**TWO STUDIES IN GREEN FINANCE:
HAVE GREEN BONDS BEEN DELIVERING ON THEIR PROMISE TO MAKE THE ENVIRONMENT MORE SUSTAINABLE IN THE FACE OF CLIMATE CHANGE?
AND
DO ENVIRONMENTAL, SOCIAL AND GOVERNANCE LABELLED FUNDS CREATE A DIFFERENT INVESTMENT ALTERNATIVE OR ARE THEY MORE OF THE SAME?**

by

Otavio Augusto Fernandes Lopes

A thesis submitted to Johns Hopkins University in conformity with the requirements for the degree of Doctor of International Affairs

Baltimore, Maryland

February 2022

Abstract:

Throughout the 20th century it became clear that anthropogenic activity is the main factor in the rapid climate shift resulting from temperature increases. In capital markets this challenge has been dealt with mainly through the classification of certain assets as green and, more recently, the Environmental Social and Governance ("ESG") scoring of assets and funds. This doctoral thesis has investigated the impact that green bond issuances in the USA had on greenhouse gas ("GHG") emissions reported at a facility level to the Environmental Protection Agency ("EPA"). It also compares ESG denominated funds and non ESG denominated funds to define if they are statistically different between them and when compared to the SP500. The analysis concludes that first time green bond issuances are corelated to statistically significant reductions in GHG emissions by the facilities associated with a green bond parent firm even using 99% confidence intervals. It further shows that there is no clear pattern to when green assets related to an issuance are created, making lagged or leading effects of treatment not obvious. The innovative approach, using facility level data, sets the steps for future analysis when more data may be available. The analysis also concludes that ESG labelled exchange traded funds ("ETFs") are not able to statistically differentiate themselves from non-ESG ETFs nor the SP500 in terms of industry allocation. When analyzing E, S, G and ESG scores we found mixed results. Group average E, S, G and ESG scores were not statistically different under the Wilcoxon Signed-Rank test. However, there was no significant evidence that ESG ETFs and non-ESG ETFs have the same median S, G and ESG scores when using non-averaged data under the Wilcoxon Rank-Sum test, which means that they differentiate enough to be considerate different.

Principal Advisor: Gordon Bodnar, Ph.D.

Committee Member: Bilal Zia, Ph.D.

Committee Member: Carlos Vegh, Ph.D.

Acknowledgments

My deepest appreciation goes to Professor Gordon Bodnar for his time and professionalism, providing me guidance from initial thoughts to final touches in the thesis as my advisor. He has been a key figure in lighting my path in a learning process that at times felt like hitting dead ends. Prof Bodnar’s pragmatism, provocative thoughts and natural interest in the topic helped me keep a curious mind while searching for ideal solutions and approaches to finalize this thesis.

I’m also deeply thankful to both Professor Bilal Zia and Professor Carlos Vegh, who had a significant impact in my professional development during my period as their doctoral student at Johns Hopkins’ School of Advanced International Studies.

I also owe gratitude to Professor John Harrington, Professor Jaime Marquez, Professor Anna Fruttero, Professor Michael Klein, Professor Matthew Kocher, Tapiwa Sikipa, Christopher Dielmann, Yaro Kulchyckyj, Yonatan Holz, Eleanor Dickens, Mariana Pinzon-Caicedo, Gustavo Carvalho among others who have contributed directly or indirectly with reviews, comments, advices, support, sharing their technical knowledge and sometimes helping by just teaching me to ask the right questions. My utmost gratitude to my parents, Luiz A. Lopes and Sueli T. Fernandes Lopes who taught me the value of education and perseverance.

The guiding question that triggered me to write this thesis was: ‘what if all capital market assets were “green” and all funds labelled “ESG”: would the climate still change?’ While this broad question remains open, I’d like to show my deepest appreciation to the professionals in the field of impact and sustainable finance research, which have been truly inspirational through their work such as (but are not limited to): Caroline Kousky, Bill Gates, Caroline Flammer, Fiona Stewart, Florian Berg, Julian F Kölbel, Roberto Rigobon, Torsten Ehlers, Benoit Mojon, Frank Packer, Quinn Curtis, Jill E. Fisch, Adriana Robertson, Jochen Schmittmann and Chua Han Teng.

Contents

List of Tables

List of Figures

List of Acronyms

ABS	Asset Backed Securities
AUM	Assets Under Management
BEA	US Bureau of Economic Affairs
BIS	Bank for International Settlements
BPL	Breusch-Pagan Lagrange multiplier test
CAGR	Compounded Annual Growth Rate
CBI	Climate Bonds Initiative
CICERO	Centre for International Climate and Environmental Research
DiD	Difference in Differences
DOL	Department of Labor
EIB	European Investment Bank
EPA	Environmental Protection Agency
ERISA	Employee Retirement Income Security Act
ESG	Environmental, Social and Governance
ETF	Exchange Traded Fund
FE	Fixed-effects
FLIGHT	Facility Level Information on Greenhouse Gases Tool
GBP	Green Bonds Principles
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GHGRP	Greenhouse Gas Reporting Program
GRI	Global Reporting Initiative
IPCC	Intergovernmental Panel on Climate Change
IR	Industrial Revolution
IVA	Intangible Value Assessment
MSCI	Morgan Stanley Capital International
NASA	National Aeronautics and Space Administration
NOOA	National Oceanic and Atmospheric Administration
NY MTA	New York's Metropolitan Transportation Authority
OLS	Ordinary Least Squares
RE	Random-effects
SASB	Sustainability Accounting Standards Board
SDG	Sustainable Development Goals
SEC	Securities and Exchange Commission
SIFMA	Securities Industry and Financial Markets Association
SRI	Socially Responsible Investing
TCFD	Task Force on Climate-Related Financial Disclosures
TOPI	Taxes on Production and Imports
UN	United Nations
UNEP	United Nations Environment Programme
V@R	Value-at-Risk

Equations

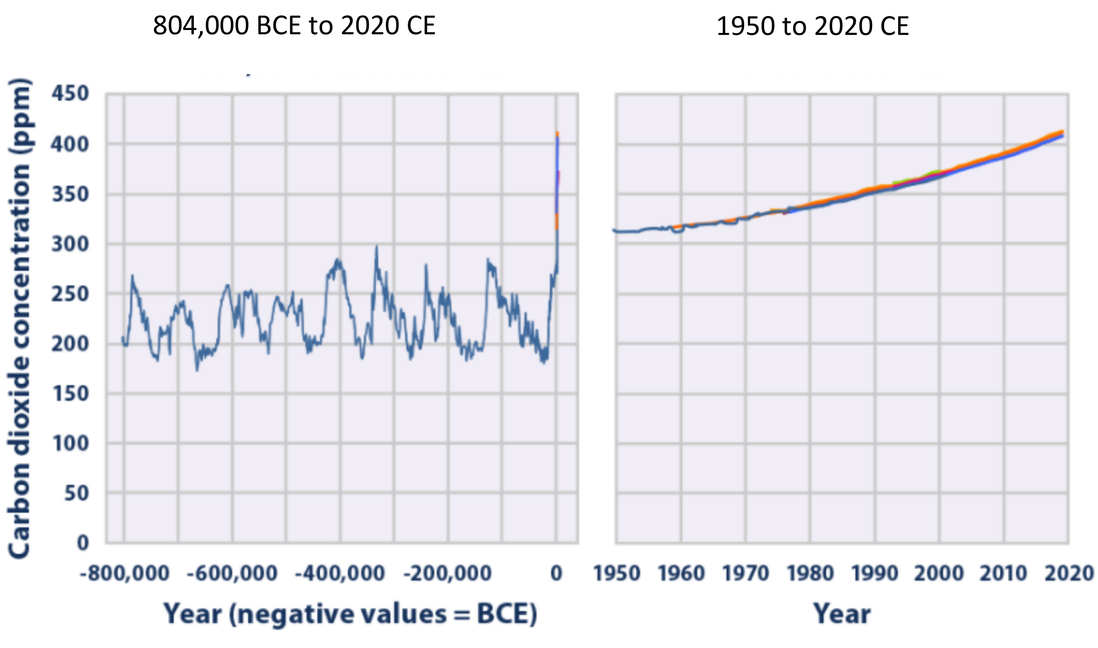
1 Chapter 1 – Introduction

1.1 Introduction

In 1698, Thomas Savery, an engineer in the British army, invented the steam powered engine which was a cornerstone in the establishment of the first railway and kickstarted an increasing trend of converting energy into movement.

Savery's invention, together with other developments, unchained a series of events known as the Industrial Revolution ("IR"), which sit just before the unprecedented increase in carbon emissions seen in Figure 1 below. On the left side of Figure 1 we see that CO2 concentration in the atmosphere has varied throughout time within a band, but that pattern was broken in the recent centuries. On the right side of Figure 1 we zoom into the colorful part of the graph on the left, which shows that most of that abnormal increase happened in the last 80 years (1950 to 2020).

Figure 1. Carbon Dioxide Concentration in the Atmosphere



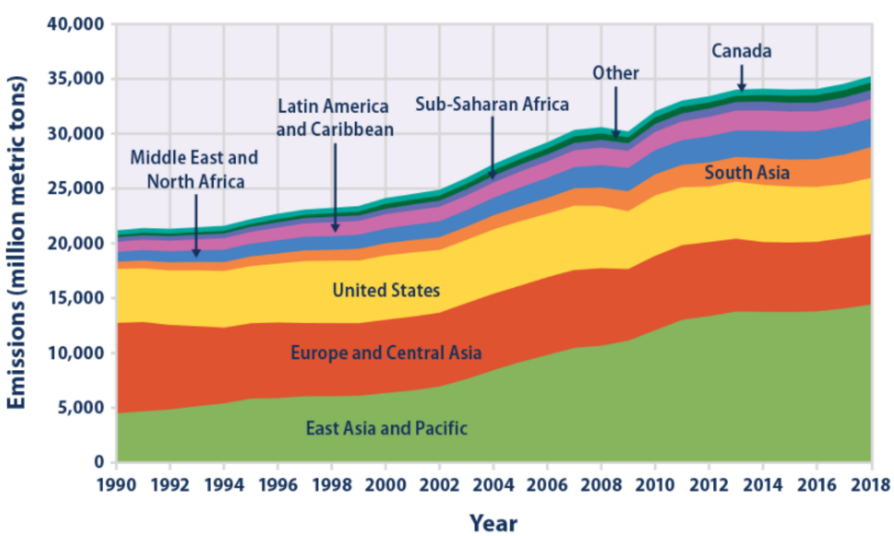
Note: Figure 1 shows two graphs with the concentration of CO2 in the atmosphere, highlighting the changes that happened in the last 7 decades. Since the 1950s CO2 concentration significantly breached a band (between 180ppm and 300ppm) seen for the past 800,000 years.
Source: Compilation of 10 underlying datasets done by the Environmental Protection Agency (EPA) (2021).

1.1.1 Climate Change Challenge

The IR spammed from 1760s to 1830s and as described in Sapiens (Harari, 2015), "opened up new ways to convert energy and to produce goods, largely liberating human-kind from its dependence on the surrounding ecosystem. Humans cut down forests drained swamps, dammed rivers, flooded plains, laid down hundreds of thousands of miles of railroad tracks, and built sky scraping metropolises. As the world was molded to fit the needs of Homo Sapiens, habitats were destroyed, and species went extinct. Our once green and blue planet is becoming a concrete and plastic shopping center."

Between 1990 and today, the global carbon emissions from fossil fuels have continued to increase as per the Figure 2 below, increasing the concentration of CO2 in the atmosphere seen in Figure 1. GHG emissions due to human activity are the main cause of Earth's increasing temperatures (NASA, 2020).

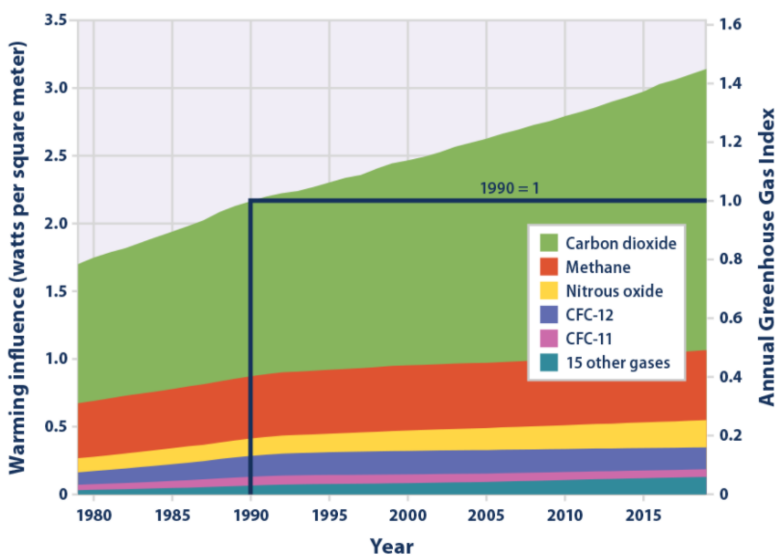
Figure 2. Global Carbon Emissions by Region, 1990-2018



Note: Figure 2 shows the origin of the carbon emissions in the past 3 decades. East Asia and the Pacific have taken the lead and have accounted for most of the increase in carbon emissions in the period. Source: Environmental Protection Agency (EPA) (2021).

The vast societal, environmental, and technological changes induced by the IR led to the socioeconomic societies we live in today and to the rapid increase in Green House Gas (GHG) emissions. GHG is mainly composed of CO2, followed by Methane, Nitrous Oxide and Fluorinated Gases as per Figure 3, which shows the continuous increase in GHG concentration in the atmosphere and its direct effect in the Earth's temperature measured in watts per square meter.

Figure 3. Radiative Forcing Cause by Major Long-Lived Greenhouse Gases, 1979-2019



Note: Figure 3 shows that among greenhouse gases carbon dioxide is the most relevant for global warming followed by methane and nitrous oxide. The figure also shows the quick increase in heating potential of these gases' concentration measured in watts per square meter.
Source: National Oceanic and Atmospheric Administration ("NOAA") (2020).

The Intergovernmental Panel on Climate Change (IPCC)[1] highlighted the substantial impact of rising temperature on the oceans, cryosphere, desertification, land degradation, food security and poverty. IPCC's most recent report (2021) has been more precise in its scenarios, with greater statistical significance, and confirmed the risks highlighted in previous reports, concluding that to prevent the worst effects of climate change we need to avoid temperatures

[1] The IPCC was created to provide policymakers with regular scientific assessments on climate change, its implications, and potential future risks, as well as to put forward adaptation and mitigation options.

from rising more than 1.5ºC. In order to do so we must get to net zero GHG emissions in every sector of the economy in 30 years (Gates, 2018). This means not only flattening the curve seen in Figure 1, which has grown since the 1700s, but turning it to a descending slope towards zero in 2050. Increasing climatic consequences and implications due to the accumulation of manmade GHG gases in the atmosphere, will be the most important risk faced in the 21st century. For more details about the increasing temperature and its impact on precipitation and droughts, please refer to Annex 1 and the IPCC Sixth Assessment Report released in 2021.

1.1.2 Initiatives to Address the Climate Change Challenge

To address this challenge, countries have made commitments to reduce GHG emissions in international agreements such as the Kyoto Protocol (1997) and the Paris Agreement (2015)[2]. On 12 December 2015, nearly 200 countries committed to the Paris Accord's climate goals, which includes as one of its three main objectives: "making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development" (Ehlers *et al*. 2020).

Given the global mobilization to face climate change and greater scrutiny on GHG emissions, all industries have been trying to adjust, including the financial industry.

The financial industry and, more specifically, the global capital markets efforts to address social and climate issues started through the Socially Responsible Investment ("SRI") bonds in the 1970s[3]. SRI bonds allowed a variety of sustainable investment options to flourish, especially

---

[2] By the deadline of 7 October 2016, the required minimum of 55 country Parties to the United Nations Framework Convention on Climate Change (UNFCCC), that represent a required total contribution of at least 55 percent of the world's greenhouse gas emissions, had submitted their instruments of ratification, acceptance, approval, or accession, allowing the Paris Agreement to enter into force as an international treaty.

[3] Understanding the origin of the environmental issues we currently face is important to realize that this is an old problem that has gotten increasingly worse and although ideas to solve it aren't as old, they have been around for at least centuries. "Ethical codes and religious beliefs shaped the earliest instances of sustainable investing; the desire to invest consistently with personal values guides what sustainable investing would eventually become". (Morningstar, 2020) Supporters of sustainable or socially responsible investing take note of its roots dating back more than 200 years ago to money management practices of the Methodists. Others suggest this goes back to the ideas long championed in Sharia investing if not beyond. The modern version of Socially Responsible Investing in America took hold in the mid-20th century, when investors began to avoid and question the so called "sin" stocks, which represented the equity of

after the 1990s, such as ESG, labelled bonds and the Sustainable Development Goals (“SDG”), as per Table 1 below. Among labelled bonds we highlight green bonds, which focus on environmental sustainability, social bonds, which focus on social sustainability, and blue bonds, which focus on oceans and water related sustainability. Sustainable principles and reporting standards have also been developing in parallel to the development of sustainable products, such as the appearance of IRIS in 2009.

The industry has been able to slowly increase the limited participation of sustainable investment bonds in the global fixed income market to fight environmental, social and governance issues such as climate change and inequality.

---

companies in certain industries. In 1950, the Boston-based Pioneer Fund, established in 1928, doubled down on this movement, becoming one of the first funds to adopt Socially Responsible Investment (“SRI”) principles. The first format of responsible investment that emerged in the XX century was marked by the environmental and social demand based on the values of shareholders and asset owners at the time. A broader conscientization of the general public about environmental protection gained significant traction throughout the second part of the century leading up to the Earth Day on April 22, 1970. Given the push against war, sweatshops, Apartheid, climate change, human trafficking and several other political and cultural issues, socially responsible investors followed suit. SRI investing grew significantly in the 1970s as shareholders activism started to engage companies around certain kinds of practices. SRI was generally a search for good corporate responsibility and corporate behavior, companies that did not have reputational stains in their past. Excluding certain business such as tobacco, alcohol, guns, and gambling, at the time, was the easiest systematic approach from a methodological standpoint to align portfolio construction and the investors’ values. In the 1990s SRI was consolidated and an unquestionable line of investment setting the foundation for other developmental approaches to emerge. Blackrock claims the first ESG index, the Domini 400 Social Index (now, MSCI KLD 400 Social Index), was launched by KLD Research & Analytics in 1990. Although Domini 400 Social Index was created in 1990 it was coined as an SRI fund at the time. The term ESG surfaced in the early 2000s when the former UN Secretary General Kofi Annan reached out to over 50 CEOs of the most important financial institutions inviting them to participate in a joint initiative under the UN Global Compact with the support of the International Finance Corporation (IFC) and the Swiss Government. In 2005 this initiative produced a report titled “Who Cares Wins” which first coined the term ESG. Today, there are over 1,000 ESG indexes, reflecting the growing appetite of investors for ESG products and the need for measurement tools that accurately reflect the objectives of sustainable investors.

Table 1. Global Capital Markets Efforts to Address Social and Climate Issues

Acronyms	First Appeared	What is it?	Comment:
SRI	1950*	Investment Principles.	Mostly driven by shareholders' desire to have investments aligned with their values.
GRI	1997	Independent international not-for-profit organization and a set of reporting standards.	Significantly involved in determining sustainability reporting standards.
ESG	2005	A concept which includes envronmental social and governance practices into the analysis of issuers.	The best use of ESG data has led to ESG ratings which have been a rapidly growing industry.
Labelled Bonds**	2007	A Broad concept of a positive impact in a certain area, green bonds are related to environment for instance.	Strictly related to the use of proceeds, not to the issuer as ESG rating.
IRIS	2009	A catalog of metrics, with a similar objective to GRI.	Created by the Global Impact Investing Network.
SDG	2015	Goals determined to promote an agenda of change until 2030.	Wider approach as per Image 2.

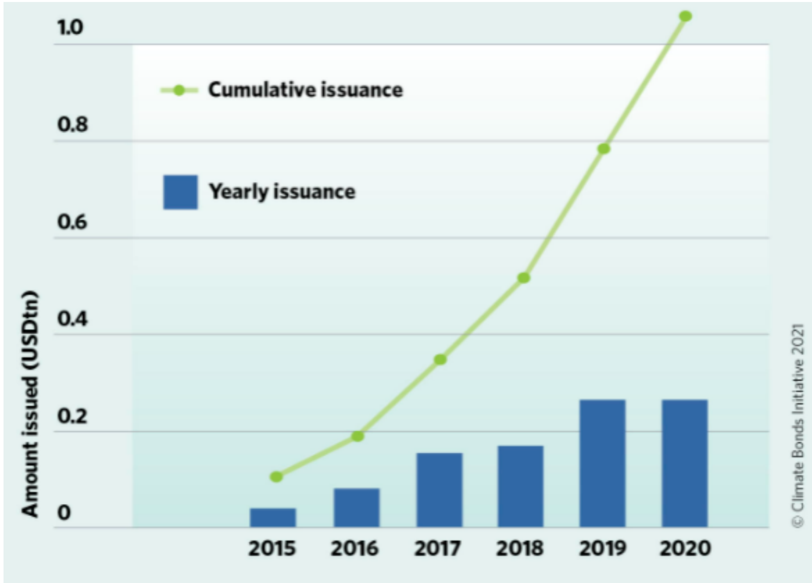
*Boston-based Pioneer Fund
**Includes Green Bonds

Note: Table 1 shows how capital markets initiatives have addressed climate and social issues in the past decades leading to where we are today.
Source: Lopes, Otavio; using information from the World Bank (2019), International Monetary Fund (2020), Global Reporting Initiative (2020), Donavon (2020), Morningstar (2020), IRIS (2020)

1.1.3 Green Bonds' Question

In 2020 the global bonds market was estimated at USD123.5 trillion, according to the Securities Industry and Financial Markets Association ("SIFMA") (SIFMA, 2018), with green bonds representing less than 1% of the total (approx. USD1 trillion) (Climate Bonds, 2021). Yet green bonds have become the main instrument through which issuers fund and publicize environmentally friendly projects, such as renewable energy or clean transport. Fund managers also like this security class as a way of meeting growing investor demand for sustainable options. As seen in Figure 4, below, the green market grew significantly over the five-year period between 2015 and 2020, raising a profound guiding question: how green are green bonds? Regulators are working on standards to help guard against greenwashing, the process of conveying a false impression that a product is more environmentally sound than it is (Kahle, 2013). Despite this significant level growth, we have seen a surprisingly small amount of research devoted to answering the question of whether green bonds are indeed 'green' (Promina, 2019).

Figure 4. Annual Green Issuance



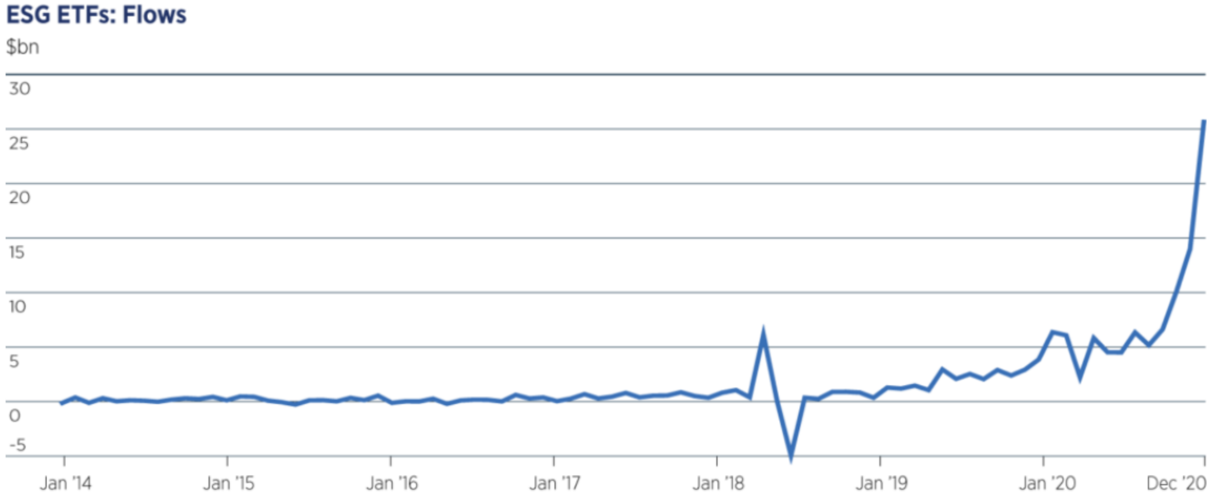
Note: Figure 4 shows the rapid increase in green bond issuances between 2015 and 2020, with cumulative issuances breaching USD1 trillion in 2020.
Source: Climate Bonds, 2021

1.1.4 ESG Funds' Question

ESG exchange traded funds ("ETF") issuances have also gone through unprecedent growth. Assets under management ("AUM") in ESG ETFs had a 223% growth in 2020. According to ESGClarity (2021)[4] ESG ETFs recorded AUM of USD189 billion at the end of 2020.

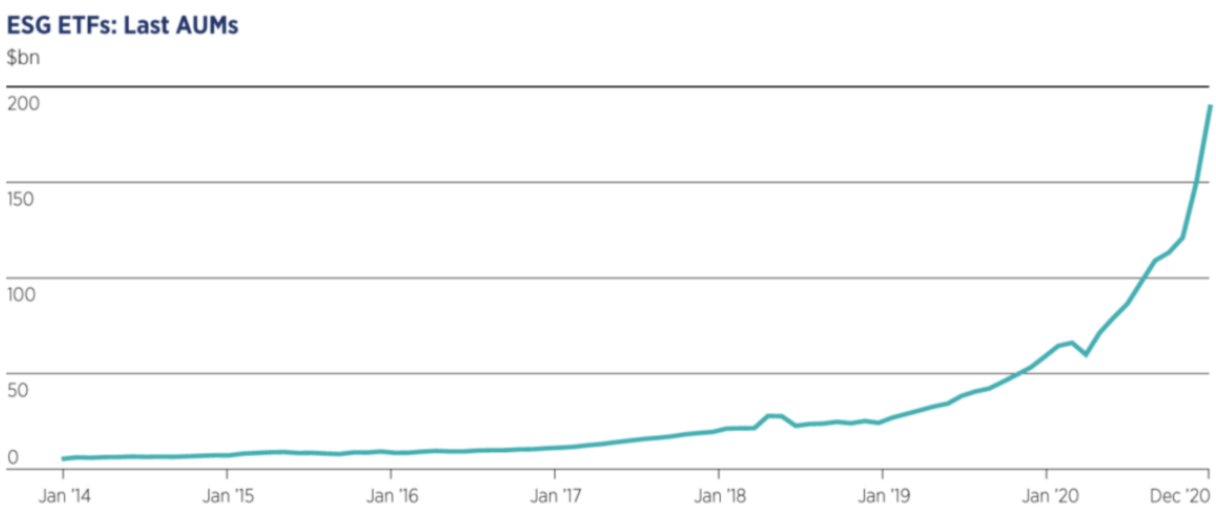
[4] Based on data from ETF analysis platform TrackInsight.

Figure 5. ESG ETF Flows Between 2014 and 2020



Note: Figure 5 shows the rapid increase in ESG ETF issuances between 2014 and 2020, with most of that increase happening during 2020.
Source: ESGClarity, 2021

Figure 6. ESG ETF AUM Between 2014 and 2020



Note: Figure 6 shows the rapid increase in ESG ETF AUM between 2014 and 2020, with most of that increase happening during 2020.
Source: ESGClarity, 2021

Like green bonds, questions about the comparability, risks, advantages, and impact of ESG funds have also been raised by stakeholders. In March 2021 the Securities and Exchange Commission ("SEC") created a Climate and ESG Task Force in the Division of Enforcement.

"Given the increasing investor focus and reliance on climate and ESG-related disclosure and investment, the Climate and ESG Task Force will develop initiatives to proactively identify ESG-related misconduct" (SEC, 2021). The SEC claims to be concerned about disclosure and compliance issues relating to investment advisers' and funds' ESG strategies. Given their fast rate of growth and concerns about transparency we also raise the question: are ESG ETFs different from non-ESG ETFs?

1.1.5 Sustainability Reliability

Both guiding questions raise concerns about the transparency of green bonds and ESG ETFs, especially regarding the reliability of their developmental impact and differentiation from standard instruments. Does the green/ESG labeling in finance have any real meaning? Are investors getting what they think they are with these securities?

To examine this topic, we will analyze both instruments in the coming chapters 2 and 3:

1. Chapter 2 looks at green bonds and examines whether green bond issuances are correlated with a measurable reduction in GHG emissions for a sample of issuers in USA. The analysis will help investor confirm that by investing in green bonds they are supporting greater GHG emissions' reduction than if they were investing in standard instruments. Testing this correlation is especially important at a time where we face significant climate change due to anthropogenic GHG emissions.
2. Chapter 3 looks at ESG investment funds: Are the investment allocations in these funds meaningfully different from standard (non-ESG) funds? Answering this question will help stakeholders identify ESG-related misconduct. The growing demand for ESG labelled funds shows appetite from investors for instruments that state to differentiate themselves based on reduced climate impact. While the SEC's task force, mentioned above, will look

deeply into disclosure and compliance issues, our question could raise a red flag about potential misstatements and the need for greater transparency in how ESG and non-ESG funds are different.

Why is This Research Relevant?

Resistance to adhere to sustainability indicators results from the market incapacity to prove that such indicators can, first, indeed help reduce inputs to continuing climate change and, second, help improve security selection and portfolio construction by increasing return or reducing risks, which could be re-stated as improve investments' net present value by raising expected cash flows or reducing the required rate of return.

Chapter 2 of this thesis focuses on the market incapacity to prove that green assets can help reduce inputs that are causing climate change. This topic has the potential to prove a connection between green bonds issuance and GHG emissions reduction, potentially helping to unlock a significant amount of resources that is reticent to migrate to sustainable investment strategies due to an unclear connection between green bonds and a positive impact on the environment. If that connection is not found this thesis will be highlighting the need for greater clarity in the relationship between green bonds and GHG emissions.

As investors seek differentiation through ESG funds, Chapter 3 investigates if investors have been given that differentiation. This topic also has the potential to unlock resources that are reticent to migrate to sustainable investment strategies due to potential misrepresentation and lack of differentiation. Hence, the potential for misrepresentation among sustainable assets is one of the main obstacles sustainable investing faces today and it's what ties these questions and this paper together.

This research can add to the literature by helping the industry focus on the right topics: providing a crystal-clear relationship between green bonds and GHG emission reductions and looking for true differentiation between ESG labelled funds and non-ESG labelled funds. Both topics would help avoiding potential for greenwashing and increase stakeholder trust on such important sustainable capital markets instruments. It will also help investors better understand the financial products they are investing in and have more information to better allocate their resources according to their goals and objectives.

Green bonds and ESG labelled instruments are fixed income markets' main instruments to deal with climate change. If this research can't prove that these instruments have the potential to change the real economy, the sustainable investment industry may have the opportunity to create a more direct connection between green bond issuances and a reduction in GHG emissions and show that ESG funds are different from funds that preceded them.

2 Chapter 2 – Green Bonds and GHG Emissions

2.1 Chapter Purpose

Despite the aforementioned growth in green bonds over the past two decades, a relatively small amount of research has been focused on determining whether or not green bonds are indeed ‘green’. Investors and society are left with questions about how green are green bonds, especially in light of greenwashing claims - when firms actively promote false claims to pretend to be less harmful to the environment than they really are. This has become an overspread risk according to the SEC (Michaels, 2021).

In this chapter we will examine whether USA green bond issuers, between 2010- 2019, reduced their GHG emissions relative to non-green bond issuers, using Environmental Protection Agency (EPA) facility-level GHG emissions data.

The Impact of Climate Change

According to the IPCC Sixth Assessment Report released in 2021, increasing climate risk, which is mainly driven by human activity and GHG emissions, can significantly pressure societies in many fronts. Many cities and governments have seen an increase in expenses related to the avoidance and recovery from natural disasters. Sub national initiatives monitoring and budgeting for climate change is quickly becoming the norm such as in San Francisco, Oslo, Paris, Milan, New York, Rome, Copenhagen, Växjö, among others (LGC, 2021).

As stated by the United Nations Environment Programme (UNEP) (2021),

> “…the adaptation costs alone faced by just developing countries will be in a range of USD140 billion to USD300 billion per year by 2030, and USD280 billion to USD500 billion annually by 2050. Once mitigation and decarbonization efforts and global resiliency efforts, in both the developing and developed world are factored in the annual cost will greatly exceed USD500 billion and possibly even more than a trillion dollars” (United Nations, 2021b).

This amount compares to the commitment made more than 10 years ago by developed countries to mobilize USD100 billion per year by 2020 current commitment of USD100 billion which is not being met as per an expert report prepared at the request of the UN Secretary-General.

The first direct impact of climate change is the increase in intensity and recurrence of catastrophic events such as floods, droughts, hurricanes, and wildfires. Rising sea levels are expected to affect 1 billion people by 2050 and 2 billion by 2100 (Friedlander, 2017). Netusil and Kousky (2021), state that “Climate change is increasing the frequency and intensity of extreme rainfall events in many U.S. cities, driving up the risk of localized stormwater flooding” (Kousky and Netusil, 2021). Such events add pressure on the public and increasingly affect the ecosystems upon which societies depend.

In the United States, for instance, taxpayer spending on the federal disaster relief fund is almost 10 times higher than it was three decades ago, even after adjusting for inflation, as per a Washington Post analysis of federal data (Stein *et al*. 2019). This increase is significantly higher than the American gross domestic product (“GDP”) growth, which doubled in the same period.

According to the National Aeronautics and Space Administration (“NASA”) over one-third of the total human population, nearly 2.4 billion people, live within 100 km (60 miles) of an oceanic coast (NASA, 2021), making them significantly vulnerable to the direct and indirect effects of rising ocean levels and increasing number of hurricanes. Findings in A Blueprint for Coastal Adaptation (2021) show that tens of millions of Americans are at risk from sea level rise, increased tidal flooding, and intensifying storms. They also describe how the design and policy decisions that have shaped coastal areas are in desperate need of updates to help communities better adapt to a changing climate (Kousky *et al*. 2021). The United Nations (“UN”) (2021) estimates that climate change could drive an additional 100 million people into poverty by 2030 (United Nations, 2021b).

Finally, the poorest countries, which have contributed the least to global warming, are likely to suffer the most from these changes. Over the period from 1990–2005, the average damage amount from climate related disasters is more than three times higher in developing countries than in developed countries (1.095 vs. 0.309 percent of GDP[5]). Climate risks such as extreme weather events, biodiversity loss and ecosystem collapse, and natural resource crises are intrinsically linked to other social and economic risks, as per the Global Risks Report of the World Economic Forum (2021), and a climate crisis is likely to worsen world inequality and related issues such as human trafficking, spread of contagious diseases and corruption (WEF, 2021). According to Noy *et al* (2011) this result is widely reported in the literature, with most explanations emphasizing the capacity of rich nations to better prepare and mitigate the cost of disasters.

The two questions that we are examining in this thesis are important to all stakeholders involved in impact financing, and anyone directly or indirectly exposed to climate risks. Green bond investors should find relief in knowing their resources are being invested in line with their expectations or learn that they need to ask extra questions prior to investing in certain impact investing instruments. Bond issuers may be able to more easily link their sustainable bonds and associated actions to the reduction in GHG emissions, facilitating the identification of their contribution to address climate change within their sector and supply chain. Sustainable issuers need to have more answers when questioned about their impact, linking their commitment to sustainability to undisputed practices and cleaner environment.

This analysis will help understand if green bond issuers in the USA can claim greater reduction in GHG emissions, hence be making a greater difference than non-green bond issuers towards the global effort to reduce GHG emissions to zero by 2050 and addressing climate change. For instance, the concept of Climate Value-at-Risk (V@R)[6], which is still an incipient and promising topic in the impact investing community, could significantly ramp up on top of more data and greater linkage between thematic bonds and global warming.

[5] The average economic loss due to standardized quarterly disaster variables averaged 1.095% of GDP for developing countries vs only 0.309% for developed countries over the period of 1990-2005. Upper and lower-middle income countries' economic loss due to standardized quarterly disaster variables averaged 0.799% and 1.257 of GDP, respectively.

[6] Climate Value-at-Risk (V@R) is a statistical method to calculates the financial risk or opportunities that certain companies or facilities are exposed to due to climate change.

2.2 Understanding Green Bonds

2.2.1 What is a Green Bond?

As defined by Blackrock[7] (2021), Green Bonds are “a type of fixed income instrument that specifically and solely dedicates its proceeds to financing new or existing projects that advance environmental objectives”. Current market practice has the issuers setting the qualifying criteria for these green projects, in fields such as renewable energy, green buildings, wastewater management, energy efficiency and public transportation (Blackrock, 2021). But currently these criteria are defined by the issuer and are not standardized.

While green bonds share many common characteristics with traditional financing, they do differ in a couple of meaningful ways. Most importantly, “unlike a debt offering from a company that presents its overall operations as environmentally friendly, green bond proceeds are ring-fenced[8] on the issuer’s balance sheet, meaning they are set aside for the exclusive purpose of financing one or more projects deemed environmentally beneficial. A green bond’s return, however, is backed by the credit of the issuer as a whole” (Blackrock, 2021), which means that although proceeds from these bonds are earmarked for green projects, they are backed by the issuer’s entire balance sheet. In general, there are: green "use of proceeds" bonds (corporate bonds), green project bonds, green covered bonds, and green securitized bonds. Table 2 below presents some basic differences between these instruments, the reader should take away that while different financial products are being labelled green, green bonds differ from ‘normal’ bonds in only one non-financial aspect: they carry a green label and finance “ring fenced” green assets.

[7] BlackRock, Inc. is the world's largest asset manager, with just over USD9 trillion in assets under management as of July 2021. Blackrock CEO’s (Larry Fink) influential annual letter to chief executives in January 2020, said Blackrock would avoid investments in companies that “present a high sustainability-related risk.”

[8] Ring-fence is a legal or technical barrier that segregates a portion of an individual's or company's financial assets from the rest. In this context it is the same as saying that the money invested in green bonds is ‘tagged’ for a specific purpose and can’t be used for a different purpose, its fungibility is limited.

Table 2, using data from ClimateBonds[9], summarizes the most important types of green financial instruments. The table provides examples of each type and differentiate them by recourse and use of proceeds. We separate them in two groups based on how they create positive environmental impact. The first group raises 'green' resources with the promise to create green assets (project and corporate finance instruments tagged for a specific use). These include the "use of proceeds" and "project" bonds. The second group raises 'green' resources based on green financial assets that have already been created (structured products). These include asset backed securities ("ABS") and "covered bonds".

Table 2. Types of Green Financial Instruments

Type	Assets creation	Proceeds raised by bond sales are	Debt Recourse
"Use of proceeds" Bond	Assets created **after** issuance	Earmarked for green projects	Recourse to the issuer: same credit rating applies as issuer's other bonds
Project Bond	Assets created **after** issuance	Ring-fenced for the the specific underlying green project(s)	Recourse is only to the project's assets and balance sheet
Covered Bond	Assets created **before** issuance	Earmarked for eligible assets included in the covered pool	Recourse to the issuer and, if the issuer is unable to repay the bond, to the covered pool
Securitisation (ABS) Bond	Assets created **before** issuance	Refinance portfolios of green assets or proceeds are earmarked for green projects	Recourse is to a pool of assets that have been grouped together under a special purpose vehicle

Note: Table 2 summarizes the most important types of green financial instruments currently used. This description is linked with the discussion about bonds' use of proceeds and consequently with when we should expect green bond issuances to impact GHG emissions.
Source: Table created by the author using information from ClimateBonds (2021 b).

Finally, there are also green loans as a form of climate related financing. As with other loans, green loans are the lending of money by an individual, organization, or other entities to other individuals, organizations etc. Different from bonds, loans are not easily tradable, they are bilateral agreements with limited to no public information. In this paper we do not analyze green loans given how limited and not comparable information is. A green loan, as any other green assets, enables borrowers to finance projects that have positive environmental impact.

[9] Climatebonds is an international organization with the goal of promoting investment in projects and assets necessary for a rapid transition to a low carbon and climate resilient economy.

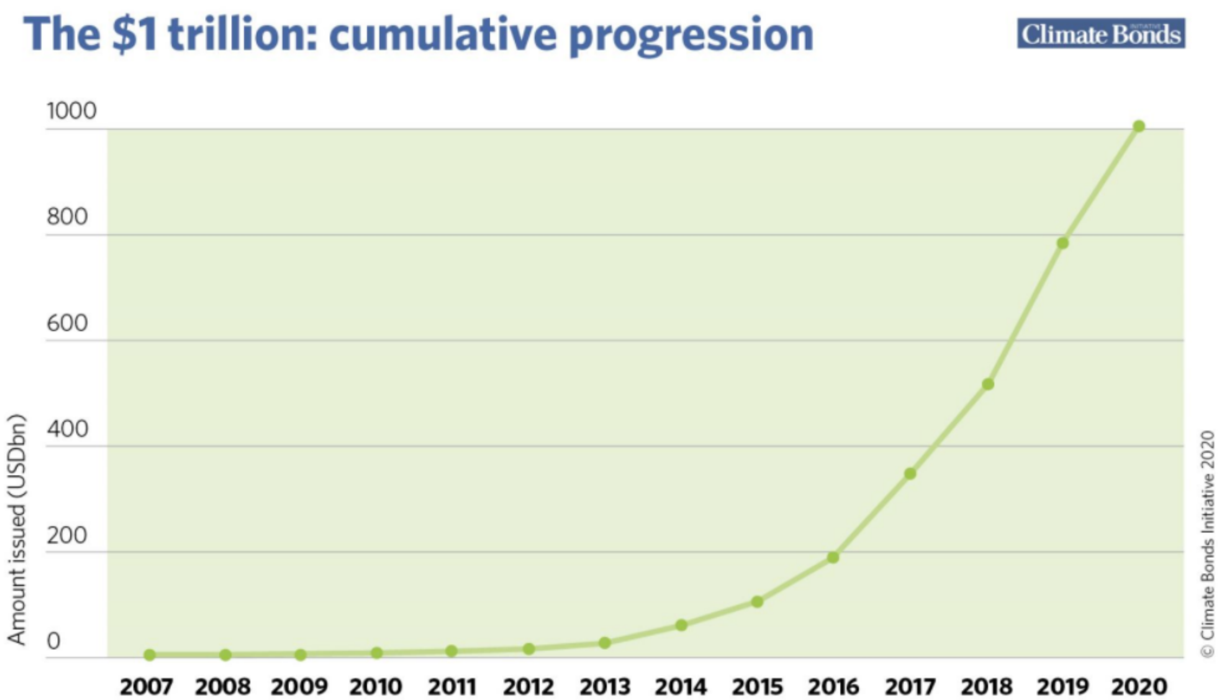
2.2.2 The Green Bond Market

Green bonds were created in between 2007 and 2008 with the seminal European Investment Bank (“EIB”) issuance of EUR600 million (USD807.2million equivalent at the time) earmarked for EIB lending projects within the fields of renewable energy and energy efficiency but not yet with the name ‘green bond’ (EIB, 2007). In 2008 the World Bank issued a ‘green’ bond to the Swedish investors that sought to address global warming, this bond included CICERO[10] as a second opinion provider (World Bank, 2019). We skip forward to 2020, when green bond issuance reached a record-breaking USD269.5 billion, which is also the year in which the cumulative green bond issuances surpassed the USD 1 trillion mark, as per Figure 7, resulting in an annual growth rate (“CAGR”) of 60% throughout its initial 13 years (Climate Bonds, 2021).

Although these issuances must have been related to green assets, independently of the type of instrument (described in Table 2 above), it is impossible to claim that these projects only exist because green financing is available. Green bonds aren’t necessarily financing new investments that would not have happened otherwise. They are a way to separate investments with positive impact on the environment from other projects, and consequently they help attract a set of investors to one’s issuance. Thus, the validity of the greenness is a crucial aspect for the integrity of this market.

[10] The Centre for International Climate and Environmental Research

Figure 7. Cumulative Progression of Green Bond Issuances



Note: Figure 7 shows the cumulative progression of green bond issuances since its inception in 2007, helping us understand why this is such an important instrument with growing relevance.
Source: Climatebonds 2021.

2.2.3 Geographical Distribution

The USA is the country with the largest issuance of green bonds in 2020, with USD51.1 billion in new issuance, followed by Germany (USD40.2 billion), and France (USD32.1 billion). China and the Netherlands rounded out the top five with USD17.2 billion and USD17 billion in issuance, respectively. The next five highest totals were in Sweden, Japan, Canada, Spain, and Norway, according to not-for-profit organization Climate Bonds Initiative, who predict that 2021 could be another record year, with issuance rising as high as USD450 billion, compared with USD269.5 billion in 2020 (Climatebonds 2021).

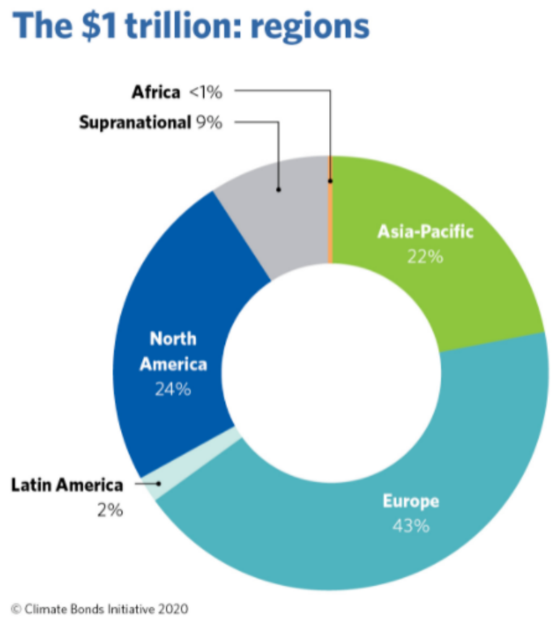
When we analyze accumulated green issuances per country the USA has the lead with USD 212 billion followed by China with USD127 billion as per Figure 8 below where regions with darker colors represent higher dollar amounts of accumulated green issuances.

Figure 8. Geographical Concentration of Green Issuances per Country

Note: Figure 8 shows the breakdown of the accumulated green bond issuances per country.
Source: Climatebonds 2021.

As per Figures 9, when analyzing the cumulative relevance of regions in the green bond market, Europe leads with 43% of the USD1 trillion of total issuances, although the USA and China are the two individual largest countries with total issuances of USD212 billion and USD127 billion, respectively. France and Germany follow with USD116 billion and USD78 billion, respectively (Climatebonds 2021).

Figure 9. Geographical Concentration of Green Issuances per Continent

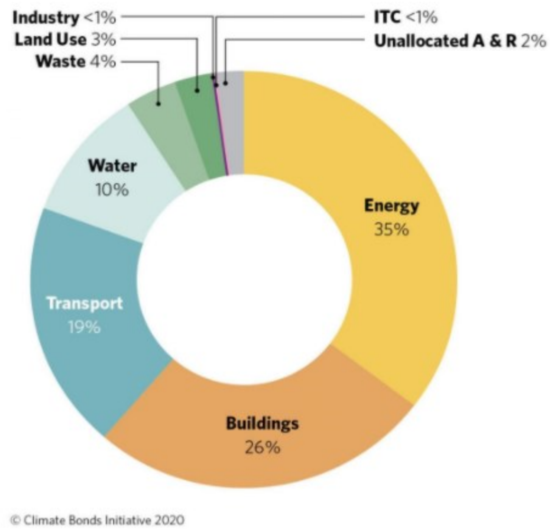


Note: Figure 9 shows the breakdown of the accumulated green bond issuances per continent.
Source: Climatebonds 2021.

2.2.4 Use of Proceeds

A common belief amongst non-experts is that greens bonds are associated with projects that have a positive impact on the climate and are not usually associated with heavily polluting industries. Ehlers *et al* (2020) have shown that in the contrary to common belief, when considering direct and indirect emissions (production process, energy, land use) and emissions from upstream and downstream activities, “firms with the highest carbon intensity comprise virtually equal shares of green bond issuers and others.” As per Figure 10, green bond proceeds have been used mainly in energy (35%), construction (26%) and transportation (19%) projects with the focus of reducing GHG emissions (Blackrock, 2021).

Figure 10. Accumulated USD1 trillion Green Bonds' Use of Proceeds



Note: Figure 10 shows the breakdown of the accumulated green bond issuances per use of proceeds.
Source: Climatebonds 2021.

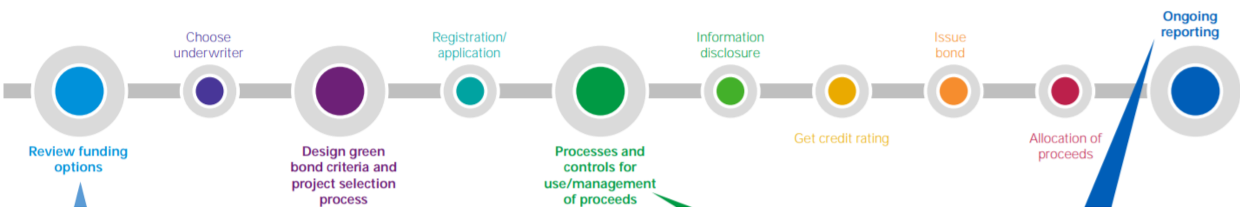
For example, New York's Metropolitan Transportation Authority ("NY MTA") has issued several series of green bonds between 2017 and 2021 that have been designated as "Climate Bond Certified" by Sustainalytics, a hired independent verifier, using a criterion designed by Climate Bonds Initiative ("CBI") (McCoy, 2021). Another example: Stanford University issued green bonds in 2021 to finance the construction of low carbon buildings. The bonds and use of proceeds were verified by Kestrel[11], who stated the bonds would "be used to finance and refinance a portfolio of capital improvement projects that align with Stanford University's plan to eliminate fossil fuel use". Kestrel affirms the bond and underlying assets support several of the United Nations sustainable development goals.

2.2.5 The Process to Issue a Green Bond

[11] Kestrel is a verifier accredited by the Climate Bonds Initiative (CBI) to evaluate corporate and municipal bonds in all asset classes worldwide for conformance with international green and social bond standards.

Issuing a green bond is a well-known process and summarized on Image 11. As documented by multilateral institutions that audit firms and asset managers, the process, which will be described in further detail below, consists of: reviewing funding options; choosing the underwriter; designing the green criteria and the project selection process; defining how to register processes, and controls for use of proceeds of the bond; information disclosure; receiving a credit rating; book building[12]; and finally, the follow the requirements of ongoing reporting.

Figure 11. Green Bond Issuance Process



Note: Figure 11 shows the common steps an issuer goes through to issue a green bond.
Source: KPMG (2016). https://assets.kpmg/content/dam/kpmg/pdf/2016/04/green-bonds-process.pdf

The green bond issuance process is similar to that of a regular bond, with an added emphasis on governance, traceability and transparency designed to increase investors' confidence in the green credentials. Figure 11 is a simple outline of a standard green bond issuance process, which could vary depending on the jurisdiction (KPMG, 2016).

The first two steps, "review funding options" and "choosing underwriter" are when the issuer reviews the business case of issuing a green bond. It should fit their financial and sustainability objectives. In this process the issuer should consider additional scrutiny over their sustainable policies and risks related to not being able to deliver the promised goals, also the issuer considers the resources needed to select, monitor, and report on the use of proceeds.

[12] Book building is the process in which financial institutions leading a bond issuance pitch the issuance to potential investors. In this process they define the final details of the issuance, most importantly the required rate of return by buyers for a certain issuance size, the size of the issuance and which investors will receive allocation in case of oversubscription.

In the description of the "design green bond criteria and project selection process" step, (purple in the image above), it becomes clear how flexible this step is:

> "…there is no universally agreed standard for a green bond and the kind of activities that can be funded. Issuers can look to several evolving guidelines and sources such as the Green Bond Principles[13] ("GBP"), the Climate Bonds Standard[14], national guidelines, green bond indices and sector-specific standards for guidance in defining their green bond and the process used to determine the eligibility of projects" (KPMG, 2016).

Since their creation in 2015, Sustainable Development Goals[15] (SDG) have also been used to guide or justify a bond being green as seen with the bond issued by Stanford University above, which was verified by Kestrel against certain SDGs[16]. The certification fee can vary but as an example, Climate Bonds' most basic certification costs the equivalent to 1/10th of a basis point of the bond principal. For example, on a USD500 million bond, the certification fee would cost USD5,000. According to their website certification fees are paid only once and immediately after the issuance of the bond[17] (Climatebonds, 2021a).

---

[13] According to the International Capital Market Association (ICMA) (2021), Green Bond Principles (GBP) are regularly updated (last update in June 2021) and are defined as "voluntary process guidelines that recommend transparency and disclosure and promote integrity in the development of the Green Bond market by clarifying the approach for issuance of a Green Bond. The GBP recommend a clear process and disclosure for issuers, which investors, banks, underwriters, arrangers, placement agents and others may use to understand the characteristics of any given Green Bond. The GBP emphasize the required transparency, accuracy and integrity of the information that will be disclosed and reported by issuers to stakeholders through core components and key recommendations" (ICMA, 2021).

[14] According to the Climate Bonds Initiative (2016), Climate Bond Standards are "The Climate Bonds Standard provides clear, sector-specific eligibility criteria for assets and projects that can be used for Climate Bonds and Green Bonds" (Climate Bonds 2021c).

[15] According to the United Nations (2021), Sustainable Development Goals are areas of focus defined in January 2015, during the General Assembly negotiation process. The process culminated in the subsequent adoption of the 2030 Agenda for Sustainable Development, with 17 SDGs at its core, at the UN Sustainable Development Summit in September 2015. The goals are: "no poverty", "zero hunger", "good health and well-being", "quality education", "gender equality", "clean water and sanitation", "affordable and clean energy", "decent work and economic growth", "industry, innovation and infrastructure", "reduced inequalities", "sustainable cities and communities", "responsible consumption and production", "climate action", "life below water", "life on land", "peace justice and strong institutions", "partnerships for the goals" (United Nations, 2021).

[16] Also, different countries can have different requirements, for instance in China, one of the largest markets for green and Sustainable bonds, guidelines have been issued by the People's Bank of China and the National Development and Reform Commission.

[17] Advisory services to establish the required internal processes and controls to meet the requirements of any certification are not included.

After the “registration”, which is a simple bureaucratic step similar to non-green bonds, the issuer must pay close attention to “processes and controls for use/management of proceeds”. The resources and systems to track, manage (allocated and unallocated proceeds) and report the use of proceeds, must be aligned with the terms of the bond. Enforcement, by stakeholders, that issuers allocate resources as promised can be difficult. The presence of a third-party auditor significantly increases the reliability on the reports presenting the use of proceeds. Moreover, issuers face significant reputational risk and access to markets (as they tap markets often) if they fail to comply of the green bonds’ issuance terms.

The following four steps: “information disclosure”, “get a credit rating”, “issue the bond” and “allocate proceeds” are statutory steps that must follow local law and the terms of the bond. The final relevant step specific for green bond issuers is “ongoing reporting”. The reporting requirements of a green bond are more detailed than non-green bonds, the report usually includes the specific allocation of proceeds and the monitoring of certain environmental goal(s)/green impact expected. It’s has been an industry trend to also hire third-party assurance that the reports are true and unbiased, reducing data quality risks and raising stakeholder confidence in the disclosure. For reference, Cicero, a well-known provider of second opinions to green bond issuances, charges approximately between USD16,000 and USD22,000 for a standard second opinion (Environmental Finance, 2021).

Despite the increasing amount of green bonds being issued, there remains a significant lack of standardization in some essential aspects of the “green” definition. Questions such as: “what guidelines should be used to justify bond’s greenness? - the Sustainable Development Goals, the Climate Bonds Standard or the Green Bond Principles? Should certain industries be excluded? Should project and non-project specific bonds fit the same green criteria? What levels of monitoring and reporting should be required? Must a green bond have independent auditors?” These questions have mostly been left to be answered by the issuers themselves, making comparability about “greenness” across issuances very difficult.

Investors will find green bonds in the market that answer each of the questions above differently. The burden to compare different green bond issuances is basically left on investors, who, as a rule of thumb, have little resources and knowledge to do so.

Market players have shown a strong desire for greater guidance from the Security and Exchange Commission (SEC). Institutions such as the Sustainability Accounting Standards Board ("SASB"), and a Task Force on Climate-Related Financial Disclosures ("TCFD") have been essential in setting the first stones to define common ground for corporate and government disclosure of information. Some private companies, such as Blackrock and Cicero, recently created the concept of shades of green in an effort to differentiate issuances within the green group. For the time being, green issuances, including the ones used in our study, can be defined as green by the issuer themselves who can also individually report on the allocation of such resources.

2.3 Greenium

Academic research in this field has tried to identify the existence of a "greenium", in other words, the possibility that sustainable bonds offer firms access to lower cost funding compared to conventional (non-green) bonds. This issue is examined in the work done by Hachenberg and Schiereck (2018), Zerbib (2019), and Larcker and Watts (2020). In simple terms "greenium" means that investors accept lower returns (pay a higher price at purchase) in green bonds either because they believe they carry less risk (lower volatility and/or risk of default) or simply are willing to pay extra to purchase a security with a sustainable focus. Despite the attention to these ideas, results about the existence of a greenium and a reduced risk related to green instruments, that would justify it, have been inconclusive. According to Schmittmann *et al* (2021), this is likely due to "…differences in samples and imperfect matching strategies to control for differences other than the green designation".

Well known studies that identify a price premium for green bonds include Baker *et al* (2018) for green municipal bonds, Zerbib (2019) for green municipal and sovereign bonds, and Kapraun and Scheins (2019) for green sovereigns, supranationals and very large corporate bonds[18].

Studies that have not found a premium for green bonds include Larcker and Watts (2020) for US municipal bonds, IMF (2019) for corporate, supranational, and sovereign bonds, and Flammer (2020) for corporate bonds. Karpf and Mandel (2017) found indications that green bonds trade at a discount to other bonds. Maltais and Nykvist (2020) found in a survey of green bond issuers that cost of capital considerations are secondary for green bond issuance decisions, which could potentially explain the existence of no greenium or even a discount in green bonds.
While some issuers have been able to issue green bonds at a discount to similar non-green bonds such discounts may not be sufficient to cover for the higher issuance costs and costs associated with achieving the pre-defined sustainability targets (Schmittmann *et al*, 2021).

This analysis will not consider whether green bonds sell at a higher price that regular bonds. Instead, it will focus on whether the issuance of green bonds leads to any measurable reduction in greenhouse gas emissions by the issuers relative to non-issuers.

2.4 First Question and Research Plan

According to Ehlers *et al* (2020), “green finance instruments have a key role to play in mobilizing private capital, and green bonds are perhaps the most successful of these instruments thus far”. The link between green bonds and a reduction in GHG emissions is indisputably necessary, for environmental progress, yet investors and issuers focus mostly on the use of

[18] In my experience talking to issuers, brokers, and traders, there is no doubt among market players of the unbalanced supply and demand dynamic in the green bond space. There are significantly more buyers than bonds being issued (primary market) or circulating in the secondary market. The greater demand than supply would suggest higher purchase prices and lower yields to investors.

proceeds, identifying the projects or initiatives being earmarked to a green issuance, to assure a bond's greenness. If the use of proceeds isn't directly connected with a reduction in GHG emissions, green bonds' main objective, which is to address environmental challenges, could be put into question. The use of proceeds has been the industry choice to assert a bond's greenness, when the ultimate climate challenge is to reduce GHG emissions as interpreted from the Intergovernmental Panel on Climate Change (IPCC) report (2021). In other words, green bonds focus their monitoring mainly in the use of proceeds being perceived as 'green' and not necessarily on scope 1[19] and 2[20] GHG emissions, and hardly ever on scope 3[21] GHG emissions.

Using the use of proceeds as a proxy for emissions reduction is logical but perhaps an unnecessary middleman to monitor global climate's true challenge: GHG emissions themselves. As Ehlers *et al* (2020) put it: "the current system of green bond labels does not necessarily guarantee a material reduction in carbon emissions."

The main question of this chapter is whether green bond issuance actually helps tackle GHG emission reduction. As the IPCC (2021) already made a clear relation between GHG emissions increase and climate change, if green bonds have a clear relation to reduction in GHG emissions, this thesis might be able to strengthen (or weaken) the connection between green proceeds and the reduction of climate change symptoms described in section "Climate Change Challenge", on page 2.

Through high historic GHG emissions, climate change is the main threat against climate balance and sustainability, and given green bonds claim to promote climate sustainability, if they

[19] Scope 1 emissions are direct greenhouse (GHG) emissions that occur from sources that are controlled or owned by an organization (EPA, 2021).
[20] Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling. Although scope 2 emissions physically occur at the facility where they are generated, they are accounted for in an organization's GHG inventory because they are a result of the organization's energy use (EPA, 2021).
[21] Scope 3 emissions are the result of activities from assets not owned or controlled by the reporting organization, but that the organization indirectly impacts in its value chain.

are not addressing GHG emissions there is potential for misrepresentation, which has been a growing risk for all stakeholders[22].

To study this question, we will examine whether first time USA issuers of green bonds produce meaningful reductions in GHG emissions relative to themselves and other USA non green bond issuers.

My research will focus on USA entities because the EPA makes available a detailed database of GHG issuances per address ("Facility") and their respective parent firms ("Parent Firm") for the year between 2010 and 2019 (EPA, 2019). Also, USA investment funds are required to make quarterly disclosures of their fund holdings.

This analysis choses to examine the change in GHG emissions ("GHG reduction") as the indicator of impact of green bonds. Given how measurable and comparable GHG reduction is, this metric allows direct evaluation of how impactful green bond issuance has been. This is also an appropriate measure because GHG reduction is paramount to avoid an unprecedented climate change, hence bonds claiming to address environmental issues must be addressing, at least partially, GHG emissions. If a green bond issuance does not result in some sort of incremental reduction in GHG emissions over time it draws into question the validity of this new security.

According to a report by the Climate Bonds Initiative (2019),

> "…there is currently little standardization in the market with regards to measuring impact. The findings of our review indicate that 79% of issuers are measuring impact on an absolute basis, whereas only 3% are contextualizing changes relative to a pre-determined baseline or benchmark. 18% are disclosing some combination of the

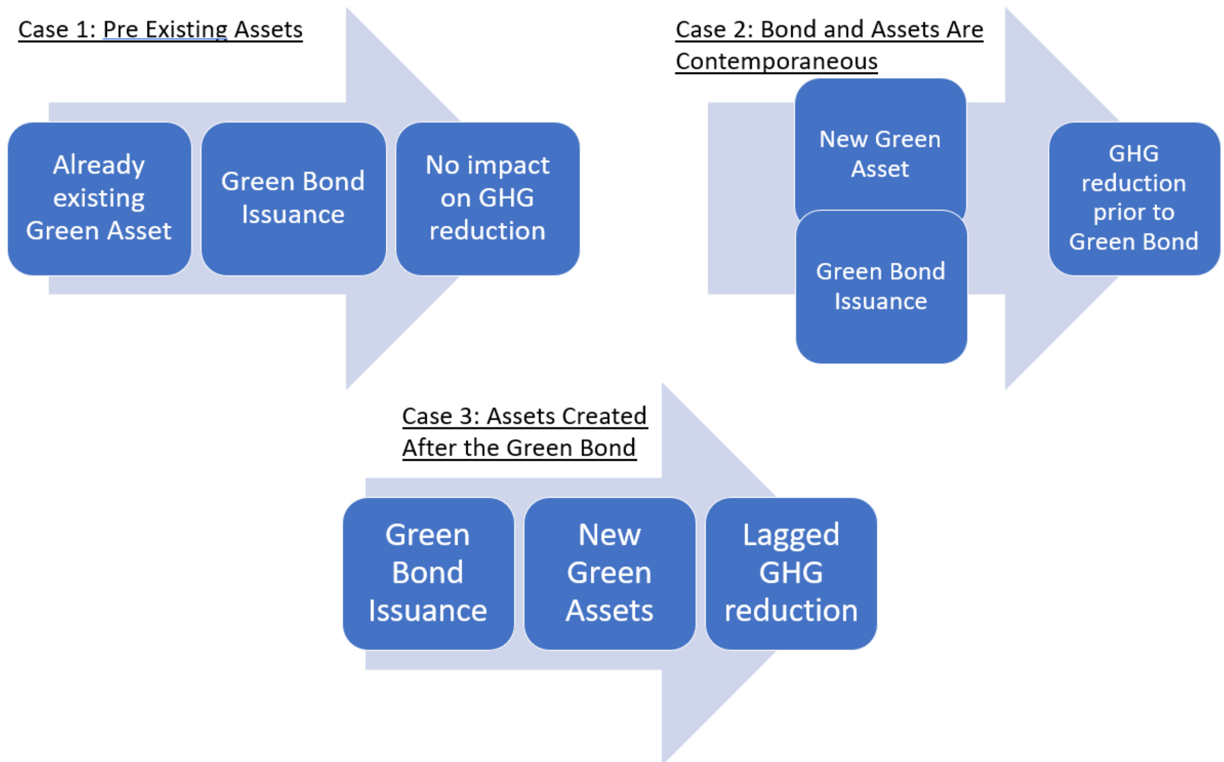
[22] Amid United Kingdom's announcement of stepped-up anti-greenwashing campaign in 2022 the country's Advertising Standards Authority (ASA) has already excluded advertisements by companies such as Ryanair, BMW, and Shell for allegedly misleading environmental claims. Too many businesses were "falsely taking credit for being green" in order to woo environmentally minded consumers, the Competition and Markets Authority said (Guardian, 2021). Similarly, In Sweden car manufacturers, including BMW, Polestar, Jaguar, Skoda, and Mitsubishi Motors were reportedly convicted by Swedish authorities for using false environmental arguments or greenwashing in their advertisements in 2021 (Bilägare, 2021).

two. Measuring in absolute terms is a good starting point. However, it provides little context for understanding the scale of the impacts themselves."

2.5 Theory

Timing is an important aspect of the relationship between green bonds and the measurement of any GHG reduction. When investors buy green bonds, they are seeking to finance green projects. Given that there isn't a rule defining the process of creating or replenishing these assets the green bonds can be financing preexisting assets, assets that were created as the focus of the green issuance or assets that will be created after the bonds are issued. Considering that such assets actually reduce GHG emissions, we have 3 timing cases of this relation summarized in Figure 12.

Figure 12. Annual Green Bond Issuance by Issuer Type



Note: Figure 12 shows the time frames in which green asset and green liabilities/sources of funds (green bonds) are created.
Source: created by the author of the thesis

In case 1 the assets would have existed for some time independently of the green bond issuance and, as so, would immediate pre and post measurement would likely not capture any impact of the bond issuance on GHG reduction as the reduction would have occurred in the past when the asset was created. In case 2, where assets are implemented around the same time as the bond issuance, (depending on the time for the asset to get to full activity) there should be a GHG reduction when comparing pre and post bond issuance. In case 3, there will clearly be a lag in between the green bonds' issuance and the GHG reduction which depends on the time of implementation of the green asset (and any additional lag to reach full effectiveness). Finally, it is also possible that the assets could have no meaningful impact on GHG emissions independently of when they are created in relation to the green bond issuance, in this case they would be considered to have no sustainable impact as explained above.

This dynamic will be discussed in more detail below as it suggests possible leads and lags to capture the effect of green bond issuance on GHG emissions.

2.6 Literature Review

There is a growing body of research describing and analyzing sustainable investing with some of the most important publishers being multilateral institutions and regulatory bodies such as World Bank Group, the Bank for International Settlements, the G20 Sustainable Finance Study Group, Interamerican Development Bank, Proparco, and KfW among others[23]. Sustainability has been widely discussed in all areas but there is little research in the academia combining finance and capital market with sustainability. A growing number of reports have been published by banks, but they continue to lack standardization and have limited contribution to an academic body of knowledge. Some individuals such as Al Gore and Bill Gates, together with other celebrities, have also been key for the evolution of the climate change topic and highlighting the importance of rapid GHG emissions reduction. In Gates' newest book "How to Avoid a Climate Disaster" (Gates, 2021) he demonstrates that society needs to deploy the tools we already have, such as wind and solar energy, in faster and smarter ways; and that we need to create and roll out breakthrough technologies that can take us the rest of the way (Gates, 2021b). The right incentives, in a system where environmental impact has not been accounted for (considered an externality), are essential to change companies and consumer behaviors, and capital markets sustainable instruments can be the key for that rapid necessary shift described by Gates, Al Gore and many others.

[23] Based on my experience, western market and specialized public perception is that European countries have had an important role in developing reporting standards and promoting the climate agenda in recent years given the environmental strategies in the United States under President Trump (who exited the Paris Agreement) and in Brazil under President Bolsonaro.

In a recent study on the link between green debt and greenhouse gas emissions, Schmittmann and Teng (2021) look at the S&P Global 1200 index and emissions data from Bloomberg and Reuters. They identify lower CO_2 emissions for green bond issuers relative to other firms from this global sample. However, for the subsets of green loans and sustainability-linked loans they were not able to identify lower CO_2 emissions (Schmittmann *et al*. 2021). Differently from Schmittmann and Teng (2021), this work focuses on bond issuers in the United States and uses GHG facility level data from the EPA's Facility Level Information on Greenhouse Gases Tool[24] ("FLIGHT") reports.

According to researchers at the Bank for International Settlements, "so far green bond projects have not necessarily translated into comparatively low or falling carbon emissions at the firm level" (Ehlers, Mojon, and Packer, 2020). In their research, leveraging the growing number of firms reporting GHG emissions, they organize all firms in percentiles of GHG emissions per revenues and designing a rating system based on carbon emission intensities. They examine whether a firm reduces its carbon intensity up to three years after issuing green bonds and find "no strong evidence that green bond issuance is associated with any reduction in carbon intensities over time at the firm level." Their conclusion is that carbon emission intensities fell on average in the two years after issuance, but they rose afterwards, in year 3 (Ehlers, Mojon, and Packer, 2020).

Among top tier economic journals, nothing as of yet has been published connecting green bonds to GHG emission. Instead, academic research has focused on the existence and magnitude of greenium. Flammer (2020) examines global companies' financial and environmental performance following the issuance of green bonds. Flammer uses a fixed effects difference in differences model to evaluate among other things, CO_2 emissions of green bond issuers.

[24] FLIGHT information "can be used by communities to identify nearby sources of greenhouse gas emissions, help businesses track emissions and identify cost-- and fuel--saving opportunities, inform policy at the state and local levels, and provide important information to the finance and investment communities" (EPA, 2019).

Regarding their environmental performance, she documents a significant improvement based on an independent environmental score, reduced CO2 emissions, and green patents filling, suggesting that green bonds are effective in improving companies' environmental footprint (Flammer, 2020). According to Flammer's work, CO2 emissions are reduced in 12.9 percentage points.

Flammer (2020) has also, two additional relevant findings: data showed that "treated and control firms had a similar pre-trend in CO2 emissions per asset size"; and findings "are only significant for green bonds that are certified by independent third parties, suggesting that certification is an important governance mechanism in the green bond market."

2.7 Methodology

Ehlers, Mojon and Packer (2020) highlight the importance of a firm-level rating based on carbon intensity to complement existing project-based green labels. They argue that such a rating system, at the facility level, "could provide a useful signal to investors and encourage firms to reduce their carbon footprint".

We will use facility level GHG emissions data consolidated at the parent firm level and regress it against two main variables: the control group ("GrIssuer") and the treatment variable ("GrBond") using ordinary least squares. We will use the difference in differences ("DiD") model[25] with first differences, where we measure the average change in of the treatment and the control groups before and after the treatment. We will isolate the effect of time by using dummy variables

[25] Difference in differences is a non-experimental statistical technique used to estimate treatment effects by comparing the change in the differences in observed outcomes between treatment and control groups, across pre-treatment and post-treatment periods. DiD is one of the most widely applied methods for estimating causal effects of programs when the program is not implemented as a randomized controlled trial. In 2018 Pamela Jakiela calculated that more than 5 percent of articles published in the Journal of Development Economics used a DiD methodology (Jakiela, 2019). Difference in differences is mostly used to estimate the program effect when you have one group that is affected by the program and another that is not, and you observe outcomes of both groups before and after the treatment.

for each year of the measured period (2010-2019). Given treatment (the first time a green bond is issued) happens in different years for each GB Issuer we also created a variable interacting the treatment group (GrIssuer) and each year, as so we will also be controlling for annual changes specifically for the treatment group. Finally, we will use some macroeconomic controls at the state level. Each of these variables are described in Table 3 below:

Table 3. Regression Variables

Regression Code	Variable Description	Unit
GHG	Grennhouse gases emissions	Metric tones of CO2 equivalent
GHG change	Changes in grennhouse gases emissions	Metric tones of CO2 equivalent
GrIssuer	Dummy for treatment group - companies that had one or more green issuances in the period	Dummy: 1 or 0
GrBond	Dummy for treatment - identifies the moment the first green bond is issued and thereafter	Dummy: 1 or 0
years	year	2010-2019
Inter - GrIssuer*years	Interaction between year and GrIssuer : year related changes for the treatment group especifically	Dummy: 1 or 0
State_GDP	Real Gross Domestic Product	Millions of US dollars
Compensation_MM_USD	Compensation	Millions of US dollars
Gross_operat_surplus_MM_USD	Gross operating surplus	Millions of US dollars
TOPI_MM_USD	Taxes on production and imports (TOPI)	Millions of US dollars
pos_Subsidies_MM_USD	Subsidies	Millions of US dollars

Note: Table 3 lists the variables being used in the regressions in the Analysis section.

By regressing GHG emission changes on GB Issuers (GrIssuer) we will show how the treatment group's GHG emissions change in comparison to the control group, independently of the treatment; and by regressing GHG emission changes on the year a green bond is first issued (GrBond) we will be able to identify if the actual issuance of a first green bond is correlated with a greater change in GHG Emissions in comparison to years prior to the issuance of the first green bond.

2.7.1 A Special Case: Treatment in Different Points in Time

The treatment (issuance of the first green bond) varies in time for each issuer, as so we don't have exact observations of the control group pre and post treatment, and hence won't be able to follow a classic DiD.

In cases where treatment happens at different times for different observations such as in our example (green bond issuers issue bonds in different years) the DiD will compare treatment and control groups throughout three different periods: the first one being before any treatment, the second period is when certain variables have been treated but others have not yet been treated and finally the third is when all variables in the treatment group have been treated. In other words, DiD compares treatment and control groups throughout the entire observational period and it also compares the control groups within themselves before treatment, while some have been treated and others have not.

2.8 Data Description

Here we will describe in detail the information used in the regressions, most importantly the green bond issuance data (from banks involved in capital markets and the Bloomberg terminal), and the GHG emissions from the EPA.

2.8.1 Green Bonds Data

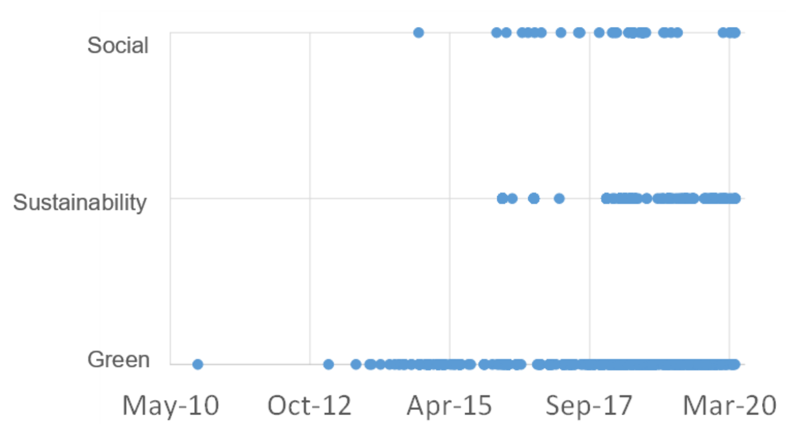
A "Universe of Green Bond Issuers" was identified based on two data sources: (i) a complete list of green bonds (including also social[26] and sustainability bonds[27]) shared by

[26] Social Bonds are related to projects or investments with some focus on social sustainability.
[27] Sustainability Bonds are related to projects or investments with some sustainable focus.

investment banks through professional contacts (the “Bank’s List”), with the most relevant contributor being Bank of America, and (ii) Bloomberg’s Green Bond Indicator (“Bloomberg’s Green Bond List”). This combination of a human produced list and an automated produced list is important given the lack of standardization in the definition of green and sustainable bond issuances and the enormous number of total bond issuances in the past years to be analyzed.

The Bank’s List had 1,574 issuances between 2010 and 2020, each issuance was labelled Social, Sustainability or Green as per Figure 13 below where each dot is an issuance.

Figure 13. The Bank’s List Overview



Note: Figure 13 shows the time-scale distribution of Social Sustainability and Green bonds in the Bank’s List.

Figure 13 shows that green bond issues were more numerous than sustainability bond issues or social bond issues. Green bond issues do not really start (in any meaningful quantity) until 2013. Some bonds are issued as a private placement and may not even be included in public trading platforms such as Bloomberg. Hence having a list of green bonds prepared by investment banks according to their deal sheet could potentially include issuances that a platform like Bloomberg could be missing. Many issuers are recurrent issuers in the market, only 123 issuers were responsible for the 1,574 issuances mentioned in this database. The top 10 issuers alone, shown on the Table 4 below, account for 48% of all issuances.

Table 4. Top 10 Largest Issuers (in number of issuances) according to the Bank's List

#	**The Bank's List Issuers**	**Green Issuances (2010-2020)**
1	New York State Housing Finance Agency	143
2	New York City Housing Development Corp	120
3	International Bank for Reconstruction & Development - World Bank Group	105
4	Indiana Finance Authority	77
5	International Finance Corporation (IFC) - World bank Group	69
6	Massachusetts Housing Finance Authority	55
7	New Jersey Infrastructure Bank	55
8	Public Utilities Commission of the City & County of San Francisco	48
9	City of Los Angeles (CA)	45
10	Metropolitan Transportation Authority (NY)	44
	Total	**761**

Note: Table 4 shows the top 10 issuers in number of issuances according to the Bank's List. It gives an idea of what type of issuers have been tapping the green market more often and helps understand the data being used for this thesis.

Sub-national government institutions occupy eight out of the top ten green bond issuers. The World Bank Group, through the International Bank for Reconstruction and Development and the International Finance Corporation take position 3 and 5, respectively. All these institutions have large funding programs and go to the market monthly (if not weekly) to raise funds for their operation. They also benefit from having a significant amount of assets that can be labelled green and used to back such green issuances.

Bloomberg is the largest trading platform in the World with 33.4% market share as of 2021. The Bloomberg's Green Bond List included 443 green labelled USA based issuances between 2011 and 2020. While the Bank's List accounts for information through word of mouth and unlisted private placements, the Bloomberg list is the most reliable automated approach to identifying all green issuers. Around 160 issuances were the same between the two data sources, Bloomberg's Green Bond List, and the Bank's List.

To reach the two lists mentioned above, the Universe of Green Bonds, we filtered the data for green tags, controlling for USA issuances only and avoiding double counting through bonds unique identifiers (CUSIP and ISIN). This final list was crossed against the list of companies reporting GHG emissions to the EPA from 2010 to 2019 (information for the entire period 2010-2019 reported as of 2020[28]) which identified 41 issuances from 20 issuers (representing 330 facilities reporting GHG emission to the EPA FLIGHT[29]). Two green bond issuers, Morgan Stanley and Pattern Energy Group were also identified in both data sources but both entities reported zero GHG emissions for all years, 2010 through 2019, hence were excluded. Also, some companies that report GHG emissions to the EPA only issued green bonds in 2021, such as Norfolk Southern Corp, Renewable Energy Group Inc, Tennessee Valley Authority, New York State Electric & Gas Corp, PacifiCorp, Public Service Co of Oklahoma, Micron technology and subsidiaries Union Electric Co and Ameren New York (which are not shown in the table below because they are subsidiaries). As per summary in Table 5 below[30]:

[28] The data was reported to EPA by facilities as of 09/26/2020
[29] About 1% of facilities are jointly owned by more than one company. We only considered facilities that were at least 50%+1 owned by a green bond issuer as we control is required to significantly influence the operation of a given facility.
[30] In my research I found out that Calpine issued “climate bonds” (Calpine, 2020), and Monongahela Power Company and The Potomac Edison Company issued “Environmental Control Bonds”. Given how broad classifications can be I’m not considering these bonds as green bonds because they haven’t been labelled green by anybody, not even the issuer themselves. In the case of Dominion Energy, the company classified its issuance as “green bonds”.

Table 5. Green Bond Issuers that reported GHG Emissions to the EPA

	All issuers in the EPA list that Issued Green Bonds	Excluded because: all years in the EPA report had zero GHG emissions reported	Excluded because: only Issued a green bond in 2021	Issuers used:
1	DTE Energy			X
2	Duke Energy Carolinas LLC			X
3	Duke Energy Florida LLC			X
4	Edison Co			X
5	NextEra Energy Capital Holdings Inc			X
6	Owens Corning			X
7	Pfizer Pharma			X
8	Toyota Motor Credit Corp			X
9	Analog Devices Inc			X
10	Berkshire Hathaway / MidAmerican			X
11	Dominion Energy			X
12	Massachusetts Institute of Technology			X
13	Avangrid Inc / Iberdrola USA			X
14	PepsiCo Inc			X
15	Clearway Energy Operating LLC			X
16	Southern Power Co			X
17	Liberty Utilities Finance GP 1			X
18	Xcel Energy			X
19	Big River Steel LLC / BRS Finance Corp			X
20	Evergy Electric Co			X
21	San Diego Gas & Electric Co		X	
22	Norfolk Southern Corp		X	
23	Renewable Energy Group Inc		X	
24	Tennessee Valley Authority		X	
25	New York State Electric & Gas Corp		X	
26	PacifiCorp		X	
27	Public Service Co of Oklahoma		X	
28	Micron Technology Inc		X	
29	Pattern Energy Operations LP	X		
30	Morgan Stanley	X		

Note: Table 5 shows how we got to the 20 green bond issuers being used for this study. More issuers were identified but were discarded given the reasons explained on the table.

The number of green bond issuers identified is relatively low, when compared to the thousands of green bond issuances and thousands of companies reporting on GHG emissions because:

a) As mentioned above although there are thousands of issuances, they are still very concentrated among a few constant issuers. These are normally government related entities, multilateral institutions and financial institutions which are unlikely required to report GHG emissions given EPA's threshold explained in the next bullet point[31].

b) the EPA only requires large emitters (more than 25,000 Metric Tons of CO2e/Year) to report on GHG emissions and it's focused on where it's produced[32].

c) Given how complex the data base is we could have not identified some green bond issuers in the EPA list. Different companies may issue green bonds at different levels of the corporate structure, while the EPA data identifies the ultimate parent. We ran different codes to compare and identify companies under the same parent but it's possible we may have missed some. For example, Xcel Energy (the parent company reporting to the EPA) issued green bonds through its subs Southwestern Public Service Co, Northern States Power Co, and Public Service Co of Colorado.

[31] In 2020, Fannie Mae and the NY MTA were the first and the seventh largest green bond issuers globally, adding up to USD13 billion and USD4 billion in issuances in 2020 alone, respectively. Neither report to the EPA.

[32] In an email dated Oct 26, 2021 the EPA stated that "facilities determine whether they are required to report based on the types of industrial operations located at the facility, their emission levels, or other factors. Facilities are generally required to submit annual reports if (i) GHG emissions from covered sources exceed 25,000 metric tons CO2e per year; (ii) supply of certain products would result in over 25,000 metric tons CO2e of GHG emissions if those products were released, combusted, or oxidized; (iii) the facility receives 25,000 metric tons or more of CO2 for underground injection."

Table 6. Time-lined Green Bond Issuers that Report GHG Emissions to the EPA

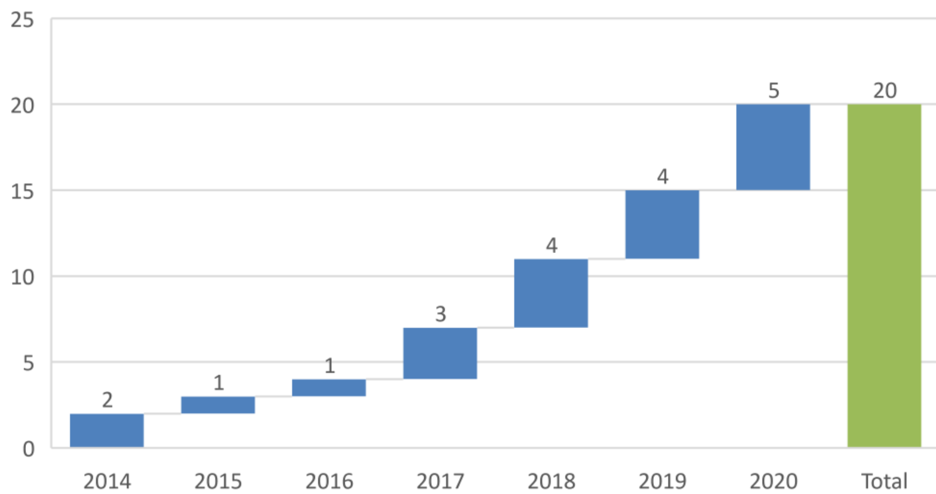
Green Bond Issuance	2014	2015	2016	2017	2018	2019	2020
Analog Devices Inc							X
Avangrid Inc / Iberdrola USA				X		X	
Berkshire Hathaway / MidAmerican				X	X	X	
Big River Steel LLC / BRS Finance Corp							X
Clearway Energy Operating LLC	X					X	X
Dominion Energy					X		
DTE Energy					X	X	
Duke Energy Carolinas LLC					X		
Duke Energy Florida LLC						X	
Edison Co							X
Evergy Electric Co			X				
Liberty Utilities Finance GP 1							X
Massachusetts Institute of Technology	X						
NextEra Energy Capital Holdings Inc						X	
Owens Corning						X	
PepsiCo Inc						X	
Pfizer Pharma							X
Southern Power Co		X	X				
Toyota Motor Credit Corp				X			
Xcel Energy					X	X	X

Note: Table 6 shows the year each issuer that is part of the treatment group for this study issued green bonds. For all of them the first one on the table is their first green issuance ever.

There were 41 green bond issuances totaling 50 tranches in between 2014 and 2020 which add up to more than USD30 billion for an average issuance size of USD600 million. The largest issuance was Pfizer's in 2020 for USD1.25 billion and the smallest was Clearway Energy's USD250 million also in 2020. Table 6 above includes all 41 green bond issuances but given cases of more than one issuance within a given year, the table only shows 29 marks, for more details refer to Annex 2 "Green Bond Details".

The distribution of the first green bond issuances is concentrated between 2017 and 2020 as per Figure 14. Out of the 20 total first time issuances (from the 20 issuers), 16 happened in this period. Although we have GHG emission data only until 2019 we kept GB Issuers that issued in 2020 as they affect regressions with leads and lags.

Figure 14. First Time Green Issuances Per Year

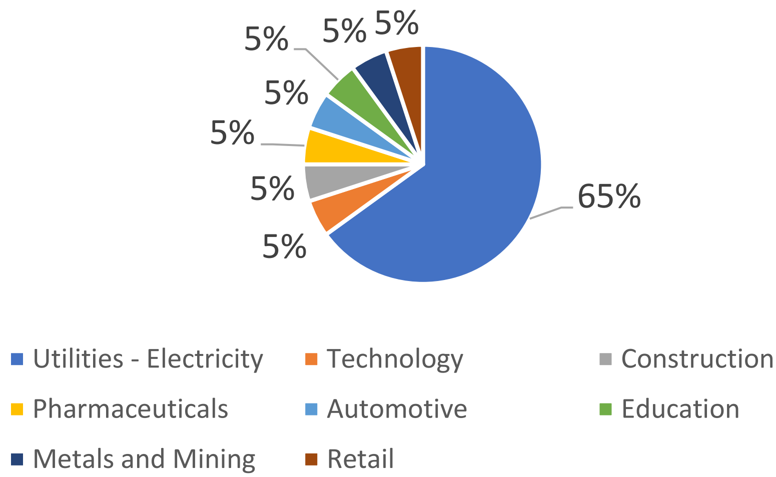


Note: Figure 14 shows how many first-time green bond issuances happened per year in our treatment group. It shows that for most of the issuers first time green issuances happened in 2017 or later.

Green bonds were created in 2007 but as seen in Figures 4, 7 and 13 most of the issuances happened in the last 4 years. As per Figure 14, above, the same can be observed in the treatment group used for this analysis. Table 6, which includes subsequent emissions shows that second and third emissions became more common in the past 4 years.

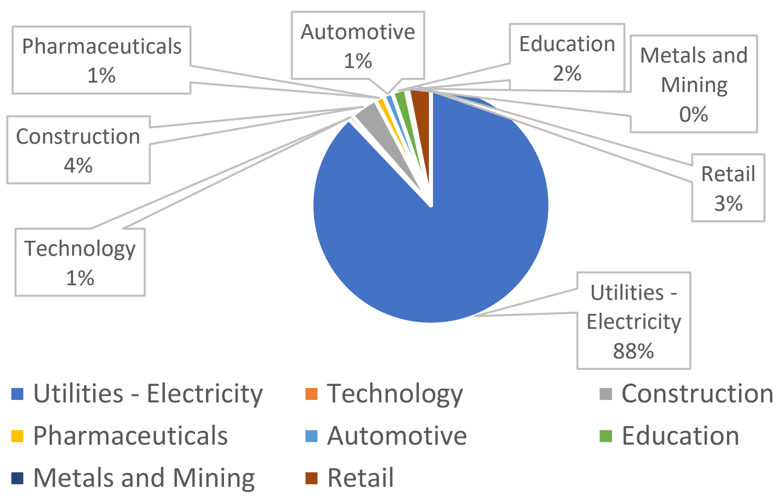
The list of green bond issuers that report GHG emissions at a facility level to the EPA are concentrated (13 out of 20) in the utilities industry as per Figures 15 and 16 below.

Figure 15. Industry Distribution of the Treatment Group (per Parent Company)



Note: Figure 15 shows a heavy concentration of parent companies in the utilities industry. Out of 20 parent companies in the treatment group 13 are in utilities.

Figure 16. Industry Distribution of the Treatment Group (per Facility)



Note: The utilities parent companies had, proportionally, more facilities reporting to the EPA than non-utilities facilities as shown by Figure 16, where at a facility level the concentration in the utilities industry increases to 88% of the number of facilities in the treatment group.

The concentration among in the utilities sector is explained given the high levels of GHG emissions in this industry and the EPA requirements for reporting. In an email dated Oct 26, 2021 the EPA stated that “facilities determine whether they are required to report based on the types of industrial operations located at the facility, their emission levels, or other factors. Facilities are generally required to submit annual reports if (i) GHG emissions from covered sources exceed 25,000 metric tons CO2e per year; (ii) supply of certain products would result in over 25,000 metric tons CO2e of GHG emissions if those products were released, combusted, or oxidized; (iii) the facility receives 25,000 metric tons or more of CO2 for underground injection." To better understand their requirements, we specifically asked about the NY MTA (the second largest green bond issuer in the US in 2020 as mentioned above). The EPA answered that "the New York MTA, for example, does not appear to meet the GHGRP's[33] definitions for facilities or applicability under the program. The GHGRP collects data for direct emitting facilities (scope 1), but this does not include mobile sources (e.g., buses and other vehicles). It also does not include indirect emissions at an individual facility related to electricity consumption, although we do collect emissions data directly from electricity generating units (i.e., the power sector)." Such requirements and rules make it more clear why most of the facilities identified are in the power utilities industry.

Table 7. Geographical Distribution of Treatment Group Facilities

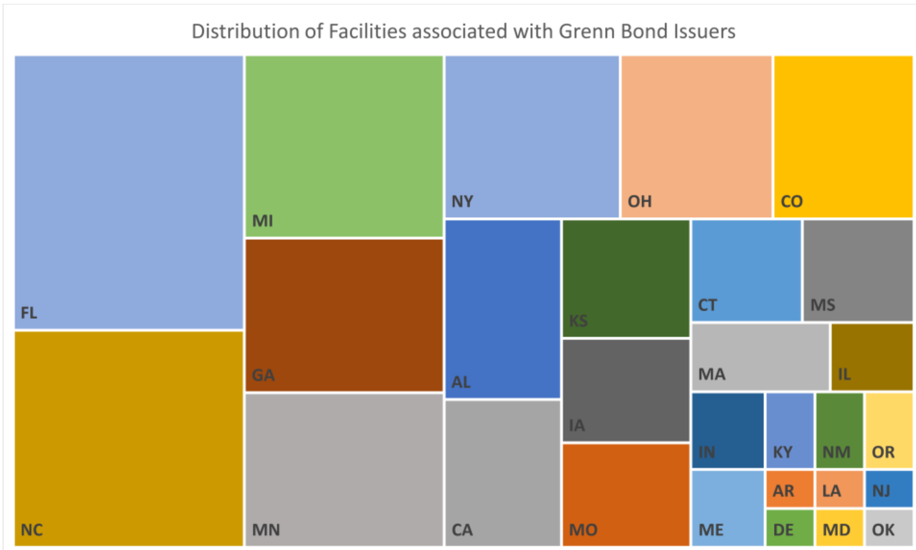
FL	10.2%
NC	8.0%
VA	6.5%
MI	5.9%
GA	5.0%
MN	5.0%
NY	4.6%
SC	4.6%
TX	4.6%
OH	4.0%
PA	4.0%
CO	3.7%
AL	3.4%
UT	3.1%
CA	2.8%
WV	2.8%
KS	2.5%
IA	2.2%
MO	2.2%
CT	1.9%
MS	1.9%
MA	1.5%
WI	1.5%
IL	0.9%
IN	0.9%
ME	0.9%
KY	0.6%
NM	0.6%
OR	0.6%
TN	0.6%
AR	0.3%
DE	0.3%
LA	0.3%
MD	0.3%
NJ	0.3%
OK	0.3%
SD	0.3%
WA	0.3%
WY	0.3%

The facilities associated with green bond issuers are distributed across 39 states (out of a total of 50) but concentrated in Florida (10%), North Carolina (8%), Virginia (6.5%), Michigan (5.9%) and Georgia (5%), as per Figure 17 and Table 7. We also see that facilities are somewhat evenly distributed across the country. Although we can't see any clear pattern on the facilities' geographical distribution, we highlight that the

[33] Greenhouse Gas Reporting Program ("GHGRP")

top 5 states are considered swing states[34] and that California seems under-represented given it is the largest state by GDP and land area and known for its environmentally friendly policies. This is a simple description of the data as we won't analyze these aspects of the data.

Figure 17. Geographical Distribution of Treatment Group Facilities



Note: Figure 17 and Table 7 show a high concentration of facilities in Florida and North Carolina. Florida has facilities from Duke Energy, Nextera Energy, PepsiCo, and Southern Power Co. North Carolina has a concentration of Duke Energy facilities, but it also has facilities of Dominion Energy, PepsiCo, and Southern Power Co.

2.8.2 GHG Emissions Data

The EPA's Facility Level Information on Greenhouse Gases Tool (FLIGHT) provides information about GHG emissions from large facilities in the U.S. These facilities are required to report annual data about GHG emissions to EPA as part of the Greenhouse Gas Reporting Program (GHGRP). An example of the information available is shown in Annex 3.

[34] Swing states are states that are not dominated by either Republican nor Democratic politicians, depending on the year and election they swing between parties.

As mentioned, GHG emissions have been divided in three scopes[35]. The first scope measures direct greenhouse (GHG) emissions that occur from sources that are controlled or owned by an organization (EPA, 2021). The second scope measures indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling (EPA, 2021). The third scope measures GHG emissions that result from activities related to assets not owned or controlled by the reporting organization (also known as 'the value chain scope'). Scope 3 emissions often represent most of an organization's total GHG emissions (EPA, 2021). According to the EPA (2021), all facilities report scope 1 emissions when reporting and disclosing GHG emissions. Emissions that would fall under scopes 2 and 3 are reported by suppliers (not facilities) although they are not categorized as such, and scope 3 emissions quantification is not required. As per email received from the EPA, for our database only scope 1 is considered.

The EPA made GHG emissions reporting mandatory from large sources in the U.S. since January 1, 2010 (AFDC, 2021). Manufacturers of vehicles and engines, suppliers of fossil fuels or industrial GHGs, and facilities that emit at least 25,000 metric tons of GHGs per year are required to submit annual reports to EPA[36]. This requirement, together with vehicle's GHG emission reporting from manufacturers, covers approximately 85% of the country's GHG emissions (AFDC, 2021).

In November 2020, EPA's FLIGHT published self-reported emissions for 9,855 facilities for 3,624 parent companies across the US between 2010 and 2019. We are not aware of any published study using this data to evaluate green bond issuance correlation to a reduction in GHG emissions.

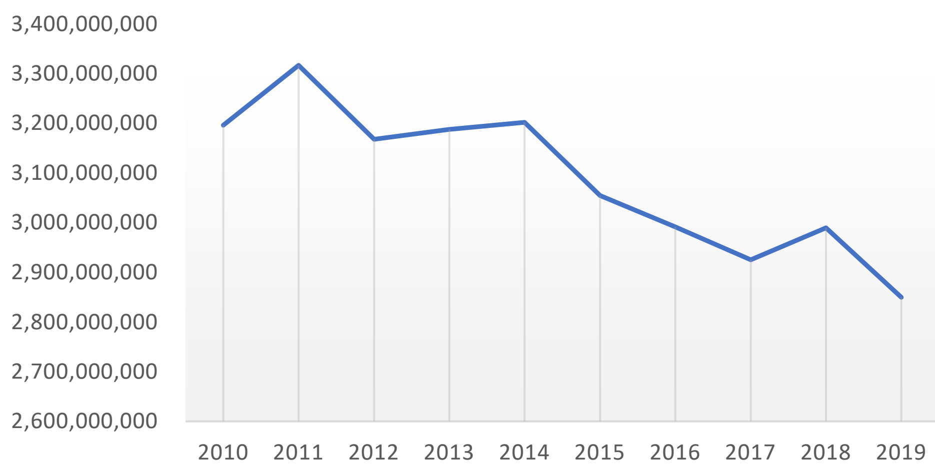
---

[35] GHG emissions are recorded according to the Center for Corporate Climate Leadership's GHG inventory guidance, which is aligned with The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (GHG Protocol Corporate Standard) developed by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD), which is the global standard for calculating corporate GHG emissions (EPA, 2021).

[36] In EPA's report all emissions data is presented in units of metric tons of carbon dioxide equivalent using Global Warming Potential values (GWP) from IPCC's AR4 as per Annex 4.

The EPA GHG data has missing data for certain reporting years of certain facilities. Out of 9,855 facilities only 4,942 reported GHG emissions for all ten years (2010-2019). For the entire data set, there is a clear downward trend in GHG emissions as per Figures 18 and 19.

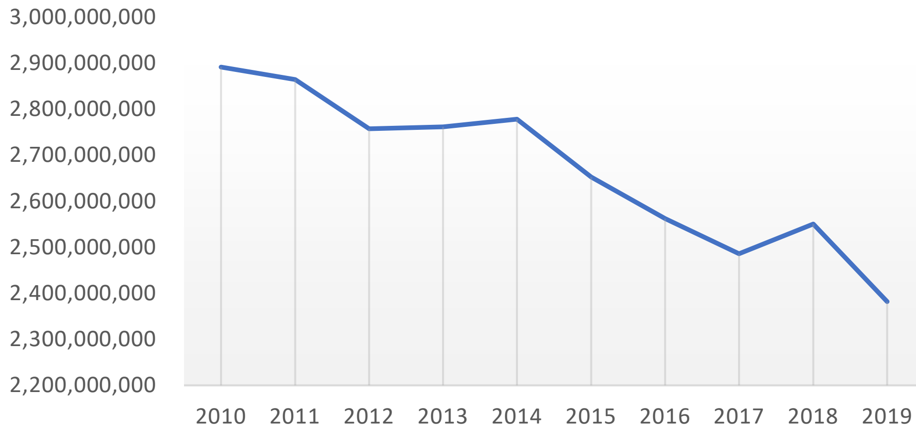
Figure 18. EPA's FLIGHT - Total GHG Emissions per Year



Note: Figure 18 shows the total GHG emissions measured in metric tons of CO2 equivalent.

Figure 18 shows the GHG emissions for all 9,855 facilities (3,624 parent firms) considered in the FLIGHT database. Calculations show an 11% reduction between 2010 and 2019 for all reporting firms, equivalent to an approximate 1% reduction per year.

Figure 19. EPA's FLIGHT – Total GHG Emissions Per Year – Facilities that Reported All 10 Years



Note: Figure 19 shows the total GHG emissions measured in metric tons of CO2 equivalent only for those facilities that reported GHG emissions for all 10 years in consideration.

Figure 19 shows the GHG emissions for the 4,942 facilities from 2,506 parent firms that reported for every year (2010 – 2019) in the FLIGHT database, calculations show an 18% reduction in GHG emissions between 2010 and 2019 for these firms, equivalent to an approximate 2% reduction per year.

Table 8. Total GHG Emissions per year for Green Bond Issuers

(In million metric tons of carbon dioxide equivalent)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	CAGR	Total Chg
All Facilities: 9855 facilities	3196	3317	3168	3188	3202	3055	2991	2925	2989	2850	-1%	-11%
Facilities that reported all 10 years: 4942 facilities	2891	2864	2757	2762	2778	2653	2562	2486	2550	2382	-2%	-18%

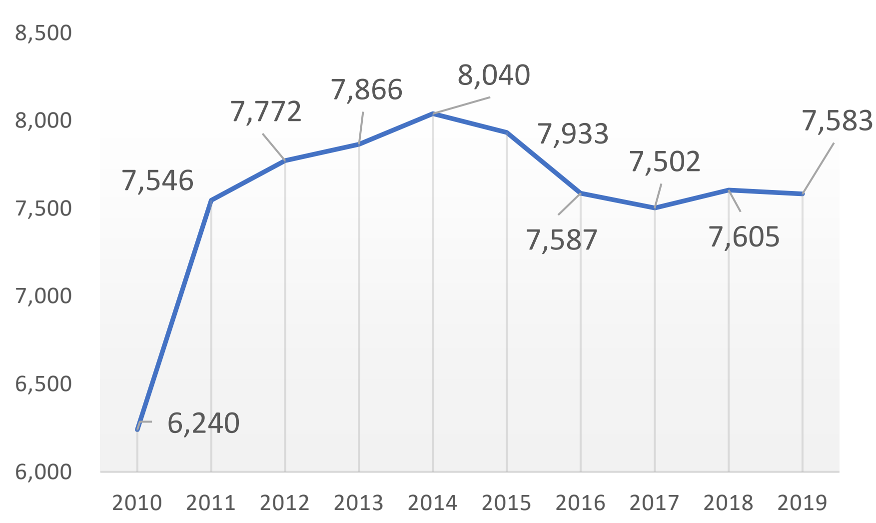
Note: Table 8 shows the calculation of change in GHG emissions for all 9855 facilities in the EPA report and for the 4,942 facilities who reported GHG emissions to the EPA for all 10 years (2010-2019).

Table 8 shows the numbers represented in the two figures preceding it adding the calculation of the compounded annual growth rate ("CAGR") for the period and the total change ("Total % Chg") in GHG emission comparing 2010 and 2019. The figures and the table calculations show a clear downward trend in GHG emissions when all facilities are considered and also when only facilities that reported GHG emissions for all 10 years observed were considered. The CAGR and Total % Chg are more negative when considering only facilities that reported GHG emissions for all 10 years. This group likely represents the actual trend of emissions better as the entire data set includes facilities that were added later and facilities that were excluded or closed throughout the period.

The facilities that did not report all years are in average smaller than the ones that reported for all 10 years. The ones that did not report for every single year represent close to 50% of the number of facilities but in average only 13.6% of GHG emissions.

As per Figure 20, we see an increase of reporting facilities from 2010 to 2014 from 6,240 facilities to 8,040 facilities. The number of reporting facilities seems to stabilize around 7,600 from 2016 onwards. When dealing with the entire data sample the decrease is less aggressive likely because more than 1,000 facilities were added in comparison to 2010. Again, we can infer that an 18% drop is likely more realistic to the real drop facilities experienced in this period than 11%.

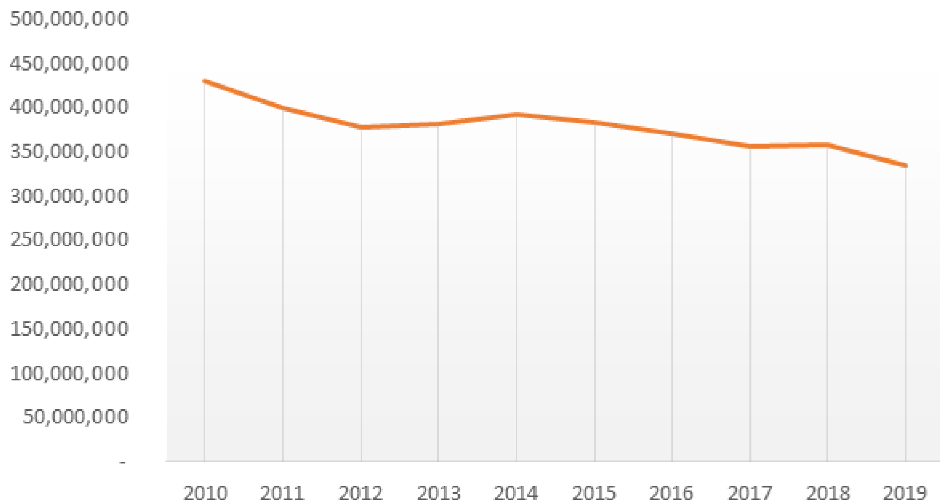
Figure 20. EPA's FLIGHT - Total Number of Reporting Facilities per Year



Note: Figure 20 shows how many facilities have been reporting GHG emissions to the EPA between 2010 and 2019.

We now look at the same data seen in Figures 18 and 19 but only for the Parent Firms and Facilities associated with green bond issuances in Figures 21 and 22 below:

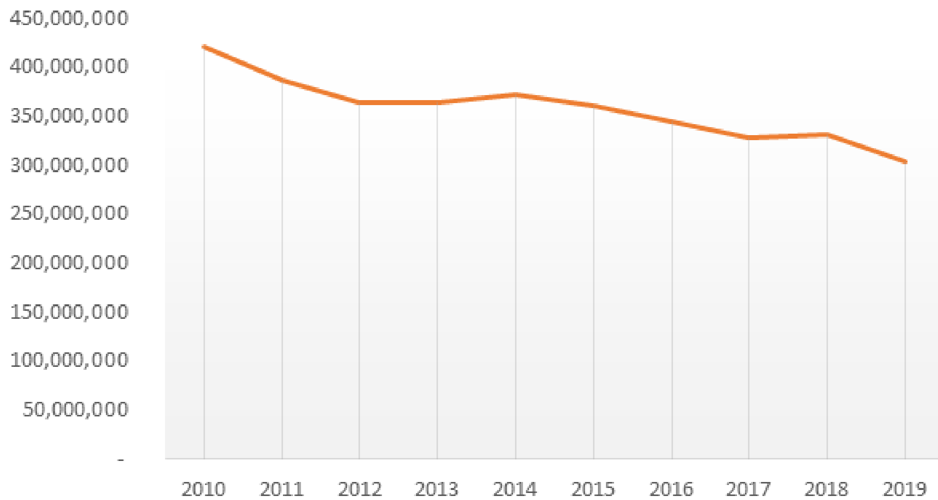
Figure 21. EPA's FLIGHT – Total GHG Emissions Per Year for Green Bond Issuers



Note: Figure 21 shows the total GHG emissions measured in metric tons of CO2 equivalent for facilities associated with firms that issued green bonds.

The chart in Figure 21 above shows the GHG emissions for the 330 facilities form 20 parent firms considered in the FLIGHT database that issues a green bond during the sample period. Calculations show a 22% reduction in GHG emissions between 2010 and 2019 these reporting facilities / firms, equivalent to an approximate 3% reduction per year.

Figure 22. EPA's FLIGHT – Total GHG Emissions Per Year for Green Bond Issuers Who Reported All 10 Years



Note: Figure 22 shows the total GHG emissions measured in metric tons of CO2 equivalent for facilities associated with firms that issued green bonds. It also, only for those facilities that reported GHG emissions for all 10 years in consideration.

The chart in Figure 22 shows the GHG emissions for the 187 facilities from 17 parent firms that issued green bonds and reported every year in the FLIGHT database, calculations show a 27% reduction in GHG emissions between 2010 and 2019 for these facilities / firms, equivalent to an approximate 4% reduction per year.

Table 9. Total GHG Emissions per year for Green Bond Issuers

(In million metric tons of carbon dioxide equivalent)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	CAGR	Total Chg
All Green Facilities: 321 facilities	431	400	377	381	392	383	370	356	358	335	-3%	-22%
Green Facilities that reported all 10 years: 187 facilities	420	387	364	364	373	360	345	328	332	303	-4%	-28%

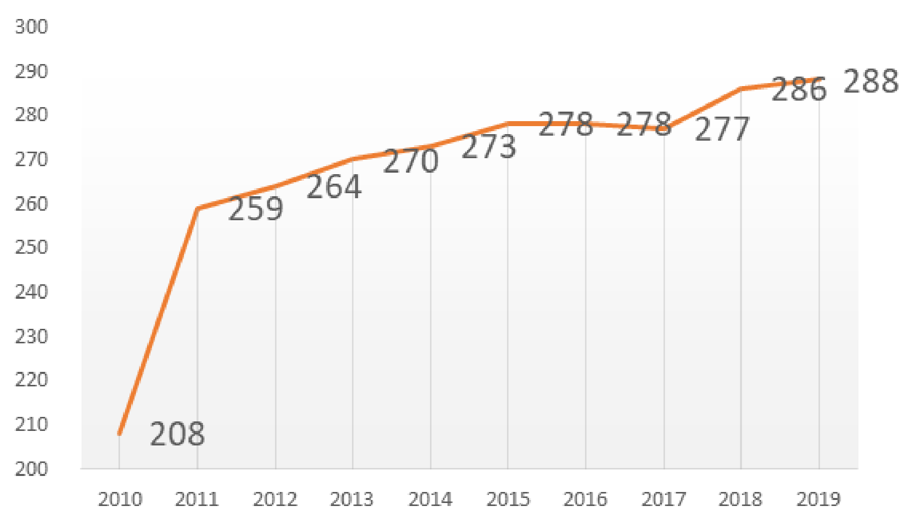
Note: Table 9 shows the calculation of change in GHG emissions for all 330 facilities associated with green bond issuers and, also, for the 187 facilities associated with green bond issuers who reported GHG emissions to the EPA for all 10 years (2010-2019).

Like earlier, Table 9 shows the numbers represented in the two figures preceding it adding the calculation of the CAGR for the period and the Total % Chg in GHG emission comparing 2010 and 2019. Like we saw for the entire dataset, the graphs in Figures 21 and 22 and the calculations for green bond issuers on Table 9, above, show a clear downward trend in GHG emissions when all facilities are considered and also when only facilities that reported GHG emissions for all 10 years observed are considered. The CAGR and Total % Chg are more negative when considering only facilities that reported GHG emissions for all 10 years. This group likely represents the actual trend of emissions better as the entire data set includes facilities that were added later and facilities that were excluded or closed throughout the period.

Here, again, the facilities that did not report all years are in average smaller than the ones that reported for all 10 years. The ones that did not report for every single year represent close to 40% of the number of facilities but in average only 6% of total GHG emissions.

As per Figure 23 below, reporting facilities have been growing steadily for green issuers since 2011 after a large increase between 2010 and 2011. Again, this strengthens the argument that the 28% drop in GHG emissions, seen among the full 10-years reporters, is likely more realistic to the real drop green bond related facilities experienced in this period than the 22% for the entire data set of green issuers, as the increasing number of reporting facilities will increase total GHG emissions towards the end of the analyzed period.

Figure 23. EPA’s FLIGHT – Number of Reporting Facilities Related to Green Issuers



Note: Figure 23 shows how many facilities associated with GB Issuers have been reporting GHG emissions to the EPA between 2010 and 2019.

In order to compare the change in GHG emissions between green bond issuer related facilities and all facilities we ran a 2-sample t-test shown on Table 10 for facilities that reported for all 10 years.

Table 10. t-Test: Two-Sample – only facilities that reported for all 10 years

Facilities that reported for all 10 years	*Green Bond Facilities*	*All Facilities*
Mean change in GHG Emissions between 2010 and 2019	(627,635)	(103,116)
Standard Deviation	1,764,299	853,356
Observations	187	4942
Hypothesized Mean Difference	0	
df	189	
t Stat	-4.0476	
P(T<=t) one-tail	3.770E-05	
t Critical one-tail	1.6530	
P(T<=t) two-tail	7.540E-05	
t Critical two-tail	1.9726	

Note: Table 10 has the results of the t-Test comparing the changes in in GHG emissions between facilities associated with GB Issuers and all facilities. Considering only facilities that reported GHG emissions for all 10 years under analysis.

Table 10 shows that among the facilities that reported for all 10 years (2010-2019), green bond related facilities had a significantly greater average change in GHG emissions, 627 thousand metric tons of carbon dioxide equivalent reduction in comparison to 103 thousand metric tons of carbon dioxide equivalent reduction for all facilities.

The two-sample t-test is highly significant ($p < 0.001$) confirming that the change between green bond issuers and all facilities (that reported for all 10 years) is significantly different, (green bond issuers have larger decreases than non-green bond issuers).

The same analysis was performed for all facilities (not limiting to the ones that reported for all 10 years) and as per Table 11 below we reach the same conclusion as the test that green bonds issuers have larger decreases in GHG emissions than non-GB issuers is also highly significant ($p < 0.002$).

Table 11. t-Test: Two-Sample – for all facilities

All facilities	*All Green Facilities*	*All facilities*
Mean change in GHG Emissions between 2010 and 2019	(298,858)	(35,123)
Standard Deviation	1,488,813	737,396
Observations	321	9855
Hypothesized Mean Difference	0	
df	325	
t Stat	-3.1612	
P(T<=t) one-tail	8.596E-04	
t Critical one-tail	1.6496	
P(T<=t) two-tail	1.719E-03	
t Critical two-tail	1.9673	

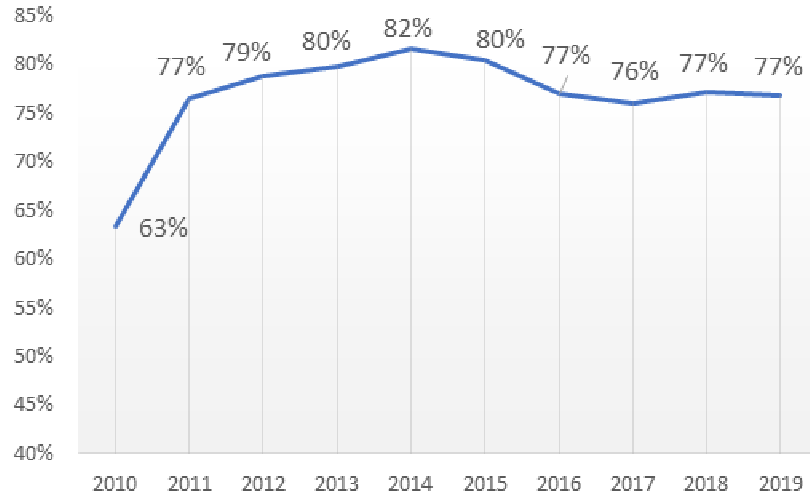
Note: Table 11 has the results of the t-Test comparing the changes in in GHG emissions between facilities associated with GB Issuers and all facilities. Considering all facilities, even when they didn't report for all 10 years under analysis.

2.8.2.1 Challenges with GHG data

There are two challenges with the EPA's data that need mentioning. They are: (i) certain reporting years of certain facilities are missing and (ii) data is self-reported. The EPA explained through email (EPA, 2021) that missing information is "most likely data considered to be confidential business information or left out by the reporter". Also, facilities that closed during the analyzed period or started to operate after the beginning of such period will naturally lead to missing data. Given we are only using the difference in between periods to analyze the rate of change in GHG emissions we do not consider changes from or to zero. As so the missing information does not affect the results.

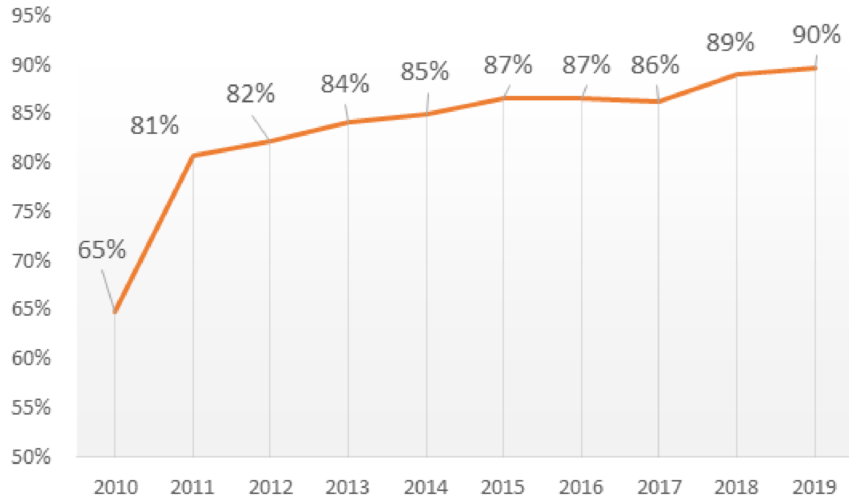
From Figures 24 and 25 we can see the percentage of facilities that reported for each year. Until 2014 reporting levels of green bond issuers were similar to the universe in the EPA's data, from 2015 onwards they detach, and a greater % of green bond issuers' facilities have been reporting GHG emissions than the entire EPA's data universe (which includes green bond issuers).

Figure 24. EPA's FLIGHT - % of Total Reporting Facilities per Year



Note: Figure 24 presents the percentage of facilities within the EPA report that reported on a given year.

Figure 25. EPA's FLIGHT - % of Green Issuers Reporting Facilities per Year



Note: Figure 25 presents the percentage of facilities associated with GB Issuers within the EPA report that reported on a given year.

Most GHG emissions data globally and in the USA is self-reported. While self-report data may lead to validity problems as companies may manipulate numbers in order to make their situation seem better than it is, or improving faster than it actually does, they are in the best position to know their own GHG emissions. This is not particular to sustainability metrics, all corporate financial information from companies is self-report, but it became mandatory, for most financials reporting, to have an auditor sign-off on them. Sustainable metrics auditing is a growing industry trend that is needed for the development of more reliable data pool[37]. For the time being we work with the best information available, which is self-reported.

2.8.2.2 Aggregating Data at the Issuer level

We analyze GHG emissions from a parent firm level, adding up emissions for all facilities monitored for that parent company[38]. As so, using the parent information from the EPA report we aggregated all 9,855 facilities into 3,624[39] parent companies, of which 20 are green issuers (0.55%).

The average annual GHG emission for each green bond issuer in the analyzed period is 19.8 million tons of CO2 equivalent, while for non-green bond issuers it's 0.9 million tons of CO2 equivalent. Companies that issue bonds in the capital markets are normally the largest in their industry, while this number is relevant for us to understand the data, it's not enough to conclude that green bond issuers are always larger than non-green bond issuers.

2.8.3 The US Bureau of Economic Affairs ("BEA") Data

The BEA makes the following economic information at the state level publicly available: Real GDP, Compensation, Gross operating surplus, Taxes on production and imports ("TOPI") and Subsidies from 1997 to 2020. All information is given in millions of US dollars. Given the EPA

[37] As we review this paper the 2021 United Nations Climate Change Conference is happening is Glasgow ("COP26"). In the COP26 leader and experts are discussing, among other topics, how carbon metrics should be standardized in terms of calculation and reporting. Other important technical topics are: auditing, comparability, value, and trading of carbon credits.
[38] When we run regressions using macroeconomic controls, we run regressions at the facility level as a single parent firm could have facilities in many different states.
[39] 149 facilities had no parent company associated with them in the EPA database and as so are not used when issuer level data is analyzed.

data includes the state in which each reporting facility is located and the year of each observation, we crossed facilities ‘state level economic data with their GHG emissions to analyze if economic activity could be a major driver of GHG emissions[40].

2.9 Model design

DiD is commonly used to recover the causal effect of interest from observational study data, exactly as the case we are dealing with, where the experimental design is out of the researcher’s control. It is considered the golden standard in such cases because it addresses unobserved confounders and some form of selection bias (Ng, 2020).

DiD combines the differences of time-series - comparing outcomes pre-treatment, during treatment and post-treatment periods - and cross-sectionally - comparing outcomes between treatment and control groups. As per Ng (2019) there are two ways to calculate difference in differences, as per Figure 26, the first strategy is to find the impact of treatment on the average behavior of the dependent variable for the treatment group and compare it to the impact of treatment on the average behavior of the dependent variable for the control group, the difference between the two could potentially be a result of the treatment. The second strategy is to compare treatment and control groups before and after treatment and finally calculate the difference between the differences of these two groups (hence the name difference in differences).

[40] As per Annex 5, the BEA information was missing for the state of Rhode Island, and the territories of Guam, Puerto Rico and the US Virgin Islands. In the Annex we show that this has very little impact in the overall data being analyzed.

Figure 26. Difference in Differences Strategies

	Strategy #1	Strategy #2
Difference 1	**Average change of treated over time** $E(Y_{it}\|T_i = 1, P_t = 1) - E(Y_{it}\|T_i = 1, P_t = 0)$	**Average change between treated and control in post-treatment period** $E(Y_{it}\|T_i = 1, P_t = 1) - E(Y_{it}\|T_i = 0, P_t = 1)$
Difference 2	**Average change of control over time** $E(Y_{it}\|T_i = 0, P_t = 1) - E(Y_{it}\|T_i = 0, P_t = 0)$	**Average change between treated and control in pre-treatment period** $E(Y_{it}\|T_i = 1, P_t = 0) - E(Y_{it}\|T_i = 0, P_t = 0)$
Difference in Differences	Difference 1 – Difference 2	

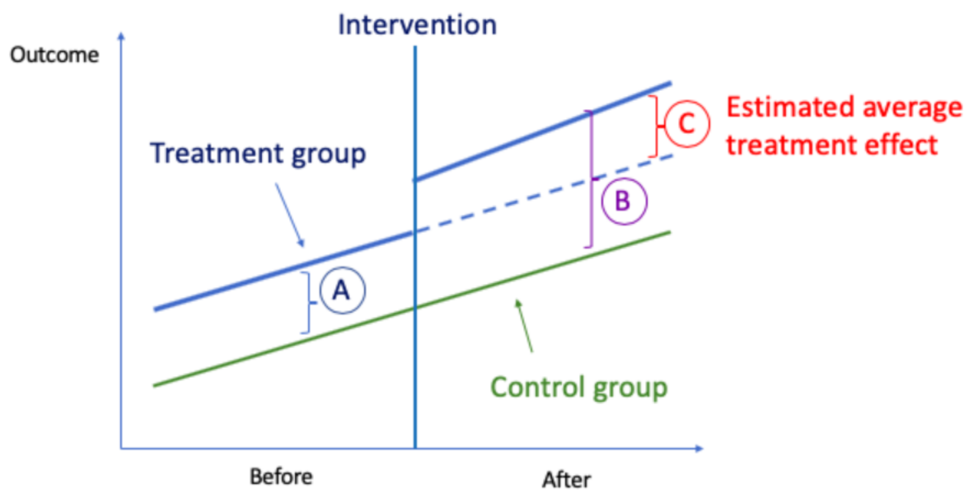
Note: Figure 26 presents the two strategies to calculate difference in differences.
Source: Ng (2019), https://medium.com/eatpredlove/regression-difference-in-differences-208c2e787fd2

In Figure 26 ‘Y_{it}’ is the outcome of unit ‘i’ at time ‘t’, ‘T_i’ is a dummy variable indicating one if treatment is assigned and zero otherwise, ‘P_t’ is a dummy variable indicating one if post treatment period and zero otherwise.

As treatment happens in different years in our treatment group, we take strategy one and compare the average behavior or each group before and after treatment. As we cannot use a dummy for before and after treatment, we calculate the annual time (year) effect on each observation for the control and treatment groups, as a way to isolate explanatory power on changes that are related to the passage of time rather than from the green bonds’ issuance, on GHG Emissions.

Figure 27 shows in a graphic format the effect “C” that we are trying to isolate in the difference in differences model. In our case the intervention is the first time a green bond is issued, and the green line after treatment is approximate by the dummy variable for each year being observed for the control group. The equations we use (Equations 1 and 2) are explained in detail in the Research Design below.

Figure 27. Difference in Differences Explanation Graph



Note: Figure 27 separates the differences between treatment and control groups and their difference before and after the intervention/treatment. The objective is to isolate "C" which is assumed to be the effect of the treatment on the dependent variable.

2.9.1 Potential Treatment Endogeneity

We are dealing with observational data for our study. Conventional treatment-effects estimators such as OLS require the conditional independence assumption. This means that we assume that no unobserved variables affect both treatment assignment and the outcome. In our case issuing a green bond is a decision taken by the parent firm itself and one could argue that given they choose to be treated there could be unobserved variables affecting treatment assignment and the outcome. In case an unobserved variable is affecting the decision of a parent firm to be treated and the outcome, we have an endogeneity problem, and we would not be able obtain accurate estimates of effects using conventional treatment-effects estimators.

There is a large literature in econometrics about treatment endogeneity, especially when randomized control trials are not possible. The entrepreneurial nature of combining data from different sources in the way we do here, can lead the way for future studies to address the uncertainty related to this problem through nonparametric control functions such as stochastic polynomial restrictions, or propensity score matching. With time, more data will become available allowing for other models to be chosen.

This risk is partially allayed by two factors: first, it is net positive for an issuer, that can issue a green bond, to do so. Which means that issuing green bonds is rationally desirable for all, hence all those that can go through the issuing process (including holding the necessary assets or engaging in green projects, as described above) will issue. Second, some regressions (namely 3 and 4) are run at the facility level, but the decision to issue green bonds is made at the holding or parent firm level. At the level we analyze GHG issuance in regressions 3 and 4 (facilities) there is no decision power and no direct especial benefit to being a green issuer. The benefit is at the corporate holding company, its funding and marketing departments.

Despite the partial mitigation these two factors provide us, we acknowledge the treatment endogeneity challenge and interpret our results taking it into consideration but given the limited information available on all the firms reporting to the EPA, ordinary least squares and panel data regressions are the best approach at this stage.

2.9.2 Leads and Lags

While designing my model we were concerned about forward or backward lagged effects from treatment: meaning that changes in GHG emissions related to a green bond issuance could happen before or after the issuance of the green bond. To answer this question, we leaned on my experience, contacted GB Issuers in my data pool and investigated the data available on green bond's use of proceeds available in GB Issuer's websites.

As described before there are two types of green bond issuers: (i) structured products with many small assets (car and house loans for example) backing a green issuance and (ii) project financing, where large complex projects are used to back a green bond. In both cases we have identified assets being generated before and after the green bond was issued (treatment moment) but always significantly close to the moment of issuance as per Tables 12 and 13 below.

Considering GB Issuers waited to issue green bonds only after they already secured the green assets to back such issuances, the real climate impact (GHG emission reduction) would happen earlier than when the green bond is issued. If they raised funds for a project that is still under development, the GHG emission reduction resulting from it would only be observable after the project is completed.

We investigated available documents and received direct information from Clearway Energy, Analog Devices, Duke Energy and Owens Corning, to understand their green bond issuance process. DTE energy, Pfizer and MidAmerican contact information provided online was inaccurate or not available. Also, we contacted Sustainalytics, which provide second party opinion on issuances (including for Toyota and ClearWay Energy) and provide ESG ratings to issuers. Finally, we did a desk review of documents available for the remaining companies. Avangrid, Nextera and Edison did not answer the emails.

As per Annex 6, in line with my expectations, Toyota (who packages small car loans as green bond backed assets) claimed to use the green bond proceeds (up to one year) after the issuance of the bond. At the same time, the reported use of proceeds for Avangrid and Clearway Energy, who finance sustainable energy projects, show that such projects became operational in the same year or one year after the issuance. In line with their statement, “once Clearway issues a green bond the proceeds are allocated to eligible projects”, Clearway Energy used proceeds to expand wind and solar projects that already existed and to prepay outstanding green bonds issued in 2014, that would mature in 2024.

Table 12 summarizes a few examples of green issuances and when projects using the proceeds were created. It shows that in most cases using the same year as the green bond issuance is the best model although there are exceptions.

Table 12. Examples of when green bonds were issued and when the proceeds were used

Issuer	**Bond Issuance**	**Asset Created**
Toyota	2017	2017
Toyota	2020	2020
Avangrid	2017	2017
Avangrid	2019	2019
Avangrid	2020	2021
Clearway	2014	2014
Clearway	2019	2014/2019
Analog Devices	2020	2020

Note: Table 12 shows that in the cases studied the use of proceeds from green issuances happens close to the year of issuance although it also shows that in some cases it can happen earlier or later.

Table 13 summarizes what we learned about the timing in which green bond proceeds are used, and the reason for such timing in each of the green product groups identified earlier: structured products and project finance. There isn’t a rule to define this relationship but in general green bond frameworks allow GB Issuers one or more years to present eligible assets to back the green bond issuance.

Table 13. Reasons for Early or Late Expected GHG Impact of Green Bond's Use of Proceeds

	Structured Products	Project Finance
Reasons for lags	Issuers may be starting a new line of business	
	Revolving assets may shift from less green purposes to greener purposes	Green field projects need financing prior to project execution, completion and impact
	Most Green Bond Frameworks allow GB Issuers 1 or more years to present eligible assets	
Reasons for leads	Issuing a green bond is not the first step of an issuer's sustainability effort. It's usually an important milestone that comes after important cultural changes, a growing set of projects in search of sustainability and the implementation of the necessary monitoring structure	
	Asset are revolving usually from before the green bond was issued	Brown field financing: Issuers may already have implemented green projects based on their business line, shareholder or management preferences and beliefs or even consumer preference. Issuing green bonds can come much later

Note: Table 13 presents some of the common reasons why green proceeds from structured products or project finance issuances may be financing older projects that were already in operation or new projects. This is important as it could affect when a potential change in GHG Emissions should be expected. Most of the data gathered does not indicate some definite bias towards early or late effects, and most data indicates that the year of the issuance is when most issuers use the green proceeds.

Duke Energy gave a different example of how green proceeds could be used: "Duke Energy complies with the established green bond principles with regards to selection criteria. Under these principles, investors allow the company to look back over the past two years and refinance costs that have already been spent towards green-eligible expenditures (as detailed in the offering documentation). Furthermore, the company is allowed to continue allocating net proceeds over the life of the bonds. As an example, if the company was to issue a 10-year green bond, it would have 12 years to fully allocate net proceeds to eligible green expenditures" (Duke, 2021).

According to Sustainalytics, who rates the sustainability of listed companies based on their environmental, social, and corporate governance performance and provide second opinions on green issuances, "it is not necessarily the case the Issuer will have already the green assets/projects in their books prior to issuing a green bond. This varies significantly from issuer to issuer. Some Issuers may indeed have existing projects/assets they are looking to count as green spend however many issuers intend to set up a framework for new/future projects. In those cases, the GB Issuer will outline a set of eligibility criteria that they will follow and that Sustainalytics review within the second-party opinion. The Issuer's "Green Bond Framework" will include this set of eligibility criteria" (Sustainalytics, 2021).

As per the above, it is impossible to point exactly when proceeds impact GHG emissions for a certain GB Issuer, nor if this effect happens with a lead of a lag to the green bond issuance. But the interviews and data show that potential lags or leads are very small, likely not more than one year. Our model considers an issuer to be green upon its first green bond issuance, as so refinancing of green proceeds should not affect this dynamic, also refinancing shouldn't significantly change GHG emissions.

For the avoidance of doubt about the predicting power of lagged or leading models we still ran regressions with a one-year lag and one-year lead to search for any different effects. The results are shown in Appendix 1.

2.10 Research Design

With aggregated level data in a longitudinal format, we observe the same parent firms in both time periods (before and after GB issuance) and can compute the quasi difference in differences regression using ordinary least squares and the interaction between years and the treatment dummy as explained below[41].

All observations are divided into two groups: the treatment group and the control group. The treatment group are identified by the variable: "GrIssuer", which denotes observations whose belong to an issuer of a green bond at any point in the sample period (these are the treatment group) All other observations (facilities owned by non-green bonds issuers) constitute the control group. The coefficient on GrIssuer will capture the difference between the treatment and control

[41] We also analyze the data using panel data regressions in Appendix 1.

samples in the period prior to the green bond issue. For each treated observation (facilities associated with a GB Issuer) there isn't a standard or common time of treatment. Treatment happens when the issuer issued the green bond, which can vary between 2014 to 2019. A second variable "GrBond" marks the year in which the green bond was issued and thereafter. The coefficient on GrBond" will measure the post issue period effect and capture the average difference between the control and treatment groups once the green bond is issued. Our first regression analyses these coefficients using Equation 1 below:

Equation 1. OLS Regression Model

$$Y_{it} = \beta_0 + \beta_1 P_t + B_2 T_i + \beta_3 2011 + \beta_4 2012 + \ldots \beta_{11} 2019 + u_{it} \quad (1)$$

where Y is the change in GHG emissions for observation i at year t, P is a dummy variable for the time of the treatment (GrBond), T is a dummy variable for the treatment group (GrIssuer), each year is a dummy variable for observations only for that specific year, and u is the error term.

Given green bonds were issued at different times by GB Issuers, there isn't an exact time of treatment and hence there isn't an exact time in which non-treated variables (control group) can be observed 'after treatment'. Which means we can't calculate the coefficient of the interaction between treatment group and post treatment period. To deal with this fact, in Regression 2, we include in my model dummy variables for all years (isolating potential year specific events that may affect the reading) and we include the interaction between each year and the treatment group dummy (GrIssuer), as per equation below:

Equation 2. OLS Regression Model

$$Y_{it} = \beta_0 + \beta_1 P_t + B_2 T_i + \beta_3 2011 + \beta_4 2012 + \ldots \beta_{11} 2019 + \beta_{12}(T_i * 2011) + \beta_{13}(T_i * 2012) + \ldots \beta_{20}(T_i * 2019) + u_{it} \quad (2)$$

Where, like in Equation 1, Y is the change in GHG emissions for observation i at year t, P is a dummy variable for the time of the treatment (GrBond), T is a dummy variable for the treatment group (GrIssuer), each year is a dummy variable for observations only for that specific year, and *u* is the error term. The interaction term, "*T * year*", will isolate potential year-specific events that may affect GB Issuers exclusively.

The key coefficient for the test of an effect of green bond issuance on GHG emissions is *β1*. If green bond issuances influence GHG emissions, we would expect *β1* < 0.

2.10.1 Analysis steps

To answer our question if GHG emissions change for first time green bond issuers, we will run twelve regressions, four main regressions as part of the core analysis and an additional eight different regressions in Appendix 1, to test if results are in line with the core analysis. Table 14, below, shows the analysis step by step:

Table 14. Regressions Table

	Order	Type	Rational	Level	Dependent Variables				Independent Variables					
					GHG*	GHG change*	GHG% change	Log of GHG	GrIssuer	GrBond	years	Inter - GrIssuer *years	Macro - state (BEA)	Lagged or led GrBond
CORE ANALYSIS	1	OLS	Understand GrIssuer coefficient	Parent Firm		x			x	x	x			
	2	OLS	Understand GrIssuer coefficient	Parent Firm		x			x	x	x	x		
	3	OLS	Add macroeconomic variables	Facility		x			x	x	x		x	
	4	OLS	Add macroeconomic variables	Facility		x			x	x	x	x	x	
			Testing other approaches - Appendix 1											
In Appendix	5	Panel RE	Test different models	Parent Firm	x				x	x	x			
	6	Panel RE	Test different models	Parent Firm	x				x	x	x	x		
	7	Panel FE	Test different models	Parent Firm	x				**	x	x			
	8	Panel FE	Test different models	Parent Firm	x				**	x	x	x		
	9	OLS	Lagged	Parent Firm		x			x		x	x		x
	10	OLS	Led	Parent Firm		x			x		x	x		x
	11	OLS	GHG % cahnge	Parent Firm			x		x	x	x	x		
	12	OLS	(level-log model)	Parent Firm				x	x	x	x	x		

* in metric tones of CO2 equivalent

** for fixed effects time invariant variables must be omitted

Note: Table 14 summarizes all regression being used to analyze the data in this chapter. The first 4 regressions are analyzed in this chapter and the following 8 are discussed in Appendix 1.

For the core part of our analysis, Regressions one and two, we run OLS regressions at the parent firm level. This means that all facilities for a given parent firm are combined so that we consider the total GHG emissions changes at the parent firm level. We then run the same regressions using state level macroeconomic data as controls, Regressions three and four, given a parent firm could have facilities in different states we run these at the facilities level.

2.11 Core Analysis

2.11.1 Regressions 1 and 2: OLS analysis of changes in GHG emission

Below we present the results of regressions one and two. Please refer to Table 15 for the results of regressions one through four. Regression one evaluates the change (simple difference) in GHG emissions (in metric tons of CO2 equivalent) on year-specific dummies (2010 is not include as we lose a year when calculating changes and 2011 is the base case), GrIssuer, the treatment group dummy and GrBond, the dummy for the year in which the first green bond is issued and thereafter. This regression only considers an unconditional treatment effect[42], a time period average plus the difference between treatment and control groups.

The key coefficient of interest in Regression 1 is GrBond. As shown in Table 15, the coefficient on GrBond indicates how much the green bond issuance affects the annual change in GHG for the issuing firms. This coefficient, negative 436,515.3, indicates that the issuance of a green bond results, in average, in GHG emission changes that are 436,515 metric tons of CO2 equivalent lower than pre-green bond issuance. This coefficient is statistically significant at the 1% level. The coefficient on GrIssuer is also negative and highly significant and indicates that on average the decline in GHG of the treatment firms (those that end up issuing green bonds) is, on

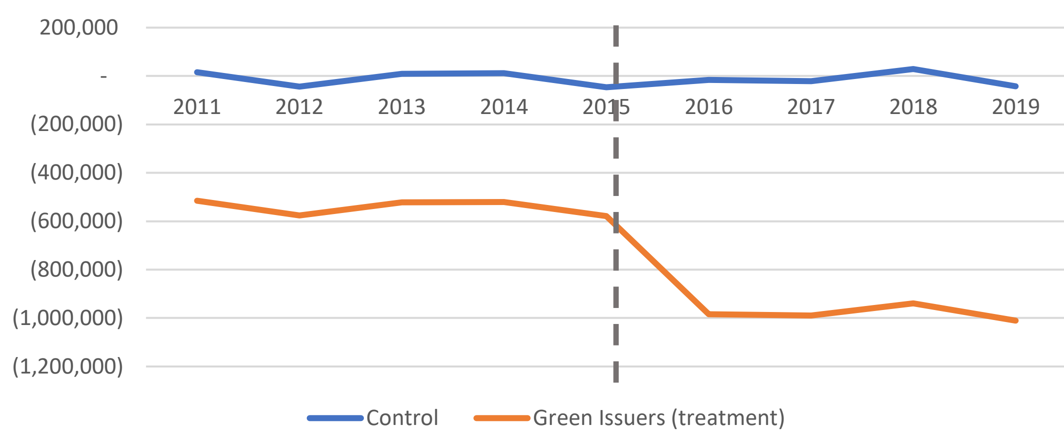
[42] When treatment selection is endogenous

average, 531,933 metric tons of CO2 equivalent per year lower than that of the control group firms.[43]

We represent the results of regression 1 graphically in Figure 28, where the blue line shows the average change in GHG emission for non-GB Issuers over time and we see that it is only slightly negative.

Using the coefficients above, the orange line shows the average change in GHG emissions for the treatment sample. For demonstrations purposes we assume that the green bond is issued in early 2016. The average GHG emission change from issuance is seen by the orange line's downslope between the end of 2015 ad the end of 2016 (dashed line).

Figure 28. Graph Representing the Results of Regression 1: Treatment vs Control – Change in GHG Emissions (metric tons of CO2 eq.)



Note: Figure 28 summarizes the statistically significant findings of regression 1. The results show that GB Issuers have been reducing its GHG emissions at a faster pace than non-GB Issuers and that upon the issuance of a first green bond there is a greater decrease in GHG emissions per year.

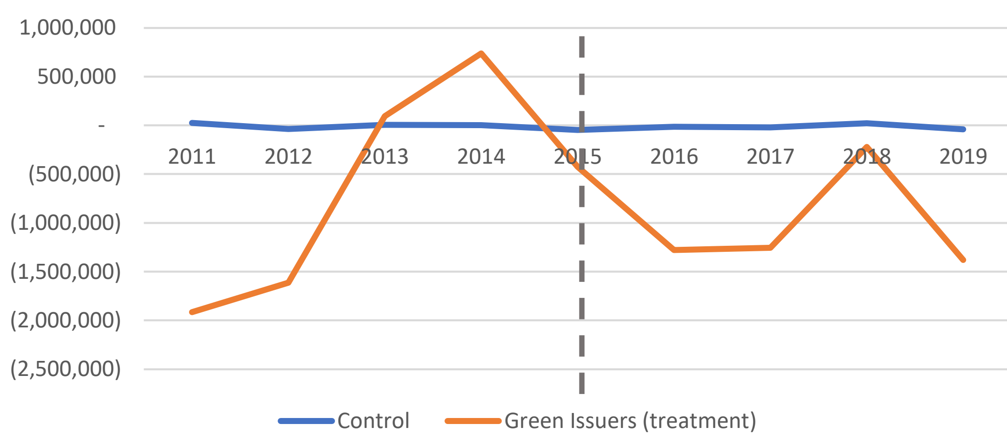
Regression 2 considers the outcome when the year dummies and the treatment group (interaction called "G*year*") is created to isolate year-specific variation in changes in GHG emissions that could be influencing the "GrBond" and "GrIssuer" coefficients in Regression 1.

[43] For reference, total GHG emissions among all facilities analyzed in 2019 alone was approximately 2.8 billion metric tons of CO2 equivalent as seen earlier in Figure 18.

For the key coefficient (GrBond), Regression 2 shows similar results to regression 1. The issuance of a green bond results in a significantly larger decline in GHG changes for the remainder of the sample period. The coefficient on GrBond is negative 675,926.6 and is statistically significant for alphas as low as 1%.

Figure 29 shows the results of Regression 2 graphically. Notice the time variation in the treatment group (orange) is much noisier than in Figure 28 (previous one), because we are allowing for year specific differences between the control and treatment groups. As before the effect of GrBond is shown as occurring in between 2015 and 2016 (dashed line).

Figure 29. Graph Representing the Results of Regression 2: Treatment vs Control – Change in GHG Emissions (metric tons of CO2 eq.)



Note: Figure 29 summarizes the statistically significant findings of regression 2. Like in Regression 1 the results show that upon the issuance of a first green bond there is a greater decrease in GHG emissions per year. It also shows that year specific trends can be volatile, especially for the GB Issuer group which includes only 20 parent firms.

Regression 3 is the same as Regression 1 but adding state level macroeconomic data as controls and running the regression at the facility level. The results for the treatment group (GrIssuer) and the treatment itself (GrBond) are both negative like in Regressions one and two, but only the coefficient for the GrIssuer is statistically significant at 1%.

Regression 4 is the same as Regression 2 but adding state level macroeconomic data as controls and running the regression at the facility level. The results for the treatment group (GrIssuer) and the treatment itself (GrBond) are both negative like in Regressions one and two, both are coefficients are statistically significant at 1%.and 5%, respectively. The macroeconomic variables added in Regressions three and four were not statistically significant and don't seem to be good explanatory variables of variations in GHG emissions.

Table 15. OLS Regressions – Core Analysis

Core Analysis OLS	Regression 1 GHG_change	Regression 2 GHG_change	Regression 3 GHG_change	Regression 4 GHG_change
GrIssuer	-531933.3*** (-11.41)	-1941282.3*** (-15.23)	-39302.3*** (-6.25)	-172755.9*** (-9.70)
GrBond	-436515.3*** (-4.65)	-675926.6*** (-5.82)	-13962.1 (-1.18)	-36111.1* (-2.08)
2012.year	-60217.0*** (-4.23)	-62986.1*** (-4.45)	-12013.8** (-2.70)	-14064.8** (-3.11)
2013.year	-6702.3 (-0.47)	-20075.5 (-1.41)	10279.8* -2.29	3933.6 -0.86
2014.year	-4980.1 (-0.35)	-22478.7 (-1.58)	10067.8* -2.2	2275 -0.49
2015.year	-63102.2*** (-4.37)	-73200.2*** (-5.10)	-10664.9* (-2.33)	-16204.6*** (-3.48)
2016.year	-31983.7* (-2.20)	-40639.2** (-2.80)	-6348 (-1.36)	-11462.2* (-2.41)
2017.year	-37631.7* (-2.57)	-46197.8** (-3.17)	-528.2 (-0.11)	-5044.4 (-1.03)
2018.year	12646.4 -0.86	-3003 (-0.21)	17432.0*** -3.39	10830.9* -2.08
2019.year	-58366.5*** (-3.98)	-65397.8*** (-4.48)	-8160.5 (-1.58)	-11902.9* (-2.29)
G2012		364785.0* -2.08		59519.8* -2.49
G2013		2029853.0*** -11.57		177580.8*** -7.46
G2014		2676623.6*** -15.24		219876.1*** -9.23
G2015		1564141.0*** -8.83		160084.1*** -6.69
G2016		1353974.4*** -7.64		149176.0*** -6.17
G2017		1381593.8*** -7.65		133154.6*** -5.48
G2018		2373717.7*** -12.84		197587.0*** -7.3
G2019		1276817.9*** -6.58		128642.5*** -4.48
State_GDP			0.0154 -0.47	0.0139 -0.43
Compensation_MM_USD			-0.0751 (-1.68)	-0.0773 (-1.74)
Gross_operat_surplus_MM_USD			0.0579 -1.17	0.0636 -1.29
TOPI_MM_USD			0.055 -0.36	0.0622 -0.41
pos_Subsidies_MM_USD			-0.712 (-0.43)	-0.859 (-0.52)
_cons	16099.2 -1.54	25494.8* -2.45	-8389.3* (-2.26)	-3560.7 (-0.95)
N	24949	24949	65260	65260
	Parent Firm	Parent Firm	Facilities	Facilities

Note: Table 15 summarizes results for regressions 1 through 4.

As per Table 14, we performed additional regressions to test the statistical relevance of coefficients for GrIssuer and GrBond with additional variables, panel data regressions, percentual changes and lagged and led regressions. For more details, please refer to Appendix 1. In all regressions, apart from the two analyzing relative changes (percentual change and log-level), the coefficients for 'GrIssuer' and 'GrBond' remain statistically relevant at the 1% level and negative, indicating that GB Issuers' GHG emissions decrease at a faster pace than non-GB Issuers and that upon the issuance of the first bond a greater decrease in GHG Emissions is observed. This is the same result we identified in regressions one through four in this chapter.

2.12 Chapter Conclusion

In line with the results shown by Schmittmann *et al* (2021), who claims "a significant reduction in emission intensity in the year of issuance relative to the previous year", we identify a consistent and meaningful relationship between reduction in GHG emissions and the issuance of a green bond.

For all four OLS regressions shows on Table 15, GB Issuers presented greater reductions in their GHG emissions in the period evaluated, ranging in between negative 1,941,282 and negative 531,933 metric tons of CO2 equivalent for Parent Firms and in between negative 172,756 and negative 39,302 metric tons of CO2 equivalent for Facilities. The result was statistically significant at a 1% level for all regressions.

The treatment, issuing a green bond for the first time, was also associated with greater reduction in GHG emissions in all four OLS regressions, ranging in between negative 675,927 and negative 436,515 metric tons of CO2 equivalent for Parent Firms and in between negative 36,111 and negative 13,962 metric tons of CO2 equivalent for Facilities. The results were statistically significant at a 1% level for all Parent Firm level regressions (Regressions 1 and 2).

Facility level regressions with macroeconomic variables had one statistically significant result at 5% (Regression 4) and a non-statistically significant result (Regression 3)[44].

As discussed earlier, results may be influenced by treatment endogeneity given GB Issuers themselves choose to issue green bonds or not. Future work in this field could dig deeper into the relationship between green bonds and GHG emissions, especially when more data about GHG emitters is made available, such as: (i) narrow down which of the steps in the green bond issuance are the most relevant for a reduction in GHG emission; (ii) simulate a randomized control trial using propensity score matching to deal with potential endogeneity; (iii) use more firm and facility level controls; (iv) run these regressions in future years when more green bond and GHG emissions data will be available.

The Model Design shows from empirical examples that it is hard to define when green assets that back a green bond issuance are created. The lack of standardization among green issuances creates challenges for research designs and to make the best use of data. According to the Model Design section, neither lags nor leads are justifiable as feasible standard models unless we divide issuances in sub-groups, for which we didn't have sufficient data.

We expect this research to contribute to the development of the sustainable bonds market, help investors make better informed decisions and guide some standardization in how GHG emissions and sustainable initiatives in capital markets can be connected.

[44] The results of the analysis done in Appendix 1 shows similar results with greater reductions in GHG emissions by GB Issuers when compared to non-GB Issuers and greater GHG reduction starting on the year the first green bond is issued. We discuss those results in detail in Appendix 1.

3 Chapter 3 – Do ESG Funds Differentiate from Non-ESG Funds?

3.1 Chapter Purpose

In this chapter we explain what are environmental, social and governance (ESG) labelled funds and analyze exchange traded funds (ETFs) to see whether ESG labelled ETFs actually differentiate their holdings from non-ESG labelled ETFs. We investigate the potential of misrepresentation among sustainably labelled assets by analyzing if the holdings of ESG labelled funds are statistically different from non-ESG labelled funds using publicly available information on funds composition.

3.2 What is ESG?

Environmental, social and governance (ESG) considerations are a major topic in asset management today. It has grown on the back of investors' desire to impose a dual mandate to the resources they invest: financial return and some form of developmental responsibility. MSCI, a leading provider of data and research on ESG investments and ratings, defines ESG investing as "the consideration of environmental, social and governance factors alongside financial factors in the investment decision-making process" (MSCI, 2021b)

ESG's roots are hard to define, and while ethical codes and religious beliefs shaped the earliest instances of sustainable investing many centuries ago, the goals of the modern version of ESG are closely linked to the goals of SRIs (Socially Responsible Investing) created in the 1950s. SRIs were the market answer to address the needs of investors who began to avoid and question the so called "sin" stocks[45]. Fast forward a few decades to today, and ESG indicators and ratings are among the main instruments to measure and compare security issuers' sustainable practices.

[45] Sin stocks are shares in companies involved in activities that are considered unethical, such as alcohol, tobacco, gambling, adult entertainment, or weapons.

As per the US Securities and Exchange Commission (SEC)[46] (2021b):

> "ESG investing has grown in popularity in recent years, and may be referred to in many different ways, such as sustainable investing, socially responsible investing, and impact investing. ESG practices can include, but are not limited to, strategies that select companies based on their stated commitment to one or more ESG factors —for example, companies with policies aimed at minimizing their negative impact on the environment or companies that focus on governance principles and transparency. ESG practices may also entail screening out companies in certain sectors or that, in the view of the fund manager, have shown poor performance with regard to management of ESG risks and opportunities. Furthermore, some fund managers may focus on companies that they view as having room for improvement on ESG matters, with a view to helping those companies improve through actively engaging with the companies."

3.3 What is an ESG Asset?

Any assets could be labelled 'ESG' as long as it (or its issuer) addresses some concern investors have related to environmental, social or governance themes. Issuers' governance has been part of credit analysis for a long time as its links to a potential credit default are widely accepted.

Today the major ESG related asset groups are: equities, corporate debt (through loans or bonds) and a wide range of portfolio funds. According to Bloomberg Intelligence (2021) base case projections, ESG labeled assets may reach USD53 trillion globally by 2025, a third of global assets

[46] The mission of the SEC is to protect investors; maintain fair, orderly, and efficient markets; and facilitate capital formation. The SEC strives to promote a market environment that is worthy of the public's trust.

under management. ESG labeled assets increased to USD30.6 trillion in 2018 from USD22.8 trillion in 2016. ESG assets are expected to end 2021 at USD38 trillion. This massive growth has fueled and been fueled by an enormous amount of sell-side research, news, speculations, new products, and op-eds. It has also attracted all stakeholders in the financial market, who have adapted and incorporated such principles as they chose to. Despite this rapid growth, a lack of standardization and legal framework have made it increasingly difficult for investors to compare and understand what is offered by the market. Highlighting this view, Jay Clayton, chairman of the Securities and Exchange Commission (SEC), said that any analysis that combined separate environmental, social and governance metrics into a single ESG rating would be "imprecise" (Clayton, 2020).

This uncontrolled labeling of ESG assets has allowed financial players to oversell the impact of their assets or mislead investors with a fake ESG-label. In May 2021, Bloomberg Intelligence held a webinar called "The Inconvenient Truths of ESG ETFs", hoping to help investors differentiate ESG ETFs (Exchange Traded Funds) (Bloomberg, 2021). For illustration, some of the inconvenient truths they raised were ESG ETF whistleblowers, the subjectivity of ESG scoring, and rebranded ESG funds.

ESG ETF whistleblowers include high level professionals that played important roles in ESG promotion, went public to criticize sustainable investing and ESG. For instance, Tariq Fancy, former CIO of Sustainable Investing at Blackrock said: "In truth, sustainable investing boils down to little more than a marketing hype, PR spin and disingenuous promises from the investment community", also, Desiree Fixler, DWS[47] former Groups Sustainability Officer said: "Only a small fraction of the investment platform applies ESG integration", such statements led SEC's chairman, Gensler, to order a review of funds' ESG disclosures in September 2021.

[47] The DWS Group is a German asset management company focused on sustainability. It previously operated as part of Deutsche Bank until 2018 where it became a separate entity through an initial public offering on the Frankfurt Stock Exchange.

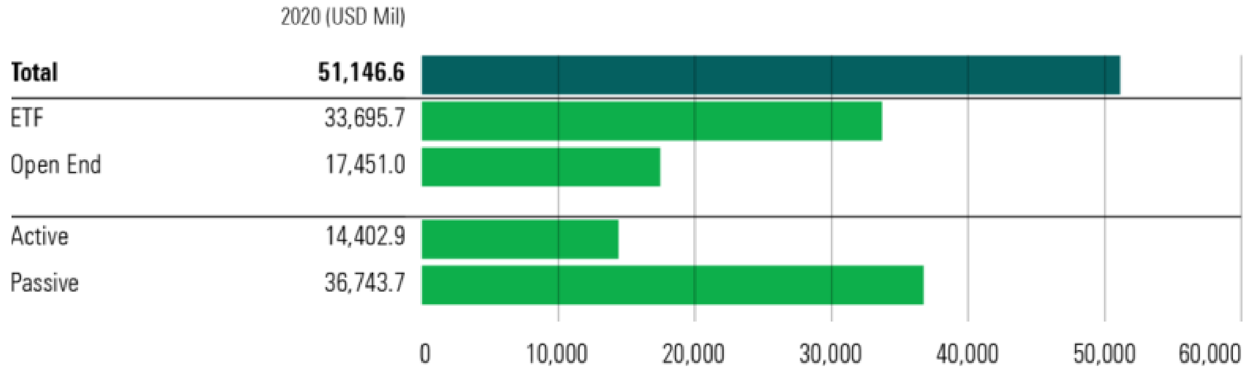
ESG scoring subjectivity is high due to the lack of transparency and simplicity of ESG methodologies, the lack of up to date, reliable and comparable data and finally the lack of controls, such as following ESG ETF’s voting practices and engagement with investees. ETF’s ESG strategies also vary widely, different funds claim to seek an ESG agenda through either or values[48], performance[49], engagement[50], stewardship[51], exclusion lists[52], best in class[53], among others.

Rebranded funds repurpose funds that already exist into sustainable ones claiming they already follow some sustainable criteria that can be tagged as ESG. Europe has been on the forefront of ESG products and investing and it serves as a reference for how the US market can develop. In 2020, 33% of Europe's ESG mutual funds and ETFs were rebranded. Bloomberg expects rebranded funds to represent 50% of the ESG funds products in the market by 2025.

As per Figure 30, this thesis focuses on ETFs given they dominated sustainable fund flows in 2020 according to Morningstar (Hale, 2021). The figure also shows that passive funds’ flows were more significant than active (they are also the largest funds), and as so we decided to keep passive funds in the analysis.

[48] investing in firms with values aligned with the fund.
[49] investing in firms where sustainability and equal or superior financial return are claimed to go together.
[50] Engagement can vary, in general it means an actively engage with invested firms through meetings, reports and ESG specific information requests, forcing companies to share and produce more ESG information. Funds can also share best practices.
[51] Investors try to influence a firm’s decisions through its voting powers.
[52] When certain companies, industries, sub-sectors, or pre-defined groups of issuers are excluded from the investment universe.
[53] When the fund continues to invest in every industry and sub-sector but only in issuers that are top performers from an ESG perspective within a pre-determined group of comparable issuers.

Figure 30. Sustainable Fund Flows by Fund Type, 2020



Note: Figure 30 summarizes the flows of sustainable fund issuances in 2020, highlighting ETF's relevance.
Source: Morningstar (Hale, 2021)

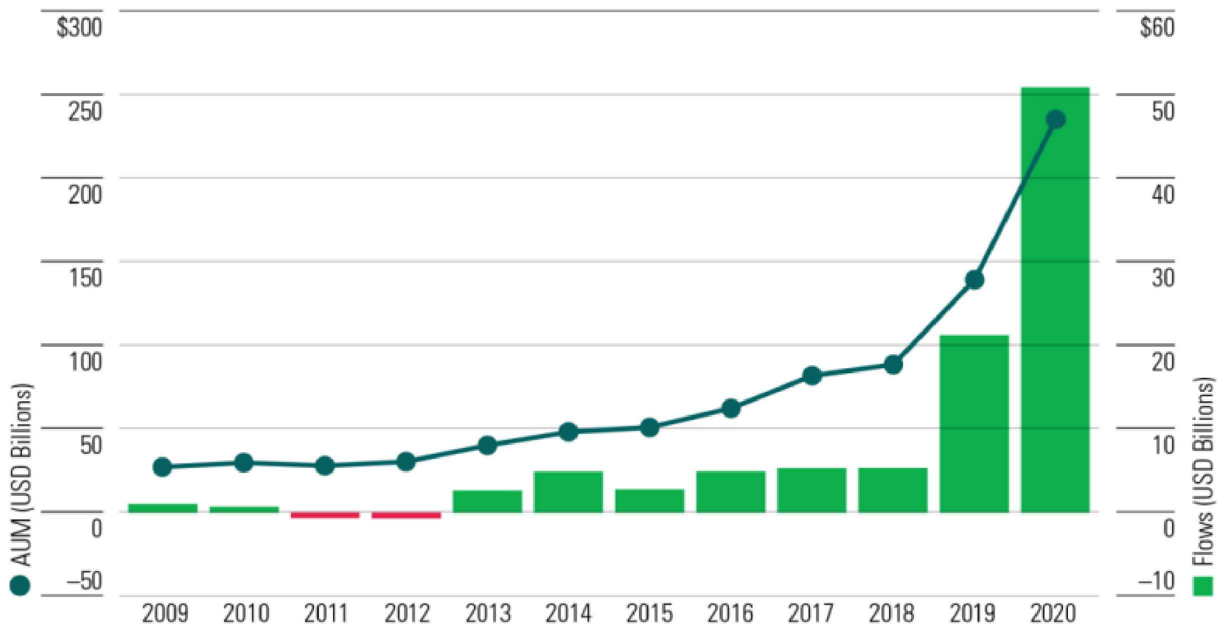
3.4 What is an ESG Exchange Traded Fund (ETF)?

Exchange Traded Funds (ETF) are "a basket of securities that you can buy or sell through a brokerage firm on a stock exchange" (Fidelity, 2021). ETFs have grown in popularity because they are simple, they can be purchased and sold like any stock, they provide a quick source of diversity and they can be more cost-effective than alternatives[54]. An ESG ETF is an ETF tagged to have environmental, social and governance considerations as part of its strategy.

As per Figure 31, below, for the fifth calendar year in a row, sustainable funds set an annual record for net flows in 2020. Especially since the last quarter of 2019, assets have reached significantly higher levels. Flows increased fourfold to USD21.4 billion in 2019, with USD7 billion of that coming in the fourth quarter. A record that was quickly surpassed in 2020, as flows reached USD51.1 billion, with USD20.5 billion of that coming in the fourth quarter.

[54] ETFs enjoy certain tax advantages as they tend to realize fewer capital gains than mutual funds.

Figure 31. Sustainable Funds Annual Flows and Assets (includes ETF and Open End)



Note: Figure 31 summarizes sustainable funds' annual flows and assets, showing how rapidly this asset class has grown in recent years.
Source: Morningstar (Hale, 2021)

According to Bloomberg Intelligence, ESG ETFs grew from 50 funds in mid-2020 to around 100 funds in mid-2021 with near USD200 billion under management and ESG ETFs could reach close to USD1 trillion by 2025 as per their forecasts.

Despite this phenomenal growth, "it is still difficult for investors to understand what exactly ESG ETFs offer" according to Shaheen Contractor, one of Bloomberg's main ESG analysts in a publication in July 2021 (Contractor, 2021). She adds bluntly, "the lack of a cohesive definition exposes investors to widespread concerns of exaggerating or misrepresenting a fund's benefits to attract business. The effect, known as greenwashing, is coming under increasing investor and regulatory scrutiny by the SEC" (Bloomberg, 2021 b).

In my professional experience assessing different ESG approaches for 4 years, I have contacted dozens of asset managers and learned that their strategies vary significantly, and, in most cases, they face challenges to significantly differentiate their funds from benchmarks. My experience confirms why many questions have been raised and left unanswered about ESG labelled instruments: lack of standardization in all aspects, from the nature of the investment to how reporting is done, and the amount of transparency offered.

Hence, it's unclear how related to environmental, social and governance causes these ESG labeled funds can be. Most funds with ESG labels differentiate their security holdings, under a sustainability perspective, by using ESG ratings provided by an outside party[55] plus some idiosyncratic approach that is driven by the fund or investor's values and beliefs.

Given the growth of ESG assets, some important voices, not necessarily whistleblowers, have surfaced to criticize some ESG claims, such as Aswath Damodaran and Brad Cornell, who on July 15, 2020 wrote an op-ed in the Financial Times saying that

> "…much as we would like to accept this virtuous story, we believe that the whole concept has been overhyped and oversold. Furthermore, it is backed by weak to non-existent evidence of promised payoffs for either companies or investors, and fraught with internal inconsistencies that undercut its credibility" (Damodaran *et al*, 2021).

They claim (i) there is no evidence that ESG assets outperform non-ESG assets; (ii) that companies' risk profile and returns will not change because they have a commitment to all stakeholders instead of the commonly accepted maximization of shareholder's profits; and (iii) that costs associated with adding ESG aspects to investments are not being fully accounted for. This study won't get into these topics, but it's important to the reader to understand how rapidly changing, dynamic and divided opinions remain around many aspects of this massive investment behavior shift.

[55] Green bonds define the use of the proceeds of a specific issuance within the environmental scope, while ESG parameters and ratings help stakeholders evaluate issuers' sustainability practices from and environmental but also social and governance perspectives.

3.5 ESG ratings

This section provides a brief overview of the process Morgan Stanley Capital International ("MSCI") undertakes while creating ESG scores[56] for issuers. Publicly traded companies' equities were the first asset class broadly rated by ESG rating agencies and continues to be the asset class with the most coverage given the easier access to standardized data through annual reports, investor presentations and financial and regulatory filings. This section also briefly describes the main controversy around ESG ratings by explaining how regulatory bodies have interpreted it.

3.5.1 How does MSCI Rate Issuers

According to MSCI's documents their ratings and scores aim to answer the following questions: "(i) of the negative externalities that companies in an industry generate, which issues may turn into unanticipated costs for companies in the medium to long term?"; and (ii) conversely, which ESG issues affecting an industry may turn into opportunities for companies in the medium to long term?" (MSCI, 2021). The analytical process undertaken to address these questions starts with industry analysis and collection of data. Then MSCI assesses an issuer's risk exposure and its risk management capabilities to create a preliminary rating. Preliminary ratings go through a reality check and a full report is prepared as per Figure 32 below:

[56] The term ESG scores and ESG ratings are used interchangeably. The main difference is that the score is represented by a number between zero and ten and the rating by an alphabetical parameter: CCC, B, BB, BBB, A, AA, or AAA. They have a clear direct relationship between them as per Table 35 below.

Figure 32. MSCI Analytical Process

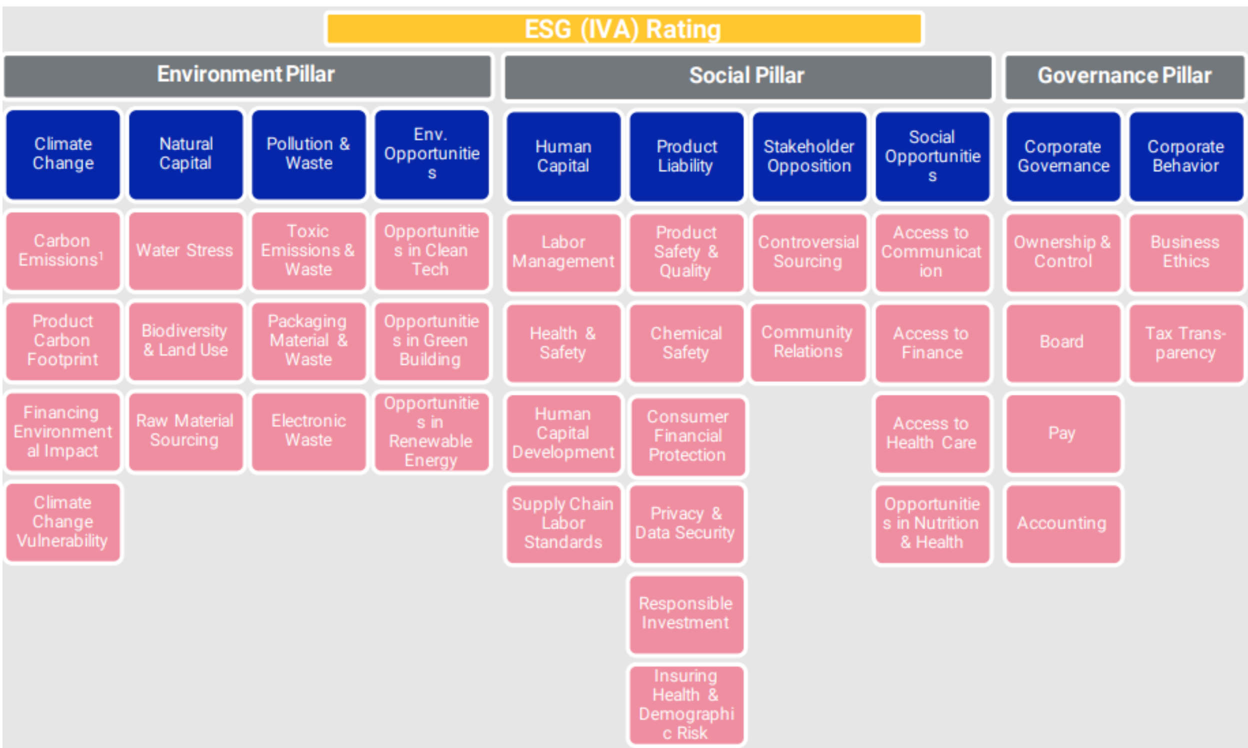
Note: Figure 32 summarizes steps taken by MSCI to assign an ESG rating to an issuer.
Source: MSCI (2014),
https://www.msci.com/documents/10199/242721/IVA_Methodology_SUMMARY.pdf/cb947ab8-509e-44fd-8e4b-afb53771fbcb

Below we go through the steps in Figure 32 above, the process starts with an in-depth industry assessment of its competitive characteristics, with particular emphasis on the special risks and opportunities created by environmental, social, and governance factors. During this analysis MSCI identifies the key issues of material impact for each industry, chosen from a list of ESG issues shown in Figure 33 below. MSCI uses company's corporate reporting (annual reports, investor presentations, financial and regulatory filings) and international stablished institutions[57] for macro environmental, social and governance data.

[57] Comprehensive Environmental Data Archive (CEDA); Eurostat; US Department of Energy; International Council on Clean Transportation; Germanwatch; Lamont-Doherty Earth Observatory, Columbia University; Organization of Economic Co-Operation and Development (OECD); World Development Indicators (WDI); UNDP; International Telecommunication Union; US EPA's Energy Star; US EPA's Toxics Release Inventory (TRI); Risk-Screening Environmental Indicators (RSEI); US Bureau of Labor Statistics (BLS); International Labor Organization (ILO); US Occupational Safety & Health Administration (OSHA); National Highway Traffic Safety Administration; US Consumer Product Safety Commission; UK Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR); International Chemical Secretariat (ChemSec); Danish Working Environment Authority; International Monetary Fund (IMF); World Health Organization (WHO); World Resource Institute (WRI); US Census Bureau Current Population Survey Supplement; UN Populations Division; US Department of Agriculture (USDA); Food and Drug Administration (FDA); World Bank Governance Indicators (WGI); Transparency International (TI); UNESCO Institute of Statistics; World Bank (WB); Refinitiv.

The list of ESG issues MSCI considers falls into ten macro-environmental, social, and governance themes of concern to investors. Since January 2015, the ten themes are Climate Change; Natural Capital; Pollution & Waste; Environmental Opportunities; Human Capital; Product Liability; Stakeholder Opposition; Social Opportunities; Corporate Governance; and Corporate Behavior. The ten macro themes in turn, fall into three pillars of Environment, Social, and Governance as per Figure 33 (MSCI, 2021).

Figure 33. E, S and G Pillars' Breakdown

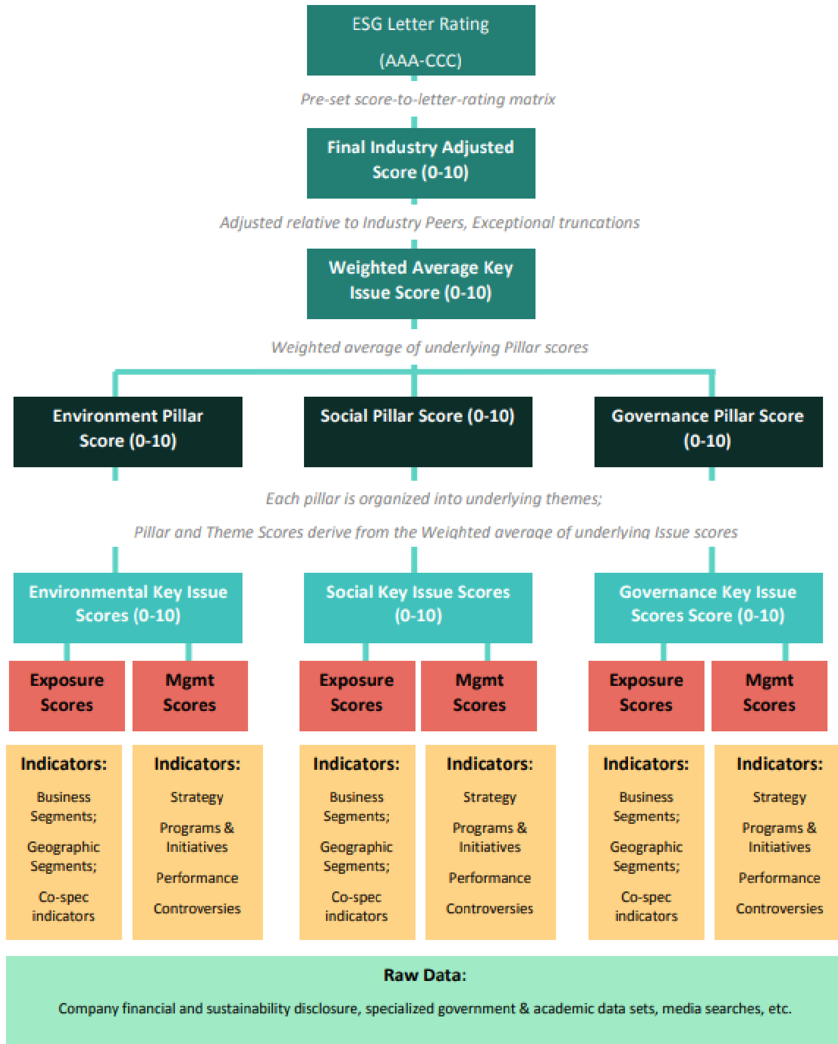


Note: Figure 33 presents how E, S and G topics are distributed and organized for the ESG rating assessment of issuers.
Source: MSCI (2021), https://www.msci.com/documents/1296102/21901542/MSCI+ESG+Ratings+Methodology+-+Exec+Summary+Nov+2020.pdf

Assessing risk management and risk exposure are a combined process according to MSCI (2021) as "companies facing higher risk exposure must have stronger management practices in place to mitigate their risks". The process can be complex as MSCI evaluates different sectors. To maintain a standard methodology across countries and industries MSCI collects raw corporate and ESG data which is then analyzed under pre-defined indicators allocated to either environment, social or governance pillars. A rating for each pillar is calculated and is then later used to calculate an ESG rating. Different industries have different weights for each pillar that can vary significantly[58] and a final industry wide reality check is performed an ESG letter rating is assigned via the process outlined in Figure 34.

[58] According to information shared by email on Nov 8, 2021 pillar weights vary between 5% and 63% depending on the industry and sub-categories within each industry. For instance, materials and utilities are “environmental” heavy, while financial institutions are more “social” and “governance” heavy. (MSCI, 2021)

Figure 34. Bottom-up Hierarchy or Score



Note: Figure 34 presents the final industry reality check process performed by MSCI before assigning a ESG rating to an issuer.
Source: MSCI (2021),
https://www.msci.com/documents/1296102/21901542/MSCI+ESG+Ratings+Methodology+-+Exec+Summary+Nov+2020.pdf

MSCI's ESG Ratings are designated by letters, but it's easier to deal with numbers while doing analysis, as so for this dissertation I'll use ESG scores, which are the source based on which ESG Ratings are produced as per the image above. MSCI's relation between ESG Scores and ESG Ratings is outlined in Figure 35.

Figure 35. ESG Rating to ESG score

Letter Rating	Leader/Laggard	Final Industry-Adjusted Company Score
AAA	Leader	8.571* - 10.0
AA	Leader	7.143 – 8.571
A	Average	5.714 – 7.143
BBB	Average	4.286 – 5.714
BB	Average	2.857 – 4.286
B	Laggard	1.429 – 2.857
CCC	Laggard	0.0 – 1.429

**Appearance of overlap in the score ranges is due to rounding error. The 0 to 10 scale is divided into 7 equal parts, each corresponding to a letter rating.*

Note: Figure 35 where the final industry adjusted company score is mapped to a letter rating.
Source: MSCI (2021),
https://www.msci.com/documents/1296102/21901542/MSCI+ESG+Ratings+Methodology+-+Exec+Summary+Nov+2020.pdf

A report is finally written taking the rating calculation and risks raised into consideration[59], but only after six committees with different mandates perform a quality review: The Quality Review Committee, Industry and Team Leads; the Fixed Income Methodology Committee, the ESG Ratings Methodology Committee; the ESG Methodology Committee; and the Ratings Policy Committee.

3.5.2 ESG Ratings Controversies

The Department of Labor ("DOL") has been closely watching ESG labelled assets eligibility and guidelines under the Employee Retirement Income Security Act (ERISA), given their growing relevance in employees' pension investments.

[59] "In certain circumstances, MSCI ESG Research applies overrides to the model determined assessments. Approval for an override by the ESG Methodology Committee (EMC) is granted under two broad scenarios, specifically: (i) where a model-determined assessment does not reliably reflect a company's operational context and/or ESG performance, (ii) or where there is sufficient uncertainty in the quality and/or quantity of information available for a company's assessment. In 2020, 32 companies received approval by the EMC for a rating override." (MSCI, 2021)

Whether ERISA fiduciaries can include ESG funds in retirement plans has been the subject of ongoing debate at least since 1994. Changes have depended on presidential administrations' approaches and beliefs, but most importantly with the question around the consistency of ESG assets with ERISA fiduciary duties. (Curtis et all., 2021)

While the DOLs guidance went through significant shifts in 2008, 2015 and 2018, the latest trend has been to accept ESG factors as an additional tool to better understand the risk and return profiles of investment options. According to Curtis *et al* (2021):

> "…in 2020, the DOL raised the stakes by engaging in formal rulemaking, rather than sub-regulatory guidance. Its proposed rule, issued on June 30, 2020, took a decidedly negative view of ESG funds as an asset class. The DOL wrote in the preamble that 'As ESG investing has increased, it has engendered important and substantial questions and inconsistencies, with numerous observers identifying a lack of precision and rigor in the ESG investment marketplace,' and said flatly that 'ESG investing raises heighted concerns under ERISA.'"

While the pecuniary perspective is less relevant to this dissertation, it's important to highlight the many questions being raised around ESG labels and what it can deliver by the industry and policy makers. Most importantly for the analysis below, the DOL highlighted in 2020 inconsistencies among ESG ratings and the fact that "there is no consensus about what constitutes a genuine ESG investment, and ESG rating systems are often vague and inconsistent, despite featuring prominently in marketing efforts" (EBSA, 2020).

Apart from regulators, researchers have also found reasons to question ESG ratings; the main one being the divergence of ESG ratings given by different rating providers to the same issuers. Berg *et al*. (2020), compares ESG ratings by different ESG rating providers, namely, KLD (MSCI Stats), Sustainalytics, Vigeo Eiris (Moody's), RobecoSAM (SP Global), Asset4 (Refinitiv), and MSCI. Figure 36 shows the correlation between ESG ratings identified by their work.

Figure 36. Correlation Between ESG Ratings from Different Rating Providers

	Asset4	RobecoSAM	Sustainalytics	Vigeo-Eiris	MSCI	KLD
Asset4	100%	62%	67%	69%	38%	42%
RobecoSAM	62%	100%	67%	70%	38%	44%
Sustainalytics	67%	67%	100%	71%	46%	53%
Vigeo-Eiris	69%	70%	71%	100%	42%	49%
MSCI	38%	38%	46%	42%	100%	53%
KLD	42%	44%	53%	49%	53%	100%

Note: Figure 36 summarizes the correlation in between ESG rating providers. Results go as low as 38%, meaning that in one hundred ESG ratings certain pairs of ESG rating providers only agree in 38 of them. Source: Berg and Kölbel, 2020 (b).

As per Figure 36 above, correlations between ratings from different ESG rating providers range from 38% to 71%. In their methodology, Berg *et al*. (2020) identify three sources of divergence between ESG ratings: different scope of categories, different measurement of categories, and different weights of categories. They find that scope and measurement divergence are the main drivers of differences in between ratings, while weights divergence is less important.

While these concerns are a reality, we will describe briefly MSCI's approach below, then to avoid significantly different ESG approaches we will only use MSCI as an E, S, G and ESG data provider in the subsequent analysis examining whether the ESG labelled funds have holdings that are materially different than non-ESG labelled funds.

3.6 The Importance of Differentiating ESG Funds

Investment funds reflect the needs and desires of its investors. A growing number of investors have become increasingly concerned about environmental, social and governance topics as per the growing demand for sustainable financial instruments, pressuring the entire industry, including the underlying companies and the managers of the funds to provide more information about their impact and differentiate their strategies in these areas.

Standardized information is key for investors to evaluate and compare investment options from a sustainable perspective. As in financial analysis, a trustworthy comparison of companies or funds require a significant amount of data that is at the same time reliable, up to date, and comparable. In ESG's relatively incipient industry, standardization and the regulatory framework has not been able to keep up with the booming number of products and assets. Hence SEC's effort to provide more regulatory clarity on information disclosure.

The burden being put on investors and financial agents trying to clarify ESG differences has been significant and while the demand for ESG labelled funds increase the industry tries to deliver to the best of its knowledge and capacity.

There is no common ruler to assess true impact of ESG funds which encompasses all industries from retail to metals and mining, from services to manufacturing. It has been the investor's responsibility to understand, allocate and monitor their ESG aspects according to what they find relevant.

Given this diverse environment we can't define what ESG labelled funds should be investing in to be more sustainable than non ESG labelled funds, but we know that ESG investors are demanding some differentiation from non ESG labelled options. While this study can't unilaterally define what does development or impact mean, it can compare the holdings of ESG funds with non-ESG funds and answer if they are materially different. Investor's demand for ESG assets and the higher costs associated with the funds assessing these assets should result in some differentiation between the holdings of ESG funds and non-ESG funds, otherwise investors aren't achieving what they want, and these additional costs may not be justifiable.

This chapter will compare ESG labelled ETFs and non ESG-labelled ETFs to understand if they are investing in statistically different issuers in terms of industry concentration and ESG rating. We identified all exposures of the 10 largest ESG and non-ESG ETFs. We calculated the weighted exposure of each ETF per industry and per ESG scoring. We then compared the results for industry distribution and ESG scoring using the Wilcoxon Signed-Rank test, and the Wilcoxon rank-sum (Mann-Whitney)[60] test ("Wilcoxon Rank-Sum"), which are non-parametric statistical hypothesis tests commonly used to compare data not normally distributed. Finally, we compare both ETF groups to the holdings of the SP500[61].

ETFs can be passively managed, which means they try to replicate the performance of a predetermined benchmark, and in this case, they wouldn't have complete freedom to differentiate in terms of industry concentration. In this exercise we did not filter for actively managed funds only because passive funds are a significant part of ESG universe, accounting for 70% of sustainable fund flows in 2020 (as per data in Figure 30), and while they remain passive, they are labelled as ESG, and as so, a differentiation in allocation should exist or the benchmark should also be considered ESG. Also, while many funds are passive, they follow a variety of benchmarks and strategies, which should allow for some differentiation between them. Finally, in case a passive fund follows the same industry allocation as, for example, the S&P500, we should be able to capture their ESG strategy differentiation through a higher ESG ratings of their holdings.

The theory is that to justify their existence and higher costs, ESG funds should not present the same security holdings as non-ESG funds or standard benchmarks. In case they are not different we can say there has been no real differentiation and that investors should not believe that by investing in ESG assets they are investing in anything different from non-ESG assets.

3.7 Literature Review

Most research related to ESG funds and ETFs specifically are looking for a superior Sharp Ratio for these assets when compared to non-ESG assets. The Sharp Ratio has excess return

[60] The Wilcoxon Rank-Sum test and the Mann-Whitney test are the same test but can be referred to by each individual name or the combined name, we chose to use Wilcoxon Rank-Sum only.
[61] The Standard and Poor's 500 (SP500) is a stock market index tracking the performance of the 500 largest companies listed on the stock exchanges in the United States. It is one of the most followed equity indices.

as the numerator and a risk variable as the denominator, hence the hypothesis usually being tested are for different (higher) return or different (lower) risk for ESG labelled assets.

3.7.1 Financial Performance Literature at a Glance

Despite the significant amount of research about ESG assets' financial performance, the industry is still struggling with defining if the ESG focus has been able to improve (or worsen) financial performance. According to Morgan Stanley's Sustainability Report (2021) "U.S. sustainable equity funds outperformed their traditional peer funds by a median total return of 4.3 percentage points" (MSISI, 2021).

Similarly, Pavlova and de Boyrie (2021) who examined the risk-adjusted returns of ESG ETFs before and during the COVID-19 market crash of 2020 concluded that "ESG ETFs did not underperform the market during the crash" and "clean ESG ETFs have positive and significant alphas[62] in the pre-COVID market crash period" (Pavlova *et al*. 2021). While analyzing the financial returns ESG funds within the first year of the covid-19 crisis (March 2020 through March 2021), Whieldon and Clark (2021) published on the Standard and Poors Market Intelligence platform that: "in the first 12 months of the COVID-19 pandemic, many large investment funds with environmental, social and governance criteria outperformed the broader market". The best performing ESG fund in the period (53% return vs 27% for the SP500) was the Parnassus Endeavor Fund, with USD5.2 billion under management.

Bruno, Esakia and Goltz (2021) studied the performance of twenty-four active simulated ESG strategies between 2008 and 2020 and found the majority did outperform by up to 3% a year, however their model shows that the 'quality factor' is the main explanatory variable to this superior return. The 'quality factor' is a ratio of high profitability over low investments. They also

[62] Alpha represents the excess return earned on an investment above a certain benchmark return. It's widely used to express returns above common market indexes (known as beta) such as the SP500 (the performance of the 500 largest companies in the stock market).

indicate that high exposure to the technology industry (which has performed above average in recent years) explains part of this alpha.

Bruno *et al* (2021) have found no evidence that ESG funds have outperformed market indexes in the US and other developed markets and that ESG strategies do not offer significant downside risk protection. They conclude that “claims of positive alpha in popular industry publications are not valid because the analysis underlying these claims are flawed”. In their paper they show that most research has been done in recent years when there has been a lot of ‘attention’ to these assets. According to their study, “alpha estimated during low attention periods is up to four times lower than alpha during high attention periods. Therefore, studies that focus on the recent period tend to overestimate ESG returns”. They continue to say that given the lack of necessary risk adjustments and a recent period with upward attention, some studies have documented outperformance where, in reality, there is none.

3.7.1.1 Fund Manager’s Interview

Whieldon and Clark (2021) provide an insight into the investment firm Parnassus’ ESG practices. Whieldon and Clark interviewed Billy Hwan, the manager of Parnassus Endeavor Fund[63]. Parts of the interview give us clues to how ESG information is integrated. Hwan mentions that Parnassus uses third-party data and describes a process that shows proximity to the issuers and their operations: “we kick the tires on the company, including talking to the management, competitors and customers”; as an alpha seeking investors he also looks for “competitive advantage”, “capable capital allocators”, and “some product risk service that's unique to the market that people want more of over time”. But when asked more specifically about ESG factors

[63] “Parnassus Investments founder and sustainable investing titan Jerome Dodson, who co-managed the fund along with senior research analyst Billy Hwan, in January 2021 stepped down from his leadership role in the firm, leaving Hwan solely in charge” Whieldon and Clark (2021).

Hwan insists that "we're active managers, we're not activist managers" (Whieldon and Clark (2021).

Hwan’s Parnassus Endeavor Fund bases its ESG label mostly on its engagement. According to him, once they decide to invest in a company, “there are a lot of things that they do on the ESG side and to engage with the company to try and make them a better ESG player." One example is that Parnassus sends invested companies an engagement letter that talks about details the fund manager learned during the due diligence process and raises issues and questions in areas that Parnassus thinks could be improved.

Because the ESG label doesn’t discriminate against any effort to become more sustainable, it bundles together strategies like Parnassus and others more and less stringent when it comes to ESG related metrics[64]. This example confirms that the onus to evaluate the developmental effectiveness (in this case of engagement) and differentiate among strategies remains with the investors, who have limited capacity and often lacks information. SEC’s Roisman (2021), reminds us that part of the onus of the current situation is also with the companies who “are constantly asked to provide ESG information; that they feel they must comply with all or a large majority of the requests; that the multitude of requests can be overwhelming; and that each request requires special attention because it is similar to, but different from, the last”.

Parnassus could be considered to follow an engagement or stewardship ESG strategy, where they try to influence companies’ practices for more sustainable practices based on their interpretation of sustainability. Such type of strategy wouldn’t necessarily lead to differentiation in industry allocation or ESG ratings, and as so, wouldn’t be captured by our methodology.

Curtis *et al*., recently published (June 2021) a study on certain aspects of ESG funds’ ‘promises’ to differentiate themselves which tackle to differentiate funds like Parnassus. In their methodology, while investigating greenwashing among ESG labelled funds (including mutual

[64] ESG related metrics are often related to emissions and pollution, energy use and security, labor safety, governance practices, diversity, and human rights, among others.

funds) and inconsistency with ERISA based fiduciary responsibilities of pension managers, Curtis *et al*., (2021) take into consideration ESG funds' holdings, voting practices, costs, and performance, to find that

> "ESG funds generally deliver greater ESG exposure in their portfolio allocations than non-ESG funds, that they are more likely than other funds to oppose management in the proxy voting, particularly when votes are salient to ESG issues, and that they do not cost more or perform worse than similar non-ESG funds."

They analyze ESG funds by comparing them to non ESG funds based on 3 approaches: (i) voting policies; (ii) ESG ratings from different rating providers; and (iii) performance and fees. While performance and fees are less relevant for our non-fiduciary analytical perspective, their study concludes about the two first approaches that "funds that market themselves as employing an ESG investment strategy invest and vote differently from funds that do not purport to do so" (Curtis *et al*. 2021).

3.8 Methodology

Using the Bloomberg terminal fund screening we started with 142,255 active funds, which we narrowed down to 7,864 non-ESG ETFs. Out of this group we selected the 10 largest equity USD denominated non-ESG ETFs domiciled in the USA (group 1). From the initial 142,255 active funds, we narrowed the list down to 532 ESG focused ETFs. Out of this group we selected the 10 largest equity USD denominated ESG ETFs domiciled in the USA (group 2).

Using Bloomberg functionalities in Microsoft Excel we identified every exposure of each of the 20 funds selected and their weights in each fund. With this information we were able to calculate the average exposure of each fund to Bloomberg industry classification[65].

[65] Bloomberg divides equity exposure in the following sectors: Communications, Consumer Discretionary, Consumer Staples, Energy, Government, Financials, Health Care, Industrials, Materials, Real Estate, Technology, Utilities

Using the International Securities Identification Number ("ISIN")[66] and MSCI data we found the E, S, G individual ratings and the ESG rating for each position in each of the 20 funds. Not all positions had ESG ratings. We calculated each fund's weighted ESG rating, but given the calculation was weighted and ratings go from zero to ten we grossed up the numbers to assume full coverage. For example, if a fund only had 50% of its exposure rated, even if all positions were rated 10, the maximum rating this fund would get would be 5, so we divide the final score by the coverage percentage, in this case 50%, grossing up the rating to make results comparable with the data that is available.

The same steps, for industry distribution and E, S, G and ESG ratings were performed for the SP500. We then compare the average results of ESG, non-ESG and the SP500's industry distribution and ESG ratings using the Wilcoxon Signed-Rank test[67]. Finally, we compare ESG and non-ESG (including the SP500) ETF's ESG scores' distribution using the Wilcoxon Rank-Sum test[68]. Both are non-parametric tests, the first, Wilcoxon Signed-Rank test, is a paired test that compares the medians of two distributions, which is appropriate when we compare pairs of average funds' exposure to a specific industry (utilities, financials, etc.). The second, the Wilcoxon Rank-Sum test, tests the hypothesis that two independent samples (that is, unmatched data) are from populations with the same median, which is also known as the Mann–Whitney two-sample statistic (MIT, 2021).

[66] ISIN numbers are the unique 12-digit numbers that are recognized by the International Standards Organization, located in Geneva, Switzerland, as security identifiers for cross-border securities transactions.

[67] The Wilcoxon Signed-Rank test is a non-parametric statistical hypothesis test used to compare the locations of two populations using a set of matched samples.

[68] The Wilcoxon Rank-Sum method determines whether two populations are statistically different from each other based on ranks rather than the original values of the measurements. It ranks all values to determine whether groups of data can be assumed to have the same median.

3.8.1 Tests' Explained

The two tests we use in this Chapter, the Wilcoxon Signed-Rank test, and the Wilcoxon Rank-Sum test, are non-parametric tests (they don't require observations' distributions to be normal). They are non-parametric because they compare the ranks of the values in the data instead of analyzing the values themselves. This characteristic makes them ideal for the analysis in this chapter. The first test ranks the differences between two data points (the pair), and the second test ranks all observations, which means you don't need pairs, data also does not need to be balanced between treatment and control groups, like in our case where for this test the SP500 is considered a non-ESG fund, adding non-ESG funds up to eleven.

Wilcoxon Signed-Rank Test

When comparing the two groups of funds (ESG and non-ESG) and the SP500 by industry allocation, we compare pairs of observations for each industry. As an example, for the utilities industry, the Wilcoxon Signed-Rank test will compare the pair of data related to the average allocation of ESG ETFs to the utilities industry and the average allocation of non-ESG ETFs to the utilities industry. When all pairs are considered we test is the differences are statistically different from zero or not. This means that the Wilcoxon Signed-Rank test is a non-parametric matched sample test for which the order of the data is relevant. Tests one through four in the Analysis use the Wilcoxon Signed-Rank test.

In an example where ESG ETFs had 20% and 30% exposure to utilities and financials, respectively, and non-ESG ETFs had exposures of 25% and 33%, respectively, the Wilcoxon Signed-Rank test will rank the differences, in this case 5% and 3% and later analyze if the differences in the ranked figures is statistically equal to zero or not, the null hypothesis.

Wilcoxon Rank-Sum test

When comparing all E, S, G and ESG scores for all funds and the SP500, we don't pair the funds, as we want to compare the group of ESG labelled ETFs with the rest of the ETFs, without defining pairs. There is no reason for us to pair the funds. Like in the previous test the Wilcoxon Rank-Sum test analyzes a rank of values (not the values themselves). In the example we just saw above, if ESG ETFs had 20% and 30% exposure to utilities and financials, respectively, and non-ESG ETFs had exposures of 25% and 33%, respectively, the Wilcoxon Rank-Sum test would rank these values in the following order: 20% (first), 25% (second), 30% (third), 33% (fourth). Notice treatment and control groups are mixed in this case. The Wilcoxon Rank-Sum test will test the null hypothesis that the treatment and control groups have the same median. We can see that this test ranks the data values, not the difference in between pre-defined pairs. Tests five through eight in the Analysis use the Wilcoxon Rank-Sum Test.

Tests Results

Once data is ranked, each test can calculate a mean and a standard deviation for the data,[69] and from there analyze how close to zero the median of differences is (Wilcoxon Signed-Rank test) or how close the treatment and control groups' medians are to each other (Wilcoxon Rank-Sum test). Finally, given our relatively small amount of

[69] Wilcoxon Signed-Rank test's mean and standard deviation are calculated as: $\mu = \frac{n(n+1)}{4}$; and $\sigma = \sqrt{\frac{n(n+1)(2n+1)}{24}}$; Wilcoxon Rank-Sum test's mean and standard deviation are calculated as: $\mu = \frac{n1(n1+n2+1)}{2}$; and $\sigma = \sqrt{\frac{n1n2(n1+n2+1)}{12}}$; where 1 and 2 represent treatment and control groups, respectively.

3.9 Description of Data

As mentioned in the Methodology, information on investment funds is easily available through Bloomberg terminals. Out of a universe of 124,255 active funds tracked by Bloomberg we selected only ETFs, and excluded duplicates given different share classes. We were left with 532 ESG ETFs, which are my group 2; and 7,864 funds with no ESG tag, which are my group 1. The ten largest funds of each of these groups are listed below on Tables 16 and 17[70]:

Table 16. List of the Top Ten Largest Non-ESG Equity ETFs (Group 1)

(US$ M)

	Ticker	Name	Curr	Domicile	Equity Focus	Tot Asset
1	SPY US Equity	SPDR S&P 500 ETF TRUST	US Dollar	Domestic	Blend	395,460
2	IVV US Equity	ISHARES CORE S&P 500 ETF	US Dollar	Domestic	Blend	298,235
3	VTI US Equity	VANGUARD TOTAL STOCK MKT ETF	US Dollar	Domestic	Blend	267,594
4	VOO US Equity	VANGUARD S&P 500 ETF	US Dollar	Domestic	Blend	252,819
5	QQQ US Equity	INVESCO QQQ TRUST SERIES 1	US Dollar	Domestic	Growth	191,055
6	VEA US Equity	VANGUARD FTSE DEVELOPED ETF	US Dollar	Domestic	Blend	104,793
7	IEFA US Equity	ISHARES CORE MSCI EAFE ETF	US Dollar	Domestic	Blend	100,745
8	VUG US Equity	VANGUARD GROWTH ETF	US Dollar	Domestic	Growth	84,538
9	VTV US Equity	VANGUARD VALUE ETF	US Dollar	Domestic	Value	82,716
10	VWO US Equity	VANGUARD FTSE EMERGING MARKE	US Dollar	Domestic	Growth	79,702

Note: Table 16 provides some detail about Group 1: Non-ESG ETFs. As expected, these ETFs are significantly smaller, in terms of assets, than the ETFs analyzed in Group 2.

Table 17. List of the Top Ten Largest ESG Labelled Equity ETFs (Group 2)

	Ticker	Name	Curr	Domicile	Equity Focus	Tot Asset (US$ M)	General Attribute
1	ESGU US Equity	ISHARES ESG AWARE MSCI USA	US Dollar	Domestic	Blend	22,048	Socially Responsible,ESG
2	ESGE US Equity	ISHARES INC ISHARES ESG AWAR	US Dollar	Domestic	Growth	6,866	Socially Responsible,ESG
3	ESGD US Equity	ISHARES TRUST ISHARES ESG AW	US Dollar	Domestic	Blend	6,842	Socially Responsible,ESG
4	ESGV US Equity	VANGUARD ESG US STOCK ETF	US Dollar	Domestic	Blend	5,319	ESG
5	SUSL US Equity	ISHARES ESG MSCI USA LEADERS	US Dollar	Domestic	Blend	3,959	ESG
6	USSG US Equity	XTRACKERS MSCI USA ESG LDRS	US Dollar	Domestic	Blend	3,831	ESG
7	SUSA US Equity	ISHARES MSCI USA ESG SELECT	US Dollar	Domestic	Blend	3,781	ESG
8	DSI US Equity	ISHARES MSCI KLD 400 SOCIAL	US Dollar	Domestic	Blend	3,441	ESG
9	VSGX US Equity	VANGUARD ESG INTL STOCK ETF	US Dollar	Domestic	Blend	2,618	ESG
10	ESML US Equity	ISHARES ESG AWARE MSCI USA S	US Dollar	Domestic	Blend	1,110	ESG

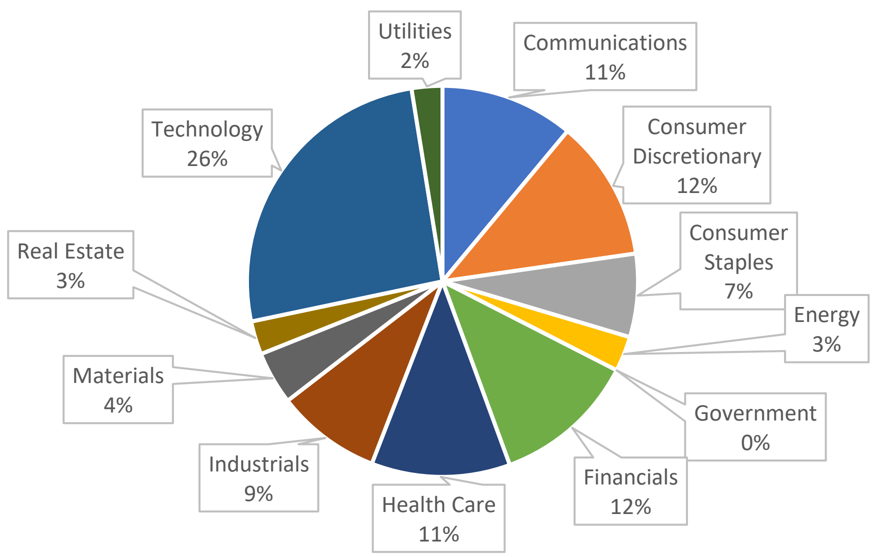
Note: Table 17 provides some detail about Group 2: ESG ETFs.

[70] For more details on the Funds' data refer to Annex 7.

3.9.1 Industry Distribution of Fund Holdings as of September 2021

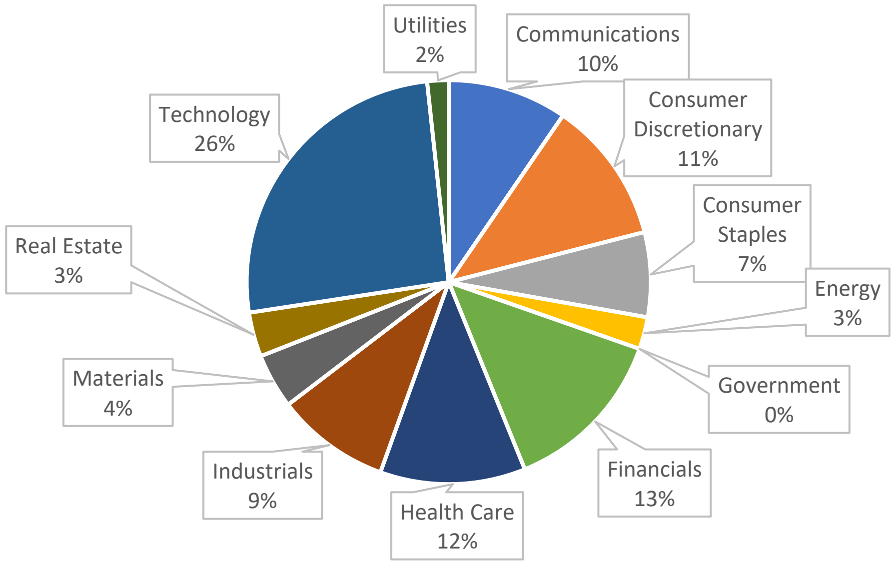
We gathered the industry exposure inside each fund from their latest disclosures through the Bloomberg terminal as of September 23, 2021 and calculated the weighted average percentage holding in each industry for the top 10 funds in each group. The results are shown in Figures 37 and 38:

Figure 37. Average Distribution per Industry of Non-ESG labelled ETFs (Group 1)



Note: Figure 37 shows the weighted distribution per industry of all 10 non-ESG labelled funds being analyzed.

Figure 38. Average Distribution per Industry of ESG labelled ETFs (Group 2)

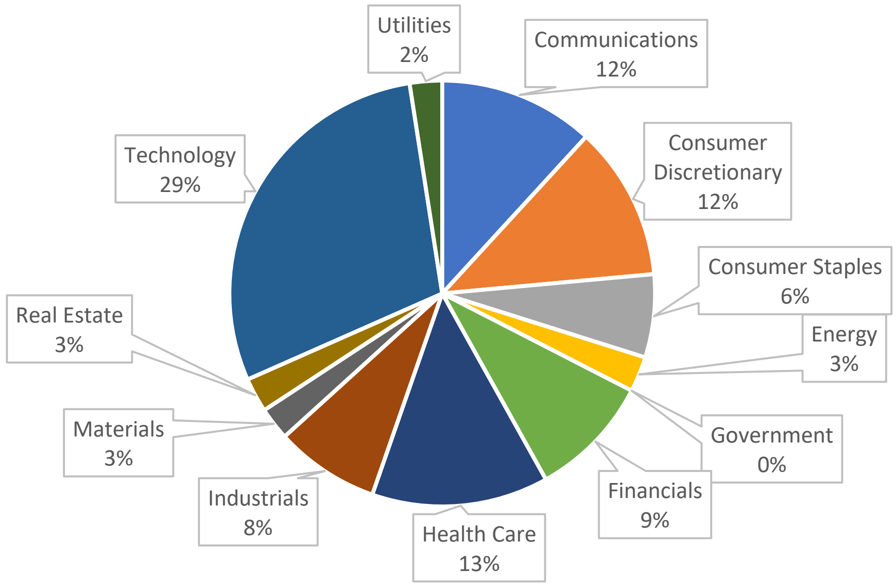


Note: Figure 38 shows the weighted distribution per industry of all 10 non-ESG labelled funds being analyzed.

Differently from the findings of Bruno *et al* (2021), who identified a skewness towards technology issuers among ESG funds, we found very similar industry distributions between ESG and non-ESG funds. This is likely because we purposely included passive funds in our analysis while their paper concentrates in active strategies. The exposures we found are very similar for ESG and non-ESG funds at a first glance, with small differences in Communications (1% difference), Consumer Discretionary (1% difference), Financials (1% difference), and health care (1% difference).

For comparison, the S&P500 industry distribution for the quarter ending in September 2021, is shown in Figure 39 below.

Figure 39. Average Distribution per Industry of the S&P500

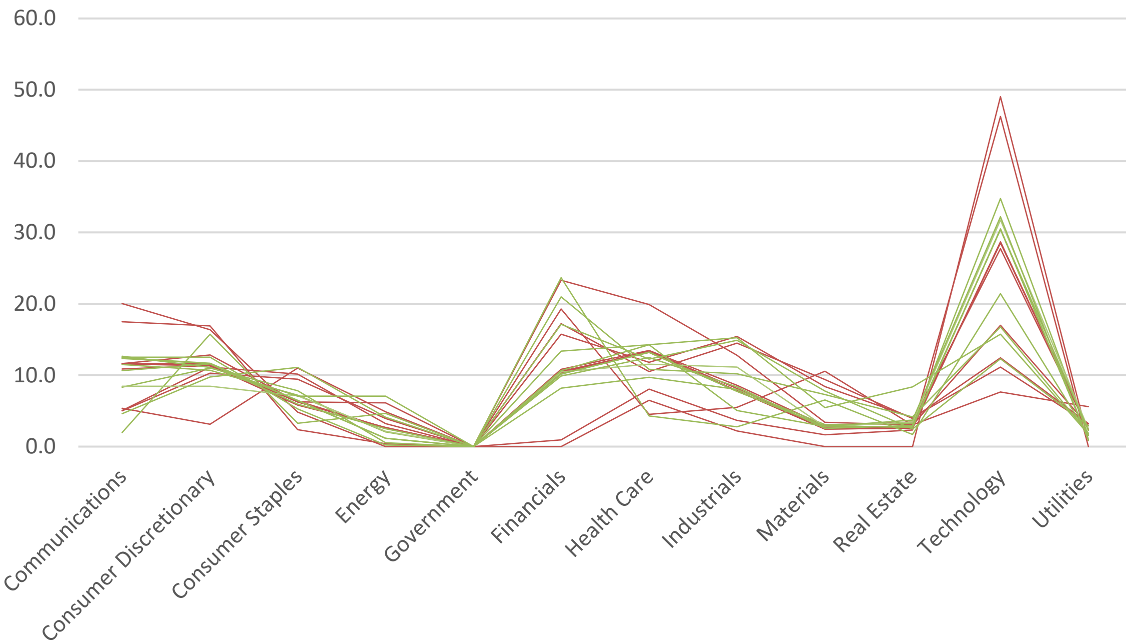


Note: Figure 39 shows the weighted distribution per industry of the SP500.

At a first glance, the distribution of assets across industries is very similar for the top 10 ESG labeled ETFs and the SP500, with the SP500 presenting a slightly larger exposure to technology companies (3% difference) and slightly lower to financials (3-4% difference).

Given that averages may hide some large differentiation among the funds within each group, we also graphed the industries exposure of the ESG funds exposures in contrast to the non-ESG funds exposures, below. Each line in the graph below is one of the 20 funds being analyzed and exposures are USD market value weighted.

Figure 40. ESG (green) and Non-ESG (red) Labelled Funds' Allocations (%)

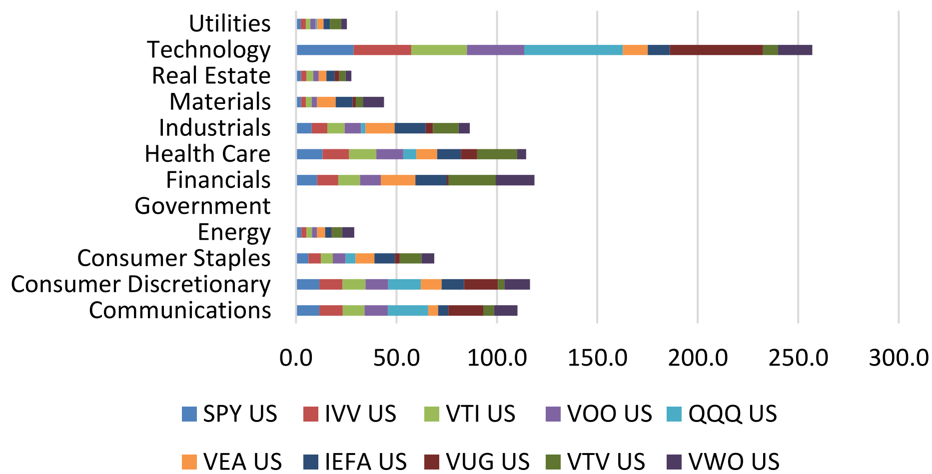


Note: Figure 40 shows how industry allocation may vary among the 20 funds being analyzed. It also allows to compare ESG (green) and non-ESG (red) funds allocations.

Based on Figure 40 above, the concentration in the technology industry for both ESG and non-ESG funds is patent, but it's important to notice that the exposure to this industry varies significantly across funds. The second most important industry for most funds is financials with a couple of non-ESG funds showing very low exposure to financials.

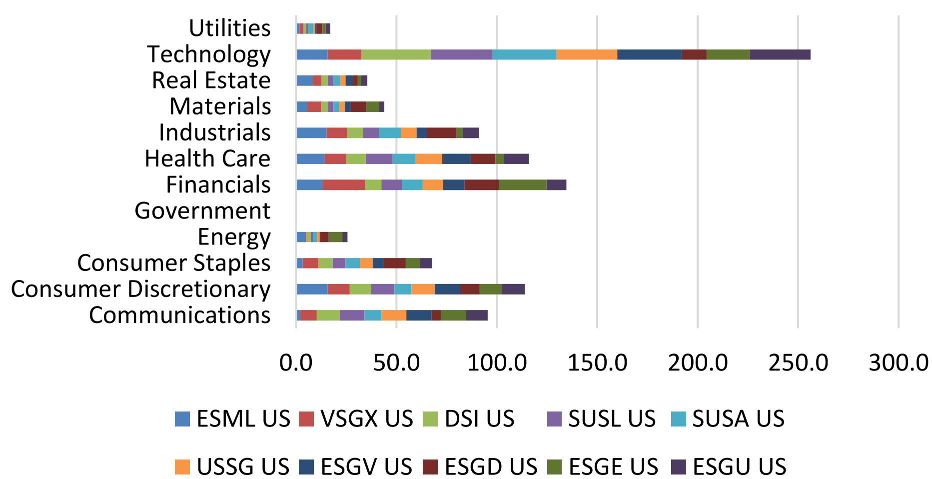
Figures 41 and 42 are another way to visualize how each fund contributes to the groups' overall industry exposure and how do they contribute to a group wide (ESG and non-ESG) picture.

Figure 41. 10 Non-ESG Equity Exchange Traded Funds Total Allocation (10x100% distributed)



Note: Considering all non-ESG ETFs allocation per industry (totaling 1000 percentage points divided among all industries) we notice a significant over allocation towards technology, close to 25%. That is also true to the other groups.

Figure 42. 10 ESG Equity Exchange Traded Funds Total Allocation (10x100% distributed)



Note: Considering all ESG ETFs allocation per industry (totaling 1000 percentage points divided among all industries) we notice a significant over allocation towards technology, close to 25%. That is also true to the other groups.

3.9.2 ESG Score Distribution

In this section we examine each funds group's weighted ESG scores using MSCI ESG Ratings[71]. The ESG Scores were calculated using dollar weighted exposure and proportionally increased to account to the fact that only about 65% of each one of them has ESG scores available as described in the Methodology. This means that we assume that the remaining, approximately 35% of non-rated exposures, have in average the same ESG rating as the 65% that is rated. The results are shown on the Table 18 and Figure 43, below:

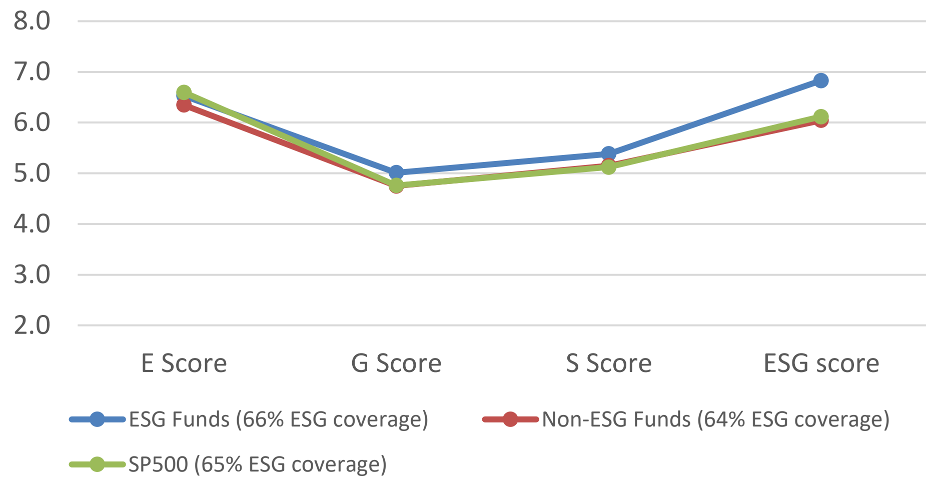
Table 18. Average ESG Scores Table

Avg ESG Scores (0-10)	**SP500**	**Non-ESG**	**ESG**
E Score	6.6	6.3	6.5
G Score	4.8	4.8	5.0
S Score	5.1	5.1	5.4
ESG score	6.1	6.0	6.8
Rated %	65.2	64.2	66.2

Note: Table 18 summarizes the average E, G, S and ESG scores per group. For the SP500 this is the fund's weighted scores. For ESG and non-ESG groups each of the 10 funds within the group has a weighted score which is averaged for the group.

[71] An MSCI ESG Rating is designed to measure a company's resilience to long-term, industry material environmental, social and governance (ESG) risks. We use a rules-based methodology to identify industry leaders and laggards according to their exposure to ESG risks and how well they manage those risks relative to peers. Based on these corporate ratings MSCI rates equity and fixed income securities, loans, mutual funds, ETFs, and countries.

Figure 43. Average ESG Scores (0-10) Graph



Note: Figure 43 compares the ratings above visually. Considering ratings vary between zero and ten, they seem very close at a first glance. It's important to highlight that the ESG scores isn't a simple linear formula of the E, S and G scores, as it may include aspects such as change momentum.

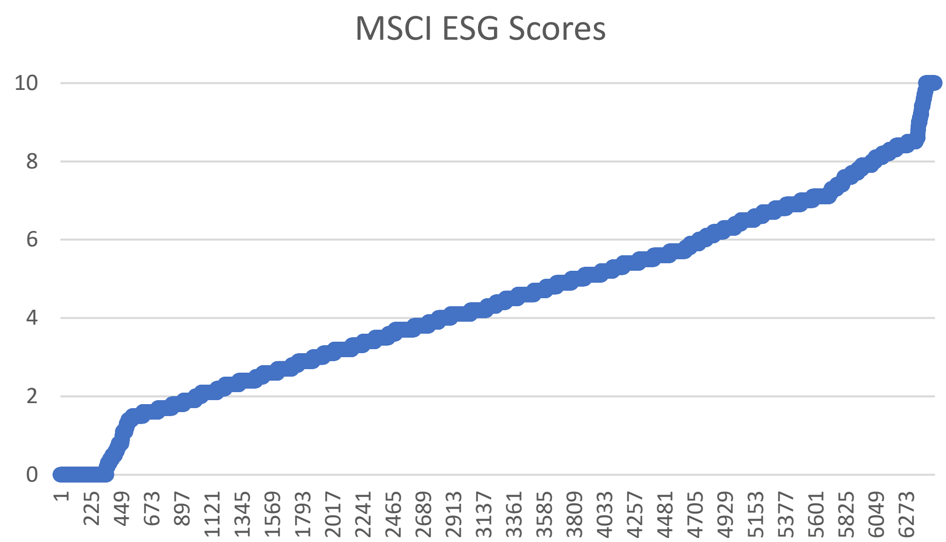
Once again, at a first glance ratings are very similar and coverage for each group is also very similar at 64%, 65% and 66%, approximately.

It's worth noticing that in my experience dealing with capital market professionals I have heard critiques that fund's ESG scores tend to be mean reverting. Although no analysis has been published in this regard, there could be two reasons for it to happen: (i) either funds are not differentiating among themselves sufficiently, for reasons such as inadequate risk, liquidity, return expectations, and end up with similar ESG ratings; or (ii) ESG scores have little variance and don't allow for great variation in funds weighted ESG scores.

Adding up each single exposure for all 20 funds in groups 1 and 2 we reach approximately 6,300 tickers[72] for which there were ESG scores. The graph below shows all 6,300 ESG scores is ascending order, which could be easily combined to result in any ESG score.

[72] A ticker is a symbol, usually an abbreviation, that is used to uniquely identify publicly traded financial instruments on a particular stock market.

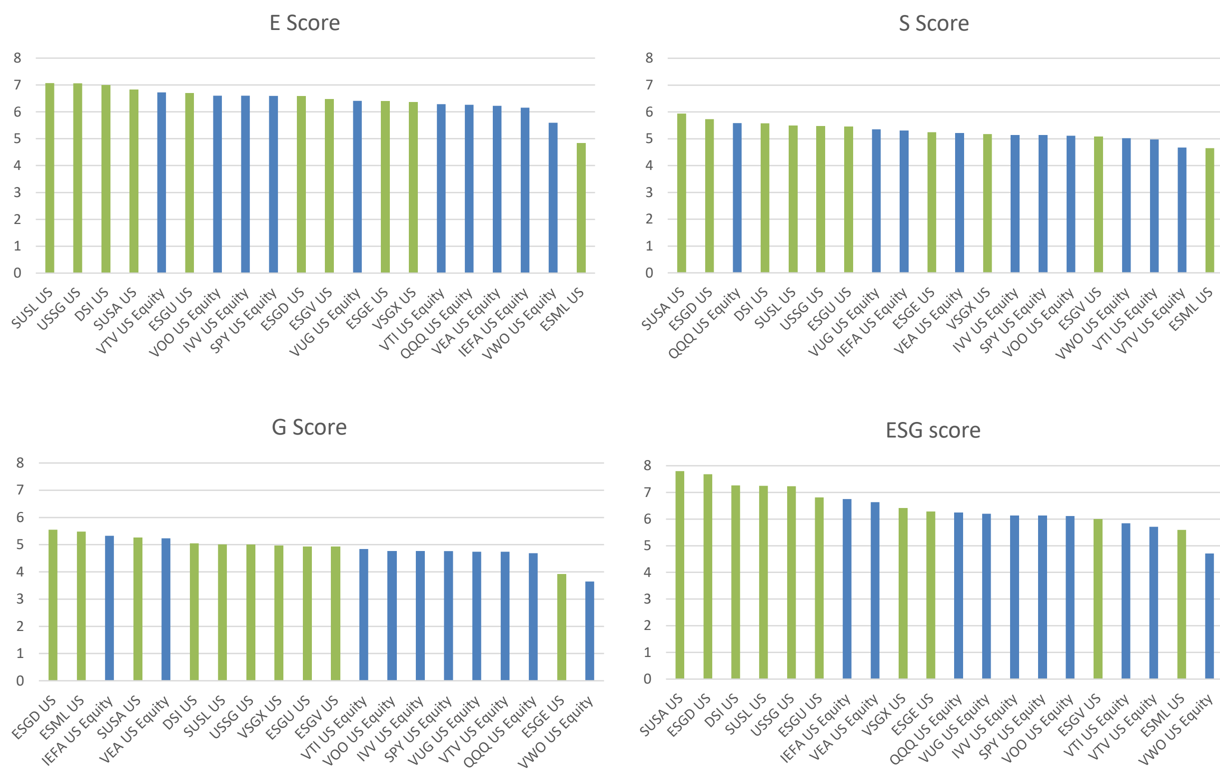
Figure 44. Distribution of MSCI ESG Scores for All Exposures in All Funds Under Analysis



Note: Figure 44 shows the ESG scores (from lowest to highest) of each underlying exposure that the 20 funds being analyzed hold. It shows that there is sufficient differentiation among the exposures to create any ESG score.

The below Figure 45 gives a visual distribution of the E, S, G and ESG rating distributions of the 20 funds being analyzed:

Figure 45. Distribution of the 20 Funds Being Analyzed According to their E, S, G and ESG Scores



Note: Figure 45 shows E, S, G and ESG scores for each fund. ESG labelled funds (green) tend to have higher score as there are more green bars on the left of each graph.

In Figure 45, above, ESG labelled funds (in green) leadership in all 4 scores subdivisions is striking as shown by the graphs above, except for QQQ US Equity (which follows the Nasdaq technology index) and IEFA US (which tracks large-, mid- and small-capitalization developed market equities, excluding the U.S. and Canada), all other top 4 performers for each indicator are ESG funds.

This result is in line with the observed by Curtis *et al*., (2021) while analyzing ESG scores from Sustainalytics[73], S&P[74], ISS and TruValue Lab[75] scores. For all different data sources, they see ESG labelled funds with a graphical visual leadership in ESG scores. For more information on each fund industry exposure or ESG ratings please refer to Annex 7.

3.10 ESG Funds Differentiation Analysis

To analyze the two groups which are not random, nor normally distributed I'll use the previously described Wilcoxon Signed-Rank test. As mentioned in the Methodology, the null hypothesis in this test states that the median difference between the pairs being analyzed is zero. In Test one we compare ESG and non-ESG funds and in Test two we compare ESG funds and the SP500. We'll compute a test statistic and a corresponding p-value, which give us a sense for how likely our data are under the null hypothesis.

We start analyzing the industry allocation of different asset groups: ESG, non-ESG and SP500 as per data on Table 19:

[73] Sustainalytics rates the sustainability of listed companies based on their environmental, social, and corporate governance performance.
[74] S&P Global Ratings is an American credit rating agency and a division of S&P Global that publishes financial research and analysis on stocks, bonds, and commodities, including ESG scores. S&P is considered the largest of the Big Three credit-rating agencies, which also include Moody's Investors Service and Fitch Ratings.
[75] Truvalue Labs applies artificial intelligence to quantify Environmental, Social, and Governance (ESG) data found in unstructured text sources including news, trade journals, non-governmental organizations, and industry reports to deliver ESG data to investment professionals.

Table 19. Percentage Allocation per Industry – Non-ESG, ESG and SP500

Sector	Non_ESG	ESG	SP500
Communications	11.0	9.5	11.7
Consumer Discretionary	11.7	11.4	11.6
Consumer Staples	6.9	6.8	6.2
Energy	2.9	2.6	2.7
Government	0.0	0.0	0.0
Financials	11.9	13.5	9.2
Health Care	11.5	11.6	13.2
Industrials	8.6	9.1	7.8
Materials	4.4	4.4	2.5
Real Estate	2.8	3.5	2.6
Technology	25.7	25.6	28.7
Utilities	2.5	1.7	2.4

Note: Table 19 shows the average exposure of ESG, non-ESG and SP500 to each industry listed. This data is used to run the Wilcoxon Signed-Rank test.

Table 20. Wilcoxon Signed-Rank test for Industry Distribution Table Results

Chapter 3 Results	**Wilcoxon signed-rank test for sectorial allocaiton**	
Alpha = 10%	**Test 1: ESG vs Non-ESG**	**Test 2: ESG vs SP500**
p-value*	0.8139	1.0000
p-value - exact	**0.8501**	**1.0000**
n**	12 pairs	12 pairs
Conclusion	Fail to reject the null	Fail to reject the null
Null Hypothesis	H0: median difference between the pairs is zero	

* p-value computed by Stata using a normal approximation should only be used for samples of 20 or more

** 12 pairs of exposures per sector (utilities, fianancials, etc.)

Note: Table 20 shows the result of the Wilcoxon Signed-Rank test for the average industry allocation of ESG, non-ESG and SP500. The results show strong evidence that the median differences between the pairs is zero.

Test one above (green) compares the industry allocation of ESG funds and non-ESG funds. The output indicates that we can only reject the null hypothesis at levels above 0.8501, which means we fail to reject the null at alphas of 1%, 5% nor 10%. Even at extremely high alphas we would still not be able to reject the null hypothesis. The null hypothesis that the median difference between the pairs (of average ESG and non-ESG funds industry allocation) is zero is valid.

Test two (blue) compares the industry allocation of ESG funds and the SP500. The output indicates that even at extremely high alphas we would still not be able to reject the null hypothesis. The null hypothesis that the median difference between the pairs (of average ESG funds and SP500 industry allocation) is zero is valid.

We now analyze the average E, S, G and ESG ratings differentiation between the three groups: ESG, non-ESG and SP500 using the same approach as above (Wilcoxon Signed-Rank test), as per data on Table 21:

Table 21. Average ESG scores per pillar – Non-ESG, ESG and SP500

Scores	**Non_ESG**	**ESG**	**SP500**
E Score	6.3	6.5	6.6
G Score	4.8	5.0	4.8
S Score	5.1	5.4	5.1
ESG score	6.0	6.8	6.1

Note: Each fund had an E, S, G and ESG score calculated, weighted by financial exposure, as described in the Methodology. We then calculated the average for these scores for the two groups: ESG and non-ESG funds. For the SP500 the scores are the weighted scores of SP500 exposures.

Table 22. Wilcoxon Signed-Rank test for E, S, G and ESG Score Results' Table

Chapter 3 Results	**Wilcoxon signed-rank test for ESG ratings**	
Alpha = 10%	**Test 3: ESG vs Non-ESG**	**Test 4: ESG vs SP500**
p-value*	0.0679	0.1441
p-value - exact	**0.1250**	**0.2500**
n**	4 pairs	4 pairs
Conclusion	Fail to reject the null	Fail to reject the null
Null Hypothesis	H0: median difference between the pairs is zero	

* p-value computed by Stata using a normal approximation should only be used for samples of 20 or more

** 4 pairs of exposures: E, S, G and ESG ratings

Note: Table 22 shows the result of the Wilcoxon Signed-Rank test for the E, S, G and ESG scores average of ESG, non-ESG and SP500. The results show evidence that the median differences between ESG ETFs and SP500 average scores is zero, but the evidence is weaker when comparing ESG ETFs and non-ESG ETFs where the exact p-value would reject the null hypothesis at an 85% confidence interval and consider their scores statistically different.

Test three (light orange) tests the null hypothesis 'Ho' that the median differences between ESG scores of ESG labelled ETFs and non-ESG ETFs is zero, meaning they are not different. Test four tests the null hypothesis 'Ho' that the median differences between ESG scores for the ESG labelled ETFs and for the SP500 is zero, meaning they are not different.

Tests three and four indicate that there is no evidence that ESG ETFs and SP500's average E, S, G and ESG ratings are meaningfully different as we fail to reject the null hypothesis that the median difference between the two groups average scores is zero, given exact p-values[76] above 10%. We reach the same conclusion when comparing ESG ETFs and non-ESG ETFs, where, given the exact p-value of 0.125, we fail to reject the null hypothesis at a 90% confidence interval. Hence, the median difference between the two groups' average scores is also zero. That said, at a confidence interval of 85% we would reject the null hypothesis and have the opposite conclusion for Test three.

Finally, as per Tables 23 and 24, we analyze the average E, S, G and ESG ratings differentiation between the three groups: ESG, non-ESG and SP500 without averaging all ratings into a single number, using the Wilcoxon Rank-Sum[77], which has the null hypothesis that the two groups being analyzed have the same median, while the alternative hypothesis is that one group has a larger (or smaller) median than the other, as explained in the Methodology.

[76] Exact p-value is indicated in this case because the sample size is smaller than 20.
[77] The Wilcoxon Rank-Sum test is similar to the Wilcoxon Signed-Rank test, but can be used to compare multiple samples that aren't necessarily paired

Table 23. ESG Scores per Fund and per Pillar

	Fund code	ESG dummy	E_rating	G_rating	S_rating	ESG_rating
1	ESML US	0	6.6	4.8	5.1	6.1
2	VSGX US	0	6.6	4.8	5.1	6.1
3	DSI US	0	6.3	4.8	5.0	5.8
4	SUSL US	0	6.6	4.8	5.1	6.1
5	SUSA US	0	6.3	4.7	5.6	6.2
6	USSG US	0	6.2	5.2	5.2	6.6
7	ESGV US	0	6.2	5.3	5.3	6.7
8	ESGD US	0	6.4	4.7	5.4	6.2
9	ESGE US	0	6.7	4.7	4.7	5.7
10	ESGU US	0	5.6	3.6	5.0	4.7
11	SPY US	1	4.8	5.5	4.6	5.6
12	IVV US	1	6.4	5.0	5.2	6.4
13	VTI US	1	7.0	5.0	5.6	7.3
14	VOO US	1	7.1	5.0	5.5	7.2
15	QQQ US	1	6.8	5.3	5.9	7.8
16	VEA US	1	7.1	5.0	5.5	7.2
17	IEFA US	1	6.5	4.9	5.1	6.0
18	VUG US	1	6.6	5.5	5.7	7.7
19	VTV US	1	6.4	3.9	5.2	6.3
20	VWO US	1	6.7	4.9	5.5	6.8
21	SP500	0	6.6	4.8	5.1	6.1

Note: Table 23 shows E, S, G and ESG weighted scores for all funds being analyzed. As mentioned in the Methodology the SP500 is included as a non-ESG fund for Tests five through eight.

Table 24. Wilcoxon Rank-Sum test for E, S, G and ESG Scores Results' Table

Chapter 3 Results	**Wilcoxon Rank-Sum for E, S, G and ESG ratings**			
Alpha = 10%	**Test 5: E socres**	**Test 6: G scores**	**Test 7: S scores**	**Test 8: ESG scores**
p-value*	0.1392	0.0242	0.0783	0.0201
p-value - exact	**0.1517**	**0.0242**	**0.0845**	**0.0197**
n**	21	21	21	21
Conclusion	Fail to reject the null	Reject the Null	Reject the Null	Reject the Null
Null Hypothesis	H0: the two groups have the same median			

* p-value computed by Stata using a normal approximation should only be used for samples of 20 or more

** 10 ESG funds, 10 non-ESG funds and the SP500

Note: Table 24 shows the result of the Wilcoxon Rank-Sum test for the E, S, G and ESG scores of ESG, non-ESG and SP500. The results show that when ESG and non-ESG funds' scores are not averaged in their groups evidence that the two groups have the same median does not exist for G, S and ESG scores.

The results of the Wilcoxon Rank-sum test show that when using the data of all funds (Table 23), instead of their averages (Table 21), for G, S and ESG scores (Tests six through eight) we reject the null hypothesis that the two groups have the same median, given that the normalized p-value[78] is below 10%. Only for E scores (Test five) we conclude the opposite, that the ESG and non-ESG funds (which in this case includes SP500) have the same median, given a normalized p-value above 10%.

In Tests five through eight data from all ETFs were included, allowing the standard deviation within each group to reflect the fact that there are differences within each group. This greater amount of data led Tests six through eight to have a different conclusion than Tests three through five. Tests six through eight conclude that the medians of S, G and ESG scores for ESG and non-ESG ETFs are not the same.

3.11 Chapter Conclusion

Chapter three highlighted some of the most important characteristics of ESG assets. It shows how passive ESG ETFs have been the most important driver in the strong growth of sustainable assets under management in the USA, and how much faster this growth has happened since 2019.

We described in detail the ESG rating process performed by MSCI and presented some important controversies about ESG investments, including ESG ETF whistleblowers, the subjectivity, and discrepancies of ESG scoring, rebranded ESG funds and the challenges regulators are facing to monitor and regulate investment managers.

[78] Normalized p-value is indicated in this case because the sample size is greater than 20.

Through the analysis using the Wilcoxon Signed-Rank test, this chapter concludes that ESG funds have not been able to differentiate themselves enough from non-ESG funds nor the SP500 from an industry allocation perspective, given exact p-values above 10%. When comparing the average E, S, G and ESG ratings also using the Wilcoxon Signed-Rank test we concluded that there is statistical evidence that ESG ETFs and SP500's average E, S, G and ESG ratings are not different as we couldn't reject the null hypothesis that the median difference between the two groups of averages is zero, given exact p-values above 10%. We reach the same conclusion when comparing ESG ETFs and non-ESG ETFs, where given the exact p-value 0.125 we fail to reject the null hypothesis at a 90% confidence interval. Hence, there is statistical evidence that the median difference between the two groups' average scores is also zero.

Finally, we compared E, S, G and ESG scores without averaging the scores for all funds within a group and using the Wilcoxon Rank-sum test. The results show that only for E scores we conclude that the ESG and non-ESG funds (which in this case includes SP500) have the same median, given a normalized p-value above 10%. For all other scores there is no significant statistical evidence, using this methodology, to conclude that they have the same median, given normalized p-values below 10% in Tests six through eight.

It's worth remembering that the methodology chosen in this chapter would not be able to pick up ESG differentiation done through engagement and stewardship strategies.

4 Chapter 4 - Final Considerations and Conclusion

Chapter one presented the historical background behind sustainable financial instruments and the paramount importance of addressing climate change and its potential impacts for society. As we cannot provide an unambiguous definition of what is sustainable or not, and compare treatment and control groups against it, we worked to analyze the potential for greenwashing for the two most common labels of environmentally linked financial instruments: green and ESG labels. We analyze if green bond issuers had lower GHG emissions (which is directly related with climate change) than non-green bond issuers, and if ESG ETFs held positions that were significantly different from non-ESG labelled ETFs.

Chapter two described the main characteristics of green bonds and highlights the exponential growth of green labelled assets in financial markets, which hit the USD1 trillion milestone in total cumulative issuances since its creation. The chapter shows that green bond issuers presented a greater reduction in GHG emission than non-green bond issuers before and after the issuance of their first green bond for the period between 2010 and 2019. After the issuance of the first green bond the difference between the two groups increases, as green bond issuers reduced GHG emissions further upon issuance of their first green bond.

Per Parent Firm, green bond issuers emitted between 1,941,282 and 531,933 metric tons of CO2 equivalent less than non-green bond issuers in between 2010 and 2019, and per Facility, bond issuers emitted between 172,756 and 39,302 metric tons of CO2 equivalent less than non-green bond issuers in the same period. All results are statistically relevant at a confidence interval of 99%. Upon the issuance of the first green bond GHG emissions were reduced further between 675,927 and 436,515 metric tons of CO2 equivalent for Parent Firms and in between 36,111 and 13,962 metric tons of CO2 equivalent at the facilities level when compared to non-green bond issuers.

Chapter three explains the main characteristics of ESG funds, especially ETFs, highlighting how broadly the terms has been used. Like green labelled assets, we show that ESG labelled assets have gone through an exponential growth and that ETFs are the most relevant product driving this growth. ETFs represented 65% of sustainable fund flows in 2020. While comparing ESG and non-ESG labelled ETFs we conclude that in terms of allocating resources to different industries, there is no significant difference between the two groups. The same is true when comparing ESG labelled ETFs and the SP500 index.

In chapter three we go on to compare ESG and non-ESG labelled ETFs in terms of average E, S, G and ESG scores using the Wilcoxon Signed-Rank test. We also compare them in terms of the same scores, but without averaging results at the group level, using the Wilcoxon Rank-Sum test. Results are mixed. For the first test we fail to reject the hypothesis that median difference between the scores is zero even using very low confidence intervals, meaning that they are not statistically different. The same result is obtained when comparing ESG-labelled ETFs and the SP500. But for the second test (where scores are not averaged at the group level), there is no significant statistical evidence to conclude that ESG and non-ESG ETFs have the same ESG scores. We reject the hypothesis that G, S and ESG scores have the same median at a 90% confidence interval. Only for E scores we fail to reject the hypothesis that medians are the same at that same level of confidence[79].

We highlighted the irreversible impact that climate change will have on Earth and its population, and how capital markets can be a very important tool in the effort to address it. This thesis raises awareness to the need for a clearer connection between sustainable financial instruments and their final impact on the environment or the climate. It also highlights the urgent need for standardization in data collection and sustainable metrics. Such changes will make it easier to differentiate investments based on sustainable metrics, avoid greenwashing and enhance the credibility of sustainable capital markets, which are essential for it to develop further and help address climate change. Finally, it shows that the term “ESG” is being used without clear or significant differentiation from non-ESG assets in capital markets, which, in face of the

[79] We would reject it at an 85% confidence interval though.

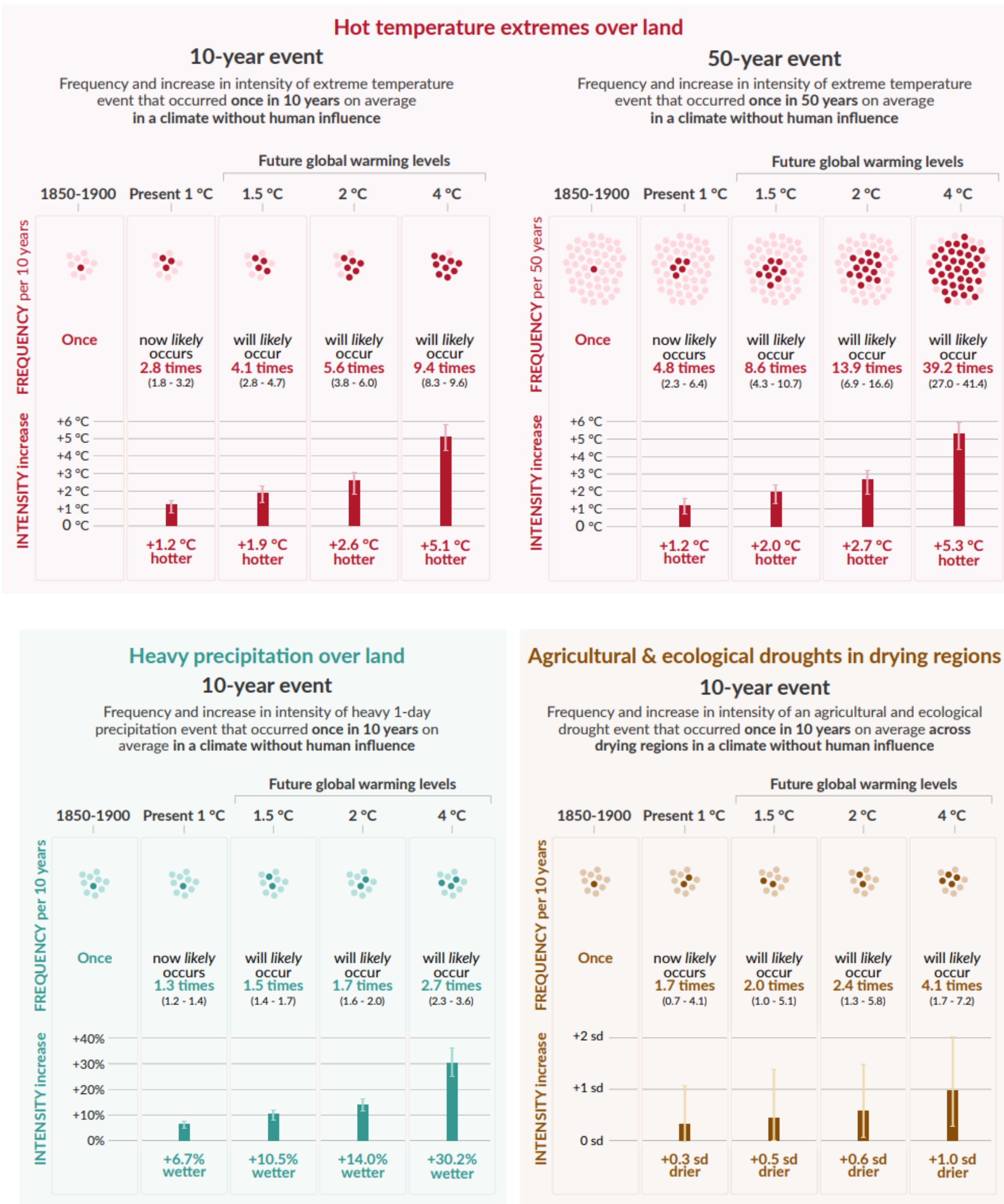
magnitude of the climate challenge we face, seems to fall short of financial markets' capability to help address this challenge with fast, clear and measurable change.

5 Annexes

5.1 Annexes for Chapter 1

5.1.1 Annex 1

Figure 46. Projected changes considering hot temperature extremes



Note: Figure 46 shows how likely extreme events are expected to happen under different scenarios of climate change. Projected changes at the extremes are larger in frequency and intensity with every additional increment of global warming.
Source: IPCC, 2021

5.2 Annexes for Chapter 2

5.2.1 Annex 2 – Green Bond Details

Table 25. 50 Green Bond Tranches

Bond	Issuer	ISIN/CUSIP	Issuance Year	Currency	Amount Issued	Amount Outstanding	Maturity date	Sector	Country of	Use of Proceeds
1	MASS INSTITUTE OF TECH	US575718AE16	2014	USD	370,000,000	370,000,000	7/1/2038	Other Industrial	US	Green Bond/Loan
2	SOUTHERN POWER CO	US843646AM23	2015	USD	500,000,000	500,000,000	12/1/2025	Electric	US	Green Bond/Loan
3	EVERGY KANSAS CENTRAL	US95709TAN00	2016	USD	350,000,000	350,000,000	7/1/2026	Electric	US	Green Bond/Loan
4	SOUTHERN POWER CO	XS1434560642	2016	EUR*	600,000,000	600,000,000	6/20/2022	Electric	US	Green Bond/Loan
5	SOUTHERN POWER CO	XS1435056426	2016	EUR*	500,000,000	500,000,000	6/20/2026	Electric	US	Green Bond/Loan
6	SOUTHERN POWER CO	US843646AT75	2016	USD	300,000,000	-	12/15/2021	Electric	US	Refinance
7	MIDAMERICAN ENERGY CO	US595620AQ82	2017	USD	375,000,000	375,000,000	5/1/2027	Electric	US	Green Bond/Loan
8	MIDAMERICAN ENERGY CO	US595620AR65	2017	USD	475,000,000	475,000,000	8/1/2047	Electric	US	Pandemic
9	AVANGRID INC	US05351WAA18	2017	USD	600,000,000	600,000,000	12/1/2024	Electric	US	Green Bond/Loan
10	MIDAMERICAN ENERGY CO	US595620AS49	2018	USD	700,000,000	700,000,000	8/1/2048	Electric	US	Capital Expenditures
11	DTE ELECTRIC CO	US23338VAH96	2018	USD	525,000,000	525,000,000	5/15/2048	Electric	US	Green Bond/Loan
12	PUBLIC SERVICE COLORADO	US744448CQ27	2018	USD	350,000,000	350,000,000	6/15/2048	Electric	US	Green Bond/Loan
13	PUBLIC SERVICE COLORADO	US744448CP44	2018	USD	350,000,000	350,000,000	6/15/2028	Electric	US	Green Bond/Loan
14	DUKE ENERGY CAROLINAS	US26442CAX20	2018	USD	650,000,000	650,000,000	11/15/2028	Electric	US	Green Bond/Loan
15	DUKE ENERGY CAROLINAS	US26442CAW47	2018	USD	350,000,000	350,000,000	5/15/2022	Electric	US	Green Bond/Loan
16	VIRGINIA ELEC & POWER CO	US927804GA61	2018	USD	600,000,000	600,000,000	12/1/2048	Electric	US	General Corporate Purpos
17	MIDAMERICAN ENERGY CO	US595620AT22	2019	USD	850,000,000	850,000,000	4/15/2029	Electric	US	Refinance
18	MIDAMERICAN ENERGY CO	US595620AU94	2019	USD	900,000,000	900,000,000	7/15/2049	Electric	US	Capital Expenditures
19	DTE ELECTRIC CO	US23338VAJ52	2019	USD	650,000,000	650,000,000	3/1/2049	Electric	US	Green Bond/Loan
20	DUKE ENERGY PROGRESS LLC	US26442UAH77	2019	USD	600,000,000	600,000,000	3/15/2029	Electric	US	Green Bond/Loan
21	AVANGRID INC	US05351WAB90	2019	USD	750,000,000	750,000,000	6/1/2029	Electric	US	Green Bond/Loan
22	SOUTHWESTERN PUBLIC SERV	US845743BT97	2019	USD	300,000,000	300,000,000	6/15/2049	Electric	US	Green Bond/Loan
23	OWENS CORNING	US690742AJ00	2019	USD	450,000,000	450,000,000	8/15/2029	Building Materials	US	Green Bond/Loan
24	PUBLIC SERVICE COLORADO	US744448CS82	2019	USD	550,000,000	550,000,000	3/1/2050	Electric	US	Green Bond/Loan
25	NORTHERN STATES PWR-MINN	US665772CR86	2019	USD	600,000,000	600,000,000	3/1/2050	Electric	US	Green Bond/Loan
26	PEPSICO INC	US713448EP96	2019	USD	1,000,000,000	1,000,000,000	10/15/2049	Food and Beverage	US	Green Bond/Loan
27	MIDAMERICAN ENERGY CO	US595620AV77	2019	USD	600,000,000	600,000,000	4/15/2050	Electric	US	Green Bond/Loan
28	DUKE ENERGY FLORIDA LLC	US26444HAH49	2019	USD	700,000,000	700,000,000	12/1/2029	Electric	US	Green Bond/Loan
29	NEXTERA ENERGY CAPITAL	AU3CB0268829	2019	AUD	500,000,000	500,000,000	12/2/2026	Electric	US	Green Bond/Loan
30	CLEARWAY ENERGY OP LLC	US18539UAC99	2019	USD	850,000,000	850,000,000	3/15/2028	Electric	US	Refinance
31	CLEARWAY ENERGY OP LLC	USU1851TAB71	2019	USD	600,000,000	600,000,000	3/15/2028	Electric	US	Refinance
32	TOYOTA MOTOR CREDIT CORP	US89236TGU34	2020	USD	750,000,000	750,000,000	2/13/2030	Automotive	US	Green Bond/Loan
33	PFIZER INC	US717081EW90	2020	USD	1,250,000,000	1,250,000,000	4/1/2030	Pharmaceuticals	US	Sustainability Bond/Loan
34	CON EDISON CO OF NY INC	US209111FY40	2020	USD	1,000,000,000	1,000,000,000	4/1/2050	Electric	US	Green Bond/Loan
35	CON EDISON CO OF NY INC	US209111FX66	2020	USD	600,000,000	600,000,000	4/1/2030	Electric	US	Green Bond/Loan
36	ANALOG DEVICES INC	US032654AS42	2020	USD	400,000,000	400,000,000	4/1/2025	Technology	US	Refinance
37	AVANGRID INC	US05351WAC73	2020	USD	750,000,000	750,000,000	4/15/2025	Electric	US	Green Bond/Loan
38	PUBLIC SERVICE COLORADO	US744448CU39	2020	USD	375,000,000	375,000,000	1/15/2051	Electric	US	Green Bond/Loan
39	SOUTHWESTERN PUBLIC SERV	US845743BU60	2020	USD	600,000,000	600,000,000	5/1/2050	Electric	US	Refinance
40	CLEARWAY ENERGY OP LLC	USU1851TAC54	2020	USD	250,000,000	250,000,000	3/15/2028	Electric	US	Refinance
41	NORTHERN STATES PWR-MINN	US665772CS69	2020	USD	700,000,000	700,000,000	6/1/2051	Electric	US	Green Bond/Loan
42	MET LIFE GLOB FUNDING I	US59217GEJ40	2020	USD	750,000,000	750,000,000	7/2/2025	Life	US	Green Bond/Loan
43	MET LIFE GLOB FUNDING I	US59217HCU95	2020	USD	750,000,000	750,000,000	7/2/2025	Life	US	Green Bond/Loan
44	PATTERN ENERGY OP LP/PAT	US70339PAA75	2020	USD	700,000,000	700,000,000	8/15/2028	Electric	US	Refinance
45	PATTERN ENERGY OP LP/PAT	USU70445AA64	2020	USD	700,000,000	700,000,000	8/15/2028	Electric	US	Refinance
46	BIG RIVER STEEL/BRS FIN	US08949LAB62	2020	USD	900,000,000	720,000,000	1/31/2029	Metals and Mining	US	Green Bond/Loan
47	BIG RIVER STEEL/BRS FIN	USU0901LAB63	2020	USD	900,000,000	720,000,000	1/31/2029	Metals and Mining	US	Refinance
48	LIBERTY UTILITIES FIN	US531546AB51	2020	USD	600,000,000	600,000,000	9/15/2030	Electric	US	Green Bond/Loan
49	LIBERTY UTILITIES FIN	USU5297NAA55	2020	USD	600,000,000	600,000,000	9/15/2030	Electric	US	Green Bond/Loan
50	SOUTHERN POWER CO	US843646AW05	2020	USD	400,000,000	400,000,000	1/15/2026	Electric	US	Green Bond/Loan

* In Euros but country of risk and issuance is the USA

Note: Table 26 shows all tranches considered for this study. They were sourced from the Bloomberg terminal and the Bank's List as per description in Chapter 2 Methodology.

5.2.2 Annex 3

Table 26. Example of GHG Emissions data from the EPA- Facility Level Information on Greenhouse gases Tool (2019)

Data Extracted from EPA's FLIGHT Tool (http://ghgdata.epa.gov/ghgp)												
The data was reported to EPA by facilities as of 09/26/2020												
All emissions data is presented in units of metric tons of carbon dioxide equivalent using GWP's from IPCC's AR4												
GHG data for some source categories are not directly comparable between 2010 and subsequent years. 12 new source categories began reporting for 2011.												
Search Parameters: year=2019; GHGs=ALL; data type=All Emitters;												
REPORTING YEAR	FACILITY NAME	GHGRP ID	REPORTED ADDRESS	LATITUDE	LONGITUDE	CITY NAME	COUNTY NAME	STATE	ZIP CODE	PARENT COMPANIES	GHG QUANTITY	SUBPARTS
2019	#540 BONANZ	1000355	410 17th Stre	39.74431	-104.98858	Denver	DENVER CO	CO	80202	BONANZA CR	303412	W
2019	121 REGIONA	1004377	3820 SAM RA	33.29857	-96.53586	MELISSA	COLLIN COU	TX	75454	NORTH TEXAS	518680	HH
2019	15-18565/15-	1010040	4200 S. Hwy	37.219099	-83.156046	Hazard	PERRY COUN	KY	40701	CAMBRIAN C	0	
2019	15-19015	1010085	1845 S. KY H	37.236617	-83.18126	Hazard	PERRY COUN	KY	41701	CAMBRIAN C	0	
2019	17Z Gas Plan	1012147	22845 Highwa	35.3181871	-119.633884	McKittrick		CA	93251	CHEVRON CO	0	
2019	220 Gulf Coas	1009263	701 Cedar La	35.56719	-97.49827	Oklahoma City	OKLAHOMA (	OK	73114	CHAPARRAL	0	
2019	220 Gulf Coas	1009238	333 West She	35.466697	-97.51453	Oklahoma City	OKLAHOMA (	OK	73102	DEVON ENER	678142	W
2019	230 Arkla Bas	1008121	333 West She	35.46734	-97.51406	Oklahoma City	Oklahoma	OK	73102	Devon Energy	0	
2019	230 Arkla Bas	1009283	1050 17th Str	39.7480769	-104.994564	Denver		CO	80265	QEP RESOUR	0	
2019	23rd and 3rd	1000112	730 3rd Aven	40.663	-74	BROOKLYN	Kings	NY	11232	NEW YORK P	44658	C,D
2019	260 - East Te	1012156	737 Eldridge	29.77455	-95.61949	Houston	HARRIS COU	TX	77079	BP AMERICA	9776	W
2019	260 East Texa	1009117	701 Cedar La	35.56719	-97.49827	Oklahoma City	OKLAHOMA (	OK	73114	CHAPARRAL	0	
2019	260 East Texa	1009170	501 Westlake	29.78037	-95.6295	Houston	HARRIS COU	TX	77079	BP AMERICA	76941	W
2019	29-6 #2 Centr	1006394		36.7452	-107.4455	Blanco	Rio Arriba	NM	87412	WILLIAMS PA	0	
2019	30-5 Central D	1002885		36.8118	-107.4036	Aztec	Rio Arriba	NM	87410	WILLIAMS PA	0	
2019	31-6 Central D	1002707		36.8363	-107.4199	BLOOMFIELD	Rio Arriba	NM	87413	WILLIAMS PA	0	
2019	31st Street La	1003742	11700 W 31S	41.835129	-87.915924	WESTCHEST	COOK COUN	IL	60154	ARCHDIOCES	18925	C,HH
2019	32-7 Central D	1002718		36.9313	-107.5604	BLANCO	SAN JUAN	NM	87412	WILLIAMS PA	0	
2019	32-8 #2 CDP	1002721		36.9569	-107.6631	BLANCO	SAN JUAN	NM	87412	WILLIAMS PA	0	
2019	340 Arkoma B	1009284	6100 South Y	36.0613546	-95.9515399	Tulsa	TULSA COUN	OK	74136	QEP RESOUR	0	
2019	345 - Arkoma	1012155	737 Eldridge	29.77455	-95.61949	Houston	HARRIS COU	TX	77079	BP AMERICA	57855	W
2019	345 Arkoma B	1009169	501 Westlake	29.78037	-95.6295	Houston	HARRIS COU	TX	77079	BP AMERICA	167141	W
2019	345 Arkoma B	1008285	333 West She	35.46734	-97.51406	Oklahoma City	Oklahoma	OK	73102	Devon Energy	0	
2019	345 Arkoma B	1011963	1323 East 71s	36.062167	-95.974333	Tulsa		OK	74136	NATURAL GAS	0	
2019	350 South Ok	1009119	701 Cedar La	35.56719	-97.49827	Oklahoma City	OKLAHOMA (	OK	73114	CHAPARRAL	0	

Note: Table 25 shows the data that can be extracted from the EPA FLIGHT database.
Source: EPA 2021, https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data

5.2.3 Annex 4 – IPCC Greenhouse Gas Protocol - Global Warming Potential Values

The following tables includes the 100-year time horizon global warming potentials (GWP) relative to CO2. This table is adapted from the IPCC (2021) Fifth Assessment Report, 2014 (AR5). The AR5 values are the most recent, but the second assessment report (1995) and fourth assessment report (2007) values are also listed for reference (GGP, 2021).

Figure 47. Global Warming Potential Values

Global warming potential (GWP) values relative to CO_2

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265
Substances controlled by the Montreal Protocol				
CFC-11	CCl_3F	3,800	4,750	4,660
CFC-12	CCl_2F_2	8,100	10,900	10,200
CFC-13	$CClF_3$		14,400	13,900
CFC-113	CCl_2FCClF_2	4,800	6,130	5,820
CFC-114	$CClF_2CClF_2$		10,000	8,590
CFC-115	$CClF_2CF_3$		7,370	7,670
Halon-1301	$CBrF_3$	5,400	7,140	6,290
Halon-1211	$CBrClF_2$		1,890	1,750
Halon-2402	$CBrF_2CBrF_2$		1,640	1,470
Carbon tetrachloride	CCl_4	1,400	1,400	1,730
Methyl bromide	CH_3Br		5	2
Methyl chloroform	CH_3CCl_3	100	146	160

(continues)

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second assessment report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
HCFC-21	$CHCl_2F$			148
HCFC-22	$CHClF_2$	1,500	1,810	1,760
HCFC-123	$CHCl_2CF_3$	90	77	79
HCFC-124	$CHClFCF_3$	470	609	527
HCFC-141b	CH_3CCl_2F	600	725	782
HCFC-142b	CH_3CClF_2	1,800	2,310	1,980
HCFC-225ca	$CHCl_2CF_2CF_3$		122	127
HCFC-225cb	$CHClFCF_2CClF_2$		595	525
Hydrofluorocarbons (HFCs)				
HFC-23	CHF_3	11,700	14,800	12,400
HFC-32	CH_2F_2	650	675	677
HFC-41	CH_3F_2	150		116
HFC-125	CHF_2CF_3	2,800	3,500	3,170
HFC-134	CHF_2CHF_2	1000		1,120
HFC-134a	CH_2FCF_3	1,300	1,430	1,300
HFC-143	CH_2FCHF_2	300		328
HFC-143a	CH_3CF_3	3,800	4,470	4,800
HFC-152	CH_2FCH_2F			16
HFC-152a	CH_3CHF_2	140	124	138
HFC-161	CH_3CH_2F			4
HFC-227ea	CF_3CHFCF_3	2,900	3,220	3,350
HFC-236cb	$CH_2FCF_2CF_3$			1,210
HFC-236ea	CHF_2CHFCF_3			1,330
HFC-236fa	$CF_3CH_2CF_3$	6,300	9,810	8,060
HFC-245ca	$CH_2FCF_2CHF_2$	560		716
HFC-245fa	CHF2CH2CF3		1,030	858
HFC-365mfc	CH3CF2CH2CF3		794	804
HFC-43-10mee	CF3CHFCHFCF2CF3	1,300	1,640	1,650

(continues)

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second assessment report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Perfluorinated compounds				
Sulfur hexafluoride	SF_6	23,900	22,800	23,500
Nitrogen trifluoride	NF_3		17,200	16,100
PFC-14	CF_4	6,500	7,390	6,630
PFC-116	C_2F_6	9,200	12,200	11,100
PFC-218	C_3F_8	7,000	8,830	8,900
PFC-318	$c\text{-}C_4F_8$	8,700	10,300	9,540
PFC-31-10	C_4F_{10}	7,000	8,860	9,200
PFC-41-12	C_5F_{12}	7,500	9,160	8,550
PFC-51-14	C_6F_{14}	7,400	9,300	7,910
PCF-91-18	$C_{10}F_{18}$		>7,500	7,190
Trifluoromethyl sulfur pentafluoride	SF_5CF_3		17,700	17,400
Perfluorocyclopropane	$c\text{-}C_3F_6$			9,200
Fluorinated ethers				
HFE-125	CHF_2OCF_3		14,900	12,400
HFE-134	CHF_2OCHF_2		6,320	5,560
HFE-143a	CH_3OCF_3		756	523
HCFE-235da2	$CHF_2OCHClCF_3$		350	491
HFE-245cb2	$CH_3OCF_2CF_3$		708	654
HFE-245fa2	$CHF_2OCH_2CF_3$		659	812
HFE-347mcc3	CH3OCF2CF2CF3		575	530
HFE-347pcf2	CHF2CF2OCH2CF3		580	889
HFE-356pcc3	CH3OCF2CF2CHF2		110	413
HFE-449sl (HFE-7100)	C4F9OCH3		297	421
HFE-569sf2 (HFE-7200)	C4F9OC2H5		59	57
HFE-43-10pccc124 (H-Galden 1040x)	$CHF_2OCF_2OC_2F_4OCHF_2$		1,870	2,820
HFE-236ca12 (HG-10)	CHF2OCF2OCHF2		2,800	5,350

(continues)

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second assessment report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
HFE-338pcc13 (HG-01)	$CHF_2OCF_2CF_2OCHF_2$		1,500	2,910
HFE-227ea	$CF_3CHFOCF_3$			6,450
HFE-236ea2	$CHF_2OCHFCF_3$			1,790
HFE-236fa	$CF_3CH_2OCF_3$			979
HFE-245fa1	$CHF_2CH_2OCF_3$			828
HFE 263fb2	$CF_3CH_2OCH_3$			1
HFE-329mcc2	$CHF_2CF_2OCF_2CF_3$			3,070
HFE-338mcf2	$CF_3CH_2OCF_2CF_3$			929
HFE-347mcf2	$CHF_2CH_2OCF_2CF_3$			854
HFE-356mec3	$CH_3OCF_2CHFCF_3$			387
HFE-356pcf2	$CHF_2CH_2OCF_2CHF_2$			719
HFE-356pcf3	$CHF_2OCH_2CF_2CHF_2$			446
HFE 365mcf3	$CF_3CF_2CH_2OCH_3$			<1
HFE-374pc2	$CHF_2CF_2OCH_2CH_3$			627
Perfluoropolyethers				
PFPMIE	$CF_3OCF(CF_3)CF_2OCF_2OCF_3$		10,300	9,710
Hydrocarbons and other compounds - direct effects				
Chloroform	$CHCl_3$	4		16
Methylene chloride	CH_2Cl_2	9	8.7	9
Methyl chloride	CH_3Cl		13	12
Halon-1201	$CHBrF_2$			376

Source: IPCC (2021) and GGP (2021) https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html and https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

5.2.4 Annex 5 – BEA Missing Observations

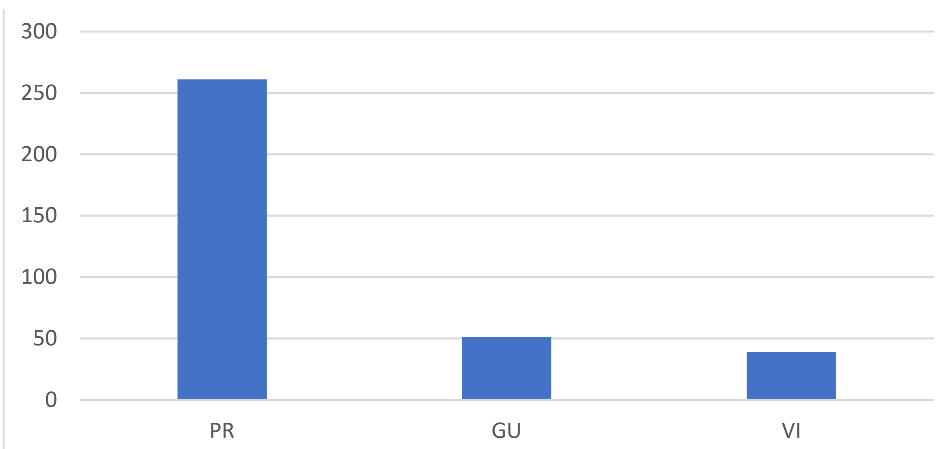
Rhode Island

Rhode Island did not have state level data form the U.S. Bureau of Economic Analysis (BEA) for subsidies, hence when regressions consider state level subsidies the overall sample is reduced by 130 annual observations of Rhode Island’s 13 facilities.

Guam, Puerto Rico, and US Virgin Islands

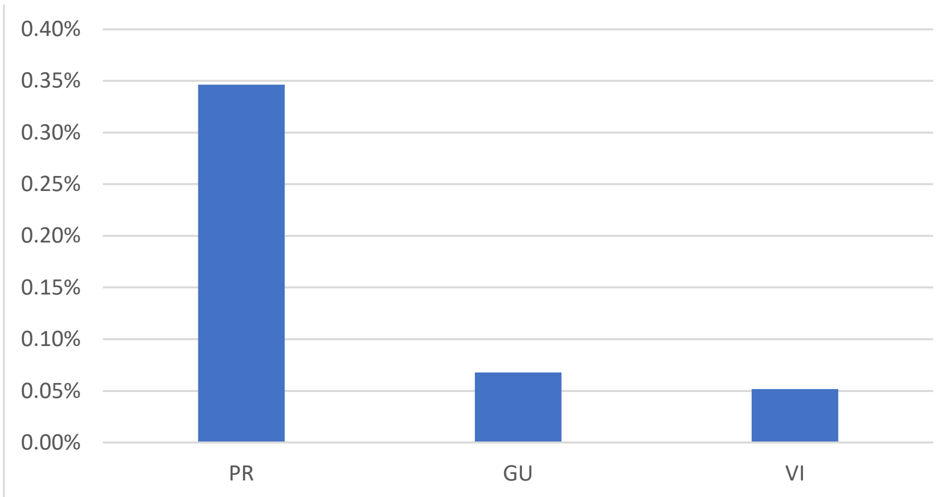
The three regions did not have state level data form the U.S. Bureau of Economic Analysis (BEA), hence when regressions consider state level data the overall sample is reduced. The impact is minimum given no green bond issuer is based in these areas and they represent a small fraction of the total annual observations per facilities (75,684) in the study as per graphs below:

Figure 48. Puerto Rico, Guam, and US Virgin Islands Facilities with GHG Data and no BEA Data



Note: These facilities are not considered when regressions using BEA data is included.

Figure 49. Relevance of Puerto Rico, Guam, and US Virgin Islands Facilities among All Facilities



Note: As noted above these locations represent a very small percentage of the total number of facilities.

5.2.5 Annex 6 – Green Bond Use of Proceeds Excerpts

Excerpt 1: Toyota Second Opinion by Sustainalytics

"TMCC estimates that it may take up to a year to fully allocate the bond proceeds. Pending allocation, proceeds may be invested in money market instruments until applied to new originations of Eligible Models. Investment income on amounts on deposit in the accounts will be distributed to TMCC. Based on TMCC's tracking process and the disclosure around the management of unallocated proceeds, Sustainalytics considers this process to be in line with market practice" (Toyota, 2021).

Excerpt 2: ClearWay Energy Second Opinion by Sustainalytics and email reply:

Second Opinion by Sustainalytics:

Management of Proceeds:

- CWEN's Treasury department will track the allocation of an amount equal to the net proceeds through a Green Bond Register. An amount equal to the net proceeds will be earmarked for allocation to financing and refinancing of eligible projects as defined by the Framework.
- Unallocated proceeds from the green bond issuances will be invested and managed in accordance with the Company's general liquidity management policies, including cash or cash equivalents, short-term liquid marketable instruments and/or to repay existing external debt obligations. Sustainalytics views this process as aligned with market practice."

Email Reply:

Clearway Energy: "The framework for our Green Bond program can be found on the ESG section of our website: http://investor.clearwayenergy.com/green-bonds. Once we issue a green bond the proceeds are allocated to eligible projects (see page 2 of the attached). For the benefit of investors, we annually update the ESG section of our website with respect to the use of proceeds from CWEN's Green Bonds. The report includes a list of Eligible Projects to which green bond proceeds were allocated to" (Clearway, 2021).

Excerpt 3: Duke Energy Email Reply:

Duke Energy: “thanks for your inquiry into Duke Energy’s green bond process. The short answer is we comply with the established green bond principles with regard to selection criteria. Under these principles, investors allow us to look back over the past two years and refinance costs that have already been spent towards green-eligible expenditures (as detailed in the offering documentation). Then, we are allowed to continue allocating net proceeds over the life of the bonds. So as an example, if we were to issue a 10-year green bond, we would have 12 years to fully allocate net proceeds to eligible green expenditures” (DUKE, 2021).

Excerpt 4: Owens Corning Email Reply:

Owens Corning: “green bond issuer must adhere to the ICMA green bond principles. They cover such items as the use of proceeds, the process for project evaluation, the management of proceeds, and reporting. Some of those items are presented in the bond prospectus to investors at the time of launch.

The process of making a bond “green” does add time prior to bond launch. The amount of time will depend on how prepared the issuer is with the above listed items. Owens Corning has published a detailed Sustainability Report (369 pages) for 15 years. The above items are well documented for us. That expedites the bond issuance process compared to a less prepared company” (OWENS, 2021).

Excerpt 5: Analog Devices Email Reply:

Analog Devices only shared a report in which examples of projects and their use of proceeds is available. All examples are contemporary to the issuance of the green bond (ANALOG, 2021).

5.3 Annexes for Chapter 3

5.3.1 Annex 7 – Funds' Detailed Information

Table 27. ESG Labelled industry allocation per fund

ESG-labelled Sector	ESML US	VSGX US	DSI US	SUSL US	SUSA US	USSG US	ESGV US	ESGD US	ESGE US	ESGU US	Total	avg	max	min
Communications	2.0	8.3	11.5	12.4	8.4	12.4	12.5	4.6	12.6	10.6	95.4	9.5	12.6	2.0
Consumer Discretionary	15.8	11.0	10.7	11.6	8.5	11.7	12.5	9.7	11.1	11.6	114.1	11.4	15.8	8.5
Consumer Staples	3.2	7.8	7.2	6.5	7.1	6.4	5.3	11.1	7.1	5.9	67.6	6.8	11.1	3.2
Energy	4.6	0.5	2.0	1.2	2.2	1.2	0.2	4.1	7.1	2.5	25.6	2.6	7.1	0.2
Government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Financials	13.4	21.0	8.2	10.1	10.4	10.2	10.6	17.1	23.7	9.9	134.6	13.5	23.7	8.2
Health Care	14.3	10.8	9.7	13.2	11.5	13.2	14.3	12.2	4.3	12.5	116.0	11.6	14.3	4.3
Industrials	15.2	10.2	8.0	7.7	11.1	7.7	5.0	14.9	2.8	8.3	91.1	9.1	15.2	2.8
Materials	5.5	7.3	3.1	2.8	2.8	2.8	2.8	7.8	6.5	2.5	43.9	4.4	7.8	2.5
Real Estate	8.4	4.2	3.2	2.7	3.4	2.7	3.7	2.4	1.7	3.0	35.4	3.5	8.4	1.7
Technology	15.8	16.8	34.7	30.4	31.8	30.5	32.2	12.3	21.4	30.4	256.2	25.6	34.7	12.3
Utilities	1.7	1.9	1.5	1.0	2.5	1.0	0.8	2.9	1.6	2.2	17.1	1.7	2.9	0.8

Table 28. Non-ESG Labelled industry allocation per fund

Non-ESG Sectors	SPY US	IVV US	VTI US	VOO US	QQQ US	VEA US	IEFA US	VUG US	VTV US	VWO US	Total	avg	max	min
Communications	11.6	11.6	10.9	11.6	20.1	5.0	5.1	17.5	5.3	11.6	110.2	11.0	20.1	5.0
Consumer Discretionary	11.6	11.6	11.4	11.3	16.4	10.3	11.1	16.9	3.1	12.9	116.5	11.7	16.9	3.1
Consumer Staples	6.2	6.2	5.8	6.4	4.8	9.4	10.2	2.4	11.0	6.2	68.8	6.9	11.0	2.4
Energy	2.6	2.6	2.7	2.6	0.0	3.9	3.2	0.4	4.9	6.1	29.0	2.9	6.1	0.0
Government	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Financials	10.6	10.5	10.8	10.3	0.0	17.2	15.7	1.0	23.3	19.3	118.6	11.9	23.3	0.0
Health Care	13.2	13.3	13.5	13.4	6.5	10.5	11.8	8.0	19.9	4.5	114.6	11.5	19.9	4.5
Industrials	7.8	7.8	8.6	8.2	2.2	14.5	15.4	3.7	12.8	5.5	86.5	8.6	15.4	2.2
Materials	2.5	2.5	2.9	2.6	0.0	9.4	8.4	1.6	3.4	10.6	43.8	4.4	10.6	0.0
Real Estate	2.6	2.6	3.4	2.6	0.0	3.9	4.1	2.3	3.1	3.0	27.6	2.8	4.1	0.0
Technology	28.7	28.7	27.7	28.6	49.0	12.4	11.1	46.2	7.6	17.0	257.0	25.7	49.0	7.6
Utilities	2.4	2.4	2.3	2.5	0.8	3.2	3.2	0.0	5.6	2.9	25.3	2.5	5.6	0.0

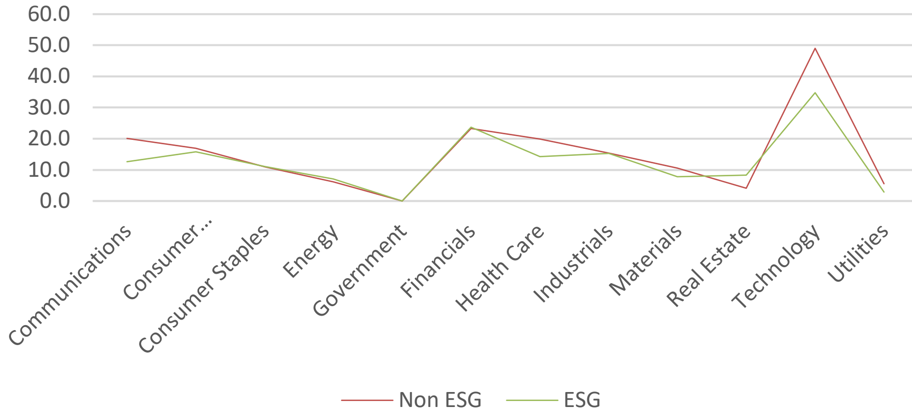
Table 29. ESG Labelled E, S, G and ESG scores per fund

ESG-labelled Scores	ESML US	VSGX US	DSI US	SUSL US	SUSA US	USSG US	ESGV US	ESGD US	ESGE US	ESGU US	Total	avg	max	min
E Score	4.8	6.4	7.0	7.1	6.8	7.1	6.5	6.6	6.4	6.7	65.3	6.5	7.1	4.8
G Score	5.5	5.0	5.0	5.0	5.3	5.0	4.9	5.5	3.9	4.9	50.1	5.0	5.5	3.9
S Score	4.6	5.2	5.6	5.5	5.9	5.5	5.1	5.7	5.2	5.5	53.8	5.4	5.9	4.6
ESG score	5.6	6.4	7.3	7.2	7.8	7.2	6.0	7.7	6.3	6.8	68.3	6.8	7.8	5.6
Rated %	76.9	59.1	67.9	67.8	69.5	67.9	67.2	60.0	61.6	64.6	662.5	66.2	76.9	59.1

Table 30. Non-ESG Labelled E, S, G and ESG scores per fund

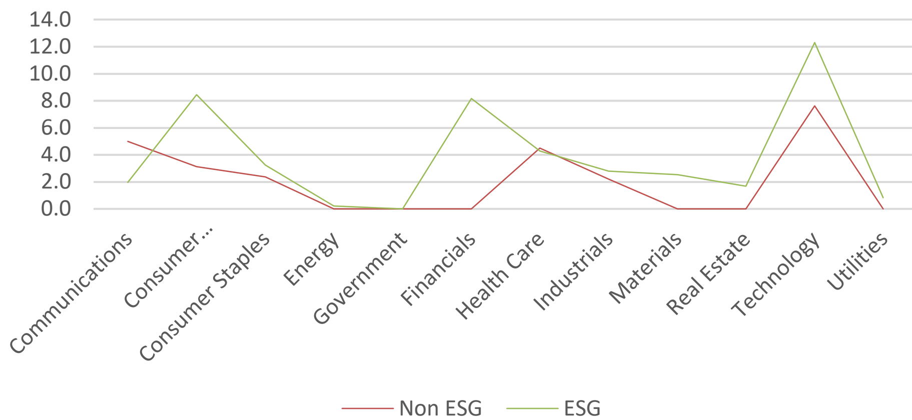
Non-ESG Scores	SPY US Equ	IVV US Equi	VTI US Equi	VOO US Ec	QQQ US Ec	VEA US Eq	IEFA US Eq	VUG US Ec	VTV US Eq	VWO US E	Total	avg	max	min
E Score	6.6	6.6	6.3	6.6	6.3	6.2	6.2	6.4	6.7	5.6	63.5	6.3	6.7	5.6
G Score	4.8	4.8	4.8	4.8	4.7	5.2	5.3	4.7	4.7	3.6	47.5	4.8	5.3	3.6
S Score	5.1	5.1	5.0	5.1	5.6	5.2	5.3	5.4	4.7	5.0	51.5	5.1	5.6	4.7
ESG score	6.1	6.1	5.8	6.1	6.2	6.6	6.7	6.2	5.7	4.7	60.4	6.0	6.7	4.7
Rated %	65.1	65.2	67.1	65.7	74.9	60.9	59.8	70.4	60.3	52.4	641.7	64.2	74.9	52.4

Figure 50. Maximum Allocation per Sector per Group (ESG and non-ESG)



Note: Both groups, ESG and non-ESG, have similar maximum allocations per sector with certain funds presenting significant exposure to technology.

Figure 51. Minimum Allocation per Sector per Group (ESG and non-ESG)



Note: ESG funds seems to have less flexibility to allocate zero resources to one specific industry as per Figure 51.

6 Appendix 1 – Chapter 2 Additional Analysis

In this appendix we continue the analysis done in Chapter 2 using panel data, lags and leads, percentual changes and log-level models. We run additional regressions and tests to make the results of the core analysis more robust. Figure 52 below shows the regression that are run in this Appendix.

Figure 52. Appendix Regressions

	Order	Type	Rational	Level	Dependent Variables				Independent Variables					
					GHG*	GHG change*	GHG% change	Log of GHG	GrIssuer	GrBond	years	Inter - GrIssuer *years	Macro - state (BEA)	Lagged or led GrBond
In Appendix	5	Panel RE	Test different models	Parent Firm	x				x	x	x			
	6	Panel RE	Test different models	Parent Firm	x				x	x	x	x		
	7	Panel FE	Test different models	Parent Firm	x				**	x	x			
	8	Panel FE	Test different models	Parent Firm	x				**	x	x	x		
	9	OLS	Lagged	Parent Firm		x			x		x	x		x
	10	OLS	Led	Parent Firm		x			x		x	x		x
	11	OLS	GHG % cahnge	Parent Firm			x		x	x	x	x		
	12	OLS	(level-log model)	Parent Firm				x	x	x	x	x		

* in metric tones of CO2 equivalent
** for fixed effects time invariant variables must be omitted

Note: these regressions were run to evaluate the robustness of the results obtained in Chapter 2.

6.1.1 Panel Data with Fixed Effects and Random Effects

Panel data, as with first differences OLS regressions, controls for non-observable variables such as differences in cultural factors, business practices and management quality. It also controls for variables that change over time but not across entities[80]. This is, it accounts for individual heterogeneity (Torres-Reyna, 2007).

[80] If the treatment was random, we wouldn't need diff in diff for an unbiased estimation of the treatment effect. Also, If the treatment was assigned to different groups based entirely on observable characteristics, we could use multiple regression and control for these characteristics to get an estimate of the treatment effect, but in our study to define the green bond issuing group is not possible as neither premise apply.

Fixed-effects ("FE") panel regressions are used when we are only interested in analyzing the impact of variables that vary over time. As Torres-Reyna (2007) defines, "when using FE, we assume that something within the individual may impact or bias the predictor or outcome variables and we need to control for this. This is the rationale behind the assumption of the correlation between entity's error term and predictor variables. FE remove the effect of those time-invariant characteristics so we can assess the net effect of the predictors on the outcome variable."

DiD FE assume that time-invariant characteristics are not correlated in between individuals; each entity is different and consequently its error term and constant (which captures individual characteristics) should not be correlated with others. If the error terms are correlated, then FE is not suitable and random-effects ("RE") could be more appropriate. Notice that given fixed effects do not allow for time invariant variables we can't keep the definition of the treatment group 'GrIssue' in the regression (treatment and control groups don't change over time) and as so we can't compare the differences between the two groups prior to green bond issuances.

To test for random-effects, we ran the Breusch-Pagan Lagrange multiplier test ("BPL"). The BPL tests if variances across entities are zero, which happens when there is no significant difference across units, hence no panel effect[81]. In our case the BPL test indicated that there is panel effect, hence checking the panel data regressions is important.

6.1.2 Log-level Approach

To understand our GHG emissions data in detail we need to understand how it has been changing over time. A simple approach is to calculate the percentage change per year per facility for every two consecutive years for which there is data available and analyze this data. The second approach is to use the logarithmic format of GHG emissions when regressing it against

[81] BPL tests whether the variance of the errors from a regression is dependent on the values of the independent variables. In that case, heteroskedasticity is present.

the dummy variable “Green Bond”, a methodology also called “log-level” regression, as shown in Equation 3 below:

Equation 3. Log-Level Regression

$$ln(y) = \beta_0 + \beta_1 x + \epsilon \tag{3}$$

The interpretation of the log-level regression is as follows: if we change *x* by 1 (unit), we’d expect the *y* variable to change by 100·β1 percent, as per Equation 4 below:

Equation 4. Log-Level Interpretation

$$\%\Delta y=100\cdot\beta 1\cdot\Delta x \tag{4}$$ [82]

Running a log-level regression will allow us to also understand the percentual rate of change in GHG emissions versus green bond issuances. Another important use of the logarithmic form is to reduce the occurrence of outliers.

Through regressions eleven and twelve we will try to understand better the changes independently of the size of the GHG emitter, as changes are relative (percentual) and not measured in metric tons of CO_2 equivalent. Percentage changes and the log-level model could help us understand the current trend in GHG emissions in relative terms. We cap (winsorize) GHG emission changes expressed in percentage at 1x change, or 100%, as low denominators (low initial year, such as for example a new facility) lead some observations to be clear outliers in percentage terms.[83]

---

[82] Technically, the interpretation is the following: $\%\Delta y = 100 \cdot (e^{\beta_1} - 1)$ but the quoted interpretation is approximately true for small values of β1.

[83] 918 observations, 0.03% of parent firms, had percentual changes above 100%.

6.1.3 Additional Analysis

For the core part of our analysis, we ran OLS regressions at the parent firm level and facility level with macroeconomic controls. As per Table 31, for this Appendix 1 analysis, we evaluate if any of the following changes in the approach leads to a different coefficient for GrIssuer or GrBond: (i) run panel fixed effects and random effects; (ii) we consider lags and leads to test for the possibility of early or late statistically relevant effects from independent variables on the dependent variable and (iii) GHG percentage changes or natural logs of GHG as dependent variables.

We continue our analysis with regressions 5 through 12 and the overall results can be seen in Table 31, below.

Table 31. Summary of coefficients: Regressions 5-12

Appendix	Random Effects	Random Effects	Fixed Effects	Fixed Effects	OLS	OLS	OLS	OLS
	Regression 5	Regression 6	Regression 7	Regression 8	Regression 9	Regression 10	Regression 11	Regression 12
	GHG	GHG	GHG	GHG	GHG_change	GHG_change	GHG % change	log_GHG
GrIssuer	19228825.2***	22198567.5***					-0.0741	3.528***
	-19.82	-22.6					(-1.01)	-7.45
GrBond	-3357845.7***	-1980916.2***	-3399519.5***	-2081448.9***			-0.00682	0.762
	(-21.43)	(-8.99)	(-21.72)	(-9.46)			(-0.10)	-1.77
2011.year	-7067.4	7495.5	-6436.6	8071.7				-0.0712
	(-0.33)	-0.35	(-0.30)	-0.38				(-1.37)
2012.year	-56400.7**	-31862.3	-55877.2**	-31392.1	-62986.1***	-62986.1***	-0.0439***	-0.125*
	(-2.61)	(-1.48)	(-2.59)	(-1.46)	(-4.45)	(-4.44)	(-5.37)	(-2.40)
2013.year	-51121.4*	-26904.7	-50827.8*	-26666.8	-20075.5	-20075.5	-0.0600***	-0.151**
	(-2.36)	(-1.24)	(-2.35)	(-1.24)	(-1.41)	(-1.41)	(-7.31)	(-2.89)
2014.year	-44780.5*	-25923.9	-44557.5*	-25774.5	-22478.7	-22478.7	-0.0203*	-0.120*
	(-2.06)	(-1.20)	(-2.05)	(-1.19)	(-1.58)	(-1.58)	(-2.47)	(-2.29)
2015.year	-92135.0***	-73202.3***	-92237.3***	-73426.5***	-73200.2***	-73200.2***	-0.0506***	0.0333
	(-4.17)	(-3.32)	(-4.18)	(-3.34)	(-5.10)	(-5.09)	(-6.10)	-0.63
2016.year	-113455.7***	-89378.5***	-113755.1***	-89805.3***	-40639.2**	-40639.2**	-0.0535***	0.0841
	(-5.08)	(-4.01)	(-5.10)	(-4.04)	(-2.80)	(-2.80)	(-6.38)	-1.58
2017.year	-136564.6***	-110254.9***	-136784.1***	-110735.0***	-46197.8**	-46197.8**	-0.0539***	0.104
	(-6.07)	(-4.92)	(-6.09)	(-4.95)	(-3.17)	(-3.16)	(-6.40)	-1.94
2018.year	-108333.1***	-87350.1***	-108333.1***	-87674.4***	-3003	-3003	0.00181	0.150**
	(-4.81)	(-3.89)	(-4.81)	(-3.91)	(-0.21)	(-0.21)	-0.22	-2.81
2019.year	-143674.2***	-118846.6***	-143324.3***	-118885.1***	-65397.8***		-0.0514***	0.159**
	(-6.33)	(-5.25)	(-6.32)	(-5.26)	(-4.48)		(-6.09)	-2.95
G2012		-3715530.3***		-3706152.6***	-1576497.3***	-1576497.3***	-0.0233	-0.367
		(-13.92)		(-13.91)	(-13.08)	(-13.04)	(-0.23)	(-0.56)
G2013		-3626497.9***		-3616888.0***	88570.7	110696.5	0.131	-0.29
		(-13.59)		(-13.58)	-0.73	-0.91	-1.3	(-0.44)
G2014		-2820437.7***		-2805448.0***	699766.2***	788269.7***	0.0583	-0.336
		(-10.55)		(-10.52)	-5.8	-6.39	-0.57	(-0.52)
G2015		-3027530.0***		-2996293.1***	-471919.3***	-430938.2***	0.0521	-0.62
		(-11.16)		(-11.07)	(-3.91)	(-3.49)	-0.51	(-0.94)
G2016		-3756106.3***		-3724666.9***	-539518.8***	-574727.2***	0.0341	-0.701
		(-13.84)		(-13.76)	(-4.37)	(-4.48)	-0.33	(-1.07)
G2017		-4262890.9***		-4203528.1***	-618624.7***	-565329.6***	0.00538	-1.005
		(-15.32)		(-15.13)	(-5.01)	(-4.08)	-0.05	(-1.52)
G2018		-3806444.9***		-3727131.4***	376699.4**	375969.3*	0.0645	-1.157
		(-12.91)		(-12.66)	-2.99	-2.56	-0.6	(-1.69)
G2019		-4590077.5***		-4490943.2***	-674800.8***		0.0399	-1.351
		(-14.49)		(-14.20)	(-4.93)		-0.36	(-1.88)
G2011		-2140899.6***		-2131627.9***	-1941282.3***	-1941282.3***		-0.336
		(-8.02)		(-8.00)	(-15.23)	(-15.19)		(-0.52)
L.GrBond					-902924.6***			
					(-7.06)			
F.GrBond						-420391.4***		
						(-3.59)		
_cons	858011.6***	838310.9***	1153304.5***	1152921.8***	25494.8*	25494.8*	0.0655***	11.66***
	-11.62	-11.41	-71.88	-72.34	-2.45	-2.44	-10.88	-304.04
N	28631	28631	28631	28631	24949	22309	24949	28631
	Parent Firm	Parent Firm	Parent Firm	Parent Firm	Parent Firm	Parent Firm	Parent Firm	Parent Firm

Note: Table 31 summarizes the inputs and the results of regressions 5-12. It includes all variables, their coefficients, statistical relevance, level, and method.

Regressions five through eight using random and fixed effects at the parent firm GHG emission level, give the same general result we found in the Core Analysis: statistically significant reductions in GHG emission once a green bond is issued. The GHG reduction varies between negative 3,399,519 and negative 1,980,916 metric tons of CO_2 equivalent per parent firm upon the issuance of the first green bond.

Regressions nine and ten, which tests for lagged and led results show that the correlation between green bond issuance and a reduction in GHG emission a year earlier and a year later, are still relevant (for alphas of 1%). We found that when the green bond issuance (independent variable) leads or lags GHG emissions, there continue to be significant correlation with reductions in GHG emissions, but at lower levels: between negative 902,924 and negative 420,391 metric tons of CO_2 equivalent.[84]

Finally, regressions eleven and twelve had mostly non-statistically significant findings and as so we can’t have statistical conclusions about how the first issuance of green bond (GrBond) affects GHG emissions. Interestingly though, regression twelve, indicates that GB Issuers and green bond issuances are associated with increases in GHG emissions.

To check this relationship further we look a little deeper into the percentage change data at the facility level below.

6.1.3.1 Analyzing % Difference Data

Based on all 98,550 observations from 9,855 facilities (one for each of the 10 years of the studied period), we calculated the % change for each consecutive year of each facility excluding

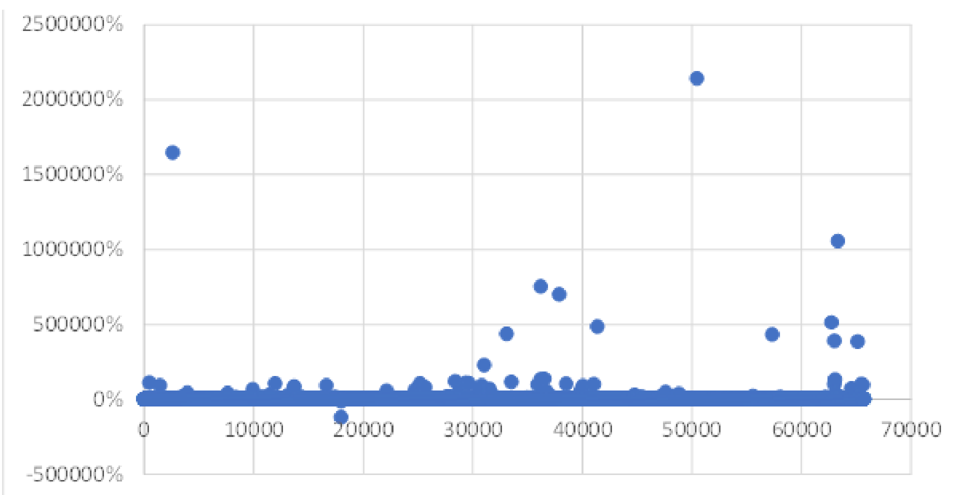
[84] We only dedicate one regression to analyze leads and lags given that our search for clear indicators of their existence is not conclusive. In line with our results, for the lagged result (as if the green bond was issued a year earlier), Schmittmann et al (2021), found that the year before the green bond issuance, there was a reduction in GHG emissions that was lower than that of the year of the issuance. Finally, when we find lower reductions in GHG emissions in the regression where the green bond variable leads (as if the bond was issued a year later than it was), Schmittmann et al (2021), find similar results and highlight that “greater effort to reduce emissions in the issuance year could make it harder in the subsequent year to reduce emission intensity further, which could explain the limited improvements in the first year after issuance”.

differences that had a zero as the nominator or denominator resulting in 65,681 observations of percentage GHG annual changes, as per the equation below, for facilities associated with GB Issuers and non-GB Issuers.

Equation 5. Calculation of Change

$$\left(\frac{\text{Year x}}{\text{Year x-1}} \right) -1 \tag{5}$$

Figure 53. GHG Percentage Change Distribution



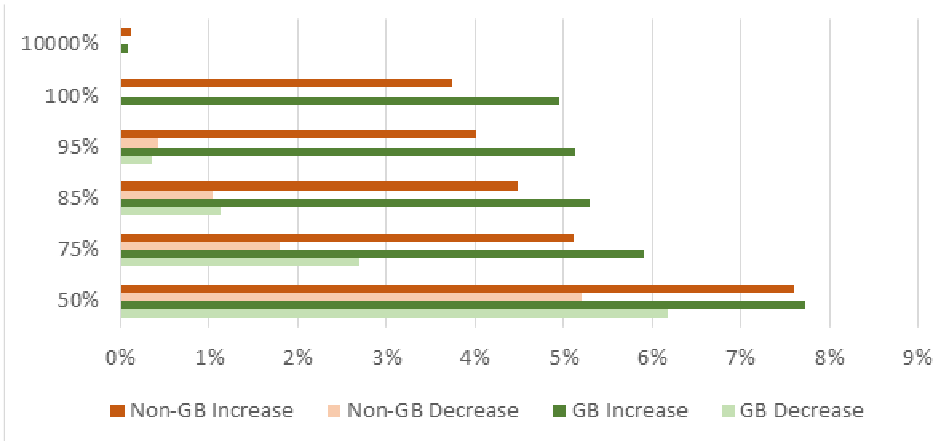
Note: Figure 53 shows how high outliers can go on the positive side while being very limited on the negative side. This justifies winsorizing the data.

Percentage changes can't be lower than negative 100%, given there are no negative GHG emissions leading outliers to be positive[85]. As so positive changes, in percentage, are not limited, but negative changes from year to year are limited in between 0% and 100%. As per Figure 54 below, results are clearly skewed to larger increases than decreases, especially among higher

[85] Only two observations had negative readings that will not be counted as the EPA recognized through email those work wrong readings.

percentage changes for GB-Issuers and non-GB Issuers. The graph shows that positive changes (darker color) are significantly more relevant the higher the rate of change in GHG emissions per year.

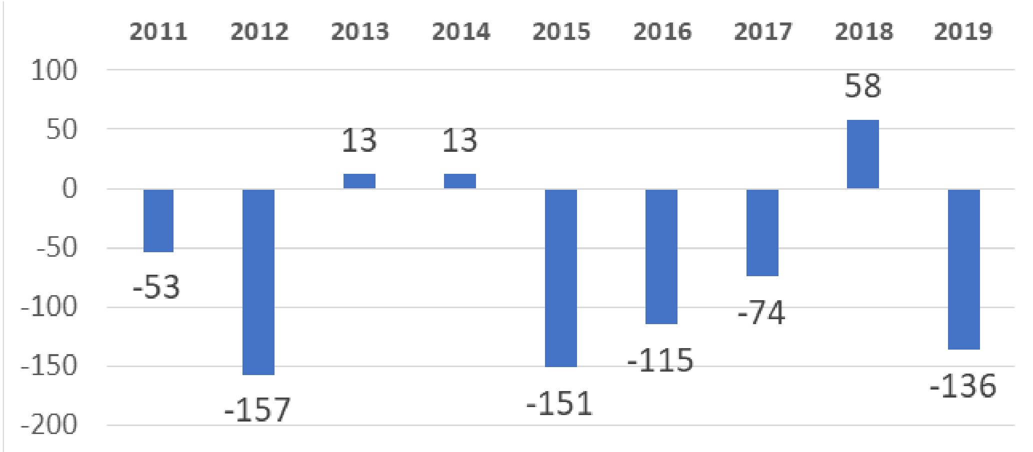
Figure 54. Percentage of Observation with GHG Emission change increase/decrease



Note: Figure 54 shows that positive outliers are not particular to the ESG or the non-ESG group. It also confirms the need to winsorizing it at the top.

Based on the percentage data above it's understandable that a non-winsorized linear model could identify an increase in percentage changes in GHG emissions due to outliers even though the absolute change in GHG emissions (measured in metric tons of CO2 equivalent) is clearly going down, as per Figure 55 below, where we show the GHG emissions change in absolute terms per year for all facilities for which data is available.

Figure 55. Change per Year in Observed Facilities in Millions of Metric Tons of CO2 Equivalent



Note: Figure 55 shoes that there is a negative trend in overall data, already seen in Figure 18 and a positive result is only justifiable given the skewness seen in Figures 54 and 55.

The graphs and tables in this sub-section make it clear that a greater number of facilities present high positive % changes that are enhanced by low starting levels of emissions given that the absolute level of GHG emissions is trending down.

6.1.4 Appendix Conclusion

This additional analysis confirms the findings of the Core Analysis. Using OLS, fixed panel data and random panel data gave us similar results to the ones in the Core Analysis. There is statistically significant evidence that GB Issuers reduce GHG emissions upon issuance of their first green bond.

Panel regression are run on the GHG absolute level, showing that the absolute level of GHG emissions in metric tons of CO2 equivalent reduce with the issuance of the first green bond.

We also show that when the green bond is assumed to be issued a year earlier of later there continues to be significant statistical evidence of a reduction in the change of GHG emissions.

Finally, we show that using relative terms (percentage changes or log-level regressions) without winsorizing can be misleading given the positive skewness and outliers. For future analysis this approach should probably be avoided.

7 Bibliography

7.1 Cited References

AFDC, Alternative Fuels Data Center, “U.S. EPA Releases Greenhouse Gas Reporting Rules” accessed on July 10, 2021, https://afdc.energy.gov/laws/425

ANALOG, Devices, “Green Bond Report 2020”, accessed in July 2021, https://investor.analog.com/static-files/1f7c94c6-9789-490b-b0ed-1c2ff2cac6f9

Baker, M., Bergstresser, D., Serafeim, G. & Wurgler, J. “Financing the Response to Climate Change: The Pricing and Ownership of US Green Bonds”. National Bureau of Economic Research, 2018.

Berg, Florian and Kölbel, Julian and Rigobon, Roberto, Aggregate Confusion: The Divergence of ESG Ratings (May 17, 2020). Available at SSRN: https://ssrn.com/abstract=3438533 or http://dx.doi.org/10.2139/ssrn.3438533

Berg, Florian and Kölbel, Julian, “Navigating the Sea of ESG - Understanding the Inconsistency of ESG Ratings”, December 1, 2020 (b): https://www.youtube.com/watch?v=dCWycf4oLmU

Bilägare, “Only one car brand has been fined for false environmental advertising”. October 1, 2021: http://www.vibilagare.se/nyheter/bara-ett-bilmarke-har-botfallts-falsk-miljoreklam

Blackrock, “Investing. How Green Is Your Bond?” accessed on April 10, 2021: https://www.blackrock.com/us/individual/insights/how-green-is-your-bond

Bloomberg, “The inconvenient truths of ESG ETFs as U.S. rises: BI tracker webinar and report”, accessed on Oct 10, 2021: Access through the Bloomberg terminal with code {SMNR VOD 3911}

Bloomberg, “Cleaning up ETF ESG greenwashing”, July 19, 2021 (b): https://www.bloomberg.com/professional/blog/cleaning-up-etf-esg-greenwashing/

Bruno, Esakia and Goltz, Scientific Beta, "'Honey, I Shrunk the ESG Alpha': Risk-Adjusting ESG Portfolio Returns", April 2021, accessed on Nov 15, 2021: https://cdn.ihsmarkit.com/www/pdf/0521/Honey-I-Shrunk-the-ESG-Alpha.pdf

Calpine. “Alpine Corporation Announces Closing Of $1.1 Billion Climate Bonds Certified Financing for The Geysers Power Company, LLC”, June 10, 2020: https://www.calpine.com/about-us/news/climate-bonds-certified-financing-for-the-geysers-power-company

Clayton, J. Financial Times. "SEC chair warns of risks tied to ESG ratings". May 27, 2020: https://www.ft.com/content/2c662135-4fd3-4c1b-9597-2c6f8f17faed

Clearway, Energy, “Use of proceeds” information received through email on July 20, 2021. Information also accessed on July 21, 2021 at: http://investor.clearwayenergy.com/static-files/7b631032-cf61-404f-b43d-9705a5015732

Climate Bonds, “Post-Issuance Reporting: In the Green Bond Market”, 2019: https://www.climatebonds.net/files/reports/cbi_post-issuance-reporting_032019_web.pdf

Climate Bonds, “Record $269.5bn green issuance for 2020: Late surge sees pandemic year pip 2019 total by $3bn”, accessed on October 5, 2021: https://www.climatebonds.net/2021/01/record-2695bn-green-issuance-2020-late-surge-sees-pandemic-year-pip-2019-total-3bn

Climate Bonds, “Climate Bonds Certification” accessed on November 9, 2021(a) https://www.climatebonds.net/certification/get-certified

Climate Bonds, “Explaining Green Bonds” accessed on July 15, 2021(b) https://www.climatebonds.net/market/explaining-green-bonds

Climate Bonds, “Climate Bonds Standard and Certification Scheme” accessed on April 7, 2021(c) https://www.climatebonds.net/standard

Contractor, S. Bloomberg Research and Analysis. "Cleaning up ETF ESG greenwashing". July 19, 2021: https://www.bloomberg.com/professional/blog/cleaning-up-etf-esg-greenwashing/

Curtis, Quinn; Fisch, Jill E.; and Robertson, Adriana Z., "Do ESG Mutual Funds Deliver on Their Promises?" (2021). Faculty Scholarship at Penn Law. 2298. https://scholarship.law.upenn.edu/faculty_scholarship/2298

Donovan, William. “The Origins of Socially Responsible Investing from Methodists to Now.” The Balance. Accessed April 14, 2020. https://www.thebalance.com/a-short-history-of-socially-responsible-investing-3025578.

DUKE, Energy, “Use of proceeds” information received through email on July 19, 2021. Also, accessed on July 20, 2021 at: https://www.duke-energy.com/our-company/investors/green-bonds

EBSA, “EBSA Proposal Pours Some Cold Water on ESG Enthusiasm”, June 24, 2020: https://www.asppa.org/news/ebsa-proposal-pours-some-cold-water-esg-enthusiasm

EnvironmentalFinance, accessed on November 10, 2021: https://www.environmental-finance.com/content/guides/esg-guide-entry.html?productid=232&editionid=1&planid=1

EPA – Environmental Protection Agency, accessed on October 2, 2021: https://www.epa.gov/climate-indicators

EPA – Environmental Protection Agency, email received in March 2021.

EPA – Environmental Protection Agency, “What are the benefits of this data?”, September 23, 2019: https://ccdsupport.com/confluence/pages/viewpage.action?pageId=141983781

Ehlers, Mojon, and Packer, BIS Quarterly Review, “Green Bonds and Carbon Emissions: Exploring the Case for a Rating System at the Firm-Level.”, September 2020, accessed on July 10, 2021: https://www.bis.org/publ/qtrpdf/r_qt2009c.htm

EIB, European Development Bank, “EPOS II – The ‘Climate Awareness Bond’ EIB promotes climate protection via pan-EU public offering”, May 22, 2007, accessed on April 8, 2020: https://www.unicreditgroup.eu/content/dam/unicreditgroup/documents/inc/press-and-media/FOR_DISTRIBUTION_MAY_22_2007_EPOSeng.pdf

EPA, Environmental Protection Agency, “Scope 1 and Scope 2 Inventory Guidance”, accessed on September 1, 2021, https://www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance

EPA, Environmental Protection Agency, “Scope 3 Inventory Guidance”, accessed on September 1, 2021: https://www.epa.gov/climateleadership/scope-3-inventory-guidance

EPA, Environmental Protection Agency, “Greenhouse Gas Emissions from Large Facilities”, accessed on December 18, 2019, http://ghgdata.epa.gov/ghgp/main.do

ESGClarity, accessed on November 9, 2021: https://esgclarity.com/assets-in-esg-etfs-jumps-220-in-2020/

Fidelity, “ETFs 101”, accessed on Oct 15, 2021: https://www.fidelity.com/learning-center/investment-products/etf/what-are-etfs

Damodaran, A. & Cornell, B. “The ESG concept has been overhyped and oversold”, July 15, 2020: https://www.ft.com/content/719e6253-4d07-402a-9f36-d461671657a1

Flammer, Caroline, Questrom School of Business - Boston University, “Corporate Green Bonds”, April 2020: http://sites.bu.edu/cflammer/files/2020/04/Corporate-Green-Bonds_Flammer_JFE.pdf

Flammer, Caroline, Harvard Business Review, “Green Bonds Benefit Companies, Investors, and the Planet”, November 2018: https://hbr.org/2018/11/green-bonds-benefit-companies-investors-and-the-planet

Flammer, Caroline. “Green Bonds: Effectiveness and Implications for Public Policy.” Environmental and Energy Policy and the Economy 1 (January 1, 2020): 95–128. https://doi.org/10.1086/706794.

Friedlander, B. Cornell University. "Rising seas could result in 2 billion refugees by 2100". June 19, 2017: https://news.cornell.edu/stories/2017/06/rising-seas-could-result-2-billion-refugees-2100

Gates, Bill, 1955-. 2021. How to Avoid a Climate Disaster: The Solutions We Have and the Breakthroughs We Need. New York: Random House Large Print.

Gates, Bill. Gates Notes, “Getting Warmer - Climate change and the 75% problem”, October 17, 2018: https://www.gatesnotes.com/Energy/My-plan-for-fighting-climate-change?WT.mc_id=20190918000000_TGNICA_BG-FB_IG-EnSus-ClimB&WT.tsrc=BGFB_IG

Gates, Bill. Gates Notes, “My new climate book is finally here”, February 14, 2021 (b): https://www.gatesnotes.com/Energy/My-new-climate-book-is-finally-here

Global Reporting Initiative: “About GRI.”, accessed on April 15, 2020. https://www.globalreporting.org/information/about-gri/Pages/default.aspx.

GGP, Greenhouse Gas Protocol, “Global Warming Potential Values”, 2021: https://www.ghgprotocol.org/sites/default/files/ghgp/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf

Guardian. “Competition watchdog gives firms deadline on ending ‘greenwashing’”, Sep 20, 2021: https://www.theguardian.com/business/2021/sep/20/competition-watchdog-gives-firms-deadline-on-ending-greenwashing

Hachenberg, B. & Schiereck, D. Journal of Asset Management. "Are green bonds priced differently from conventional bonds?", August 6, 2018: https://doi.org/10.1057/s41260-018-0088-5

Harari, Yuval N., Yuval N. Harari, John Purcell, and Haim Watzman. 2015. Sapiens: a brief history of humankind.

Hale, Jon. “Morningstar, Sustainable Funds U.S. Landscape Report. More funds, more flows, and impressive returns in 2020.” (10 February 2021).

ICMA, International Capital Markets Association, “Green Bond Principles”, accessed on September 18, 2021: https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

IMF. “Sustainable finance: Looking farther”. Global Financial Stability Report October 2019.

IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press.

IRIS, “From IRIS to IRIS+ | IRIS+ System.” Accessed April 15, 2020. https://iris.thegiin.org/history/.

Jakiela, P. “What Are We Estimating When We Estimate Difference-in-Differences?”, September 30, 2019: https://blogs.worldbank.org/impactevaluations/what-are-we-estimating-when-we-estimate-difference-differences

Kahle, Lynn R., and Eda Gurel-Atay (Eds.) (2013), “Communicating Sustainability for the Green Economy”. Armonk, NY: M. E. Sharpe.

Kapraun, J., & Scheins, C. “(In)-Credibly Green: Which Bonds Trade at a Green Bond Premium?”. In Proceedings of Paris December 2019 Finance Meeting EUROFIDAI-ESSEC, March 2019.

Karpf, A., & Mandel, A. “Does it pay to be green?”, 2020. Available at SSRN 2923484.

Kousky, C. & Netusil, N. Wharton Risk Management and Decision Processes Center. "The Coming Storm: How U.S. Cities Are Managing Stormwater from Increasingly Extreme Rainfall Events", August 2021: https://riskcenter.wharton.upenn.edu/wp-content/uploads/2021/08/The-Coming-Storm.pdf

Kousky, Caroline & Flemming, Billy & Berger, Alan. A Blueprint for Coastal Adaptation, Uniting Design, Economics, and Policy. Island Press, Washington. May 20, 2021.

KPMG, “Green Bonds – The Process”, March 2016: https://assets.kpmg/content/dam/kpmg/pdf/2016/04/green-bonds-process.pdf

Larcker, D. F., & Watts, E. M. “Where's the greenium?”. Journal of Accounting and Economics, 2020.

LGC. Local Government Commission, “Budgeting for Climate Resilience”, accessed on Sep 4, 2021: https://www.lgc.org/newsletter/budgeting-for-climate-resilience/

Maltais, A., & Nykvist, B. “Understanding the role of green bonds in advancing sustainability”. Journal of Sustainable Finance & Investment, 2020.

McCoy, Patrick. Metropolitan Transportation Authority, “Authorized Officer Certificate of The Metropolitan Transportation Authority in Connection with Climate Bond Initiative Annual Reporting”, April 30, 2021: https://new.mta.info/document/37931

Michaels, Dave. The Wall Street Journal, “SEC to Hunt for Climate-Friendly Marketing That Misleads Investors”, March 4, 2021: https://www.wsj.com/articles/sec-to-hunt-for-climate-friendly-marketing-that-misleads-investors-11614898102?mod=searchresults_pos2&page=1

MIT – Massachusetts Institute of Technology, “Chapter 5 - Nonparametric statistics and model selection”, accessed on October 20, 2021: https://www.mit.edu/~6.s085/notes/lecture5.pdf

Morningstar, Inc. “ESG Investing Comes of Age.” Accessed April 14, 2020. https://www.morningstar.com/features/esg-investing-history.

MSCI, “Executive Summary: Intangible Value Assessment (IVA) Methodology”, August 2021. Accessed on November 17, 2021, shared via email by MSCI, similar version online: https://www.msci.com/documents/1296102/21901542/MSCI+ESG+Ratings+Methodology+-+Exec+Summary+Nov+2020.pdf

MSCI, “Executive Summary: Intangible Value Assessment (IVA) Methodology”, December 2014. Accessed on November 13, 2020:

https://www.msci.com/documents/10199/242721/IVA_Methodology_SUMMARY.pdf/cb947ab8-509e-44fd-8e4b-afb53771fbcb

MSCI email, “ESG Industry Weight Matrix”, received on November 8, 2021

MSCI, “ESG 101: What is Environmental, Social and Governance?”, Accessed on September 14, 2021 (b): https://www.msci.com/esg-101-what-is-esg

MSISI. Morgan Stanley Institute for Sustainable Investing. "Sustainable Funds Outperform Peers in 2020 During Coronavirus". February 24, 2021: https://www.morganstanley.com/ideas/esg-funds-outperform-peers-coronavirus

NASA, “Global Climate Change, Vital Signs of the Planet”, accessed on January 28, 2020 at: https://climate.nasa.gov/causes/

NASA, NASA Science – Share the Science, “Living Ocean”, accessed on July 28, 2021 at: https://science.nasa.gov/earth-science/oceanography/living-ocean

Ng, Gerwyn. “Generalized Regression Difference in Differences with Fixed Effects, Multiple Treatment Periods and Dynamic Treatment Effects.”(December 20, 2019), , accessed on Nov 2, 2020: https://medium.com/eatpredlove/regression-difference-in-differences-208c2e787fd2

NOAA - National Oceanic and Atmospheric Administration, accessed on October 2, 2021: https://www.esrl.noaa.giv/gmd/aggi

Noy, Ilan, and Aekkanush Nualsri. “Fiscal Storms: Public Spending and Revenues in the Aftermath of Natural Disasters.” Environment and Development Economics 16, no. 1 (2011): 113–28. http://www.jstor.org/stable/26263709.

Owens, Corning, “Use of proceeds” information received through email on July 22, 2021

Pavlova, Ivelina & Boyrie, Maria. Finance Research Letters. "Is ESG investing for values or performance?" April 7, 2021: https://www.sciencedirect.com/science/article/pii/S154461232100132X

Pronina, Lyubov. Bloomberg Businessweek “What Are Green Bonds and How ‘Green’ Is Green?”, March 24, 2019: https://www.bloomberg.com/news/articles/2019-03-24/what-are-green-bonds-and-how-green-is-green-quicktake?sref=bduckV2z

Roisman, E. US Securities and Exchange Commission. "Can the SEC Make ESG Rules that are Sustainable?" June 22, 2021: https://www.sec.gov/news/speech/can-the-sec-make-esg-rules-that-are-sustainable

SEC - Securities and Exchange Commission, accessed on September 2, 2021 at: https://www.sec.gov/news/press-release/2021-42

SEC - Securities and Exchange Commission. "Environmental, Social and Governance (ESG) Funds – Investor Bulletin". Feb. 26, 2021(b): https://www.investor.gov/introduction-investing/general-resources/news-alerts/alerts-bulletins/investor-bulletins-1

Schmittmann, J. & Teng, C. IMF Working Paper “How Green are Green Debt Issuers?”, July 2021, WP/20/194.

SIFMA, “SIFMA Fact Book”, 2018: https://www.sifma.org/wp-content/uploads/2017/08/US-Fact-Book-2018-SIFMA.pdf

Stein, Jeff & Dam, Andrew. The Washington Post, “Taxpayer spending on U.S. disaster fund explodes amid climate change, population trends”, April 22, 2019: https://www.washingtonpost.com/us-policy/2019/04/22/taxpayer-spending-us-disaster-fund-explodes-amid-climate-change-population-trends/

Sustainalytics, “Second Opinion Report”, information received through email on July 19, 2021

Torres-Reyna, O. Princeton University, “Panel Data Analysis Fixed and Random Effects Using Stata”, December 2007: https://www.princeton.edu/~otorres/Panel101.pdf

Toyota, “Use of proceeds”, accessed on July 19, 2021 at: https://www.toyotafinancial.com/content/dam/tmcc-webcommons/toyotafinancial/documents/investor-relations/green-bond/TMCC_Green_Bond_Framework_Second_Party_Opinion_May_2021.pdf

United Nations, “Department of Economic and Social Affairs - Sustainable Development - The 17 Goals”, accessed on July 3, 2021 at: https://sdgs.un.org/goals

United Nations, UN News – Climate and Environment, “The trillion-dollar climate finance challenge (and opportunity)”, June 27, 2021 (b): https://news.un.org/en/story/2021/06/1094762

WBGBlogs, accessed on March 9, 2021: https://blogs.worldbank.org/impactevaluations/what-are-we-estimating-when-we-estimate-difference-differences

WEF. World Economic Forum. "The Global Risks, 16th Edition". 2021: https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2021.pdf

Whieldon E. & Clark, R. S&P Global Market Intelligence, “ESG funds beat out S&P 500 in 1st year of COVID-19; how 1 fund shot to the top”, April 6, 2021: https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/esg-funds-beat-out-s-p-500-in-1st-year-of-covid-19-how-1-fund-shot-to-the-top-63224550

World Bank, “10 Years of Green Bonds: Creating the Blueprint for Sustainability Across Capital Markets”, March 18, 2019: https://www.worldbank.org/en/news/immersive-story/2019/03/18/10-years-of-green-bonds-creating-the-blueprint-for-sustainability-across-capital-markets

Zerbib, O. D. “The effect of pro-environmental preferences on bond prices: Evidence from green bonds”. Journal of Banking & Finance, 2019.

7.2 General References

Benhamou, Mathieu, Emily Chasan, and Saijel Kishan. “Top Sustainable Investment Funds Are Beating the Market.” Bloomberg.Com. Accessed April 15, 2020: https://www.bloomberg.com/graphics/2020-ten-funds-with-a-conscience/.

Dunant, Etienne. “Demystifying the Ideal: Water and Sustainability in Ancient Greek Laws.” Global Justice and Sustainable Development, January 1, 2010, 131–34. https://doi.org/10.1163/9789004188228_008.

“Jon Hale: ESG Is a Paradigm Shift | The Long View.” Accessed April 14, 2020. https://the-long-view.simplecast.com/episodes/jon-hale?share=true.

Kell, Georg. “The Remarkable Rise Of ESG.” Forbes. Accessed April 15, 2020. https://www.forbes.com/sites/georgkell/2018/07/11/the-remarkable-rise-of-esg/.

“Transforming Our World: The 2030 Agenda for Sustainable Development .:. Sustainable Development Knowledge Platform.” Accessed April 15, 2020. https://sustainabledevelopment.un.org/post2015/transformingourworld.

Cnote. “CNote | The History of Socially Responsible Investing.” CNote (blog), November 15, 2019. https://www.mycnote.com/blog/the-history-of-socially-responsible-investing/.