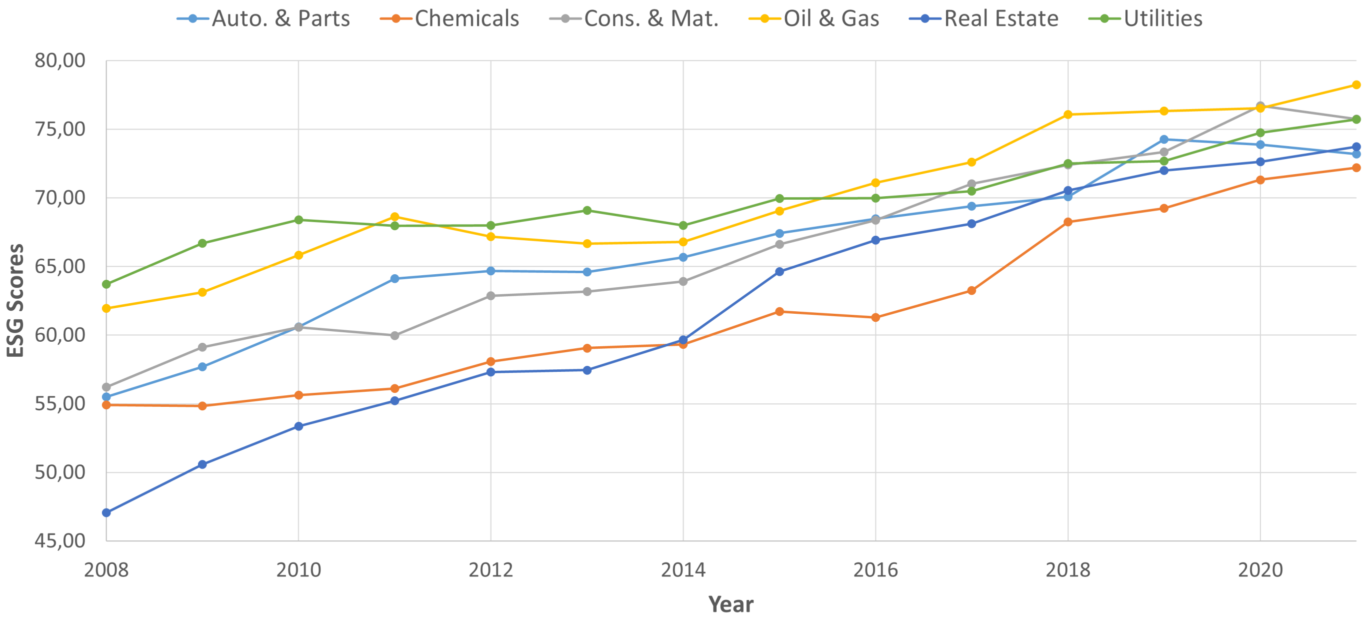
Table 5.2: Descriptive statistics of the ESG scores of the top 40 companies excluding the carbon intensive super-sector of the STOXX Europe 600 Index from 2008 to 2021

	Mean	**Median**	**Std**	**Min**	**Max**
ESG Score	78,57	81,08	10,39	43,07	95,72
ESG Combined Score	64,28	64,25	15,23	27,28	95,10
Controversies	56,90	64,10	35,23	0,74	100,0
Environmental Score	82,75	85,52	12,91	33,53	99,14
Social Score	81,43	84,42	12,60	30,58	98,19
Governance Score	72,03	74,69	17,44	11,84	98,27

Source : Refinitiv Eikon Datastream

Figure 5.3 shows the evolution of the ESG score of the selected companies from the most carbon-intensive super-sectors. The real estate sector is the clear laggard in 2008 but all converge to an average of 75 in 2021. At the end of the time period, the chemical sector has the lowest average score and, surprisingly, the oil and gas sector has the highest average score.

Figure 5.3: Evolution of the average ESG score of the selected companies of the STOXX Europe 600 Index per super-sector from 2008 to 2021



Source : Refinitiv Eikon Datastream

5.1.2 Exogenous variables

5.1.2.1 Price of carbon

As described in the literature review, the price of carbon is increasing since the inception of the EU ETS in 2008. Table 5.3 describes the prices of carbon used in the study. These are the average yearly spot and future prices of 1000 carbon EUA contracts from 2008 to 2021. We observe a low degree of discrepancy between the mean and the median which indicates that on a yearly basis, the difference in price is relatively low. Whereas the standard deviation for the whole panel is quite high which is normal considering the steep increase in carbon price. This can be further observed in figure 5., where we observe a steep increase in carbon prices at the end of 2021 and reaching a maximum at end of 2022.

Table 5.3: Descriptive statistics of the average yearly spot and future prices of carbon from 2008 to 2021 (€)

	Mean	**Median**	**Std**	**Min**	**Max**
Spot price	15,99	15,22	12,42	4,51	53,44
Future price	17,54	16,59	13,21	5,36	56,64

Source : Refinitiv Eikon Datastream

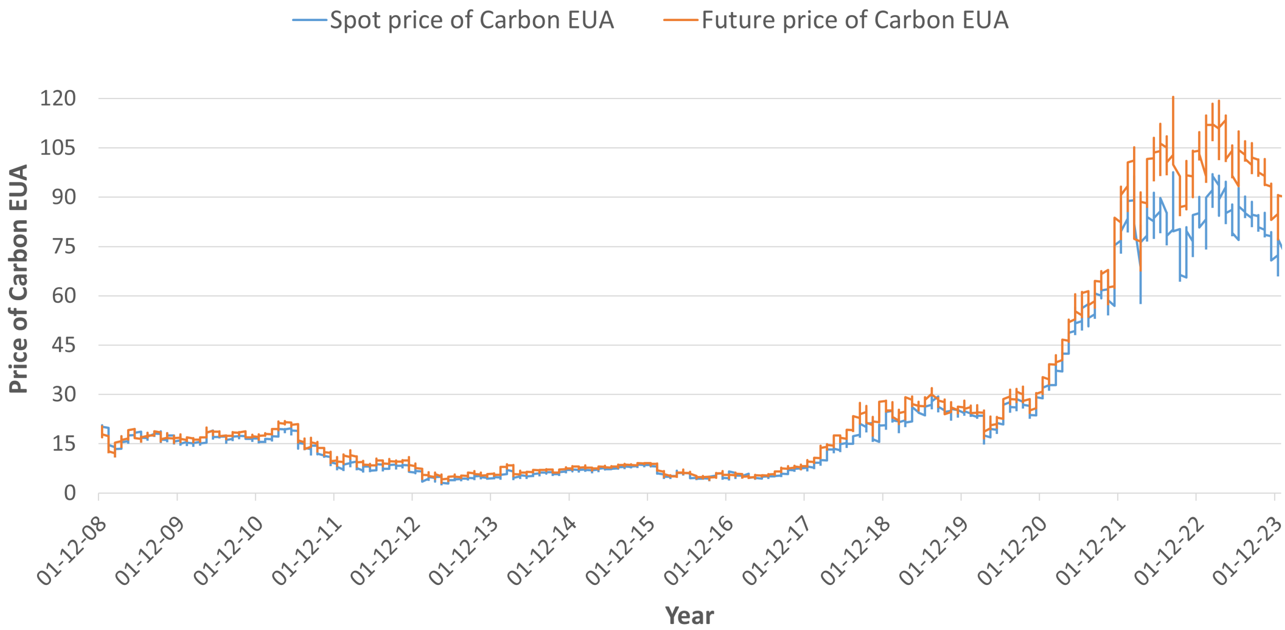
Table 5.4 shows the descriptive statistics of the average intra-year spot and future price of carbon from 2008 to 2021. We observe a rise in the price but also in the standard deviation which denotes a rise in the volatility of carbon prices beginning in 2021. This corresponds with the fourth phase of the carbon EU ETS in January 2021. This goes hand in hand with the increase in carbon price as shown by figure 5.3 which gives the evolution of the monthly spot and future price of carbon EUA from 2008 to 2023.

Table 5.4: Descriptive statistics of the intra-year spot and future prices of carbon from 2008 to 2021 (€)

Spot	**Mean**	**Med**	**Std**	**Min**	**Max**	**Future**	**Mean**	**Med**	**Std**	**Min**	**Max**
2008	20,0	20,1	0,5	18,6	20,6	**2008**	25,8	26,3	3,9	16,4	34,4
2009	16,6	16,8	1,7	11,3	19,8	**2009**	16,6	16,8	1,6	11,3	19,8
2010	16,5	16,6	0,9	14,5	19,0	**2010**	17,4	17,4	0,9	15,4	19,9
2011	14,8	14,9	3,4	7,4	19,7	**2011**	16,6	16,8	3,7	8,5	21,9
2012	7,9	7,9	0,8	6,0	10,3	**2012**	9,5	9,4	1,1	7,1	13,0
2013	4,5	4,5	0,7	2,8	6,7	**2013**	5,4	5,3	0,8	3,3	8,0
2014	5,9	6,0	0,7	4,4	7,2	**2014**	6,9	6,8	0,7	5,3	8,8
2015	7,7	7,6	0,6	6,4	8,7	**2015**	8,3	8,2	0,5	7,0	9,2
2016	5,3	5,3	0,8	3,9	8,1	**2016**	5,6	5,5	0,8	4,1	8,7
2017	5,8	5,3	1,1	4,4	8,2	**2017**	6,2	5,7	1,2	4,6	8,6
2018	15,7	15,9	4,4	7,6	25,2	**2018**	17,6	17,4	5,4	8,1	28,0
2019	24,8	25,1	2,2	18,7	29,8	**2019**	26,6	26,6	2,0	21,0	31,9
2020	24,8	25,0	3,6	15,2	33,3	**2020**	26,4	26,5	3,7	16,9	35,1
2021	53,4	53,4	12,7	31,5	88,9	**2021**	56,6	57,0	13,4	32,8	93,2

Source : Refinitiv Eikon Datastream

Figure 5.4: Evolution of the monthly spot and future price of carbon EUA from 2008 to 2023 (€)



Source : Refinitiv Eikon Datastream

5.1.2.2 Economic control variables

The descriptive statistics of the economic control variables are shown in table 5.5, they reflect the great diversity of the STOXX Europe 600 Index. We can observe an important standard deviation and minima and maxima miles apart from each other. This denotes the pertinence of this index in assessing the ESG performance of companies form various size and sectors all over Europe. For the rest of this study, we use the natural logarithm of the market values, total assets and total liabilities. In order to use the same scale for the operating income, which can be negative, we use the natural logarithm of the value in million of dollars plus one, $ln(1 + OI/10^6)$.

Table 5.5: Descriptive statistics of the exogenous control variables of the selected companies of the STOXX Europe 600 Index from 2008 to 2021

	Mean	**Median**	**Std**	**Min**	**Max**
Market Value (M€)	18910	7340	42450	176	80659
Total Assets (M€)	53,6	15,1	119,1	0,21	1241,0
Total Liabilities (M€)	35,1	9,0	79,9	0,45	1009,40
Operating Income (M€)	3,4	0,7	15,0	-12,5	282,9
Leverage	2.43	1,64	7,17	0,91	126,2
Return on Asset	5,0	4,5	6,5	-38,32	66,95
Asset Turnover	0,67	0,60	0,55	0,01	4,00

Source : Refinitiv Eikon Datastream

5.1.2.3 ESG actions control variables

We observe in table 5.6 that for all actions scores, the standard deviation is high which is correlated with the minimum scores of zero and the maximum of nearly 100. This illustrates that companies vary greatly in their involvement towards contribution to the environmental and governance pillar according to LSEG's scope and measurements. Nevertheless, on average, both environmental innovation and management scores increase during the studied period as illustrated by figure 5.4. This is in line with what we observe previously with the increase in various ESG scores which should be confirmed by the two subsidiary research questions.

The environmental management team variable is a dummy which means that it is equal to 1 if the company has a dedicated team and 0 otherwise. Thus the average of this variable for each year gives us the percentage of company having said team. On average, 80% of companies have a dedicated team but the standard deviation is high denoting a great variation within the panel. These discrepancies are both between companies and between time periods as illustrated in figure 5.5 where we observe an important decrease during the period from 2015 to 2019.

In terms of independent board members, the mean and the median are the same at 57% which is roughly what is observed in figure 5.5. The variance is around 50% of the mean but this difference is between companies rather than between years. It should be noted that there are several companies and years when the value of the action variables were missing this means that in reality these numbers are, conservatively, lower than illustrated.

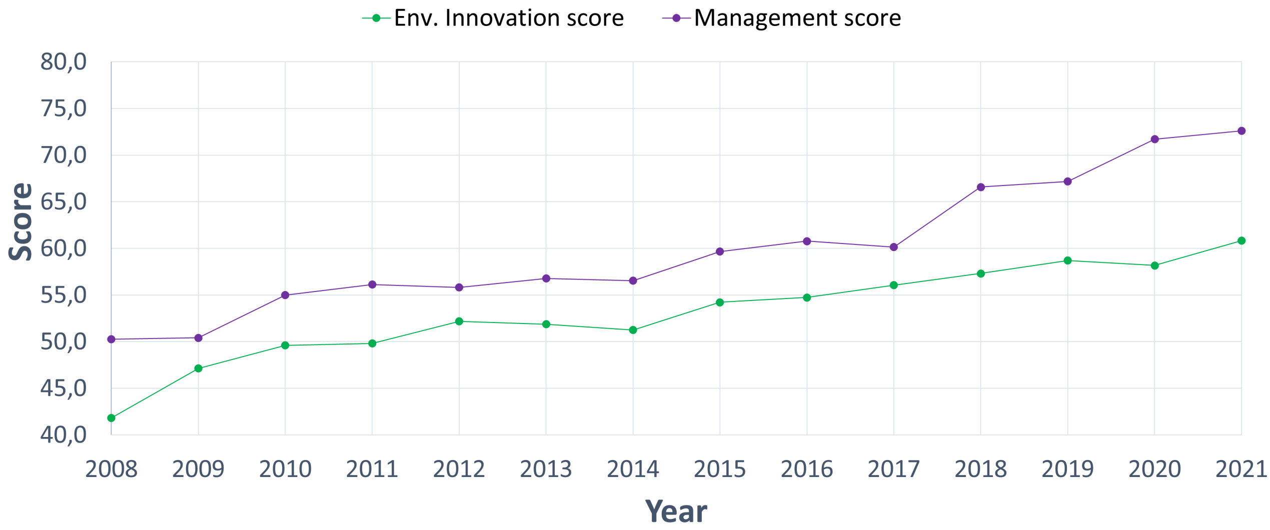
Table 5.6: Descriptive statistics of the ESG actions scores of the selected companies of the STOXX Europe 600 Index from 2008 to 2021 (%)

	Mean	**Median**	**Std**	**Min**	**Max**
Env. Innovation Score	53,14	57,65	33,28	0,00	99,79
Env. Mgt. Team	79,65	100,00	40,28	0,00	100,00
Management Score	59,97	65,12	28,31	0,00	99,88
Ind. board members	57,97	57,14	24,69	0,00	100,00

Source : Refinitiv Eikon Datastream

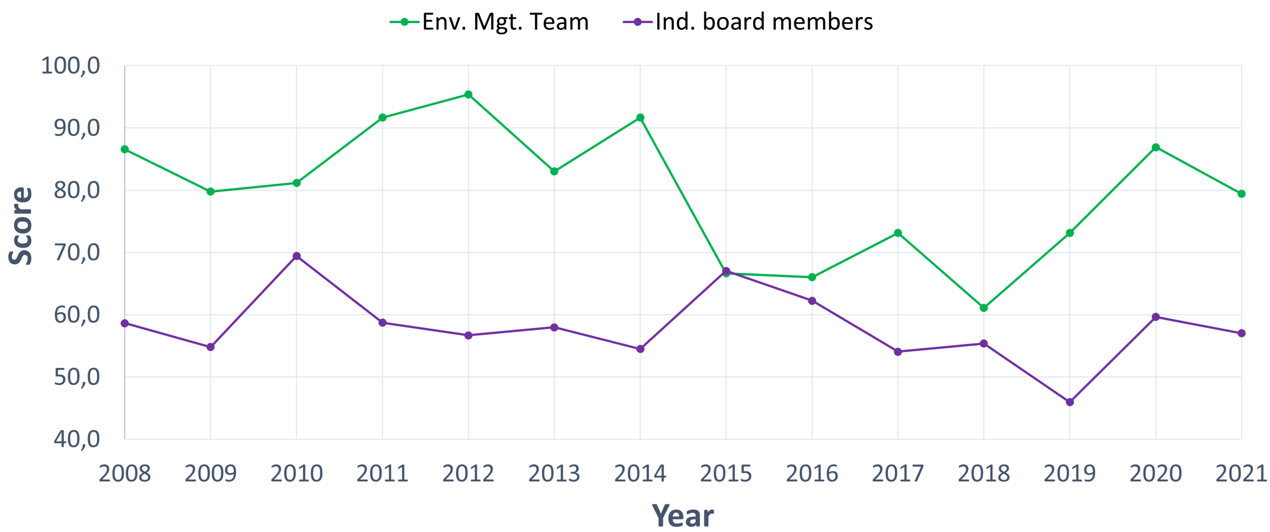
Analysing figure 5.5, we observe a monotonous increase in the percentage of environmental innovation and the same can be aid for the management score. This is consistent with literature findings considering that ESG should encompass all pillars in a holistic approach towards ESG topics. Considering figure 5.6, we notice the variations in the average presence of environmental management teams with a decrease between 2015 and 2018. For the independent board members, despite the slight variations, the yearly average is around the overall average fo 58%.

Figure 5.5: Evolution of the average environmental innovation and management scores of the selected companies of the STOXX Europe 600 Index from 2008 to 2021



Source : Refinitiv Eikon Datastream

Figure 5.6: Evolution of the average environmental management teams and independent board members from the selected companies of the STOXX Europe 600 Index from 2008 to 2021



Source : Refinitiv Eikon Datastream

5.2 Unconditional correlations

The unconditional correlation is the correlation which can exist between two variables without taking any other variable into account. It gives an overview of the way two variables move each one according to the other *ceteris paribus*. Table 5.7 below shows the global unconditional correlation matrix of all endogenous and exogenous variables used in the econometric regressions.

We observe strong correlation between both ESG scores and the three ESG pillars which was already visible in figure 5.1 as all variables increase over time. What is most interesting is the low and even negative correlation between the ESG controversies score and the ESG score which is negative which can be explained by the fact that as of 2015 when ESG scores were high and still increasing the ESG controversies were decreasing. The combination of both phenomenons explain the negative correlation. Lastly, there is a correlation between the environmental pillar and the social pillar but the correlation between these two pillars with the governance pillar is weaker. Regarding the environmental innovation score and the management score, the correlations are high respectively with the environmental pillar and the governance pillar which was expected.

The economic variables on the other side are poorly or even negatively correlated with the various ESG indicators. Given the low level of correlation, it seems necessary to rely on the econometric regressions to obtain more information on the link that may exist.

Table 5.7: Unconditional correlation matrix

ESG	ESGc	Cont	Env	Soc	Gov	Inov	Mgt	l_MV	l_TA	l_TL	Lev	ROA	ATO	Spot	Fut	
100%	80%	-23%	85%	87%	65%	49%	58%	46%	46%	49%	-26%	-21%	-4%	15%	14%	**ESG**
	100%	34%	70%	69%	51%	34%	45%	22%	19%	23%	-24%	-11%	-7%	10%	9%	**ESGc**
		100%	-17%	-22%	-16%	-18%	-15%	-36%	-43%	-40%	-7%	17%	-6%	-5%	-5%	**Cont**
			100%	63%	31%	68%	23%	39%	41%	44%	-24%	-20%	-7%	8%	7%	**Env**
				100%	41%	27%	35%	40%	41%	44%	-24%	-18%	-4%	14%	13%	**Soc**
					100%	15%	96%	28%	25%	25%	-11%	-10%	0%	17%	16%	**Gov**
						100%	12%	31%	35%	34%	-12%	-6%	4%	6%	5%	**Inov**
							100%	27%	23%	22%	-6%	-6%	-2%	13%	12%	**Mgt**
								100%	80%	76%	-3%	2%	-4%	3%	2%	**l_MV**
									100%	97%	-2%	-23%	-10%	5%	5%	**l_TA**
										100%	-22%	-27%	-4%	5%	5%	**l_TL**
											100%	9%	-10%	2%	2%	**Lev**
												100%	16%	-6%	-5%	**ROA**
													100%	-7%	-6%	**ATO**
														100%	100%	**Spot**
															100%	**Fut**

Source : Author

6 | Models and regressions

In this section, we describe the different econometric methods and models developed to answer the research questions. The first part is dedicated to the methodology used while the second presents the different results. In each of these models, we study the impact of several exogenous or independent variables on an endogenous or dependent variable.

6.1 Methodology

The methodological approach follows Zhang et al. (2023) who study a panel of Chinese A-share listed companies in Shanghai and Shenzhen from 2011 to 2019. The authors analyse the impact of the introduction of carbon emission trading policy on the ESG performance of these companies using Bloomberg ESG score data.

The methodology is threefold, first we perform some preliminary regressions in order to observe if the spot and future prices of carbon can explain some variations of ESG performance of the selected companies. These univariate regressions are performed on the ESG, ESG combined and three pillars scores. They are the fundamental benchmarks of the analysis and are done for contemporary and lagged prices of carbon in order to measure if the price of carbon at the previous period can influence the contemporary ESG scores.

Second, we add the economic control variables in order to control for various economic factors which may influence the ESG performance. These regressions are done on the ESG and ESGc scores by using the most relevant price of carbon found during the preliminary regressions. The price of carbon is again lagged in order to account for inter-temporal influence of carbon price.

Third , we complete the multivariate model with the addition of the environmental action variables, the percentage of green innovation and the presence of environmental management teams, and the managerial action variables, the management score and the percentage of independent board members. The addition of these ESG factors should add some granularity to the regressions and permit to answer the two subsidiary research questions.

6.1.1 Fixed effects model

We work on panel of data from 108 companies on 14 years which means a panel of a maximum of 1512 single observations, which is reduced to 1481 observations accounting for missing values in ESG scores. The most appropriate model for this type of analysis is a fixed effect model. The results of Hausman test for panel data permits to reject the null hypothesis which states that the constants of each company or year is zero throughout the time period studied at the statistical significance threshold of 1%. The alternative hypothesis is that there exist some characteristic fixed constants for each companies throughout this time period, called fixed effects. These results leads to the use of a fixed effects model instead of random effects or stacked ordinary least squares model.

In other words, the company fixed effects are linked to idiosyncratic characteristics of the firm for instance its business model, its risk appetite or the way it values ESG as being material to its value chain. The year fixed effects reflect the way each year is specific compared to the previous and subsequent ones, which encompasses the customer's tastes for ESG, climate related news, changes in regulation, etc.

Lastly, the explanatory power of a model is given by the R^2, or R-Squared, which measures the amount of variations of the dependent variable which can be explained by the variations of the independent variables. For a fixed effect model, the explanatory power of the regression is also expressed by the R^2_{intra}, or R2 within, which means the R-Squared cleaned from the fixed effects on variability.

6.1.2 Econometric regressions interpretations

The interpretation of the econometric results displayed depends on the scale of the variables used in the regression which can both take either a level value or a logarithmic value. In other words, the endogenous variable on the one side of the regression and the exogenous variables on the other side can display either a level value meaning the raw value or a logarithmic value of the variable. This changes the way one can interpret the results; mathematically this implies studying the partial derivative of the endogenous variable y regarding the exogenous variable considered x_i.

Given the following multivariate regression where y and x_i can be expressed in either form :

$$y = \alpha + \sum_{i=1}^{N} \beta_i.x_i + \epsilon \tag{6.1}$$

Given a level-level regression :

$$\beta_i = \frac{\partial y}{\partial x_i} \tag{6.2}$$

One can interpret the results of the unitary marginal increase of the independent variable x_i as the variation of the dependent variable y of β_i as both variables are on the same numerical level, *ceteris paribus.*

Given a log-log regression :

$$\beta_i = \frac{x_i}{\partial x_i}\frac{\partial y}{y} \tag{6.3}$$

One can interpret the results as an elasticity, the increase in one percentage point of the independent variable x_i leads to the variation of $\beta_i\%$ of the dependent variable y,*ceteris paribus*.

Given a level-log regression :

$$\beta_i = \frac{\Delta y}{\%\Delta x_i} \tag{6.4}$$

One can interpret the results of the increase in one percentage point of the independent variable x_i as the variation of $\frac{\beta_i}{100}$ of the dependent variable y, in other words $\Delta y = \frac{\beta_i}{100}\%\Delta x$, *ceteris paribus*.

Given a log-level regression :

$$\beta_i = \frac{\%\Delta y}{\Delta x_i} \tag{6.5}$$

One can interpret the results of the unitary marginal increase of the independent variable x_i as the variation of of 100 x β_i of the dependent variable variable y, in other words $\%\Delta y = 100\beta_i\Delta x$, *ceteris paribus*.

6.2 Econometric regressions

6.2.1 Preliminary regressions

We start by regressing the ESG scores with the carbon prices taking into account only company fixed effects then we add time fixed effects to observe the impact the years could have on the ESG scores. The, we do the same regressions again but this time lagging the carbon prices by one then two periods to see if the previous prices influence the contemporary ESG scores.

6.2.1.1 Contemporary carbon price

These regressions are of the form :

$$ESG_{it} = \alpha + \beta Price_t + \sum_{n=1}^{N-1} \delta_i D_i + \epsilon_{it} \tag{6.6}$$

One reads this equation as the variations of the ESG_{it} score of company i at time t is explained by a linear combination of the intercept of the fixed effect model, α, the spot or future price of carbon at time t, $Price_t$, the sum of companies fixed effects, $\sum_{n=1}^{N-1} \delta_i D_i$ and an error term, ϵ_{it}.

Table 6.1: Preliminary regressions results, contemporary carbon spot price

	ESG	ESGc	Env	Soc	Gov
Constant	62.90***	59.35***	67.12***	64.44***	55.21***
Spot Price t	0.207***	0.134***	0.125***	0.193***	0.266***
R-squared	0.75	0.61	0.77	0.68	0.60
R2 within	0.08	0.02	0.02	0.05	0.07

Source : Author

Table 6.2: Preliminary regressions results, contemporary carbon future price

	ESG	ESGc	Env	Soc	Gov
Constant	63.08***	59.53***	67.30***	64.44***	55.12***
Future Price t	0.179***	0.112***	0.102***	0.193***	0.266***
R-squared	0.74	0.60	0.77	0.68	0.60
R2 within	0.06	0.01	0.01	0.04	0.06

Source : Author

The preliminary results from the contemporary regressions are all statistically significant at the threshold of 1%. The coefficients of the regressors indicate that a marginal increase in carbon price leads to an increase in all ESG scores. Furthermore, the absolute R-Squared (for the whole panel) is at least 60% and goes up to 75%, which means that at raw value the variations of the price of carbon are able to explain at least 60% of the variations of the ESG scores across the whole panel.

Nevertheless, the R2 within a certain company is only a few percent which means that variations of the price of carbon explains poorly the ESG score of a company across all time periods. In other words, for a certain company, the price of carbon explains only a fraction of the variations of the ESG scores across for all time periods.

6.2.1.1.1 Accounting for time fixed effects

These regressions are of the form :

$$ESG_{it} = \alpha + \beta Price_t + \sum_{n=1}^{N-1} \delta_i D_i + \sum_{y=1}^{Y-1} \delta_i' T_i + \epsilon_{it} \tag{6.7}$$

One reads this equation the same way as previously with the addition of the sum of year fixed effects, $\sum_{y=1}^{Y-1} \delta_i' T_i$ which account for a year by year specific fixed effect.

Accounting for year fixed effects, the regressors stay statistically significant at the threshold of 1%. Furthermore, we observe that the coefficients of the regressors are greater than previously which means that the marginal increase in carbon price has a more important impact on the ESG score than previously observed without taking into account the influence of the year fixed effects. To conclude, this means that each year is different from the other and has embedded specific characteristics which is reflected in the sharp increase in R2 within.

Table 6.3: Preliminary regressions results, contemporary carbon spot price

	ESG	ESGc	Env	Soc	Gov
Constant	44.91***	43.09**	50.57***	41.87***	41.03***
Spot Price t	0.563***	0.472***	0.463***	0.672***	0.557***
R-Squared	0.83	0.67	0.80	0.79	0.65
R2 within	0.40	0.18	0.16	0.38	0.17

Source : Author

Table 6.4: Preliminary regressions results, contemporary carbon future price

	ESG	ESGc	Env	Soc	Gov
Constant	40.40***	39.31***	46.87***	36.49***	36.57***
Future Price t	0.611***	0.512***	0.502***	0.729***	0.604***
R-Squared	0.83	0.67	0.80	0.79	0.65
R2 within	0.40	0.18	0.16	0.38	0.17

Source : Author

6.2.1.2 Lagged carbon price

These regressions are of the form :

$$ESG_{it} = \alpha + \beta Price_{t-1} + \sum_{n=1}^{N-1} \delta_i D_i + \epsilon_{it} \tag{6.8}$$

One reads this equation as the variations of the ESG_{it} score of company i at time t is explained by a linear combination of the intercept of the fixed effect model, α, the spot or future price of carbon at the previous period $t-1$, $Price_{t-1}$, the sum of companies fixed effects, $\sum_{n=1}^{N-1} \delta_i D_i$, and an error term, ϵ_{it}.

Table 6.5: Preliminary regressions results, lagged carbon spot price

	ESG	ESGc	Env	Soc	Gov
Constant	65.14***	61.79***	68.79***	67.79***	56.27***
Spot Price $t-1$	0.132***	0.023***	0.068***	0.067***	0.316***
R-squared	0.75	0.61	0.79	0.68	0.61
R2 within	0.01	0.001	0.001	0.002	0.02

Source : Author

Table 6.6: Preliminary regressions results, lagged carbon future price

	ESG	ESGc	Env	Soc	Gov
Constant	65.79***	62.33**	69.27***	68.59***	56.95***
Future Price $t-1$	0.074***	-0.015	0.029	0.005	0.237***
R-squared	0.75	0.61	0.79	0.68	0.61
R2 within	0.04	0.00	0.00	0.00	0.02

Source : Author

Considering the lagged spot price of carbon, we observe that all coefficients remain positive and statistically significant at the threshold of 1%. Nonetheless, their intensity is greatly reduced from the contemporary regression. Even if the R-squared decreases slightly, the R2 within decreases such that it becomes nearly negligible.

For a lagged future price of carbon, we notice that the price of the previous year influences positively the actual ESG score and governance score but not the environmental or social scores. We note the same decrease in R-Squared and R2 within denoting the decrease in explanatory power of the regressor. As for the coefficients of the regressors, they decrease in intensity which means that the ESG score at time t is less prone to an increase as a consequence of the marginal increase in carbon spot or future price a $t-1$, *ceteris paribus*.

6.2.1.2.1 Accounting for time fixed effects

These regressions are of the form :

$$ESG_{it} = \alpha + \beta Price_t + \beta' Price_{t-1} + \sum_{n=1}^{N-1} \delta_i D_i + \sum_{y=1}^{Y-1} \delta_i' T_i + \epsilon_{it} \tag{6.9}$$

One reads this equation the same way as previously with the addition of the lagged price of carbon considered and the sum of year fixed effects, $\sum_{y=1}^{Y-1} \delta_i' T_i$ which account for each year's specific fixed effects.

Table 6.7: Preliminary regressions results, lagged carbon spot price

	ESG	ESGc	Env	Soc	Gov
Constant	69.63***	61.07***	71.54***	75.85***	58.47***
Spot Price $t-1$	0.176*	0.173	0.084	0.041	0.48***
R-Squared	0.84	0.67	0.82	0.79	0.67
R2 within	0.37	0.15	0.13	0.35	0.17

Source : Author

Table 6.8: Preliminary regressions results, lagged carbon future price

	ESG	ESGc	Env	Soc	Gov
Constant	69.20***	60.63***	71.32***	75.74***	57.33***
Future Price $t-1$	0.179*	0.176	0.085	0.042	0.49***
R-Squared	0.84	0.67	0.82	0.79	0.67
R2 within	0.37	0.15	0.13	0.35	0.17

Source : Author

Accounting for year fixed effects, both set of regressions display statistically significant regressors at the threshold of 1% which denotes from the lagged regressions without year fixed effects. Moreover, we observe the same increase in R2 within as for the contemporary price of carbon regressions.

6.2.1.3 Conclusion

The preliminary regressions confirm that their exists a statistically significant relation between the spot and future prices of carbon within the carbon EU ETS and the ESG scores of the most carbon-intensive companies of the STOXX Europe 600 Index. One could conclude first that the spot price has more explanatory power than the carbon future price, the maximum yearly spot price or the maximum yearly future price which were all tested during this study. This implies that the carbon spot price is now the reference price which is in line with the literature on carbon pricing. Second, that this relation diminishes in the intensity with time. The exercise was done for a two-periods-lagged regression and were not statistically significant; for the rest of the study we only keep a one-lagged carbon price.

6.2.2 Econometric regressions with economic control variables

6.2.2.1 Contemporary spot price of carbon

This regression is of the form :

$$ESG_{it} = \alpha + \beta_1 ln(MV_t) + \beta_2 ln(TA_t) + \beta_3 ln(TL_t) + \beta_4 ln(1 + OI_t/10^6) + \beta_5 Lev_t + \beta_6 ROA_t + \beta_7 ATO_t + \beta_8 Spot_t + \sum_{n=1}^{N-1} \delta_i D_i + \left(\sum_{y=1}^{Y-1} \delta_i' T_i \right) + \epsilon_{it} \quad (6.10)$$

With MV the market value of the firm, TA the total assets, TL the total liabilities, OI the operating incomes, Lev the leverage, ROA the return on total assets, ATO the asset turnover, the spot of carbon, $\sum_{n=1}^{N-1} \delta_i D_i$ the firms fixed effects as well as $\sum_{y=1}^{Y-1} \delta_i' T_i$ the year fixed effects and ϵ_{it} the error term. As explained in a previous section, we consider the logarithmic values of the economic variables as mentioned in 6.10.

Table 6.9: Results of the econometric regression with economic control variables, contemporary spot price of carbon

	ESG	**ESG**	**ESGc**	**ESGc**
Constant	-119.72***	-0.16	-94.16***	-2.79
l_MV	3.04***	0.95*	3.81***	2.28***
l_TA	16.26***	6.05***	12.97**	4.94*
l_TL	-6.97***	-3.94***	-5.87***	-3.42*
l_OI	0.49	2.14***	0.52	1.75**
Lev	-0.32***	-0.30***	-0.28***	-0.27***
ROA	-0.18***	-0.08**	-0.05	0.002
ATO	-1.84	0.93	-1.99	0.05
Spot Price t	0.145***	0.512***	0.085***	0.407***
R-Squared	0.80	0.85	0.66	0.69
R2 within	0.29	0.44	0.15	0.22
Firm FE	YES	YES	YES	YES
Year FE	NO	YES	NO	YES

Source : Author

First of all, we compare the results of the first two columns with the results of Zhang et al (2023). The economic control variables are statistically significant except for the contemporary operating incomes and both asset turnovers. The rest of the control variables are statistically significant at the threshold of 1%. Consistently with what Zhang et al. find, size matters in terms of ESG score and companies with higher market value (l_MV) and total assets (l_TA) have better overall ESG scores. On the same line, total liabilities (l_TL) and leverage (Lev) are both correlated with lower ESG scores which is explained by the fact that companies with higher leverage lose a certain ability to finance themselves thus impacting negatively the ESG score of the firm.

Contrary to the studied Chinese companies, the ESG scores of European companies is statistically positively correlated with the operating incomes (l_OI) when accounting for both fixed effects. The other discrepancy is that the return on assets (ROA) is negatively correlated with the ESG score which is contrary to what is found by Zhang et al. (2013). Their conclusion is that companies with better profitability have better ESG score which seems to not be the case for the selected firms. One can explain that by assuming that higher profitability comes with cutting corners in certain areas thus penalising the overall ESG score. As for the spot price of carbon, it remains statistically positively correlated with the dependent variable meaning that increasing the carbon spot price drives the companies towards higher ESG scores, *ceteris paribus*. As observed in the preliminary regressions, the addition of year fixed effects increases the R-Squared and the R2 within, thus the explanatory power of the model.

The ESG combined scores are also statistically significantly correlated with the economic control variables except for the return on assets which significance disappears. The ESG combined score is less correlated because of its construction but the conclusions remains the same.

In terms of robustness of the results, following Cottrell and Lucchetti (2024), we perform the Arellano heteroscedasticity autocorrelation consistency test (HAC) to ensure no heteroscedasticity (which means that the variance of the error term is independent of the cross-sectional unit), no autocorrelation (which means that the covariance of the error term with its lagged value is zero in each time period) and for panel data that the between variation is removed (which means that the mean error of unit i is equal to the mean error of unit j). The results of the spot price is robust and remains statistically significant at the threshold of 1% but the other variables loose their significance.

6.2.2.2 Lagged spot price of carbon

This regression is of the form :

$$\begin{aligned}ESG_{it} = \alpha + \beta_1 ln(MV_t) + \beta_2 ln(TA_t) + \beta_3 ln(TL_t) + \beta_4 ln(1 + OI_t/10^6) + \beta_5 Lev_t \\ + \beta_6 ROA_t + \beta_7 ATO_t + \beta_8 Spot_t + \beta_8' Spot_{t-1} + \sum_{n=1}^{N-1} \delta_i D_i + \left(\sum_{y=1}^{Y-1} \delta_i' T_i \right) + \epsilon_{it} \quad (6.11)\end{aligned}$$

The addition of the economic control variables to the lagged price of carbon do not provide more insight to the mechanism than the previous regressions. The fist and fourth columns provide the same explanatory power than the contemporary regressions and the lagged spot price is, for the ESG score, of the same order of magnitude while loosing its statistically significance for the ESG combined score.

Table 6.10: Results of the econometric regression with economic control variables, lagged spot price of carbon

	ESG	**ESG**	**ESG**	**ESGc**	**ESGc**	**ESGc**
Constant	-131.41***	-74.01***	24.71	-100.38***	-55.74***	5.10
l_MV	2.38***	2.27***	0.34	3.33***	3.24***	1.97**
l_TA	16.24***	13.08***	6.96***	12.43***	9.98***	5.97**
l_TL	-5.77***	-6.01***	-4.79***	-4.58**	-4.77**	-4.05*
l_OI	1.14*	1.02*	2.37***	1.31*	1.21	2.17***
Lev	-0.24***	-0.28***	-0.30***	-0.22**	-0.24***	-0.26***
ROA	-0.20***	-0.22***	-0.10**	-0.07	-0.09	-0.01
ATO	-2.98**	-1.64	0.76	-2.56	-1.51	0.09
Spot Price t		0.282***	-0.005		0.219***	0.030
Spot Price $t-1$	0.119***	-0.262***	0.266**	0.029	-0.267***	0.303*
R-Squared	0.80	0.82	0.85	0.66	0.67	0.68
R2 within	0.24	0.30	0.42	0.12	0.14	0.19
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	YES	NO	NO	YES

Source : Author

The second and fifth columns considering both prices, in a kind of arbitrage situation where companies could find themselves, are inconclusive as their intensity are similar but carry an opposite sign which means that the overall effect depends on the delta between prices. This means that a continuous increase of carbon price would favour the contemporary rather than the lagged price thus increasing the ESG scores. Accounting for year fixed effects, the third and sixth columns illustrate that given the previous and current prices of carbon, the effect of the lagged carbon price is dominant in respect to the current spot price. Which means that statistically, companies take action by watching at the previous price of carbon rather than the actual one, when regarding each year of the given period separately, though the statistical significance is lower (respectively 5% and 10%).

6.2.2.3 Econometric regressions on the pillar scores

This regression is of the form :

$$Pillar_{it} = \alpha + \beta_1 ln(MV_t) + \beta_2 ln(TA_t) + \beta_3 ln(TL_t) + \beta_4 ln(1 + OI_t/10^6) + \beta_5 Lev_t + \beta_6 ROA_t + \beta_7 ATO_t + \beta_8 Spot_t + \sum_{n=1}^{N-1} \delta_i D_i + \left(\sum_{y=1}^{Y-1} \delta_i' T_i \right) + \epsilon_{it} \quad (6.12)$$

The three pillar scores are regressed on the exogenous variables in order to illustrate that the price of carbon influences all pillar scores and not only the environmental score. The regressions are done for the contemporary price of carbon with and without year fixed effects as they provide the most explanatory power.

Table 6.11: Results of the econometric regression of the various pillar scores without year fixed effects

	ESG	**Env**	**Soc**	**Gov**
Constant	-119.72***	-95.61***	-191.366***	-54.70**
l_MV	3.04***	3.42***	3.74***	1.76*
l_TA	16.26***	12.57***	22.23***	11.93***
l_TL	-6.97***	-4.75**	-8.91***	-6.22***
l_OI	0.49	-0.40	-0.05	2.31**
Lev	-0.32***	-0.53***	-0.33***	0.01
ROA	-0.18***	-0.14***	-0.10*	-0.32***
ATO	-1.84	2.23	-3.78**	-5.24**
Spot Price t	0.145***	0.095***	0.138***	0.225***
R-Squared	0.80	0.81	0.76	0.64
R2 within	0.29	0.16	0.27	0.13
Firm FE	YES	YES	YES	YES
Year FE	NO	NO	NO	NO

Source : Author

Table 6.12: Results of the econometric regression of the various pillar scores with year fixed effects

	ESG	**Env**	**Soc**	**Gov**
Constant	-0.16	-11.44	-35.15*	62.88**
l_MV	0.95*	2.03***	0.98	-0.35
l_TA	6.05***	4.94**	9.10***	2.21
l_TL	-3.94***	-2.35	-5.03**	-3.52
l_OI	2.14***	0.67	2.06***	4.10***
Lev	-0.30***	-0.51***	-0.32***	0.02
ROA	-0.08**	-0.08*	0.03	-0.21***
ATO	0.93	4.06**	0.008	-2.58
Spot Price t	0.512***	0.408***	0.575***	0.567***
R-Squared	0.85	0.82	0.80	0.67
R2 within	0.44	0.22	0.41	0.20
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Source : Author

We notice that all pillar scores are positively statistically significantly correlated with the contemporary spot price of carbon at the threshold of 1%. The increase in intensity of the coefficient is consistent with the reported values of the ESG scores from table 6.9. For the other control variables, the same mechanism is at play than for the ESG scores with a predominance of the size and assets of the company and a penalty for liabilities. The leverage is also statistically negatively correlated with ESG score for the same reasons as prior. These results are consistent with the regression on the overall ESG score. Indeed, the weights we computed for the environmental (around 37%), social (around 36%) and governance (around 27%) pillars give when we aggregated the same coefficient as the one found for the ESG score.

6.2.2.4 Conclusion

In conclusion, the addition of the economic control variables add some explanatory power to the model and information to the mechanism between ESG scores and the spot price of carbon. However, statistically companies seem to favour the contemporary spot price of carbon rather than the lagged price though it still provides useful economic information. Some companies of the panel have access to the EU ETS - see LegiFrance (2021) for the list of French companies which are legally bounded to the European carbon market and *Wallonie Environnement* (2013) for the list for the Walloon region. This means that the price of carbon for the considered period is still too low for these companies to begin to trade for futures or hedge against foreseeable rises in carbon price. This is consistent with the low price of carbon during the three first phases (see figure 5.4).

Moreover, the last regressions on the various pillar scores proves that the carbon-pricing policies act on all pillars and not only on the environmental pillar, even if it carries the most weight. Finally, the ESG combined score reacts the same way as the overall ESG score, which is normal given its construction, but with lower coefficients. Nonetheless, the ESG combined score increases with the rising price of carbon which indicates a lowering of controversies thus lowering reputational risk.

6.2.3 Econometric regressions with environmental action variables

This regression is of the form :

$$\begin{aligned} ESG_{it} = \alpha + \beta_1 ln(MV_t) + \beta_2 ln(TA_t) + \beta_3 ln(TL_t) + \beta_4 ln(1 + OI_t/10^6) + \beta_5 Lev_t \\ + \beta_6 ROA_t + \beta_7 ATO_t + \beta_8 Spot_t + \beta_9 Inov_t + \beta_{10} EMT_t \\ + \sum_{n=1}^{N-1} \delta_i D_i + \left(\sum_{y=1}^{Y-1} \delta_i' T_i \right) + \epsilon_{it} \end{aligned} \quad (6.13)$$

Comparing tables6.9, 6.11 and 6.12 with table 6.13, the addition of the environmental actions variables diminishes marginally the intensity of the spot price coefficient. This means it lowers the overall impact of carbon pricing on the ESG score while remaining statistically significant. Nevertheless, this is counterbalanced by the two new variables

Table 6.13: Results of the econometric regression with environmental action variables

	ESG	**ESG**	**Env**	**Env**
Constant	-105.15***	-4.81	-73.58***	-25.73
l_MV	2.39***	0.88*	2.36***	1.81***
l_TA	16.12***	6.60***	11.45***	6.69**
l_TL	-8.02***	-4.49**	-5.44**	-3.65
l_OI	0.47	1.9.***	-0.22	0.37
Lev	-0.50	-0.07	1.08*	-0.86
ROA	-0.22***	-0.14***	-0.21***	-0.19***
ATO	-2.14*	0.15	1.59	2.39*
Inov	0.143***	0.113***	0.293***	0.379***
EMT	5.688***	4.23***	5.867***	5.112***
Spot Price t	0.114***	0.417***	0.042**	0.203***
R-Squared	0.83	0.86	0.88	0.88
R2 within	0.41	0.51	0.46	0.48
Firm FE	YES	YES	YES	YES
Year FE	NO	YES	NO	YES

Source : Author

which are both statistically significant at the threshold of 1% for all regressions. First, the environmental innovation score is positively correlated with the ESG scores which means that an increase in green innovation within companies pushes the ESG and environmental scores up. Second, the presence of an environmental management team (dummy variable) has a drastic effect on the ESG score with a single increase between 4.2 and 5.8 base points if such team is present. Lastly, the overall explanatory power of the models, both R-Squared and certainly R2 within, increase which means these variables add some information to the regressions.

6.2.4 Econometric regressions with managerial action variables

This regression is of the form :

$$\begin{aligned} ESG_{it} = \alpha + \beta_1 ln(MV_t) + \beta_2 ln(TA_t) + \beta_3 ln(TL_t) + \beta_4 ln(1 + OI_t/10^6) + \beta_5 Lev_t \\ + \beta_6 ROA_t + \beta_7 ATO_t + \beta_8 Spot_t + \beta_9 Mgt_t + \beta_{10} IBM_t \\ + \sum_{n=1}^{N-1} \delta_i D_i + \left(\sum_{y=1}^{Y-1} \delta_i' T_i \right) + \epsilon_{it} \end{aligned} \quad (6.14)$$

Table 6.14: Results of the econometric regression with managerial action variables

	ESG	**ESG**	**Gov**	**Gov**
Constant	-94.07***	-0.69	-80.40***	4.18
l_MV	2.41***	0.88*	3.22***	1.98***
l_TA	15.97***	6.33***	15.09***	5.97*
l_TL	-8.62***	-4.54**	-8.22***	-4.39
l_OI	0.05	1.32***	-0.05	1.02
Lev	-0.87*	-0.40	-1.30*	-0.86
ROA	-0.11***	-0.03	-0.15***	-0.10*
ATO	-1.15	0.69	1.67	3.12*
Mgt	0.251***	0.217***	0.077***	0.046***
IBM	-0.028**	-0.079***	-0.031	-0.073***
Spot Price t	0.088***	0.446***	0.0876***	0.473***
R-Squared	0.86	0.89	0.82	0.84
R2 within	0.50	0.60	0.16	0.23
Firm FE	YES	YES	YES	YES
Year FE	NO	YES	NO	YES

Source : Author

Comparing tables 6.9, 6.11 and 6.12 with table 6.14, the addition of the management actions variables increase both explanatory powers while being statistically significant at the threshold of 1% (except for IBM without year fixed effects). On the one hand, the marginal increase in management score leads to an increase in ESG and governance scores. On the other hand, the percentage of independent board members has a relatively low coefficient intensity while being negative. This is surprising and goes against the finds of He et al. (2022) that a more independent board leads to lower misconducts which could be interpreted as higher ESG score as it should improve the governance score. Despite that, the effect is relatively low on the panel as there are limited fluctuations in the percentage of independent board members. It should be noted that these regressions on the ESG score of the top 40 comparison companies give opposite results with IBM coefficients of 0.058*** and 0.020*** respectively without and with time fixed effects. The same pool of data for both governance regressions give an IBM coefficient of 0.65***.

6.3 Conclusions

Main research question

"Has the evolution of the price of carbon of the EU ETS influenced the ESG performance score of the companies from the most carbon-intensive super-sectors of the STOXX Europe 600 Index ?"

The econometric regressions performed in this study show that the variations of the price of carbon within the EU ETS between 2008 and 2021 for the selected 108 STOXX Europe 600 Index companies can statistically significantly explain the variations of their ESG, ESG combined and pillar scores. Furthermore, the marginal increase in spot or future price of carbon both lead to a positive increase of all ESG-linked scores, *ceteris paribus.*

Subsidiary research question 1

"Can carbon emission trading policies promote corporate ESG performance by pushing for environmental innovation investments ?"

As a matter of fact, according to the panel studied, the econometric regressions all converge to show that statistically the variations of green innovations of all selected companies are statistically significantly positively correlated with the variations of the ESG and environmental scores, *ceteris paribus.* Moreover, the presence of an environmental management team dedicated to the implementation of the environmental strategy of the firm improves substantially positively the results of said scores.

Subsidiary research question 2

"Can carbon emission trading policies promote corporate ESG performance by pushing for better management practices ?"

Lastly, analysing the data from the selected companies and timespan, on the one hand it appears that the management score statistically significantly positively contributes to the ESG and governance scores, *ceteris paribus.* On the other hand, though it is statistically significant and quite negligible in effect, the percentage of independent board members is negatively correlated to the ESG scores. To nuance these results, they only apply to the selected carbon-intensive companies; as when we perform the same regressions on the 40 comparison companies we find opposite results which are both statistically significant and of higher intensity.

7 | Limitations

This study aimed at better explaining the link between the ESG performance of European companies and the pricing of carbon within the EU ETS. The limitations we notice are of two natures, either a limitation of size or a limitation of scope.

First, one must acknowledge the limitation of size, meaning that the pool of firms selected is modest in comparison to the amount of European companies. As a matter of fact, the available data is not as prolific as one might think. By choosing the STOXX Europe 600 Index, we aimed at concentrating our efforts to the study of a comprehensive set of companies which are operating on the continent. One could perform a similar study by encompassing all 600 companies and decline its study in accordance to the super-sectors. Another possibility is to select a bigger pool of companies but here arises the limitation of quality data available and comparable to each other. Without a greater implementation of a common ESG taxonomy, it is difficult to aggregate ESG scores between agencies which limits the construction of a broad consistent panel. Furthermore, information is fading away with time which means that companies which do not have accurate ESG data for the moment will remain as missing values in further panels the years to come as there are no means to rate companies *ex post*. In terms of available time horizon, it is quite limited with a maximum timespan of 2008 to 2021 for our companies on Refinitiv Eikon Datastream. For the most virtuous companies, this horizon can be pushed to 2023 but this is a far stretch and there are too few of them. Indeed, ESG became material at different times for companies or even is still not material. The consequence is that for many index (example MSCI), one would recommend to start in 2012 in order to maximise your pool of data which already limits the time frame and the comparative nature of the work between rating agencies.

Second, one must address the limitation of scope, meaning the impact of the exogenous or independent variables which could impact the ESG scores. Literature on the subject is evolving quickly as the topic is still new. This is certainly true when studying other subjects than the traditional impact of ESG on financial performance. This can be attested by the amount of recently published papers in this bibliography. We stuck to the economically standard variables but no doubt that in the future researchers will find other determinants of the ESG performance of a firm. Moreover, the additional action variables used could also be changed for other which may be more material to the topics according to the available data, pool of companies, geography, etc. On this note, we studied more in detail the environment and management scores but the social score was left aside. Further developments in the field should provide future studies with adequate social action variables to analyse their impact on this often overlooked pillar score.

8 | Conclusion

We begin this study by introducing carbon pricing and ESG ratings, which stands for Environmental, Social and Governance ratings, as two measures able to diminish greenhouse gases emissions. Carbon pricing materialises itself in the European Union by the EU Emission Trading Scheme (EU ETS). It is applicable in to all EU Member States and the European Free Trade Association countries (EFTA). The sectors covered by the system are electricity and heat generation facilities, energy intensive industries (oil refineries, steel, aluminium, cement, etc.) as well as aviation and maritime transport to a certain extent. It is a cap and trade system which means that the EU Commission allocates a certain amount of carbon allowances (EUA) to a country which then transfers them to its companies which can either buy more allowances to cover their needs, trade them if it have too much or bank them for future times.

On the other side, the ESG rating of a company is a marker of the willingness of a firm to measure its negative impact on the ecosystem and improve itself for society as a whole. As a matter of fact, policy-makers seek out more and more ways for companies to improve their ESG scores in order to contribute positively to the EU Green Deal. However, literature on the subject illustrates that there exist many rating agencies using all different taxonomies. This leads to a plethora of scores which often do not compare to one another. This is reflected in the poor correlation between ESG ratings as a whole but also among individual constituents of this overall score (Berg et al., 2022, p. 8).

The goal of this study is to analyse the correlation between the price of carbon within the EU ETS framework and the evolution of the ESG score of various companies of the STOXX Europe 600 Index. For this purpose, we select a set of the most polluting super-sectors within the index and in comparison a set of the top 40 companies outside these super-sectors as comparison variables. We study a panel of 108 companies from the six most polluting super-sectors from 2008 to 2021. In order to add some granularity to the initial scientific question we also study two subsidiary questions. We also analyse in the two subsidiary research questions the environmental and managerial actions companies can take and how they can impact their ESG scores in a carbon-pricing environment. This brings us to the main scientific question:

> "*Has the evolution of the price of carbon of the EU ETS influenced the ESG performance score of the companies from the most carbon-intensive super-sectors of the STOXX Europe 600 Index ?*"

The literature review brushes a picture of what negative externalities are and how, in the case of carbon emissions, one could price them in order to push the producers to pay the right price for their production. As a reminder, a negative externality arises when a party deteriorates the situation of another party without bearing the entire cost for doing so. As a result, the producer does not have any incentive to lower its production which is superior to what it should be in an optimal situation. Putting a price on externalities permits for society to lower the production and to recuperate a certain amount of financial means in order to compensate for the degradations. We analyse three different pricing policies: a carbon tax, a price floor of carbon and a carbon quota; all coming with their own advantages and drawbacks. The choice is far from trivial as attested by the wide range of carbon policies implemented worldwide. The EU put in place an open carbon market with the possibility for the firms to regulate the price by buying and selling freely their allowances. Economically, it lets the companies adjust their intertemporal budget constraint with the fluctuation of spot or future price of carbon thus adjusting their production to maximise their profit (Tirole, 1988).

In terms of data collection, we build a panel of 108 companies of the six most carbon-intensive super-sectors from the STOXX Europe 600 Index and added a panel of the top 40 companies outside these super-sectors as comparison variables. The set of endogenous variables selected are the overall ESG, the ESG combined and the three pillar scores of the companies. The exogenous set is composed of the spot and future carbon prices which are the average yearly prices on the EU ETS for a lot of 1000 EUA. As control variables, we have several economic variables such as market value, total liabilities, etc. but also four action variables, two for the environment and two for the management pillar score. Then, we analyse the descriptive statistics of all variables and graph their evolution over the studied time period in order to highlight the most salient elements. We conclude this section with an analysis of the unconditional correlations between the variables of interest.

The preliminary econometric regressions confirm that there exists a statistically significant positive relation between the spot and future prices of carbon within the carbon EU ETS and the ESG scores. They also indicate that the spot price of carbon has the most explanatory power over other prices such as the future price or the maximum spot or future price. Moreover, the addition of the economic control variables add some explanatory power to the model and information to the mechanism between ESG scores and the spot price while indicating that statistically companies seem to favour the contemporary spot price rather than the lagged price, meaning the price from a previous period. This means that the price of carbon for the considered period is still too low for these companies to begin to trade for futures or hedge against foreseeable rises in carbon price. To end with the two subsidiary questions; first the environmental action variables, statistically the variations of green innovations of all selected companies are statistically significantly positively correlated with the variations of the ESG and environmental scores which is further boosted by the presence of an environmental management team. Second, it appears that the management score statistically significantly positively contributes to the improvement of the ESG and governance scores. Nevertheless, for the selected companies, it appears that the presence of more independent board members does not foster higher ESG score which is the opposite of the comparison companies.

In a nutshell, this study tries to derive the conclusions of Yadu Zhang, Yiteng Zhang and Zuoren Sun (2023) to a still fairly unexplored link between ESG scores and carbon pricing within the EU. Furthermore, we add to the study two carbon prices - spot and future - in order to be as exhaustive as possible. Then, we consider different periods in order to analyse if companies adapt to the previous price of carbon in order to counter the possible increase in price. Lastly, we analyse the environmental and managerial actions companies can take and how they can impact their ESG scores in a carbon-pricing environment. As a result, we demonstrated that there exists a statistically significant positive impact of carbon price on the various ESG scores of carbon-intensive companies of the STOXX Europe 600 Index during the period 2008 to 2021.

Thomas Van Gyseghem
Liège, May 21th 2024

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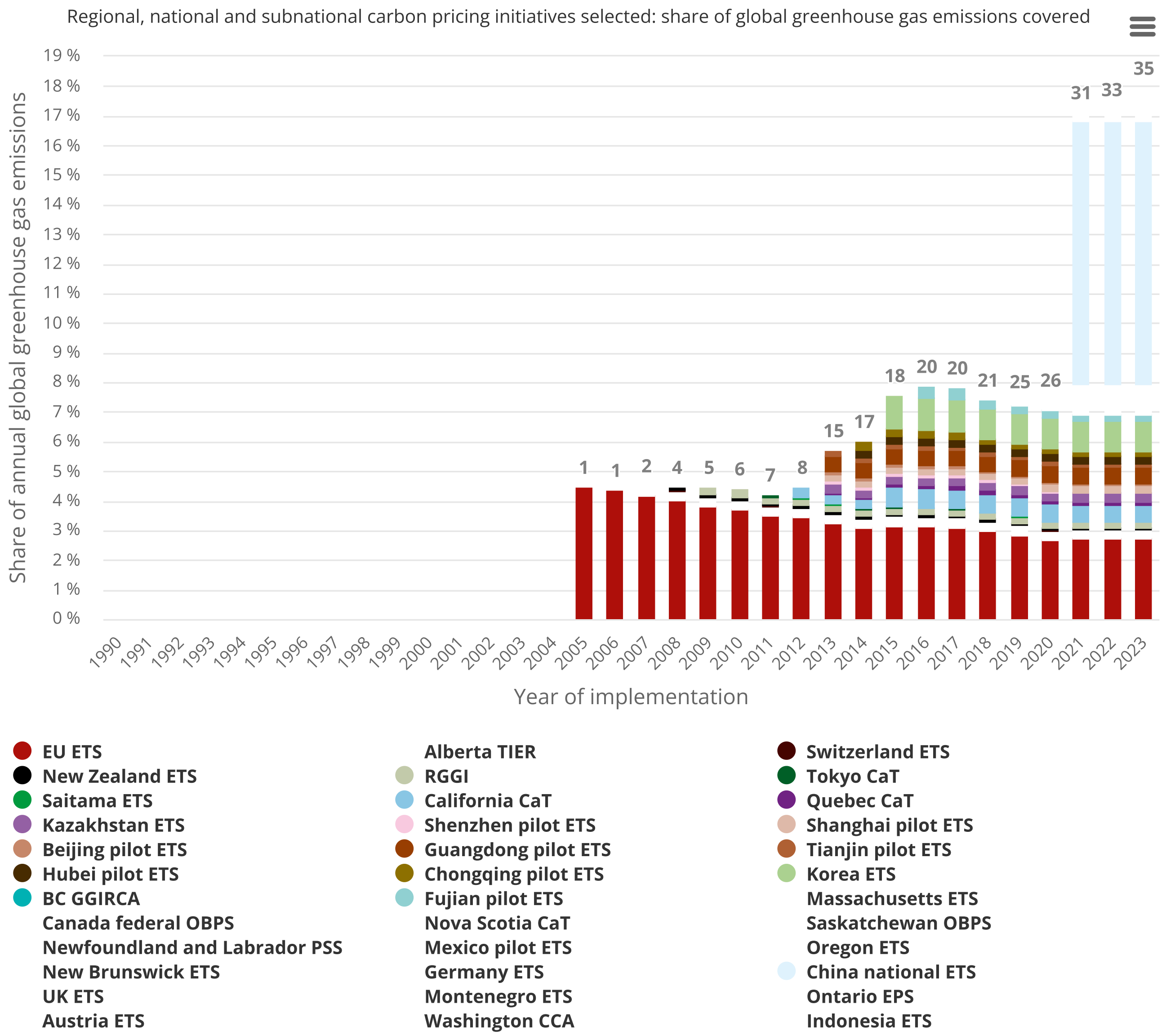
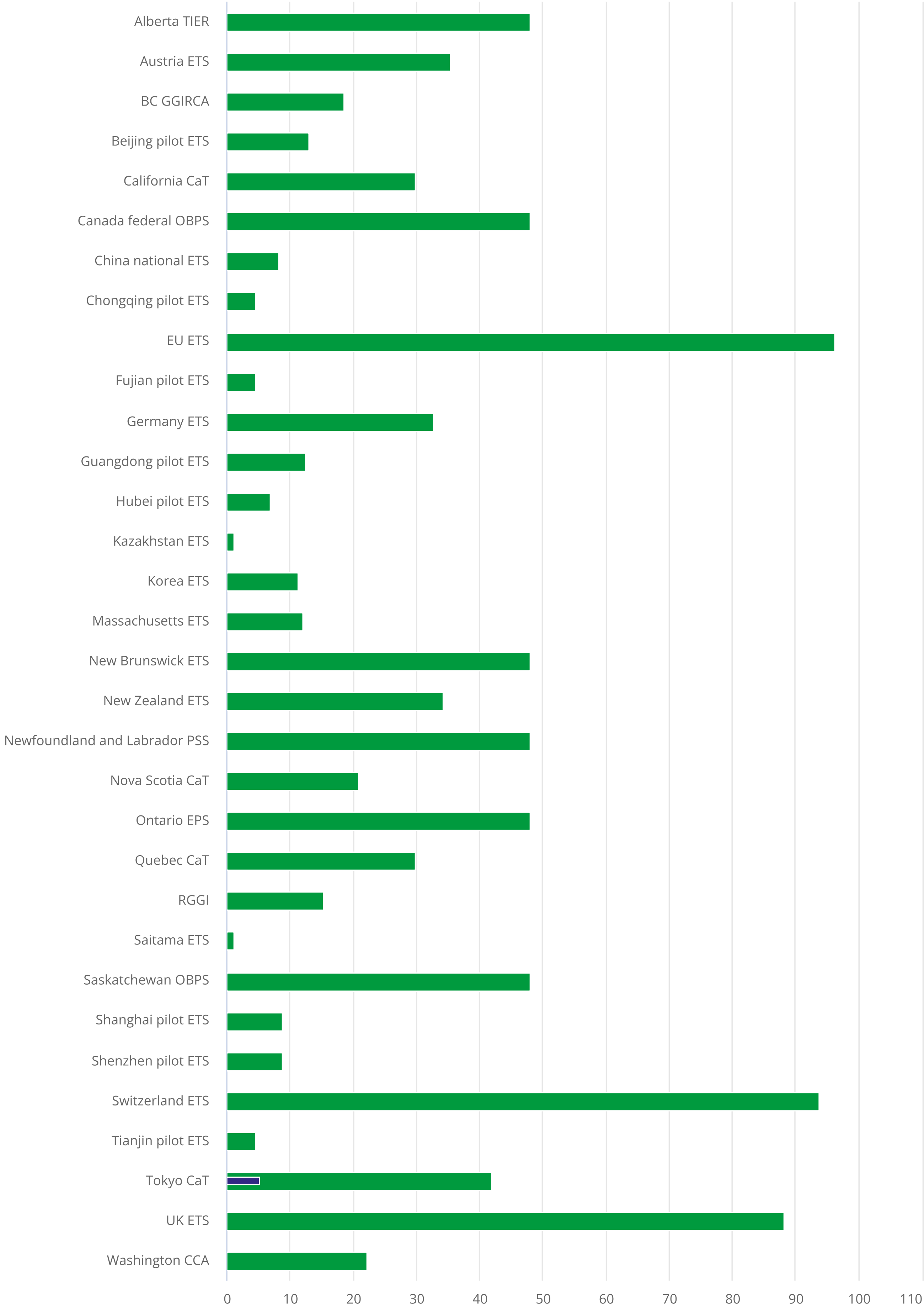
A | Appendix 1: Carbon pricing worldwide

Figure A.1: Implemented carbon ETS worldwide



Source : The World Bank, 31 March 2023

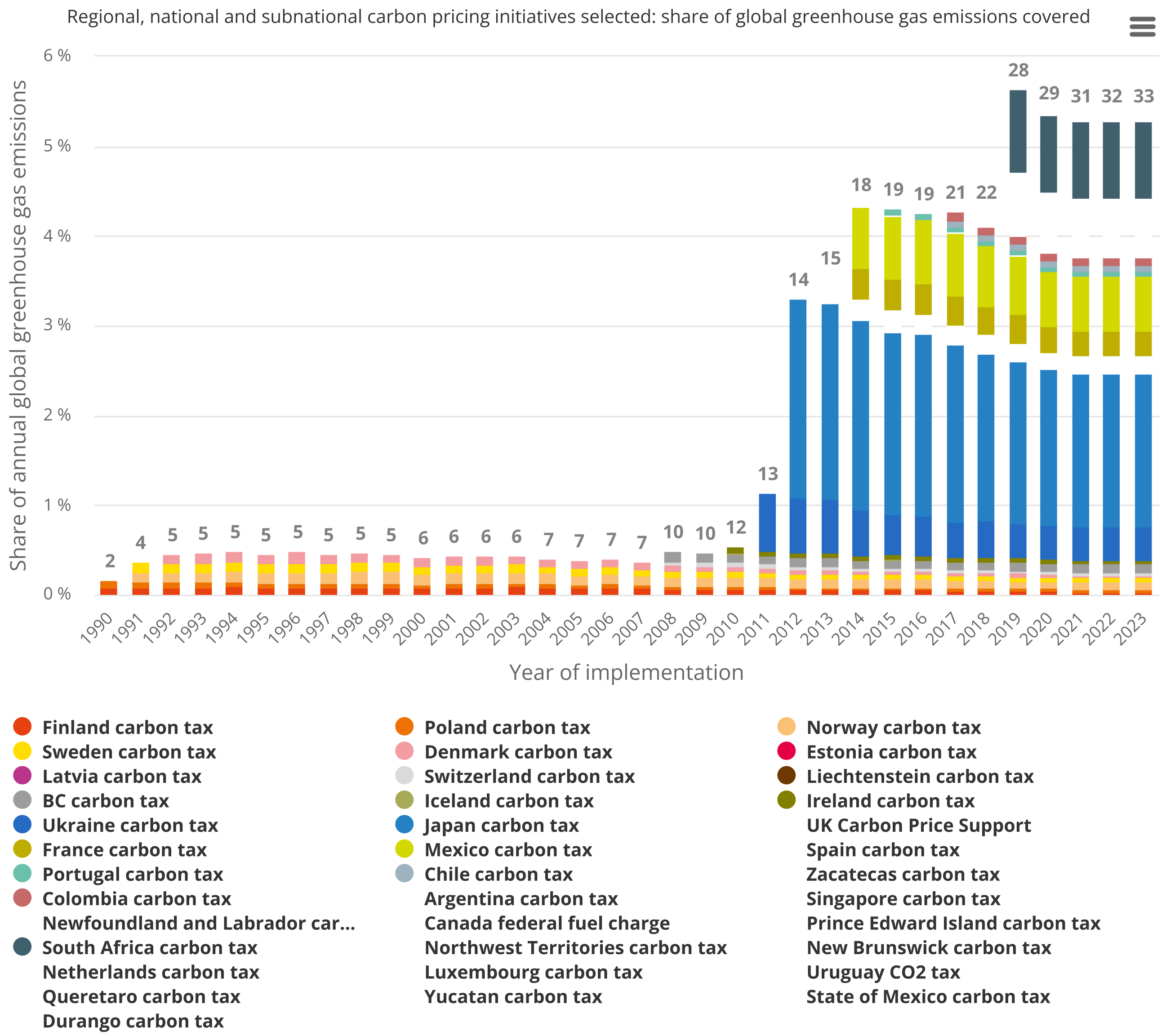
Figure A.2: Prices of carbon ETS worldwide



Source : The World Bank, 31 March 2023

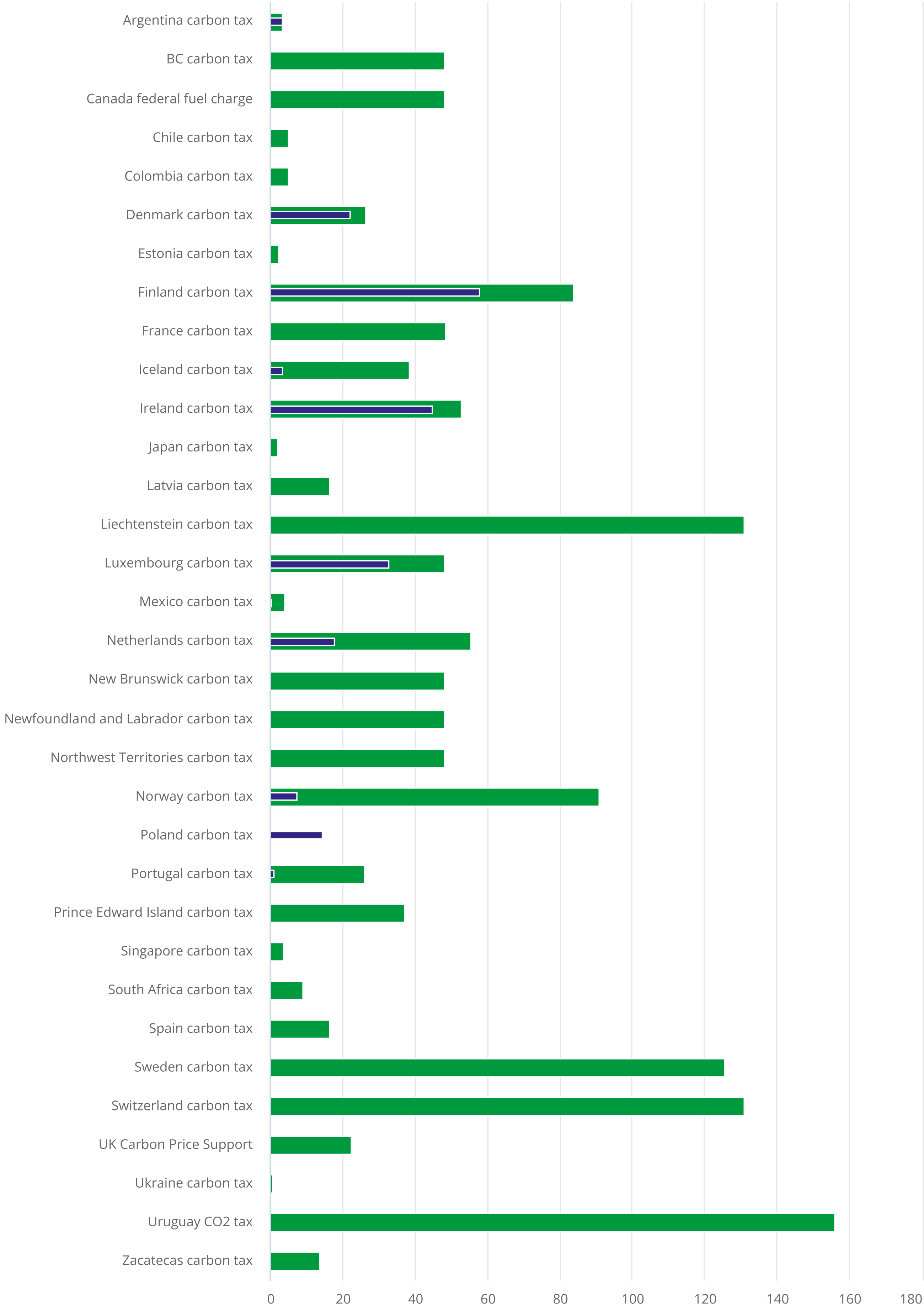
B

Figure A.3: Implemented carbon taxes worldwide



Source : The World Bank, 31 March 2023

Figure A.4: Prices of carbon taxes worldwide



D

Source : The World Bank, 31 March 2023

B | Appendix 2: Selected companies by super-sectors

Table B.1: Selected companies from the STOXX Europe 600 Index by super-sectors

Company	**Super-sector**
BMW	Automobiles and Parts
CONTINENTAL	Automobiles and Parts
FORVIA	Automobiles and Parts
MICHELIN	Automobiles and Parts
NOKIAN RENKAAT	Automobiles and Parts
PEUGEOT	Automobiles and Parts
PORSCHE	Automobiles and Parts
RE ULT	Automobiles and Parts
RHEINMETALL	Automobiles and Parts
STELLANTIS	Automobiles and Parts
VALEO	Automobiles and Parts
VOLKSWAGEN	Automobiles and Parts
AIR LIQUIDE PF	Chemicals
AKZO NOBEL	Chemicals
ARKEMA	Chemicals
BASF	Chemicals
BAYER	Chemicals
BRENNTAG	Chemicals
CLAIRANT	Chemicals
CRODA INTER TIO L	Chemicals
DSM KONINKLIJKE	Chemicals
ELEMENTIS	Chemicals
EMS-CHEMIE	Chemicals
FUCHS N	Chemicals
GIVAUDAN	Chemicals
JOHNSON MATTHEY	Chemicals
K + S	Chemicals
LANXESS	Chemicals
SOLVAY	Chemicals
SYMRISE	Chemicals
UMICORE	Chemicals
VICTREX	Chemicals
YARA INTER TIO L	Chemicals
ACS ACTIVE	Construction and Materials
BALFOUR	Construction and Materials
BOSKALIS WESTMINSTER	Construction and Materials
BOUYGUES	Construction and Materials
CRH PUBLIC LIMITED	Construction and Materials
EIFFAGE	Construction and Materials

Source : Author

Table B.2: Selected companies from the STOXX Europe 600 Index by super-sectors

Company	**Super-sector**
FERROVIAL	Construction and Materials
FLSMIDTH	Construction and Materials
GEBERIT	Construction and Materials
HEIDELBERG MATERIALS	Construction and Materials
KINGSPAN	Construction and Materials
NCC B	Construction and Materials
SAINT GOBAIN	Construction and Materials
SIKA	Construction and Materials
SKANSKA B	Construction and Materials
VINCI	Construction and Materials
BP	Oil and Gas
ENI	Oil and Gas
GALP ENERGIA	Oil and Gas
NESTE	Oil and Gas
OMV	Oil and Gas
PETROFAC	Oil and Gas
REPSOL YPF	Oil and Gas
ROYAL DUTCH SHELL	Oil and Gas
SAIPEM	Oil and Gas
SBM OFFSHORE	Oil and Gas
SIEMENS GAMESA RENEWABLE	Oil and Gas
STATOIL	Oil and Gas
SUBSEA	Oil and Gas
TGS-NOPEC	Oil and Gas
TOTAL	Oil and Gas
TULLOW OIL	Oil and Gas
VESTAS WINDSYSTEMS	Oil and Gas
WOOD GROUP (JOHN)	Oil and Gas
BRITISH LAND	Real Estate
CASTELLUM	Real Estate
COFINIMMO	Real Estate
COVIVIO	Real Estate
DERWENT LONDON	Real Estate
GECINA	Real Estate
GREAT PORTLAND ESTATES	Real Estate
HAMMERSON	Real Estate
ICADE REIT	Real Estate
IMMOFINANZ	Real Estate
KLEPIERRE REIT	Real Estate

Source : Author

Table B.3: Selected companies from the STOXX Europe 600 Index by super-sectors

Company	**Super-sector**
LAND SECURITIES GROUP	Real Estate
PSP SWISS PROPERTY AG	Real Estate
SEGRO	Real Estate
SHAFTESBURY CAPITAL	Real Estate
SWISS PRIME SITE	Real Estate
UNIBAIL RODAMCO WE	Real Estate
WERELDHAVE	Real Estate
CENTRICA	Utilities
CEZ	Utilities
DRAX GROUP	Utilities
E ON N	Utilities
EDF	Utilities
EDP ENERGIAS DE PORTUGAL	Utilities
ENAGAS	Utilities
ENDESA	Utilities
ENEL	Utilities
ENGIE	Utilities
FORTUM	Utilities
GAS NATURAL SDG	Utilities
IBERDROLA	Utilities
NATIONAL GRID	Utilities
PENNON GROUP	Utilities
RWE	Utilities
SEVERN TRENT	Utilities
SNAM RETE GAS	Utilities
SSE	Utilities
SUEZ ENVIRONNEMENT	Utilities
TERNA RETE ELETTRICA NAZ	Utilities
UNITED UTILITIES GROUP	Utilities
VEOLIA ENVIRON	Utilities

Source : Author

Table B.4: Top 40 companies excluding the selected super-sectors from the STOXX Europe 600 Index

Company	**Super-sector**
BARCLAYS	Banks
BCO SANTANDER	Banks
BNP PARIBAS	Banks
HSBC	Banks
ING GRP	Banks
INTESA SANPAOLO	Banks
LLOYDS BANKING GRP	Banks
UBS GROUP	Banks
RIO TINTO	Basic Resources
ANHEUSER-BUSCH INBEV	Food & Beverage
DANONE	Food & Beverage
DIAGEO	Food & Beverage
NESTLE	Food & Beverage
ASTRAZENECA	Health Care
NOVARTIS	Health Care
NOVO NORDISK B	Health Care
ROCHE HLDG P	Health Care
SANOFI	Health Care
ABB	Industrial Goods & Services
AIRBUS GROUP SE	Industrial Goods & Services
SCHNEIDER ELECTRIC	Industrial Goods & Services
SIEMENS	Industrial Goods & Services
ALLIANZ	Insurance
AXA	Insurance
PRUDENTIAL	Insurance
ZURICH INSURANCE GROUP	Insurance
BRITISH AMERICAN TOBACCO	Personal & Household Goods
CIE FINANCIERE RICHEMONT	Personal & Household Goods
IMPERIAL BRANDS	Personal & Household Goods
L'OREAL	Personal & Household Goods
LVMH MOET HENNESSY	Personal & Household Goods
RECKITT BENCKISER GRP	Personal & Household Goods
UNILEVER NV	Personal & Household Goods
Industria de Diseno Textil SA	Retail
ASML HLDG	Technology
BT GRP	Telecommunications
DEUTSCHE TELEKOM	Telecommunications
ORANGE	Telecommunications
TELEFONICA	Telecommunications
VODAFONE GRP	Telecommunications

Source : Author