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Carbon Emission and Corporate Financial Performance: an empirical study of the US Energy and Technology Sectors

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Carbon Emission and Corporate Financial Performance: an empirical study of the US Energy and Technology sectors

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Abstract

Corporate transparency and socially responsible actions, for the past decade, have become fundamental values as well as strong variables in nowadays business operations. Today, firms have to disclose more about their ESG or Environmental, Social and Governance information regarding their operations.

With this empirical study, we aim to investigate the link between ESG indicators, CSR and firm performance, by focusing on the Carbon Emission and its impact on the firms' returns. We believe the Energy and Technology sectors will give us enough diversified data which will help us to draw a realistic picture of the sectors performance in relation with the CO2 Emission. These sectors are made of a large number of listed and successful companies in the US. This approach will give us a better and more accurate understanding of the link between the general corporate financial performance and carbon footprint emissions.

Thus, using multiple linear regressions, the paper found that there are significant and sufficient proofs of the CO2 Emission having an influence on the firms' financial performance for both sectors at time t. We also wanted to see if the Carbon Emission levels at time t-1 are having an impact on the Firm Value at time t, and we discovered that there is not enough statistically significant information to support this hypothesis.

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List of Acronyms

ESG – *Environmental Social Governance*

SRI – *Socially Responsible Investment*

CSR – *Corporate Social Responsibility*

CFP – *Corporate Financial Performance*

PRI – *Principle for Responsible Investments*

ROE – *Return-on-Equity*

List of Exhibits

Exhibit 2.8: *The pyramid of CSR*

Glossary

Active ownership – To actively engage in proactive communication with holding companies and to exercise voting right to influence companies towards more ESG friendly policies.

Board of Directors – The body of elected or appointed members who jointly oversee the activities of an organization.

Capital Structure – Refers to the way a company's finances its assets through combination of equity, debt or hybrid securities.

Compensation and Inventive Programs – A formal scheme used to encourage specific action or behaviors of a group of people.

Conventional funds – In this paper, a conventional fund refers to a fund not following a stated ESG or SRI policy.

Key Performance Index – Is a measurement to help companies to track if they are developing in the right direction.

Materially Map – Certain ESG factors have more impact on certain companies, this map shows which factors are the most material for which sectors.

S&P 500 – Is a stock index for the 500 largest stock listed companies in the US.

Sin Stock – A stock that doesn't meet certain ethical standards.

Socially Responsible Investment – Is any investment strategy that seeks to not have adverse social impact.

SRI fund – A fund that invests accordingly to Socially Responsible Principles.

Triple Bottom Line – An accounting framework with three parts: social environmental and financial.

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1. Introduction

Investors' concern about Environmental, Social and Governance (ESG) issues is growing at a fast pace, even though investors are more focused towards Socially Responsible Investments (SRI). Scandals such as Enron, WorldCom or Volkswagen have highlighted the importance of strict governance as well.

Forum for Sustainable and Responsible Investment[1] shows this trend in its SRI report regarding the US market. The Global sustainable investment assets have reached $22.89 trillion at the beginning of 2016 which represents an increase of 25% from 2014. The United States accounts for 36% of the global assets employing sustainable investing strategies which corresponds to over 26% of the managed asset across USA, Canada, Asia, Australia, New Zealand & Europe (under professional management). These numbers show how important ESG indicators are regarding the investment decisions.

This evolution is deeply screened by the firms who wants to provide investor with extra-financial data. The ESG indicators aim to intercept further dimensions regarding corporate performance (Bassen & Kovacs, 2008). Bassen & Kovacs states that: "*The concept of ESG issues refers to extra-financial material information about the challenges and performance of a company on these matters. It thus delivers additional relevant information, allowing more differentiated investment judgements by enabling investors to better asses risks and opportunities*". Moreover, ESG aren't just key indicators for the non-financial firm performance, they also aim to grade competencies of a firm's management and potentially support risk management (Galbreath, 2013).

From the same perspective, the stock market gives a higher importance to ESG data, by using them as a support to SRI decisions. The New York Stock Exchange Euronext launched multiple ESG indices in 2013 as a benchmark for hedge fund managers and corporations, since the responsible investments' demand kept

[1] Annual Report. (2017). [online] US SIF. Available at: https://www.ussif.org/files/Publications/2017USSIFAnnualReport_online.pdf [Accessed 9 Jul. 2019]

growing. Since then, it has become common in the US to use it but nowadays it is an observable trend worldwide.

It is a loss to think as ESG data only as useful information for the investment decision process. Indeed, ESG indicators can become a real asset for managers when it comes to take decisions with their current positions. As an example, about the use of ESG data in this case, we can see how the Swedish National Pension Funds, which is working actively with ESG issues, use these indicators in order to get a better understanding and improve their investments and holdings. Moreover, this national pension fund is also practicing an active ownership process, where their voting rights are used to move their holdings away from short-term strategy and toward long-term vision, objectives (Fjarde AP Fonden, 2014). *"During the year, we have continued our in-house focus on integrating sustainability into the asset management process. Our long-term goal is to integrate sustainability into all of the Fund's analytical and investment processes,"* states Eva Halvarsson, CEO of the Second AP Fund in 2014.

In Norway, the Norges Bank Investment Management set up sustainable practices regarding their investment policies. The NBIM's core directives is the investment on their fund within an extremely long-term perspective, as they want to ensure the national wealth will last for as long as possible. Therefore, the fund now focuses its activities towards more sustainable investments by making sure the companies they invest into have a positive impact on the environment and on surrounding communities. NBIM also states they might divest from firms that don't respect their engagements and that impose substantial costs on the society or other companies.

We understand that not all investors are asset managers of large firms, but nowadays it is essential even for private investors to understand the companies' strengths and weaknesses in order to take the best and most aware decision as possible. That's the reason why we believe ESG indicators could allow these investors to enjoy a more comprehensive knowledge about present and future business risks, which in turn would enable them to make better-informed decisions.

1.1. Problem description

Even though ESG awareness is growing among professionals, investment practices including ESG indicators have not become a systematic or obvious approach for investors in their investment decision process yet. The certain lack of evidence regarding the relationship between financial performance and ESG performance is the main reason of it. Some researchers have already tried to determine links between these two performance indicators (Galema, Auke & Scholtens, 2009; Statman, 2000; Kreander, Gray, Power & Singlair, 2005; Renneboog, Horst & Zhang, 2007). Although, most of the time, the results of these researches were inconclusive and/or statistically significant. In response of that, we decided to research if ESG indicators have an impact on a firm's financial performance.

A lot of different approaches try to measure the connection between ESG performance and corporate financial performance.

One of them is to compare SRI funds with ordinary funds (Kreander, Gray, Power & Singlair, 2005). However, this method could be problematic as the samples could suffer from survival biases. Furthermore, the performances of a fund depend largely on the investor's stock picking competencies and ability to measure the market, which make it complicated to study the impact of ESG indicators on the fund's performance. Moreover, the final result might be skewed by the transaction costs and their impacts, as Schröder (2005) explains.

The second approach is to benchmark SRI funds/portfolios against indexes such as S&P 500 (Schröder, 2005). The process of matching SRI funds with equity indices would eliminate potential bias problems, but not all of them. The main point to look at is that equity indexes performance is much more influenced than ESG performance, which isolates the relationship between corporate financial performance and ESG indicators. Thus, it is unreliable to benchmark SRI funds against conventional indexes (Schröder, 2005).

Today, most companies work actively with CSR issues and ESG indicators, by taking ESG improvements projects and providing more disclosure (KPMG, 2008). Then, it is quite interesting to consider the bridge between companies and investor community regarding the perceived relevance of ESG issues. Nevertheless,

investors are struggling when it comes to evaluate the ESG indicators when selecting stocks (Nielsen & Noergaard, 2012), which became a critical need to address in order to bring companies and investors at the same page.

In order to recognize why carbon footprint became a significant topic in many industries with high CSR goals, it is essential to explain the concept of stakeholder theory. Why? Because Corporate Ecological Sustainability, an aspect of CSR, is the needs of a firm's direct and indirect stakeholders without compromising its ability to meet the needs of future stakeholders as well (Bansal & Hoffman, 2012).

The traditional definition of a stakeholder is "any group or individual who can affect or is affected by the achievement of the organization's objectives" (Freeman, 1984). This definition must be considered alongside the definition of Corporate Social Responsibility, which states that it is the "responsibility of enterprises for their impacts on society". It is therefore obvious why ecological sustainability, and in particular carbon foot printing, has become a major aspect of CSR.

Carbon Footprint refers to the total amount of greenhouse gases produced to directly or indirectly support human activities, usually expressed in equivalent tons of carbon dioxide (CO2). Carbon footprints are now being measured for nearly all products in the world. The measure most commonly used is calculated in CO2 equivalents. The two main types of carbon footprint relevant to organizations are Corporate Carbon Footprint (CFF) and the Product Carbon Footprint (PFF). The objective of CCF is to quantify a company's direct and indirect Greenhouse Gas emission. On the other hand, PCF measures the amount of GHG emitted during the life cycle of a given product. It is essential to mention that companies have different ways to calculate CCF and PCF, thus it requires particular attention when comparing industries, or draw relationships with financial performance (Elfriede Penz & Pia Polsa, 2018).

The purpose of this study will be to investigate the relationship between ESG indicators and particularly the carbon footprint emissions, with their impact on CFP regarding different industries and sectors. We will investigate if an improvement in ESG performance can or cannot lead to shift in the firm's value.

2. Background and literature

2.1. Origin of the ESG concept

The ESG concept origin is related to the SRI field. We know that SRI strategies are composed of economic indicators, but also with environmental, social and governance (ESG) issues. Staub-Bisnang (2012) defines the ESG aspects as the three pillars of sustainability. The World Commission on Environment and Development (1987) who published the Brundtland report, is considered as one of the earliest definitions of sustainability (Barkemeyer, 2014). The three dimensions of sustainability outlined are the environmental, social and economic aspects. This concept is comparable to the Triple Bottom Line, which is the process that regroups the People, Planet and Profit aspects (Elkington, 1997). The notion of Planet refers to the environmental aspect and to the company's responsibilities towards this aspect. The People category denotes the company's social duties to their employees and/or community working with. The last aspect – Profit – is characterized by the intrinsic economic value and benefits a firm could create. These concepts are the main ones of many, and companies are using them to base their CSR policies (Hopkins, 2007). However, we can see that in both definitions and concepts, the aspect of corporate governance is left out. Nevertheless, recent studies demonstrate that a suitable governance and sustainability can't be treated separately, and that corporate governance must be included with any sustainability process (Galbreath, 2013; Saltaji 2013). As we can see with the US SIF Foundation report (2012), investors are likely to take more and more corporate governance criteria into consideration for their SRI analysis in addition to traditional environment and social indicators.

2.2. ESG – Environmental Aspects

Environmental indicators are made of essential factors for investors and business executives. According to Eccles and Serafiem (2013), it is critical to, when determining which environmental factor has to be examined, take a deep look at its materiality. The environmental focus definitely defers depending on the company's business sector. As an illustration, the carbon emission issue is way more important for coal factory compared to a hedge fund or a regular bank.

Thanks to the studies of Eccles and Serafiem (2013), we can understand that a universal set of variables can't be compatible to all companies, this logic can't be applied, as the sector, the industry, the size and the needs of a company might differ from one another. Nevertheless, there are common issues for the companies nowadays such as: Climate change, Environmental accidents & Remediation, Use & management of water, Management of energy (oil, electricity, nuclear …), Fuel management and logistics, Air pollution and GHG emission, Waste management and Biodiversity impact.

Environmental factors are likely to become a fundamental aspect of a company's sustainability and success. Water use, waste & energy management, oil and gas usage are the main critical points for corporations.

2.3. ESG – Development of the indicator

In order to get a better understanding of the ESG concept and its meaning, it is critical to consider one of its underlying frameworks, which is the *Principle for Responsible Investments* (PRI) created by the United Nations Environment Program Finance Initiative (UNEP FI) and UN Global Compact (Humphrey et al, 2012). The goal of this report is to guide asset managers and investors on the integration of ESG factors within their investment decision process in order to reach a long-term sustainable growth (UNEP FI & the UN Global Compact, 2011).

The guidelines of this report state (1) We will incorporate ESG issues into investment analysis and decision-making processes. (2) We will be active owners and incorporate ESG issues into our ownership policies and practices. (3) We will seek appropriate disclosure on ESG issues by the entities in which we invest. (4) We will promote acceptance and implementation of the Principles[2] within the investment industry. (5) We will work together to enhance our effectiveness in implementing the Principles. (6) We will each report on our activities and progress towards implementing the Principles.

This framework mostly address institutional investors. These six principles given by the UNEP FI and the UN Global Compact must be considered as "common

[2] Principles for Responsible Investments (PRI)

ground" from which asset managers and investors develop their whole personal and private investment plans.

Both the pre and post investment phases were highlighted when we discussed the integrated approach of ESG factors. The Principles for Responsible Investment or PRI guidelines present the issue that investors are often limited partners and could dispose of a constrained and strict active control of their operation. In order to make sure of the quality of the investment it is critical to ensure the quality of the ESG disclosure as well as the policies, system and resources the asset managers will integrate to the ESG considerations during the pre-investment stage (UNEP FI & the UN Global Compact, 2011). The post-investment phase appears once the investment decision has been made. In case an investor is in a passive role and prefers to only monitor their investment, it is important to use an active ownership approach. Some investors might combine their ownership in order to keep a proactive dialogue within the firm's top management and executives (UNEP FI & the UN Global Compact, 2011).

2.4. ESG – Integration barriers

Nielsen and Noergaard (2012) identified two main barriers, in which ESG isn't an accepted integrated aspect into the investment analysis universe.

The first barrier is the *Lack of Comparability*, as there is no standardized method to measure ESG performance which then, enables some lack of transparency regarding the rating agencies.

The second barrier corresponds to the *Lack of Proof* in the situation whereas ESG impacts positively, negatively or doesn't have an effect on financial performance, a topic that was already questioned in several previous studies. The ESG research should be consistent and provide strong results over the years that ESG implementation in the investment decision process will realize as good returns as the market at minima. Until this "condition" isn't fulfilled, then mainstream investors don't even consider making an investment based on ESG performance Nielsen and Noergaard (2012).

Some other aspects that have been identified as integration barriers refer more at an organization level. As an example of it, firms tend to reward and provide incentives for employees who succeed on short-term performance and objectives (short-term incentives). This is in total opposition with the ESG objectives, which are related to a long-term strategy. Then, the ability to integrate ESG objectives is undermined by the short-term rewarding system (Eccles & Serafiem, 2013). Moreover, the short-term objectives aren't the only issues to ESG change, as the structure of the objectives themselves represents a real challenge to any ESG improvement. In today's corporations, it is something common to reward specific divisions or units; but not at a corporate wide level; within a same company with the purpose of boosting the global performance. This incentive strategy goes against the core beliefs of the ESG improvements, since it is essential to perform cross-division collaboration in order to boost ESG performance (Eccles & Serafiem, 2013).

The Svenska Dagbladet (2015) wrote an article about Swedfund[3], where their sustainability expert Lars-Olle Larsson highlights the Swedish law on sustainability, which was undergoing an update. ESG disclosure needs to be made by the major companies as the law enforces the firm's management to be fully transparent in their annual reports, which in turn gives long-term strategic goals, as well as a clearer role in the corporation.

2.5. Corporate Social Responsibility

Carroll (1979, p.40) defines Corporate Social Responsibility as: "*the social responsibility of business encompasses the economic, legal, ethical, discretionary (philanthropic) expectations that society has of organizations at a given point in time*". This quote represents the definition and foundation of the CSR's pyramid of Carrol (1991). The author builds a 4-parts pyramid based on the philosophy that a company has duties towards the society. These duties aren't only economical and legal, but also discretionary (philanthropic) and ethical.

[3] Swedfund is a development financier of the Swedish state with the main purpose of eliminate poverty by launching sustainable businesses in the toughest region of the world and in the most promising growing market.

Exhibit 2.8: The Pyramid of CSR

Source Carroll (1991, p.42)

The Corporate Social Responsibility topic has been studied for about 40 years. An example of this, over 37 different definitions has been identified by Dalhsrud (2007); the CSR concept is evolving in a constant basis (Carroll & Shabana, 2010 – Vogel, 2005). Another classification about CSR approach has been developed by Garriga and Melé (2004), in which they propose the following four categories:

- Instrumental theories
- Political theories
- Integrative theories
- Ethical theories

Environmental & Social aspects of the ESG concept are covered by the CSR practices. With major environment issues nowadays such as climate change or the fast-growing world population, two of the most critical axes of development are the Gaz emissions and the water consumption (Dolique, 2007). The eco-efficiency concept is a tool that allows companies to measure and monitor their impact on the environment throughout the complete lifecycle of their products. The reduction of resources and waste consumption is the main goal of this tool, as well as the objective to rely more on renewable materials and to provide more multifunctionality on the company's products (Melquiot, 2003). Regarding the social aspects, the human rights and healthcare policies are the main issues of a company, as well as the prohibition of the forced and child labor. Other issues are defined by the regulations of working hours and salaries, the diversity within a

company without discrimination regarding the race, the gender or the religion, the safe and healthy working place, and finally the training and development programs opportunities (Laville, 2009 – Stellmann, 2000).

2.6. Corporate Governance

The Encyclopedia Britannica defines the corporate governance as the "rules and practices by which companies are governed or run". Corporate governance roots belong to different theories. For example, Jensen and Meckling (1976, p.308) defines an underlying theory which is the agency theory by stating that: *"an agency relationship as a contract under which one or more persons (the principal(s)) engage another person (the agent) to perform some service on their behalf which involves delegating some decision making authority to the agent."* It can be assumed that the decisions made by the agent isn't necessary in the best interest of the principal in case both parties aim to optimize their personal welfare. Adam Smith theory in 1776 (cited by Tricker, 2012) is based on this dilemma: "It cannot be expected from a firm's directors (agents) who are managing other people's money that they are taking care of it in the same way as they would do it with their own money". Then, the manner to make the agents behave in the best interests of the shareholders (principals), the latter must give the proper incentives or/and bear costs to manage the agent, the so-called agency costs (Jensen & Meckling, 1976).

Fama and Jensen (1983, p.302), based on this theory, propose that companies must: "*separate the ratification and monitoring of decisions from initiation and implementation of the decisions*". To put this in perspective, it is needed to separate the management from the board of directors. Thus, the executive function would be performed by the management, and would delegate the tasks within the organization, when the board only supervises the executive activities performed. Establishing unitary boards with both executive directors and non-executive outside directors is a strategy commonly realized in the US (Tricker, 2012).

Legal coverage can be used to protect the shareholders in case the situation goes wrong. The US and other common-law countries propose the strongest protection for shareholders compared to some other legal systems as La Porta et. (1998) found. The company's laws are followed strictly by the company as it is based on cases laws and it might varies depending on the states where the company's business is

in. On the federal stage, US Securities and Exchange Commission (SEC) supervise the protection of the investors, by asking to listed companies to create a board audit, nomination and remuneration committee. The Sarbanes-Oxley law (2002) also strengthened the protection of the shareholders, by increasing the disclosure obligations for companies towards their shareholders. In extension to these regulations, some other guidelines and principles about corporate governance encourage companies to implement on a more voluntary basis good governance practices, as it was published by several international agencies and also companies (Tricker, 2012).

2.7. Convergence of concepts: CSR and Corporate Governance

When companies want to run their business and wish to have an impact on the business environment they are operating in, both CSR and corporate governance concepts will be concerned. In this situation the concepts are considered as strategic management tools even though each concept covers specific areas. Although, the mix of the two concepts gives a complementary and complete understanding on the issues surrounding company's business activities (Rosam & Peddle, 2004). The increase in regulatory pressure influences greatly this convergence of concepts, as the corporate scandals that have occurred the past decade strengthened the demand for business ethics, as well as the request of SRI investors (Money & Shepers, 2007). Ethics, accountability, disclosure and transparency issues rose in the 21st century, which gives new areas for corporate governance to focus on. In order to integrate environmental and social issues into business strategies and decision-making processes, the CSR use corporate governance as a useful tool to reach the objective. It will give greater benefit to a larger number of shareholder but also stakeholders (Gill, 2008). The creation of committees and board functions is an example of the implantation of CSR topics. Money and Schepers (2007) states that executives believe in the relationship of responsibility and performance. Moreover, directors strongly think that in order to create and achieve more stakeholder value it is necessary to reach simultaneously greater shareholder value. Rosam & Peddle, (2004, p.3) explained that: "*Both CSR and CG (corporate governance) are concepts that allow organizations to operate profitably yet in a socially and environmentally responsible manner to achieve business sustainability and stakeholder satisfaction*". Finally, the convergence of the CSR and corporate governance

concepts serves the need for long-term performance and these two approaches provide an efficient tool for the companies' risk management. Moreover, it allows the firms to build a better reputation by avoiding scandals (Money & Schepers, 2007).

2.8. Carbon Emissions & CFP: findings and issues

Regarding the carbon emission management, a direct financial impext exists coming from both the regulatory and investment perspective. The regulatory aspect corresponds to when companies aren't capable of fulfilling their reponsibilities in terms of carbon emissions reduction to meet the target set by the public institutions. In case the carbon emissions of a firm is too high, the company will have to pay fines or either buy emission allowance. When the firm's carbon emissions is below the target set, then the company have the opportunity to sell their surplus of carbon emission allowances. Therefore, a good carbon emission management could lead a company to lessen the financial burden of the regulations and even make a profit in the best case scenario. Additional impacts, other than the tangible financial one, can appear such as increasing the company's reputation, or better relationships with customers, suppliers and even governments (Brammer & Pavelin, 2005; Sen & Bhattacharya, 2001; Brown & Dacin, 1997).

Greening speaks to a significant practice that firms must exercise; such a practice has advantages beyond those of producing goods to become profitable. Right now, firms are expected to implement methods that alleviate natural environmental damage, improve its preservation, and advance its recovery. Although, the discussion concerning carbon emissions and corporate financial performance has not settled yet. Some studies propose that the connection among carbon emission and CFP is negative, while others contend that it is certain. Conflicting conversations are still ongoing.

The discoveries of Narayan and Sharma (2015) recommend that both the mean-fluctuation investor and the constant relative risk aversion (CRRA) investor in carbon emissions trading are described by a high utility and can create supernormal financial returns through forecast products delivered from a forward return framework. Kopidou et al. (2016) affirms that the two significant drivers of

decreased carbon emissions and employment were financial performance indicators, principally economic growth concerns and resource intensity issues. Hayami et al. (2015) shows that organizations that create less waste will generally produce higher CFP. Besides, Philip and Shi (2016) state that the financial risk teams in companies that use state-dependent hedge ratios to deal carbon emissions portfolio risks on the marker would be able to get higher gains from hedging. Cucchiella et. al. (2017) applies an economic framework on the control of emissions (using Italian companies). This research suggests that, through the inclusion of an Environmental Management System (EMS) alongside a better emission's control, it leads to an increase in a company's profitability. Moreover, a study made by Lucas and Noordewier (2016), from 941 publicly traded US manufacturing firms, shows that environmental management practices in "dirty" industries generate positive marginal impact on the firm financial performance. Lee and Min (2015) investigate the effect of green research and development investment on environmental and financial performance (focusing on Japanese manufacturing firms). The study draws a negative relationship between carbon emissions, green research and development investment; the conclusion is that companies should control their emissions to reach high CFP. Furthermore, a study conducted by Gallego-Alvarez (2015) on the influence of the carbon emissions on CFP made on 89 companies for the 2006-2009 time period states that a decrease in carbon emission enabled increased in financial returns.

On the other hand, some researches also showed opposite results. Salahuddin et al. (2016) demonstrate that economic growth generates no significant short-term or long-term impact on carbon emissions. Yu et al. (2016) witness another non-significant relationship between operational efficiencies (R&D expenses, sales, net income, total assets, number of employees) and environmental efficiencies (emissions saving, monetary saving, direct & indirect emissions, investment in emissions abatement). The study of carbon tariffs and their impact on the financial performance of companies in developing economies made by Wang et al. (2016) also state that there is a negative correlation. Finally, Dragomir (2012), demonstrate that financial information isn't related to a firm's environmental performance data.

Researches demonstrate some mixed relationships between carbon emissions and corporate financial performance. Chan et al. (2013) for example, shows that the emissions trading have no impact on steel, iron and cement industries. Nevertheless, they witness a positive effect on material costs, along with revenue in the power sector. Moreover, Jia et al. (2016) analyse that the firm's emissions announcements have a significant impact on carbon expected financial gains, but they generate a non-significant effect on price volatility. Misani and Pogutz (2015) investigate the relationship between environmental results and procedures on CFP using carbon-intensive firms, and they conclude that companies reached their highest financial returns when their carbon performance was neither high nor low but intermediate.

2.9. Presentation of the US technology and energy sectors

2.9.1. The US technology sector

The US technology sector is one of the industries we will be focusing on. This sector covers technology equipment (hardware), software and also IT services. This industry is one of the most competitive in the US, which enable technology corporations with some strategic choices in order to increase their profit such as innovation, pricing strategies and internationalization for example. Innovation and Research & Development investments are the critical points and value driver of the firms not only due to the product's obsolescence, but also because it's a strategy to build market differentiation and to stimulate replacement purchases (smartphones). Another critical factor for the technology sector's companies is the brand image. Also, the fierce competition leads to the pressure on prices, which in turn leads the companies to outsource and manufacture their products in "low-cost regions", mainly in South-East Asia. Even though this strategy allows companies to make huge costs savings and to increase their margins, the company's brand image deteriorates as it is exposed to labor conditions, child labor and other human rights abuses (Van Liemt, 2007).

Commitments to ESG issues vary greatly between companies of the technology sector. Google and Microsoft benefit from good reputation within the technology sector. However, scandals and concerns rise regarding the working conditions, for instance with Foxconn and Apple business relationship. The environmental impact of the life cycle of technological products as well as their energy consumption are

the main issues at the moment (Martinuzzi et al., 2011). The governance issues also appeared recently to become an important concern, as the respect of the shareholders' rights needs to be looked at in this industry (MacLeans, 2013). Finally, "green products" are considered as the new way to differentiate products (Albino, Balice and Dangelico, 2009).

2.9.2. The US energy sector

In 2020, the United States will become a net energy exporter and will remain so for a long period as the result in large increases in natural gas, crude oil and natural gas plant liquids (NGPL) production and because of the slow growth in US energy consumption (EIA, 2019).

Nevertheless, some factors may affect the energy sector, both positively and negatively. Regarding a positive change, the US economy will grow faster, thanks to the likely increase in energy demand from developing countries, which modernize their infrastructures and economies. Moreover, the rising of geopolitical tensions (e.g. with Iran), would result in higher oil prices, which would therefore lead to more profit for the US energy sector. Finally, with the recent ending of US waivers on countries using Iranian or Venezuelan oil could exacerbate supply concerns.

However, some negative issues can pop up in the energy sector. For example, the critical pollution problems in China could result in energy use cuts in which the restrictions would be dramatic for the energy sector. Also, the efforts on conservation and new technology could greatly affect the demand's growth for energy products.

Even though energy is one of the main carbon emitting sectors, the firms' energy transition performance remains too weak. Asset managers and investors use various options and strategies in order to address these weak performances, through divestment and activism processes. The human rights performance is still limited for the companies in this sector as scandals and allegations comes up on a monthly basis. Nevertheless, we can notice an improvement on board governance, executive compensation, community engagement and social dialogue issues (Vigeo Eiris,

2018). The energy sector faces several exposures such as the environmental, social and governance ones (S&P Global, 2019).

Several aspects define the environmental exposure; the greenhouse gas emissions, the spills and leaks which could lead to water and soil contamination, and last but not least, the pace of the energy transition away from carbon-based fuels. The environmental impact regarding plastic waste is another critical topic about consumer focus. Because plastics are mainly derived from petrochemicals, the water use and the risk of contamination is relevant to this topic. Finally, exploration in protected area both on land and sea expose the companies to environmental risks. The social cohesion, safety management and consumer behavior risks correspond to the key social risks in the oil and gas sector. Safety management is a critical risk as the operations of drillings, the tough environmental conditions could lead to important issues. Social cohesion is also a key risk as the relationships between communities and governments are important. Without a clear and transparent one, there will be delays and a raise in costs for companies' reserve development. Lastly, the energy slides away from carbon fuels, and this long-term consumer behavior will influence the reduction of disposable plastics.

The governance aspect is the one with the most exposure, as the lack of transparency is superior compared to other sectors. However, government ownership can exacerbate the sector's lack of transparency if needed. Furthermore, companies face high severity regarding safety incidents, which means that risk management and company culture have a higher importance.

3. Theory and hypotheses

This study aims to discover and to link the carbon emissions to the Corporate Financial performance. The discussion about this topic hasn't be resolved yet. Some school of thought have postulated that the link between these is negative while others believe the opposite.

3.1. The construction of hypotheses

We will study the relationship between ESG performance and Corporate Finance Performance by focusing on a single factor which is Carbon Emission.

Companies are expected to implement activities which will mitigate the damage of natural environment, allow its preservation and enhance its recovery. Although, the discussion about carbon emissions and corporate financial performance is still conflicting as researches shows different results. Our goal will be to determine whether there are correlations between carbon emission and firm performance with different time dimensions.

To build the hypotheses, we use the Carbon emission levels to investigate if there is a link between this indicator and financial performance of the firms. The first hypothesis is tested to determine if there is a link between the Firm Value and the Carbon Emission levels at time t. The second hypothesis will test whether the Emission levels at time t-1 impact the value of a firm at time t.

Hypothesis 1: Firm Value is impacted by Carbon Emission at time t.

Hypothesis 2: Carbon Emission levels at time t-1 impact the value of a firm at time t.

This set of hypotheses lays down the basis of our research, and therefore will be study using the methodology proposed in the following thesis's section.

4. Data

4.1. Sample

This research study is built on samples of S&P 500 companies which belong to two different sectors: technology and energy. A key concept within previous research studies is the lack of industry level studies. The Soana's studies (2011), which focus on the relationship between Corporate Social Performance and Corporate Financial Performance in the banking sector in the US, strengthened our motivation to focus on studying multiple industries, as we know that CSP characteristics vary greatly from one industry to another. Barnett (2007) also states that industry level studies give a better understanding about the CSR business case on a more specific level.

This study focus solely on the United States of America. The reasons we want to work within only one country are the following. First of all, it reduces potential noise that would affect results, which can come from differences in cultural factors, regulatory backgrounds and macroeconomics trends (Renneboog, Ter Horst, & Zhang, 2008).

Moreover, we noticed throughout our literature researches that cross-country studies agree about the existence of variation in terms of information disclosure regarding ESG. The choice of the US is due to the size of the country and also the importance of its financial markets as the access to large sample of listed companies within the same industry is easier. An example would be the technology industry in which the US are hosting leaders in terms of software (Oracle, Microsoft), hardware (Apple, Dell and HP) and internet companies as well (Google, Facebook). Also, the US market is one of the most advanced in the world regarding SRI with about $22.94 trillion at the beginning of 2016 in global sustainable investment assets (US SIF Foundation, 2017).

4.2. Sources of Data

Our research is based on data collected from the S&P 500 Information Technology sector and from the S&P 500 Energy sector. The financial related data will be gathered from the Wharton Research Data Services (WRDS), as it allows

us to download all the necessary company's information such as their debt-to-equity ratio for example.

Nevertheless, we gathered the ESG-related data from the Thomson Reuter Eikon database, mainly due to the fact that Reuters have a larger period and more accurate data related to the ESG analysis. The Eikon database allows us to collect all the data we need from every companies and for each factor we need to use for the regression model.

We collect and study data for a period given from 2009 to 2018 included, which gives us a 10-year span. This will allow us to display enough information over time to draw conclusion from our regressions' studies. This extended time period will be representative and accurate as it will take into account the data post 2008 crisis up 2018. We decided to collect the data in an annual basis as the carbon emission levels are given over annual periods.

5. Empirical methods

In the Theory and Hypotheses section above, we scaled up our research questions and hypotheses we want to test through our study. Therefore, a quantitative research process will be used in order to build a model which answer our questions. Hence, this thesis's section give a broad outline of the quantitative method and variables used to achieve our goal before moving on to the data part.

5.1. Our methodological approach

When doing the literature review, we saw that there is a certain deficit about researches looking into the link between Corporate Financial Performance and Carbon Emission from multiple industries perspective and over time. The Multiple Linear Regression method gives the advantage to take into account both cross-sectional variations and variations over time in a time series dimension. Therefore, it gives more information compare to one-dimensional approach, and can also be more easily generalized in the way it breaks down the influence of temporal errors which would affect the data.

Our methodology and analysis are based on the same approach Derwall (2007) used to study the relationship between CFP and eco-efficiency, by taking account market and accounting perspectives. Nevertheless, we won't use the Fama-Macbeth model for our analysis as Derwall (2007) used, instead, we use the Ordinary Least Squares (OLS) estimation method and multiple linear regression model. In comparison to previous researches, variables aren't lagged as previous findings demonstrates that it exists no clear direction of causality between CFP and ESG performance but a "virtuous circle" instead (Soana, 2011). The multiple linear type of regression is better suited for our study as it can minimize the aggregation bias effect from aggregating firms into broad groups.

This study examine the relationship between corporate financial performance and carbon emissions; therefore, we want to determine if and how the CFP of a firm is impacted by its carbon emissions.

5.2. Dependent Variable

We are using one identifiable indicators in order to take into account the companies' financial performance that we will use as a proxy to firm value in our hypotheses. This research use the Return-On-Equity (ROE) for the first regression model, which can be evaluated as the corporate shareholder return indicator. ROE measures how effectively management is using the companys' assets to create profit as well. Therefore it is useful to determine if this ratio is correlated to carbon emissions, for example. The Return-On-Equity ratio is a good metric to use as investors look at it for long-term strategies.

$$\text{Return on Equity} = \frac{\text{Net Income}}{\text{Average Shareholders' Equity}}$$

For the second regression model, we use the change in Return-on-Equity from t to t+1. By regressing the change in ROE we are able to determine if the Carbon Emission levels have an impact on the Firm Value over a period of time.

5.3. Independent Variables

Analysis for this research is composed of independent variables, which refer to Carbon Emission. We take into account the carbon emission levels of each companies for both sectors during the time span 2009-2018. We collected the ESG data on Thomson Reuters Eikon corresponding to the carbon emissions under the Environmental section of the indicator, such as the level disclosed by each firm. For the second regression model, we use the CO2 per Asset metric as a proxy of Carbon Emission levels that we calculated with the data collected.

5.4. Control Variables

Metrics such as growth, firm size, leverage, and capital intensity are the control variables used in this research.

The growth factor represent how the firm grew in a determined period of time and it will be computed from the companies' growth rate of sales. This metric is considered to be a control variable as it demonstrates the capability of the sales team to impact the revenues over a period of time. Therefore, it is considered to be a strategic measure used by senior management of firms in terms of corporate strategy and decision-making.

Firm size is another key control variable for this study as the visibility to corporate shareholders is largely determined by the size of a company. Also, firm size has a major impact on the economies of scale levels for the firms. We choose to use this variable also due to issues encountered as market experience, high advantages related to R&D, larger financial base, and also market power which are mainly linked to larger companies. This metric is given by the sum of the natural logarithm of the net sales at t-1 and t.

The Debt-to-Equity ratio is the metric used as a proxy for the leverage variable as this ratio determine the company's financial leverage. This measure reflects the ability of stakeholder equity to cover all outstanding debts in case the business has a downturn. A high leverage ratio indicates that the firm has high risk to the shareholders. Therefore, the Debt-to-Equity ratio is a good proxy to account for the firm's risk.

Lastly, capital intensity is the final control variable we will incorporate in our model to determine whether carbon emissions have an impact on CFP. Capital intensity is defined as a company metric of efficiency in assets' employment. Thus, the calculation of this value gives the amount of funds invested to generate sales revenues. This value is given with the following computation: Total assets at t divided by the total sum of net sales at t-1 and t (average of these two values).

5.5. Regression Equation

With full awareness of the independent variables, dependent variables and control variables, the regression equation we use to find insights for the first hypothesis is the following one:

$$Financial\ Performance_{i,t} = \beta_0 + \beta_1(Carbon\ Emission_{i,t}) + \beta_2(Growth_{i,t}) + \beta_3(Firm\ Size_{i,t}) + \beta_4(Leverage_{i,t}) + \beta_5(Capital\ Intensity_{i,t}) + \varepsilon_{i,t}$$

We are going to modify the first model for the second hypothesis and use the change in Return-On-Equity and the CO2 per Asset metrics to determine whether Carbon Emission levels at time t-1 impact the Firm Value at time t:

$$\Delta ROE_{,t} = \beta_0 + \beta_1(CO2\ per\ Asset_{i,t-1}) + \beta_2(Growth_{i,t-1}) + \beta_3(Firm\ Size_{i,t-1}) + \beta_4(Leverage_{i,t-1}) + \beta_5(Capital\ Intensity_{i,t-1}) + \varepsilon_{i,t}$$

β_0 ; *is the intercept*

$i = 1,2,\ldots, N$; *corresponds to the cross section unit*

$t = 1,2,\ldots, T$; *pertains to the time period*

β_k ; *is the gradient parameter*

$\varepsilon_{i,t}$; *is the random error*

$Carbon\ Emission_i$; *is level of emission produced by the company*

CO2 per Asset ; corresponds to the emissions by total assets

$Financial\ Performance_{i,t}$; *refers to Return-on-Equity*

6. Results and Analysis

For the research, we use a multiple linear regression model, which is based on Ordinary Least Squares (OLS). We used the XLSTAT software on excel to run our regression and analyze the outcomes.

6.1. Carbon Emissions Grade & Firm Value with the first model

The results of the research made for the first hypothesis: "*Firm value is impacted by Carbon Emissions at time t",* are presented in this section. The **Table 1** shows the summary of the analysis for the US energy and technology companies under studies. We decide not to incorporate the companies for a specific year in which data were incomplete or non-existent as it could have impacted our analysis and make the results non-representative.

Table 1: Summary statistics for the sample companies

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
ROE	190	-0,979	1,104	0,094	0,251
Growth	190	-78,152	222,808	1,588	29,293
Firm Size	190	7,376	12,980	9,988	1,181
Debt-to-Equity	190	0,037	45,055	2,870	5,479
Capital Intensity	190	0,316	7,714	1,936	1,248
CO2 Equivalent Emissions Total	190	10829,000	128000000,000	12292785,302	25321994,536

We fiund that the average Return-on-Equity (ROE) for the companies coming from both the energy and technology sectors is about 9,4%. The average CO2 emission corresponding to these companies is 12292785.

The **Table 2** below presents the correlation matrix and the coefficients among the studied variables.

The correlation matrix demonstrates which variables interact whether positively or negatively with the other variables with this regression. The Return-on-Equity (ROE) is positively correlated with the Growth, Debt-to-Equity, Firm Size and most importantly with the CO2 emissions total. Although, ROE has a negative association with the Capital Intensity variable. The CO2 emission factor has a negative correlation with most of the variables except with ROE and Firm Size.

Growth is positively associated to Firm Size, Debt-to-Equity and ROE variables, and negatively linked to the others. The firm size has a positive correlation with Growth, ROE and CO2 emissions factors. Leverage is positively correlated with Growth and ROE, and there is a negative link with other variables. Capital Intensity does not have any positive correlation with the other variables, both dependent and explanatory.

Table 2: Correlation Matrix of the Different Variables

	Growth	Firm Size	Debt-to-Equity	Capital Intensity	CO2 Equivalent Emissions Total	ROE
Growth	1,000	0,050	0,028	-0,121	-0,002	0,185
Firm Size	0,050	**1**	-0,100	-0,562	0,653	0,215
Debt-to-Equity	0,028	-0,100	**1**	-0,057	-0,148	0,257
Capital Intensity	-0,121	-0,562	-0,057	**1**	-0,196	-0,129
CO2 Equivalent Emissions Total	-0,002	0,653	-0,148	-0,196	**1**	0,017
ROE	0,185	0,215	0,257	-0,129	0,017	**1**

The **Table 3** below displays the goodness of fit coefficient of our model according to the Return-on-Equity (ROE) dependent variable. As we know, R^2 indicates the percentage of variability of the dependent variable, which is explained by the explanatory variables. Given the R^2 found with our Multiple Linear Regression, we can say that 17,4% of the ROE's variability is explained by the 5 explanatory variables: Capital Intensity, Firm Size, Leverage, Growth and CO2 emissions total.

Table 3: Goodness of Fit Statistics

Observations	190
Sum of weights	190
DF	184
R^2	0,174
Adjusted R^2	0,152
MSE	0,053
RMSE	0,231
MAPE	219,885
DW	1,169
Cp	6,000
AIC	-551,281
SBC	-531,799
PC	0,879

Also, we need to look closely at the outcomes of the analysis of variance (**Table 4**) as these results would enable us to state whether the explanatory variables give significant information to the model or not.

For the analysis of variance, we use the Fisher's F test. Given the fact that the probability to the F value is lower than 0,0001 with ROE, it means that we would take a risk lower than 0,1% in assuming that the hypothesis of the explanatory variables having no effect is wrong. Thus, we can say with confidence that all five variables are bringing significant amount of information as the p-value are significant at level 1%.

Table 4: Analysis of Variance

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	5	2,070	0,414	7,774	**<0,0001**
Error	184	9,800	0,053		
Corrected Total	189	11,870			

Computed against model Y=Mean(Y)

The following tables (**Table 5**) display the Type I and Type III Sum of Squares. With these results, we will have insights whether a variable brings significant information or not, once every other variable is included in our model. The Type I SS takes into account the order in which the variables are added to the model and the impact of it. On the other hand, the Type III SS does not take into account the variable selection order.

Table 5: Type I & III Sum of Square Analysis

Type I Sum of Squares analysis (ROE):

Source	DF	Sum of squares	Mean squares	F	Pr > F
Growth	1	0,407	0,407	7,649	**0,006**
Firm Size	1	0,504	0,504	9,454	**0,002**
Debt-to-Equity	1	0,890	0,890	16,717	**<0,0001**
Capital Intensity	1	0,026	0,026	0,491	0,484
CO2 Equivalent Emissions Total	1	0,243	0,243	4,558	**0,034**

Type III Sum of Squares analysis (ROE):

Source	DF	Sum of squares	Mean squares	F	Pr > F
Growth	1	0,333	0,333	6,253	**0,013**
Firm Size	1	0,791	0,791	14,845	**0,000**
Debt-to-Equity	1	0,839	0,839	15,759	**0,000**
Capital Intensity	1	0,080	0,080	1,506	0,221
CO2 Equivalent Emissions Total	1	0,243	0,243	4,558	**0,034**

We notice with the Type I and Type III Sum of Squares for the ROE variable above that every factors have a contribution when the other variables are already taken into account in the model, except for the Capital Intensity variable. The Firm Size and Leverage (Debt-to-Equity) are the most dominant variables with this analysis as they are statistically significant at the 1% level with their p-values <0,01. Moreover, the Growth and most importantly the CO2 Emissions total are also statistically significant at the 5% level with their p-values < 0,05.

The analysis of the **Table 6** is useful to compare the coefficients of the model and the effects of the parameters.

We can see from the results that the 95% confidence of all variables except Leverage and Firm Size, includes 0 in their range. Also, we notice that for all variables, the confidence range are somewhat narrow. The p-values for the Firm Size and Debt-to-Equity shows that they are statistically significant. The explanatory variables are significant at the 1% level (p-value < 0,01). The Carbon Emissions Total and Growth factors are also statistically significant but at the 5% level (p-values < 0,05).

Table 6: Model Parameters

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	-0,852	0,247	-3,456	**0,001**	-1,339	-0,366
Growth	0,001	0,001	2,501	**0,013**	0,000	0,003
Firm Size	0,089	0,023	3,853	**0,000**	0,044	0,135
Debt-to-Equity	0,012	0,003	3,970	**0,000**	0,006	0,019
Capital Intensity	0,021	0,017	1,227	0,221	-0,013	0,055
CO2 Equivalent Emissions Total	0,000	0,000	-2,135	**0,034**	0,000	0,000

The equation of the model below shows that the Growth, Firm Size, Debt-to-Equity and Capital Intensity factors have a positive impact on the dependent variable ROE. Although, the CO2 emission variable has a negative link with the Return-on-Equity.

ROE = -0,852389109851587+0,00144438564476853*Growth+0,0892703090725697*Firm Size+0,012378910906985*Debt-to-Equity+0,0209779170068532*Capital Intensity-1,94737483400425E-09*CO2 Equivalent Emissions Total

The Standardized Regression Coefficients are given by the **Table 7** below. They are useful in comparing the influence of the explanatory variables on the dependent variable and their significance.

Table 7: Standardized coefficients

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Growth	0,169	0,068	2,501	**0,013**	0,036	0,302
Firm Size	0,421	0,109	3,853	**0,000**	0,205	0,636
Debt-to-Equity	0,271	0,068	3,970	**0,000**	0,136	0,405
Capital Intensity	0,104	0,085	1,227	0,221	-0,063	0,272
CO2 Equivalent Emissions Total	-0,197	0,092	-2,135	**0,034**	-0,379	-0,015

The **Table 7** above shows that the Firm Size variable has the corresponding Beta with the higher impact on the regression equation, whereas the Growth Beta is considered the smallest in regard to the Return-on-Equity (ROE). Again, the p-values corresponding to Firm Size and Debt-to-Equity are statistically significant at the 1% level (p-value < 0,01) and the CO2 Emissions Total & the Growth are still statistically significant at the 5% level with p-values < 0,05. As the CO2 Emissions Total Beta is negative, for every 1-unit increase in the predictor variable, the ROE variable will decrease by 0,197 units.

To summarize this analysis, we run the Multiple Linear Regression model with the objective to find whether carbon emission impacts firm value (represented by firm financial performance) of companies from the energy and technology. This analysis helps us to understand which of the explanatory variables are the most dominant and have the greater impact on the Return-on-Equity, thus on the financial performance.

The correlation matrix given by the **Table 2** demonstrates that the ROE is positively associated to the Carbon Emissions Total.

The use of the Fisher's F test for the analysis of the variance in **Table 4** shows that we can say with confidence that the CO2 emission grade, Firm Size, Leverage, Growth and Capital Intensity variables bring significant amount information.

However, even if all variables are bringing information, the Debt-to-Equity and Firm Size are the explanatory variables that are the most significant at the 1% level given their p-values < 0,01 found in the model parameters (**Table 6**). The CO2 Emissions and Growth variable are also statistically significant but at a 5% level (p-values < 0,05). The fact that the CO2 Emissions variable is significant corroborate our literature research, in which we saw that the Firm's Carbon Emission impact the value of the Firm.

The **Table 7**, shows the significance of the variables in the model, as well as the Beta's signs and values for each factors. As we can expect, the explanatory variables Growth, Firm Size and Debt-to-Equity (which are statistically significant) have a positive impact on our regression, therefore on the firm value. Any 1-unit change in these variables leads to an increase of the firm's financial performance, hence the firm value.

Even if our analysis shows that the CO2 Emission levels of a company impact its financial performance, our regression model has some limits. The formulation of this regression can be seen as regressing levels on levels and not changes on changes which would potentially give more information. The first regression model enables us to determine that a firm has high Return-on-Equity when Carbon Emission levels are low. However, since data is given at the end of the financial period, we investigate the impact that happens at the same period for the financial performance as well as the Carbon Emission of the firms.

To conclude this analysis, the aim was to determine the impact of the CO2 Emission on the firm value, and we can say that the explanatory variable demonstrate a negative but significant impact on our dependent variable (ROE). Therefore, as seen on our literature research, we can say that the level of carbon emissions influence the value of a firm and that an increase in these emissions would lead to lower firm value.

6.2. Carbon Emissions Grade & Firm Value with the second model

The results of the research made for the second hypothesis: "*Carbon Emission levels at time t-1 impact the value of a firm a time t",* are presented in this section. The **Table 8** shows the summary of the analysis for the US energy and technology companies under studies. We decide not to incorporate the companies for a specific year in which data were incomplete or non-existent as it could have impacted our analysis and make the results non-representative.

Table 8: Summary statistics for the sample companies

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
ΔROE	413	0	413	-1,068	4,420	0,141	0,361
CO2 per Assets	413	0	413	0,000	1385,424	78,089	168,194
Firm Size	413	0	413	6,051	12,980	9,374	1,408
Debt-to-Equity	413	0	413	-25,819	108,428	3,112	8,751
Growth	413	0	413	-78,152	222,808	5,767	27,027
Capital Intensity	413	0	413	0,289	7,714	2,229	1,481

We fiund that the average ΔReturn-on-Equity (ΔROE) for the companies coming from both the energy and technology sectors is about 0,141. The average CO2 per Assets corresponding to these companies is 78,089.

The **Table 9** below presents the correlation matrix and the coefficients among the studied variables.

The correlation matrix demonstrates which variables interact whether positively or negatively with the other variables with this regression. The change in Return-on-Equity (ΔROE) is positively correlated with the Debt-to-Equity and Growth. Although, ΔROE has a negative association with the Capital Intensity variable, Firm Size and most importantly the CO2 per Assets factor. The correlation matrix indicates that any increase in the CO2 per Assets variable enables a decrease in the Firm Value the following year.

Table 9: Correlation Matrix of the Different Variables

	CO2 per Assets	Firm Size	Debt-to-Equity	Growth	Capital Intensity	ΔROE
CO2 per Assets	1,000	0,361	-0,080	-0,114	-0,182	-0,090
Firm Size	0,361	**1**	-0,073	-0,143	-0,465	-0,019
Debt-to-Equity	-0,080	-0,073	**1**	0,036	-0,027	0,451
Growth	-0,114	-0,143	0,036	**1**	-0,011	0,078
Capital Intensity	-0,182	-0,465	-0,027	-0,011	**1**	-0,161
ΔROE	-0,090	-0,019	0,451	0,078	-0,161	**1**

The **Table 10** below displays the goodness of fit coefficient of our model according to the ΔReturn-on-Equity (ΔROE) dependent variable. As we know, the R^2 indicates the percentage of variability of the dependent variable which is explained by the explanatory variables. Given the R^2 founds with our Multiple Linear Regression, we can say that 23,6% of the ΔROE's variability is explained by the 5 explanatory variables: Capital Intensity, Firm Size, Leverage, Growth and CO2 per Assets.

Table 10: Goodness of Fit Statistics

Observations	413
Sum of weights	413
DF	407
R^2	0,236
Adjusted R^2	0,227
MSE	0,101
RMSE	0,318
MAPE	203,327
DW	1,187
Cp	6,000
AIC	-940,984
SBC	-916,843
PC	0,786

Also, we need to look closely at the outcomes of the analysis of variance (**Table 11**) as these results would enable us to state whether the explanatory variables give significant information to the model or not.

For the analysis of variance, we use the Fisher's F test. Given the fact that the probability to the F value is lower than 0,0001 with ΔROE, it means that we would take a risk lower than 0,1% in assuming that the hypothesis of the explanatory

variables having no effect is wrong. Thus, we can say with confidence that all five variables are bringing significant amount of information as the p-value are significant at level 1%.

Table 11: Analysis of Variance

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	5	12,701	2,540	25,156	**<0,0001**
Error	407	41,099	0,101		
Corrected Total	412	53,800			

Computed against model Y=Mean(Y)

The following table (**Table 12**) displays the Type I and Type III Sum of Squares. With these results, we have insights whether a variable brings significant information or not, once every other variable is included in our model. The Type I SS takes into account the order in which the variables are added to the model and its impact. On the other hand, the Type III SS does not take into account the variable selection order.

Table 12: Type I & III Sum of Square Analysis

Type I Sum of Squares analysis (ΔROE):

Source	DF	Sum of squares	Mean squares	F	Pr > F
CO2 per Assets	1	0,437	0,437	4,332	**0,038**
Firm Size	1	0,012	0,012	0,118	0,732
Debt-to-Equity	1	10,715	10,715	106,115	**<0,0001**
Growth	1	0,197	0,197	1,954	0,163
Capital Intensity	1	1,339	1,339	13,261	**0,000**

Type III Sum of Squares analysis (ΔROE):

Source	DF	Sum of squares	Mean squares	F	Pr > F
CO2 per Assets	1	0,219	0,219	2,164	0,142
Firm Size	1	0,056	0,056	0,550	0,459
Debt-to-Equity	1	10,085	10,085	99,872	**<0,0001**
Growth	1	0,116	0,116	1,145	0,285
Capital Intensity	1	1,339	1,339	13,261	**0,000**

We notice with the Type I Sum of Square Analysis ΔROE variable that the CO2 per Assets, the Debt-to-Equity and the Capital Intensity factors have a contribution when the other variables are added turn by turn in the model. The level of significance is at the 1% level for the Capital Intensity and Debt-to-Equity variable with their p-values<0,01. Regarding the CO2 per Assets factor, its level of significance corresponds to 5% and its associated p-value is lower than 0,05.
The Type III SS Analysis shows that the Debt-to-Equity and Capital Intensity are the only varibales with a level of significance. Both factors are statisticaaly significant at the 1% level with the corresponding p-values < 0,01. Therefore, we notice that the Growth and Capital Intensity variables are the only statistically significant in both analysis which make them having the greater impact on the dependent variable.

The analysis of the **Table 13** is useful to compare the coefficients of the model and the effects of the parameters.

We can see from the results that the 95% confidence of all variables except Leverage and Capital Intensity, includes 0 in their range. Also, we notice that for all variables, the confidence range is really narrow. The p-values for the Capital Intensity and Debt-to-Equity show that they are statistically significant. The explanatory variables are significant at the 1% level (p-value < 0,01). The CO2 per Assets variable on the other hand is not statistically significant.

Table 13: Model Parameters

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
Intercept	0,284	0,140	2,031	**0,043**	0,009	0,559
CO2 per Assets	0,000	0,000	-1,471	0,142	0,000	0,000
Firm Size	-0,010	0,013	-0,742	0,459	-0,036	0,016
Debt-to-Equity	0,018	0,002	9,994	**<0,0001**	0,014	0,022
Growth	0,001	0,001	1,070	0,285	-0,001	0,002
Capital Intensity	-0,044	0,012	-3,642	**0,000**	-0,067	-0,020

The equation of the model below shows that the Growth and Debt-to-Equity factors have a positive impact on the dependent variable ΔROE. Although, the CO2 emission variable has a negative link with the change in Return-on-Equity.

ΔROE = 0,283923382256373-1,4746134299943E-04*CO2 per Assets-9,94282491483341E-03*Firm Size+1,80032005480051E-02*Debt-to-Equity+6,30304033090518E-04*Growth-4,37833416423244E-02*Capital Intensity

The Standardized Regression Coefficients are given by the **Table 14** below. They are useful in comparing the influence of the explanatory variables on the dependent variable and their significance.

Table 14: Standardized coefficients

Source	Value	Standard error	t	Pr > |t|	Lower bound (95%)	Upper bound (95%)
CO2 per Assets	-0,069	0,047	-1,471	0,142	-0,160	0,023
Firm Size	-0,039	0,052	-0,742	0,459	-0,141	0,064
Debt-to-Equity	0,436	0,044	9,994	**<0,0001**	0,350	0,522
Growth	0,047	0,044	1,070	0,285	-0,039	0,134
Capital Intensity	-0,179	0,049	-3,642	**0,000**	-0,276	-0,083

The **Table 14** above shows that the Debt-to-Equity variable has the corresponding Beta with the higher impact on the regression equation, whereas the Capital Intensity Beta is considered the smallest in regard to the ΔReturn-on-Equity (ROE). Again, the p-values corresponding to Debt-to-Equity and Capital Intensity are statistically significant at the 1% level (p-value < 0,01) and the CO2 per Assets varaiable is still not statistically significant. As the Leverage variable Beta is positive, for every 1-unit increase in the predictor variable, the ΔROE variable increase by 0,436 units. Regarding the Capital Intensity beta, a 1-unit increase will make a 0,179 decrease in the ΔROE variable.

To summarize this analysis, we run the Multiple Linear Regression model with the objective to find whether firm value (represented by firm financial performance) at time t of companies from the energy and technology sector is impacted by their carbon emission at time t-1 represented by the CO2 per Assets metric. The analysis helps us to understand which of the explanatory variables are the most dominant and have the greater impact on the change Return-on-Equity, thus on the financial performance.

The correlation matrix given by the **Table 9** demonstrates that the ΔROE is negatively associated to the CO2 per Assets factor.

The use of the Fisher's F test for the analysis of the variance in **Table 11** shows that the CO2 per Assets, Firm Size, Debt-to-Equity, Growth and Capital Intensity variables bring significant amount information.

However, even if all variables bring information, the Debt-to-Equity and Capital Intensity are the explanatory variables that are the most significant at the 1% level given their p-values < 0,01 found in the model parameters (**Table 13**). On the other hand, the CO2 per Assets is not statistically significant in this regression model.

The **Table 14** shows the significance of the variables in the model, as well as the Beta's signs and values for each factors. As we can expect, the explanatory variables Capital Intensity and Debt-to-Equity are statistically significant and have an impact on our regression, therefore on the firm value. Any 1-unit change in these variables will lead to a decrease with the Capital Intensity variable and an increase with the Leverage related factor, of the firm's financial performance hence the firm value.

The regression model used to test the second hypothesis also present its limits. We saw during the literature research that most of the recent paper published show a negative and significant link between Carbon Emission at time t-1 and Corporate Financial Performance at time t. Even though our analysis demonstrates that there is a negative relationship between CO2 per Assets at t-1 and Firm Value at time t, the significance of the results are not strong enough to accept the second hypothesis. This can be due to the size of the sample or to the number of missing data. The data sample cannot be considered as large, due to the fact that we focus solely on two industries and only on listed companies.

To conclude this analysis, the aim was to determine the impact of the CO2 Emission (by using the CO2 per Assets proxy) on the firm value, and we can say that the explanatory variable demonstrate a negative but non-significant impact on our dependent variable (ΔROE). Therefore, we can say that the Carbon Emission levels at time t-1 don't have an significant impact on the Firm Value at time t, as there is not enough evidence to support the opposite.

7. Conclusion

This research study investigates the relationship between Carbon Emission and Corporate Financial Performance, for an extensive data sample of S&P500 companies belonging to the Energy and Industry sectors during a 10-years period from 2009 to 2018. The Carbon Emission Levels data were collected from the Thomson Reuter Eikon database for each firm during the determined period of time. The financial-related data such as Debt-to-Equity ratio, Return-on-Equity, Capital Intensity, Growth were downloaded from the WRDS database as it allowed us to have all the complete information needed coming from one source.

The first equation modelling analysis shows that the Carbon Emissions impact significantly and negatively the firm value of the firms, which means that an increase in Carbon Emissions levels would decrease the corporate financial performance of the company. These results are in accordance with the different paper outlined in during our literature review which states that the Carbon Emissions levels can impact the value of firm.

The findings are consistent with the predictions and results from the previous economical & financial theories and researches reviewed in the literature part of this study. The outcome of our research provides evidence that the market actually values the carbon emission related issues when it comes to determine the value of a firm. The Carbon Emissions and more generally the ESG indicators play a key role in company valuation and it became a major factor in the decision-making process of the investors.

The second equation modelling analysis shows that the Firm value at time t isn't impacted by the Carbon Emission levels at time t-1. The regression's analysis outlined that the CO2 per Assets variable, even though negatively correlated with the change in Return-On-Equity, is not statistically significant. Therefore, we have to reject the second hypothesis due to the lack of solid results. We believe the size and the completeness of the data played a key part on finding significant results. The companies don't have the obligation to disclose their ESG-related information which made it complicated for us to find complete data for all the company studied.

Like all researches, ours is subject to limits. The first limit lies in the disclosure of the Carbon Emissions made by the company themselves. Our study, therefore, our regressions, are using the CO2 Emissions that are stated by the companies, hence we had to face missing data for some periods of time and also for companies. The issue that comes with the lack of disclosed CO2 emissions data means that the regressions run will have less observations as we decided to not use any mean or mode to complete the missing data. With a greater or a full data sample, the results might be slightly different even though we believe that the outcome would remain the same as demonstrated in numerous studies.

The time period can also be a limit as we focused on data coming from after the 2010s mostly. A representative panel study can be made by using data from the 1990s where regulations were less severe in the 20th century. For example, a research study for the same topic during a 30 years period could enable more precise results and also help to determine if there is a real impact on a such long period. Although the data available regarding the Carbon Emissions might not be fully complete which can be problematic.

Finally, our study focused on only two sectors within the S&P500, then we were limited in terms of company diversification. A research study of this topic made with data collected from several countries and different sectors could lead to a more accurate representation of the subject.

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