Transformative Drivers of Environmental Sustainability in Contemporary Organizations [2017-2020]

By

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Dedication

To Mom and Dad, without whom none of this would be possible. Everything I am, and all that I've done, is because of you. All of my accomplishments will always be dedicated to you.

To my grandfather, Dada, whose pride and keen interest in my academic and professional journey has meant the world to me. You have cheered me on for as long as I can remember. Your intellect is something I have always looked up to, and I am grateful for your influence in my life.

ABSTRACT

Seventy-one percent of global emissions are attributed to just 100 companies, which are all from the fossil fuel sector. The world's current trajectory of exponential population growth is yielding widespread environmental degradation, highlighting the need for transformation in the usual business models and substantial action towards environmentally responsible initiatives. For global collaboration on combatting climate change, the United Nations introduced international climate treaties, the most recent and notable example being the Paris Agreement, which aims to keep the global temperature rise below 2°C, and ideally within 1.5°C relative to pre-industrial levels.

Using a bottom-up approach, this research explores the emissions reduction efforts of for-profit companies. Towards this end, it draws upon extensive datasets for the 2017-2020 period from the Carbon Disclosure Project, on over 100 large corporations across eleven industries in the U.S. and Europe. It aims to address whether the Kyoto Protocol and Paris Agreement may have influenced corporate strategy, which in turn would affect changes in corporate governance, risk management, and targets and performance, thereby translating to lowered emissions and/or energy intensity reductions. Additionally, a modified version of the IPAT model is applied at the corporate level to assess drivers of environmental impact, which helps identify areas needing change. The IPAT also helps track changes in emissions, revenue, and use of renewable versus non-renewable energy in these 100+ corporations, both before and after the COVID-19 pandemic came into play.

The thesis found that over the four-year period of 2017-2020, these 102 European and U.S. companies represented 5.5% of the 2021 global CO_2 emissions. For both regions, the highest-emitting industries are in exactly the same order: Power Generation, Airlines, and Fossil Fuels. In the three-year period of 2017-2019, prior to COVID-19, emissions dropped in both regions and most sectors due to a joint improvement in energy and carbon efficiency. Moreover, the pandemic's impact in 2020 was just as significant as that of technology's impact over three years.

A notable finding was that COVID-19 lockdowns reduced emissions significantly more in the U.S. than policies and business strategies could before the pandemic year of 2020. Interestingly, the research also saw that emissions can be reduced with increasing revenue and possible profitability, depending on cost increases.

This thesis demonstrates that corporations in advanced industrialized nations have the potential to play an instrumental role in reducing emissions through improving both energy and carbon efficiency, and by making robust efforts. These corporations can set an example for their counterparts in developing nations, proving that it is possible to reduce emissions while increasing revenue. Ultimately, this can create a pathway toward stabilizing climate change.

Highlights:

- IPAT model applied to organizations to assess drivers of environmental impact
- Role of corporations in anthropogenic climate change and how they can mitigate it
- Impact of Kyoto Protocol and Paris Agreement on a select group of companies in Europe and the U.S.
- CDP data showing influence on business strategy from Kyoto and Paris treaties

Keywords:

Carbon Disclosure Project; IPAT; Change Management; Climate Change; Corporate Strategy; Corporate Social Responsibility; GHG Emissions; Kyoto Protocol; Paris Agreement; COVID-19; Net-Zero; Sustainability.

Acronyms:

BY: Base Year

CAI: Carbon Accountability Institute

CDP: Carbon Disclosure Project

CH_4: Methane

CO_2: Carbon Dioxide

COP: Conference of the Parties

CSR: Corporate Social Responsibility

EKC: Environmental Kuznets Curve

ETS: Emissions Trading System

GDP: Gross Domestic Product

GHG: Greenhouse Gas Emissions

HFCs: Hydrofluorocarbons

ICP: Internal Carbon Pricing

IPCC: Intergovernmental Panel on Climate Change

N_2O: Nitrous Oxide

NDCs: Nationally Determined Contributions

NF_3: Nitrogen Trifluoride

PHCs: Perfluorocarbons

SBTi Science-Based Targets Initiative

SEC: Securities and Exchange Commission

SF_6: Sulfur Hexafluoride

TY: Target Year

UN PRI: United Nations Principles for Responsible Investment

UN: United Nations

UNCCS: United Nations Climate Change Secretariat

UNFCCC: United Nations Framework Convention on Climate Change

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CHAPTER 1: INTRODUCTION

With the advent of the catastrophic implications of climate change (Ripple et al., 2019), the instrumental role that corporations should play in taking stewardship of the environment is becoming increasingly clear (Alibašić, 2018). Recent evidence finds that 71% of global emissions are from just 100 companies, which are all in the fossil fuel sector (Riley, 2017; Griffin, 2017). Climate experts assert that without formidable efforts by businesses to reduce greenhouse gas [GHG] emissions, the planet is moving towards an irreversible and calamitous global temperature rise of 3-6℃ by the end of the century, which would result in risks such as the extinction of numerous critical species, global food scarcity, and 3.5 billion people living in scorching temperatures outside the human climate niche (IPCC, 2021; Riley, 2017; Xu et al., 2020).

The world's current trajectory of exponential population growth is yielding widespread environmental degradation (Ehrlich, and Ehrlich, 2009; Gans & Jost, 2005; Leridon, 2020; Ripple et al., 2020; Bocken et al., 2014), highlighting the need for transformation in the usual business models and profound action towards environmentally responsible initiatives (Henry et al., 2019; Ceesay et al. 2021).

The mounting pressure on corporations has resulted in them finding different strategies to measure their environmental impact. One example is the Triple Bottom Line concept, a three-dimensional framework that prompts companies to consider not only their standard bottom line of financial performance but also the results of their social and sustainable undertakings (Liute & de Giacomo, 2021; Slaper & Hall, 2011).

Managing the planet's climate crisis is mainly contingent on the ability of corporations to decarbonize within the coming decades, following commitments such as the UNFCCC's *Race to Zero* campaign, which requires companies to halve their carbon emissions by 2030 (UNFCCC, 2021a; Rockström et al., 2017; Wade & Rekker, 2020). By playing an influential role as non-state actors, organizations can fortify national efforts to limit emissions and curtail the emissions gap between actual progress and the action needed to meet climate targets, thus moving on track towards a pathway that would mitigate global warming to 1.5℃ above pre-industrial levels by 2100 (Hale, 2018). Today, over 4,500 non-state actors from 92 countries worldwide have pledged to take transformative, rapid, and substantive action to meet the targets underlined in the Paris Agreement and are continually becoming the engine of mitigation and adaptation to climate action (UNFCCC, 2021a; Kinley, 2016). In addition, the *Yearbook of Global Climate Action* report from the United Nations shows that by 2018, 70% of international initiatives had rendered a high or medium-high output performance, indicating that these non-state actors were poised to catch up with the climate targets they should be aiming for (UNCCS, 2018).

Firms' economic viability and prosperity are contingent on their ability to balance the interdependent forces of people, planet, and profit, to fulfill an obligation to become more sustainable (Liute & de Giacomo, 2021; Bhat, 1998). This balancing act also leverages the competitive advantage of sustainable companies (Hussain et al., 2018; da Silva et al., 2019). One avenue that an estimated 1,200 organizations are already implementing or plan to implement is internal carbon pricing [ICP]. This voluntary measure helps companies assign a monetary value to their GHG emissions to assess and mitigate the scale and impact of their long-term future operations and business decisions. It also acts as a means of risk management, lest they must report and manage their emissions to meet government-imposed regulations (Bento & Gianfrante, 2020; WBCSD, 2015, CDP, 2021b). Almost half of the largest 500 companies in the world are pricing carbon or working towards it as of today, spanning eleven different industries, including manufacturing, power and fossil fuel, and financial services (CDP, 2021b).

Over the years, organizational change management has swiftly become a pivotal concept in the business world. Former CEO of General Electric, Jack Welch, famously said, “When the rate of change on the outside exceeds the rate of change on the inside, the end is near” (Daft, 2007, p.454). Companies are constantly subject to improving their operations to remain competitive both technologically and economically, for which they need to be innovative and open to change. However, the kind of radical, organization-wide transformations needed for businesses to adapt to the threat of climate change consistently can pose an arduous challenge. Thus, one viable solution is to utilize the wealth of knowledge offered by researchers and leaders who can better guide and inform companies through change management coaching. Organizational change experts can direct businesses on rapid divestment and clean investment decisions at a low cost. Further input should be welcome from strategic management and finance scholars, whose strengths would be employable in the decarbonization pathway. Solid research put forward by academic experts could ensure buy-in from the company’s executives, and academics can also facilitate effective internal and external communication throughout the company to initiate tactical avenues for transformation (Schaffer, 2017; DuBois & DuBois, 2012; Wade & Rekker, 2020).

Academic research is conducive to guiding companies in developing their commitment parameters and decarbonization pathways. Academia today is presented with imperative opportunities to conduct advanced and expansive research on both theoretical and practical fronts for leading organizations towards finding and adopting suitable methodologies that help them translate climate targets into action. One such approach is to see how frameworks implemented at the national level could be reapplied to organizations (Wade & Rekker, 2020; Robiou Du Pont et al., 2017), such as the IPAT model formulated by Commoner, Ehrlich, and Holdren in the 1970s (Waggoner & Ausubel, 2002).

Research Inquiry and Questions

This thesis will mainly draw upon the in-depth reports, data, and surveys provided by the Carbon Disclosure Project [CDP], along with the Carbon Majors Database by Richard Heede, to analyze data on 102 high-emitting companies worldwide and their current and future sustainability strategies, as expanded on in the *Methodology* section. It aims to address the following research question:

> "Have international climate treaties like the Kyoto Protocol and Paris Agreement yielded any measurable impact, which has trickled down to large, high-emitting corporations, causing them to transform their business strategy, governance, and energy use towards lowering GHG emissions and becoming more environmentally responsible?"

To answer the research question, we created a theoretical framework by using existing IPAT/IPACT/STIRPAT frameworks from the literature and applying them to the corporations. This resulted in a new theoretical framework that helps identify the main factors responsible for changes in emissions over time at a micro-level. The key drivers of emissions in this new framework are revenue growth, energy efficiency, and carbon intensity.

The orginal IPAT model evaluates a nation's environmental impact based on drivers such as population, affluence, and technology (Chertow, 2000). Despite certain limitations to the IPAT model, adopting it at the company level, as done by da Silva et al. (2019), can provide deeper insights regarding the main drivers of environmental impact beyond intensity and facilitate decision-making to achieve future targets. Therefore, establishing a proper theoretical framework of the IPAT model at the company level with more drivers than da Silva et al. (2019) is a necessary first step of the thesis. For example, what is the best substitute for population, *P*, at the company level? What is affluence, *A*, at the company level? Can these be operationalized? Why are these drivers important? After establishing the new theoretical framework, the application follows.

The sample will consist of 102 large public and private companies across eleven industries in the United States and Europe, responsible for substantial carbon emissions, comparing the pre-COVID-19 period of 2017 to 2019 with the pandemic year of 2020. One of the objectives is to determine a change in the drivers towards sustainability. Another objective is to assess and compare the impacts of international climate agreements against those induced by the COVID-19 pandemic during the 2017-2020 time period.

The upcoming chapters will provide an overview of the Kyoto Protocol and Paris Agreement, discussing their objectives and accomplishments both on a national and corporate scale. The IPAT framework will also be introduced and explored, first at a national level, then at a corporate level, with each component defined in detail.

The methodology of the study will be presented in Chapter 5, which will also offer additional information on the 102 companies and 11 industries examined. Chapter 6 will present the results and findings of the IPACT model.

Following this, the next two chapters will analyze the STIRPAT model, including its definitions and scope, as well as the outcomes derived from its application.

Finally, we will investigate the targets set by the companies and conduct four case studies to assess their progress in meeting those targets by 2030, using their pre-COVID performance as a benchmark. Similarly, we apply the aforementioned approach to a country to evaluate its progress towards achieving its set target.

CHAPTER 2: KYOTO PROTOCOL

After years of global negotiations, the Kyoto Protocol was signed in Kyoto, Japan, on the 11th of December, 1997 at the 3rd Conference of the Parties [COP3], and it was a landmark environmental treaty that represented the first time that nations agreed to legally-mandated, country-specific emissions reduction targets (UNFCCC, 2021f). The primary mission of the Kyoto Protocol was to limit and stabilize atmospheric concentrations of the seven GHGs, namely carbon dioxide [CO_2], methane [CH_4], nitrous oxide [N_2O], hydrofluorocarbons [HFCs], perfluorocarbons [PHCs], sulfur hexafluoride [SF_6], and nitrogen trifluoride [NF_3], to "a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1998, "Article 2" section). Unfortunately, due to a complex ratification process, the Kyoto Protocol only came into force on the 16th of February 2005, after Russia finally signed up, thus satisfying the clause of having '55% of 1990 CO_2 emissions of the Parties included in Annex I' on-board (Freedman & Jaggi, 2005; King, 2015; UNFCCC, 2021f).

By founding the first mechanisms for reducing GHG emissions, the Kyoto Protocol saw that each country was allocated a particular allowance for emissions depending on their historical responsibility for the build-up of GHGs in the atmosphere. Deemed as Annex I parties, the reduction targets were set mainly for the industrialized or developed nations, since at the time, they were the major emitters rather than developing nations, which were given no restrictions requirements as per the Protocol (UNFCCC, 2021f; Madrigal, 2009). Thus, although 192 parties had ratified, only a total of 37 industrialized countries, including the U.K., U.S., Australia, New Zealand, Canada, and most EU nations, were essentially expected to make emissions reductions of up to 5% compared to 1990 levels by the first commitment period of 2008-2012 (UNFCCC, 2021f, Maamoun, 2019).

However, the U.S. Senate refused to ratify due to former president George W. Bush thinking it would hurt the U.S. economy, Canada later invoked its legal right to withdraw in 2011, for not achieving its targets by the end of the first commitment period, and also to not hurt its booming oil industry, with Environment Minister Peter Kent stating that "Kyoto was not the way forward for Canada or the world." A common grievance was also that the largest emitter, China, was not doing enough, and thus the protocol would be futile without its efforts (The Guardian, 2011; Beggin, 2017; King, 2015; Madrigal, 2009).

Eventually, compliance to the first commitment period was by 36 countries, out of which only nine countries, including Austria, Iceland, Denmark, Japan, Lichtenstein, Luxembourg, Norway, Switzerland, and Spain emitted higher levels of GHG emissions than they had committed under the Kyoto Protocol. Moreover, six of these nine countries had minimally higher emissions, whereas Austria, Spain, and Japan were 13%, 15%, and 44% over their Kyoto target limit, respectively (Shishlov et al., 2016).

Developing nations like India, China, Brazil, and South Africa had no emissions restrictions, but they were encouraged to adopt green policies in order to be more environmentally responsible and sustainable. To evidence their solidarity and accelerate transfers of technology, developed nations, which were the Annex I parties, were expected to help developing countries, in return for which they would receive a Certified Emission Reduction Credit. This initiative was called the Clean Development Mechanism (UNFCCC, 2021d; Britannica, 2020; King, 2015; Madrigal, 2009).

As of June 2013, the Kyoto Protocol had a total of 192 parties, excluding the United States and Canada. With the first commitment period of 2008-2012 expiring, the Doha Amendment was adopted in Qatar on 8th December 2012, extending a second commitment period from 2013-2020, which included new commitments for Annex I parties, and had been accepted by 147 parties by October 2020 (UNFCCC, 2021f).

Progress and Results of the Kyoto Protocol at the National Level

According to the UNFCCC, some success in the Kyoto Protocol's 1st commitment period was that the progress was better than expected; GHG emissions were reduced by about 22.6% instead of the original 5% target, perhaps because the 2008 economic crisis also really helped reduce emissions in developed nations (UNFCCC, 2015; King, 2015; Shishlov et al., 2016). It also inspired other green mechanisms such as carbon taxes and carbon pricing in many countries (UNFCCC, 2018). Other data suggests that countries which were legally bound by the Protocol were actually able to reduce their carbon emissions by 7%, compared to their anticipated business-as-usual levels (Maamoun, 2019). Moreover, even though the United States was not part of the Protocol, it has still markedly lowered emissions in the past few decades (le Quéré et al., 2019).

Another study by Kim et al. (2020) highlights that participating in the Protocol as an Annex I party yielded substantial positive results on cutting down carbon emissions, although it is to be noted that the parties' Gross Domestic Product [GDP] was also negatively altered in the long run. The study's findings showed that without following the Protocol's imperative to lower carbon emissions, Annex I parties were on track to produce 14% more CO_2 as per the 2005 base-year model; however, 7% of GDP growth amounting to USD 2.3 trillion would also have been earned in the event of their non-participation. Moreover, the marginal benefits of emissions reductions from the Protocol covered only a fraction of the GDP loss – if we were to use the mean benefits value of USD 279 billion, it would account for only 12% of the total GDP loss. Kim et al.'s (2020) research proposes the need for future international climate frameworks to be able to strike a balance between economic and environmental performance by prioritizing sustainable development, as well as safeguarding the interests of developing countries which cannot afford GDP losses while also investing in emissions reductions and climate policy adaptations.

Some experts consider the progress to be not too significant since the two highest emitters in the world were not bound by the Protocol, because the U.S. did not ratify the treaty, and China was exempt from it as a developing nation (Britannica, 2020). However, the world has changed – developing nations are now rapidly surpassing higher emissions than developed ones, thus prompting the question of whether their emissions should really be left unrestricted (Figure 1).

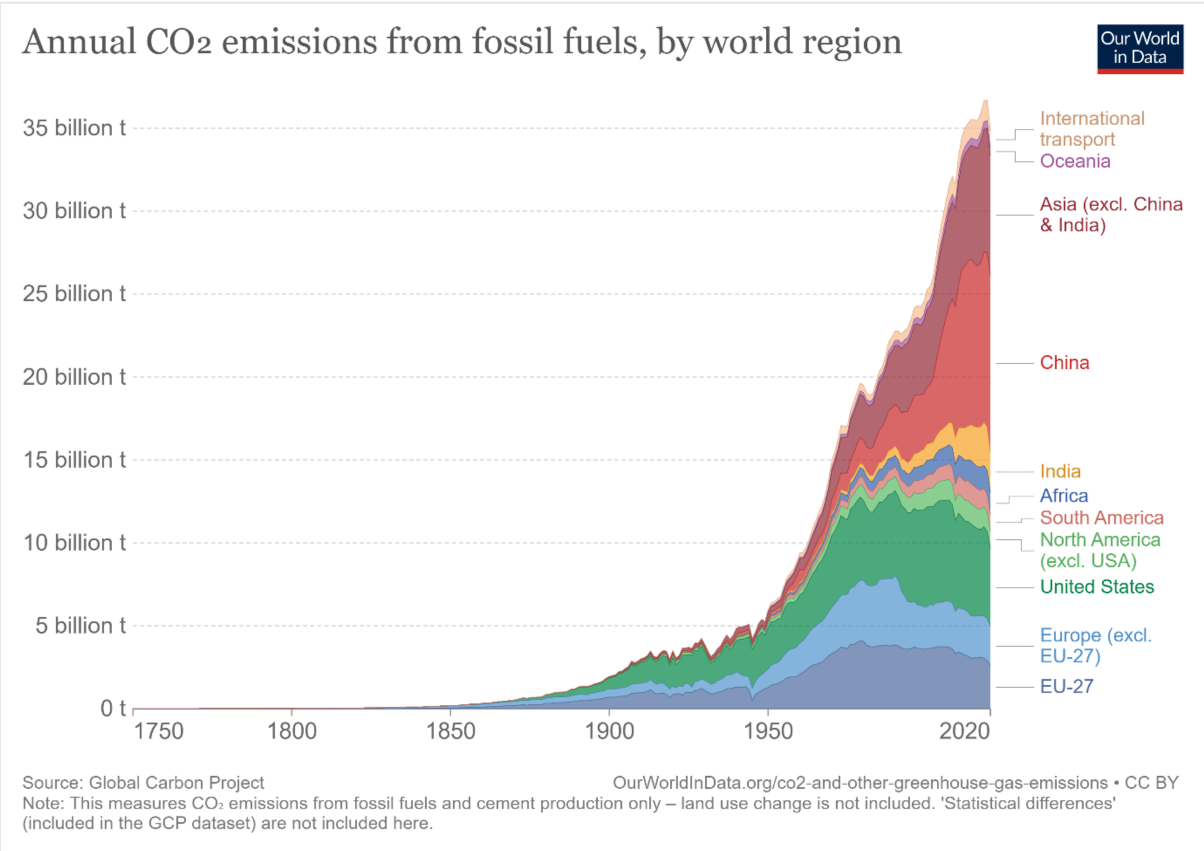

Figure 1: Distribution of CO_2 emissions across the world: 1750 - 2020

Today, the world's three largest emitters, namely India, China, and the United States, are causing 50% of global emissions, along with the fact that nineteen of the world's top thirty emitters are developing countries (Martínez-Zarzoso & Maruotti, 2011; Mott et al., 2021). While GDP per capita has nearly tripled since 1960, carbon emissions have also quadrupled, and two-thirds of these impacts have come forth in the last three decades alone (Figure 2).

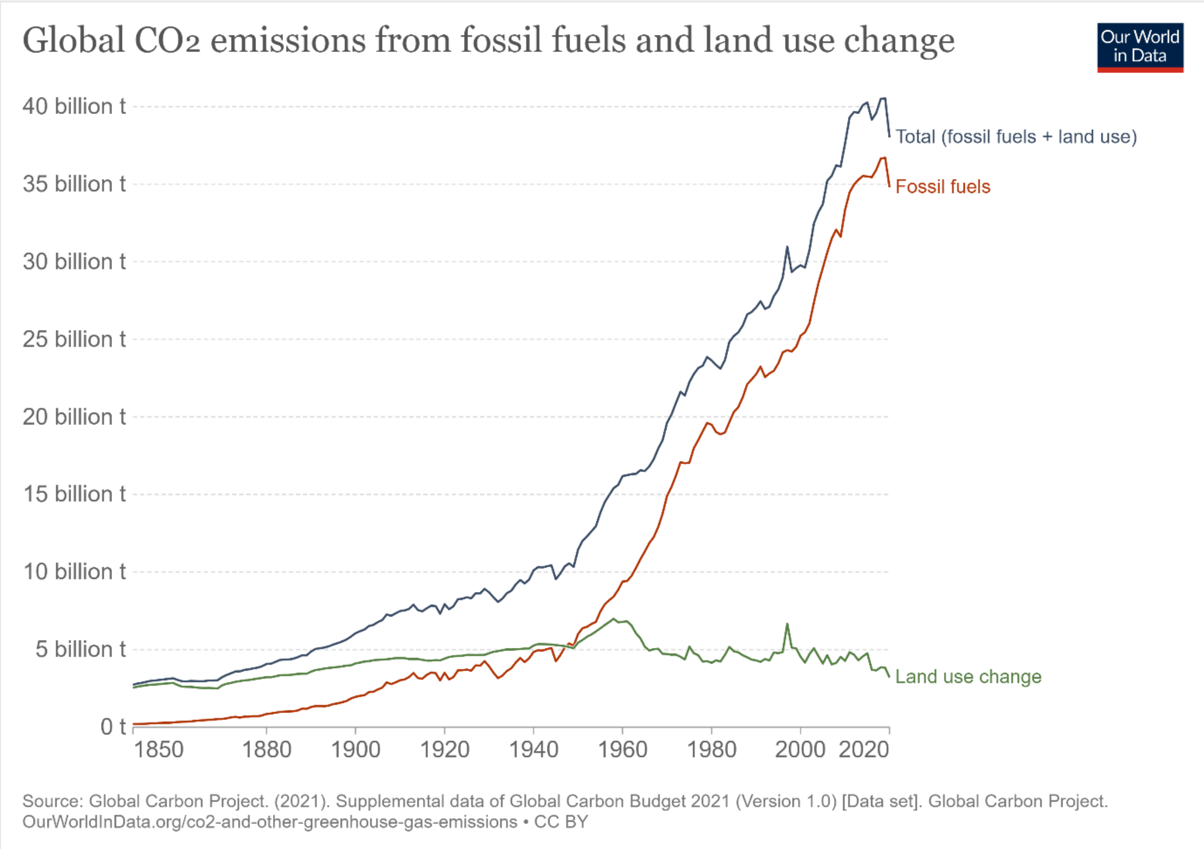

Figure 2: Global CO_2 emissions

Progress and Results of the Kyoto Protocol at the Corporate Level

The EU Emissions Trading System [ETS], a carbon allowance system developed by European countries mainly for meeting the Kyoto Protocol's targets, enables nations to utilize it as a market mechanism for overall reductions in their carbon emissions. It currently operates in all EU countries, as well as Iceland, Norway, and Liechtenstein. It assigns specific allowances to all companies based on their historical performance. If a company ends up with higher emissions than its allowances, it can buy allowances in the ETS market from other companies with higher allowances than their actual emissions. This mechanism allows buying companies to offset their additional emissions against the allowances. Thus, ETS promotes nations to monitor and manage their overall emissions, and companies also have an incentive to decrease their emissions. So far, ETS restricts emissions from around 10,000 installations in the manufacturing industry and the power sector, along with airlines operating in those countries, thereby covering approximately 40% of the EU's GHG emissions (EU Commission, 2022; Freedman & Jaggi, 2011).

The "evolving technology and economies of the climate issue form an important backdrop to business engagement with international negotiations" (Begg et al., 2014, p.24). The Protocol's idea of emissions limits was initially met with opposition from trade associations such as the Global Climate Association, which debated that climate mitigation efforts would impose critical economic damage. However, these claims were unsubstantiated, since it was uncovered that the costs of climate action had been overstated for several years (Begg et al., 2014). Big Oil companies during the 1990s to the 2010s published misleading models of inflated predicted costs, in order to undermine the potential results of climate action and sway public opinion against the effectiveness of international climate treaties (Franta, 2021; TEDx, 2021). Additionally, with the accumulating evidence showing the costs of inaction as well as the proven success of market-based instruments such as the EU's ETS, such claims regarding economic concerns were rendered less viable (Begg et al., 2014, European Commission, 2022). With this cited among other reasons, companies such as BP, General Motors, DuPont, DaimlerChrysler, and Ford withdrew from the Global Climate Association between 1997 to 2000 (Begg et al., 2014).

In light of the developing technological and economic outlook, and moreover, the momentum in the policy process that created new opportunities to influence implementation rules, the establishment of business groups that were more productively engaged with international negotiations began pushing forward. For example, the Business Environmental Leadership Council of the Pew Center on Global Climate Change was formed in support of the Kyoto Protocol, consisting of 37 companies including BP, Boeing, Hewlett Packard, Shell, IBM, Intel, Whirlpool, and United Technologies as a first step in the global collaboration towards addressing climate change. Their mission states that businesses in the U.S. and around the world can and should take concrete steps for setting and meeting emissions reduction targets by investing in more new and efficient technologies, products, and practices. Other such business groups in favor of the Protocol are namely the U.S. and European Business Councils for Sustainable Energy, the EU-Japan Business Dialogue, the U.S.-based Social Venture

Network, and a coalition of 150 European and Japanese companies called E-mission 55, which is joined by Deutsche Telekom and insurance firm Gerling Group (Begg et al., 2014).

Insurance giant Swiss Re has warned that climate change could cut the world economy by USD 23 trillion by the year 2050, through weather impacts and hits to agriculture and industry (Flavelle, 2021). The economic risk has become apparent for many companies, and insurance and reinsurance firms face massive liabilities from increasing weather-related claims. In addition, it is estimated by the World Resources Institute that shareholders in leading oil and gas corporations might lose up to 6% or more of their investment value due to sustainability-related regulations imposed on the industry. Since quantifying these risks, the financial sector's perceived self-interest in negotiations has grown (Begg et al., 2014).

Early research by Freedman and Jaggi (2005) showed a notable positive association between high emissions disclosure rates and companies based in ratifying countries, also stating that these companies were more forthcoming about sharing their comprehensive plans on tackling the climate emergency. In contrast, firms from non-ratifying home countries were not disclosing their emissions data or plans, despite having operations in ratifying countries – and although such firms were still required to comply with the Protocol, they had found a loophole to avoid or diminish voluntary disclosure about their emissions and pollution performance. Their findings also indicated a direct correlation between firm size and disclosure thoroughness, meaning larger companies provided more meticulous disclosures than smaller ones. They claim that there were "no significant differences" in disclosures between the selected firms based on the industry they belonged to, ranging from companies earning revenues of $6 billion or more from the "chemicals, oil and gas, energy, motor vehicles, and casualty insurers industries," which were industries most likely to be impacted by climate change (Freedman & Jaggi, 2005, p.221).

Freedman and Jaggi's (2005) research also had an interesting finding about their sampled Japanese firms, wherein some had disclosed current costs of curbing their carbon emissions, but none had disclosed any forecasted future costs. The authors argue that the absence of such critical cost information would impede even the most experienced financial statements users from gaining clarity on the firm's impact on climate change. The authors suggest that regulators consider making detailed emissions disclosures mandatory to combat the lack of voluntarism from corporations for facilitating investment decisions.

In further studies conducted closer to the end of the first commitment period, Freedman and Jaggi (2011) additionally addressed the differences in disclosure rates within ratifying countries, since developing nations like India and China had ratified the Protocol but had not set any emissions restrictions because they were not required to; only developed nations had to create reductions targets. By sampling 510 firms headquartered in India, Japan, Canada, the EU, and the United States from the Forbes 2000 list of the largest companies worldwide, the authors utilized disclosure data from the companies' websites and their annual statements, ESG, and sustainability reports, as well as CDP questionnaire data. Satisfying their conjectures, corporations from a non-ratifying country like the United States inclined toward lower emissions disclosure rates compared to those from all the ratifying countries, with the exception of Indian firms, whose disclosure rates were even lower than those of U.S.-based firms. In a surprising finding from the same study, Canadian and Japanese corporations had been making substantially greater disclosure contributions than firms from the EU, despite the EU having been a frontrunner both in terms of setting emissions reduction targets as well as disclosure rates. Although Japanese and Canadian companies were not required to start making emissions cuts until 2008, it was determined that firms from the two countries took the issue of GHG pollution with great seriousness, hence such results.

Freedman and Jaggi's (2011) findings were consistent with their own beliefs (Freedman & Jaggi, 2005) and the case made by the New York Attorney General and environmental groups, stating that firms would not provide sufficient disclosures of their own accord; they should be obligated to disclose information more thoroughly since voluntary disclosures were not motivating them enough to improve their sustainability performance.

In encouraging news as of 21st March 2022, the Securities and Exchange Commission [SEC] in the U.S. has approved a landmark proposal mandating all publicly-traded companies to disclose emissions information as well as the climate risks they are subject to. Although several U.S. companies already share emissions data in their annual sustainability reports, there are wide discrepancies between businesses and competitors. This initiative would be the first time that all companies have to report emissions data in a standardized manner to the SEC, where they must detail how climate risks distress their business and strategy. While all companies would have to share information about emissions generated at their own facilities, large firms are additionally required to trace emissions from their suppliers and customers if this information is deemed material to investors or incorporated in the firm's targets. All large companies would also need to have their reported numbers scrutinized by an independent audit firm. The SEC will also obligate corporations that have declared public pledges about cutting their carbon footprint to outline how they aim to reach their goal and provide pertinent data. In addition, any company that has set an ICP must list details about the price and explain how it is implemented. Lastly, companies will be required to disclose how much they intend to rely on carbon offsetting to meet these goals. Similar plans are underway in the U.K. and Japan, which will mandate disclosures from certain large corporations beginning in April 2022, while the EU is also implementing a climate disclosure rule for all large companies listed on the European Stock Exchange starting in 2024 (Joselow & Macmillan, 2022).

CHAPTER 3: PARIS AGREEMENT

In order to combat climate change and mitigate its negative impacts, world leaders at the 21st UN Climate Change Conference of the Parties [COP21] in Paris adopted the breakthrough Paris Agreement in December 2015. It focused on reframing and replacing the Kyoto Protocol to better suit the world's shifting economic and political developments, like the growth of developing countries and the increasing existential peril of climate change (Thakur, 2021; Zhou, 2020). It came into force in November 2016, built upon the foundations laid by the 2009 Copenhagen Accord, with 192 parties currently on board. The primary mission of the Paris Agreement is to keep the global temperature rise well below 2℃, and ideally within 1.5℃, compared to pre-industrial levels (Thakur, 2021; UNFCCC, 2021e; United Nations, 2021).

Keeping the temperature rise below 2℃ requires global emissions in 2030 to be 25% less than 2018 levels (Le Quéré et al., 2019). Figure 3 illustrates different paths towards a lower increase in the temperature anomaly by 2100. To achieve the 2℃ mission, worldwide GHG emissions must peak and swiftly decline. The more stringent the temperature anomaly target, the faster the reduction rate would need to be. Also, the longer the delay, the faster emissions will need to fall to meet the 2℃ target. Current policies are insufficient and will lead to a 2.7 – 3.1℃ increase in the temperature anomaly.

Pathways towards a 2℃ trajectory transpired in the nations of the European Union, where emissions had already peaked and begun to fall in the mid-1970s. There was an especially noticeable continuity in decline in 2005-2015. On the one hand, many European countries hit their peaks and subsequently bring emissions down by switching their energy sources from coal to oil, gas, and nuclear power. However, rapid industrialization in China caused worldwide emissions to spike again beginning in 2000 (Le Quéré et al., 2019).

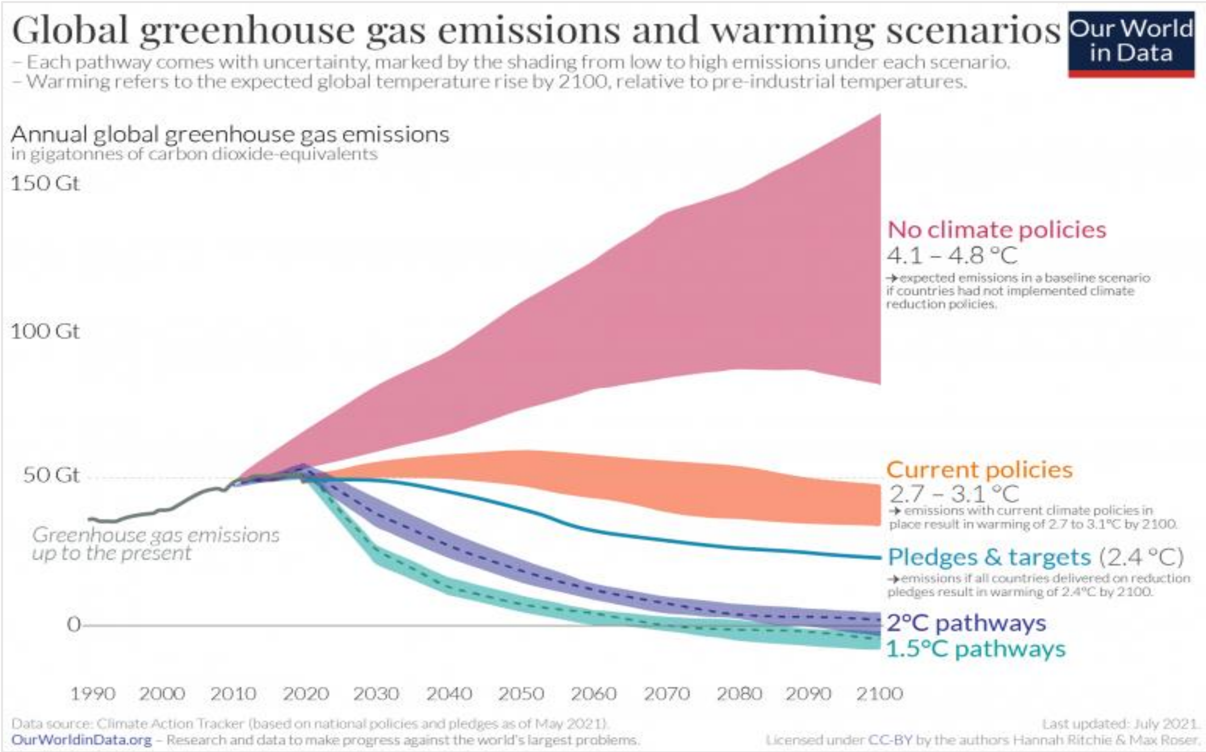

Figure 3: Pathways to a lower increase in temperature anomaly

A study by Le Quéré et al. (2019) showcases the story of a group of nations in the 2005-2015 period comprising 18 developed countries, which represents 28% of worldwide emissions, and how they were able to take the ‘peak-and-decline’ route with between –2.9% and –1.4% emissions reductions per year. These 18 countries were the United Kingdom, Sweden, Romania, France, Ireland, Spain, Bulgaria, the Netherlands, Italy, Germany, Denmark, Portugal, Austria, Hungary, Belgium, Finland, Croatia, and the United States. For example, Sweden increased its GDP while at the same time reducing consumption and production emissions, as seen in Figure 4.

By lowering the fossil share of final energy, the amount of available energy supplied to consumers for end consumption, the peak-and-decline group made emissions reductions of 47% and lowered energy use by about 36%. This policy initiative was the most potent method they employed for reductions, followed by the implementation of different climate and energy policies. By 2015, each country had, on average, 35 policies in place to promote energy efficiency and 23 policies furthering the need for renewable energy. The study highlights a negative correlation of –54% between the number of policies advocating for reduced energy use and, subsequently, the marked declines in energy use. Similarly, decreases in fossil share of energy were negatively correlated by –75% with policies on renewable energy. Finally, decreases in total emissions were also negatively correlated with the number of climate policy frameworks in place. Thus, these notable negative correlations indicated how emissions were reduced at a larger scale by implementing a higher number of climate policies. From the results of this study, the authors concluded that future emissions reductions are contingent on persistent decreases in fossil shares in energy and structural decreases in energy use altogether, for which policy support will need to be bolstered (le Quéré et al., 2019). The framework of their analysis is discussed in the Methodology section under 'The IPAT Framework at the Corporate Level'.

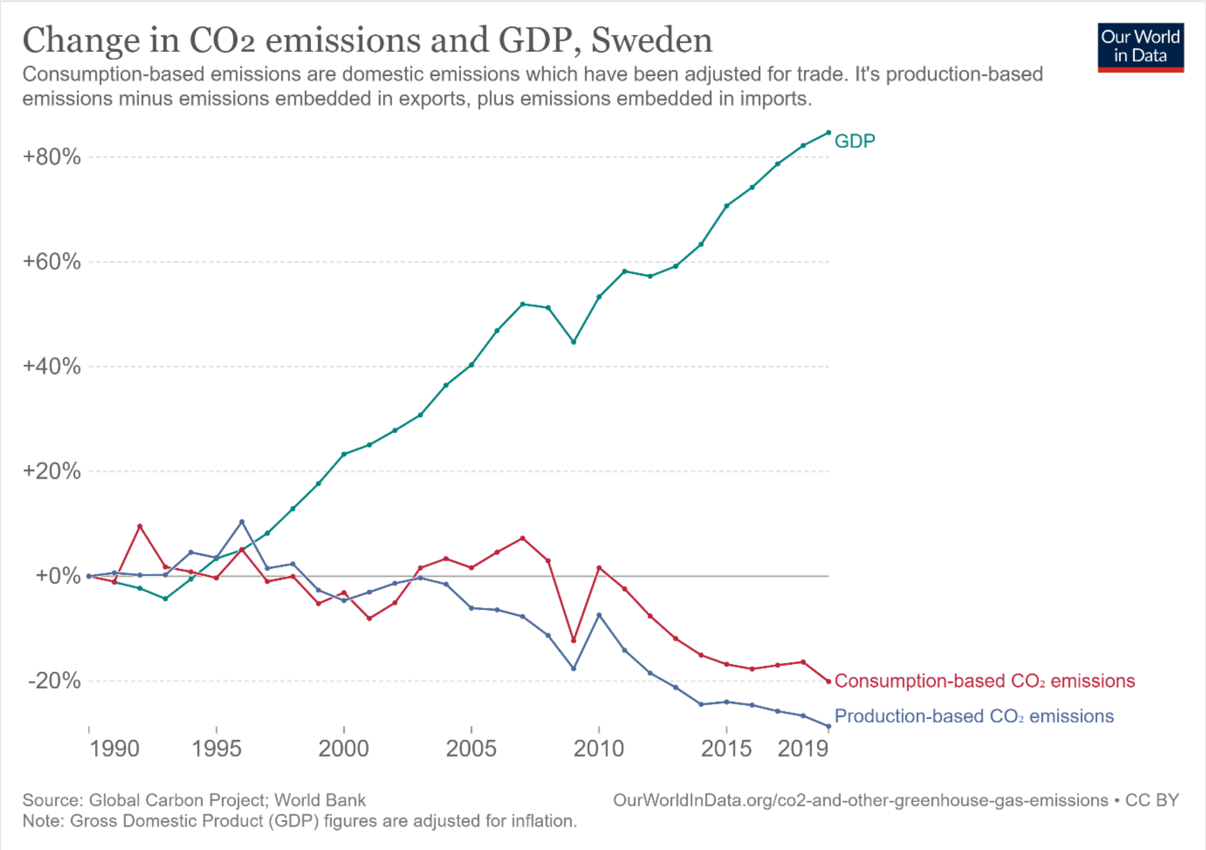

Figure 4: Sweden's decoupling of CO_2 emissions with the economy

Progress and Results of the Paris Agreement at the National Level

As of 22 September 2021, Turkey announced it is preparing to ratify the Paris Agreement before the year's Conference of the Parties [COP26] in November 2021 in Glasgow (Hacaoglu, 2021). The United States also re-joined after coming under the Biden administration since its withdrawal from the Agreement when Donald Trump was U.S. President (Denchak, 2019).

Like the Kyoto Protocol, the Paris Agreement provides pathways for developed nations to assist developing countries financially and technologically, making for collaboration towards controlling and alleviating the impacts of climate change. However, unlike the Kyoto Protocol, the Paris Agreement urges all parties – rich or poor, developed or undeveloped – to do their part and slash GHG emissions (UNFCCC 2021e, United Nations, 2021). A noteworthy positive outcome of this policy has been on China, which previously had no restrictions under Kyoto. Although the country generates a quarter of the world's GHG emissions on its own today and has been the biggest global CO_2 producer since 2006, China is now leading the switch to green energy in an effort to align with the Paris Agreement's 2°C goal. As of 2020, China's solar power generation is 3.3 times more than that of the United States and the highest in the world, as are its wind power installations being triple that of any other country (Brown, 2021).

NDCs are Nationally Determined Contributions that each party is obligated to report, where they must outline their climate actions such as targets, policies, and government measures and their progress in meeting them. The Agreement requires all parties to review and increasingly strengthen their commitments every 5 years (UNFCCC, 2021b; UNFCCC 2021c; UNFCCC 2021e, United Nations, 2021). Notably, unlike its predecessor, the Kyoto Protocol, the Paris Agreement does not legally bind parties to meeting their emissions reduction targets. While the legal obligation did prompt action in Annex I participants and added to the effective implementation of the Kyoto Protocol, it also proved to have negative economic impacts on their GDPs. Although, since the Paris Agreement monitors developing countries and holds them equally responsible for lowering emissions, it is expected that in this climate treaty and the next ones, these lower-income countries will be given adequate financial and technological support from industrialized nations, which would also protect them from incurring economic losses when adjusting to new climate regimes (Kim et al., 2020).

Other factors to consider in the efficiency of the Paris Agreement are that developing nations are not solely responsible for the damages they deal to the environment; a lot of this damage is due to industrialized nations' involvement and consumption demands. For example, deforestation is the second-largest source of anthropogenic GHG emissions and costs the world between USD 2 to 5 trillion annually in forest loss (Pendrill et al., 2019; Kindermann et al., 2008; Black, 2008). According to a CDP (2020) report, 80% of deforestation is brought about by the agriculture and forestry industries, driven by demands for cattle, palm oil, soy, and timber. Here is the issue of 'outsourcing' deforestation: recent research by Hoang and Kanemoto (2021) indicates that five of the G7 countries, namely Germany, France, Japan, Italy, and the United Kingdom, have 91-99% of their deforestation footprints in nations abroad, attributing 46-57% of this to tropical deforestation in 2015. With the exception of Norway and Sweden, tropical deforestation is driven by developed nations' demands and consumption patterns, which sharply amplified their GDP per capita from 2001 to 2015. Their dependency on tropical deforestation has also grown since not much change has occurred in their international trade patterns. While industrialized nations pocket economic gains, the tropical deforestation footprint is charged to net exporters of its commodities, meaning developing countries such as Brazil and Indonesia (Hoang & Kanemoto, 2021). Kindermann et al. (2008) promote avoided deforestation as a more cost-effective addition to the existing forest management methods that climate policy considers, encouraging that carbon markets could create more opportunities for this solution. Reforestation techniques could move us closer to reaching the Paris Agreement's goals (The Economist, 2015).

The recent NDC Synthesis Report by the UNFCCC in 2021 regrettably shows that while the majority of countries have elevated their ambitions, they are still not on track to meet the conditions of the Paris Agreement, and developing countries remain in critical need of support in order to take climate action (UNFCCC, 2021g). The global energy system continues to be dominated by fossil fuels, which account for 81% of primary energy demand (Welsby et al., 2021). After having seen decades of growth, reductions in their rate of production and utilization are imperative for meeting the internationally pledged targets for climate action. Research suggests that 33% of oil, 50% of gas, and 80% of coal reserves in the world must stay untapped to keep temperatures below the 2°C limit. To gain at least a 50% chance of achieving the more aspirational objective of the Paris Agreement and keeping warming below 1.5°C, 58% of oil reserves, 59% of gas reserves, and 89% of coal reserves must remain in the ground (Welsby et al., 2021; Spash, 2016; Nogrady, 2021).

Spash (2016) attempts to promulgate the deficiencies of the Paris Agreement, insinuating that it will never reach even the more relaxed target of keeping the temperature rise below 2°C, far be it 1.5°C. Spash (2016, p.929) attributes this "failure to be anywhere near on target" to strategically ambiguous wording that does not highlight the sources of anthropogenic GHG emissions or the structures that generate them, and no mention of oil, natural gas, coal, or fracking. The author emphasizes that in fact, the Paris Agreement encourages further industrialization, economic growth, and energy use under one of its resolutions in the opening statements, and given the outlined actions and current trajectory of progress, we are past meeting the 2°C target and will likely reach 3°C of global warming (The Economist, 2015; Spash, 2016).

Progress and Results of the Paris Agreement at the Corporate Level

A study by Dietz et al. (2018) analyzed 138 of the largest companies globally, operating in sectors with high carbon footprints, comprising the oil and gas, coal mining, cement, automotive, electricity, steel, and paper industries, for the period of 2013-2030, including present and past performance as well as projections for the future. Their research about the current scenario pinpointed the following findings: 85% of the 138 companies had made a public pledge or published policy regarding the issue of climate change and that they intended to reduce emissions or improve their energy efficiency towards that end. But only 40% expressed support for the role of public policy in mitigating climate change, while 67% stated that climate change was material to their business. Another finding showed that although 77% of the companies disclosed their operational emissions, only 47% used an international assurance standard or had the data verified by an independent third party. Notably, only 38% of these 138 firms had set a long-term, time-specific quantitative target for increasing energy efficiency or lowering emissions, meaning up to at least five years from the date of their pledge. In addition, 49% explicitly designated a board member of the company responsible for overseeing their climate change policy, and 47% incorporated environmental, social, and governance [ESG] concerns into executive compensation.

Dietz et al. (2018) also found sector, size, and region to be associated with the implementation of carbon management practices: the automotive manufacturers had implemented the most, while steel and coal mining businesses were lagging the farthest behind; corporations with a large market capitalization were implementing more than medium- and small-capitalization companies; and those headquartered in Western Europe and the Asia-Pacific region were more active implementers than those in emerging markets and North America. To see improvement in the performance of mining firms, Mebratu-Tsegaye et al. (2021) recommend that governments should mandate the inclusion of climate risk assessments into mining contracts, restrict deforestation by holding mining companies accountable for all direct, indirect, and induced impacts on forests during operations, regulate water use efficiency with penalties for overuse or release of non-treated waste water, and integrate renewable energy sources into mining projects. Since the steel sector generates 8% of the world’s total carbon emissions, Bhatnagar (2021) proposes the need for steelmakers to adopt newer technologies like carbon capture that can recycle up to 90% of exhaust gas, use green hydrogen or alternative smelting reduction procedures, capitalize on increased sustainable steel production, and focus on enhancing their ESG performance not just for the sake of meeting regulations but also to better manage stakeholder expectations.

Dietz et al. (2018) also set out to assess how many companies were commensurate with the Paris Agreement's primary goal of limiting the temperature rise to below 2℃ using NDCs, and they discovered that in the 41 out of 138 companies that even had targets, only 59% were aligned with NDCs and the 2℃ benchmark. Naturally, the aligned companies had implemented more robust carbon management practices, albeit this excluded the majority of firms in the study since they had either not created or aligned targets. Thus, Dietz et al. (2018) revealed that while many companies had taken the first steps towards addressing the need for climate action, only a handful had progressed to more advanced stages of setting long-term time-specific targets or involving board members in executive decisions for policy-making, especially towards meeting the goals of the Paris Agreement.

Another high-emitting business sector explored in this thesis is retail, placing among the top ten most carbon-intensive industries. Due to its extensive hold on the consumer market, the retail industry holds the key to influencing consumer behavior, trends, and preferences. Retail can also affect changes in the construction industry by influencing the supply stream of materials and technology used in construction (Ferreira et al., 2019). In a study conducted on the top 27 retailers in the world, Ferreira et al. (2019) share largely positive findings, stating that 85% of them publish sustainability and Corporate Social Responsibility [CSR] reports every year, with 63% of retailers also publicly supporting and aligning their targets with those of the Paris Agreement. In addition, standardized reporting has seen an upward trend, with 89% of retailers adhering to reputable sustainability frameworks like the GHG Emissions Protocol, 81% following the CDP, and 78% adhering to the Global Reporting Initiative. With both investor and consumer perceptions in mind, retailers are forming a proclivity for better transparency and accountability, even more so since the Paris Agreement. In most retailers' CSR reports, absolute GHG emissions reductions are emphasized, with long-term commitments of up to 30 years listed as well, while some retailers such as Carrefour and Target have also released short-term climate targets. Retailers have also been found to either follow upon or improve their nations' NDCs (Ferreira et al., 2019).

CHAPTER 4: THE IPAT FRAMEWORK

IPAT Framework at the National Level

As discussed in the introduction, the IPAT, formulated by Commoner, Ehrlich, and Holdren in the 1970s, argues that the driving forces of environmental impact are population, affluence and technology (Chertow, 2000). The IPAT, also known as the Kaya formulation, is a simple but powerful identity for establishing targets and the requirements for technology (i.e., the carbon intensity of production) to offset economic growth while at the same time reducing emissions to hit the set targets. Although a powerful tool to guide policymakers, its limitation is that one cannot derive causal relationships amongst its factors. Therefore, the IPAT at the national level can be stated as:

$$I = P * A * T$$

Where *I* represents environmental impact, calculated through population *P*, affluence *A* and technology *T*. Operationalizing the above in terms of CO_2 emissions, the framework becomes:

$$CO_{2,t} = P_t * \frac{GDP}{P}_t * \frac{CO_2}{GDP_t}$$

where the impact *I* is measured by the nations' CO_2 emissions at time *t*, while the drivers are population at time *t*, and affluence *A*, which is calculated using GDP per capita as a crude measure of the standard of living of a nation, and technology is measured by emissions per $ of GDP (i.e., carbon intensity). The key for emissions reductions is reducing carbon intensity rather than population and affluence, which would have ethical implications as well as acceptability concerns for the public. The difficulty with achieving 2030 targets through emissions reductions is that it will be done under an expanding population and affluence, which are forces that add to GHG emissions, thus making it more challenging to achieve the targets set by the respective nation. Chapter 9 illustrates what it would take for Canada to hit its ambitious 2030 target (i.e., 40-45 percent below 2005 levels by 2030) (Environment and Climate Change Canada, 2021). The Kaya identity can also be expressed in growth rates as follows:

$$g_{e,t} = g_{p,t} + g_{A,t} + g_{T,t}$$

where $g_{e,t}$ represents the growth rate of emissions at time *t* relative to past years, $g_{p,t}$ represents the growth rate of population at the same time period *t*, $g_{A,t}$ measures the growth rate of affluence (i.e., measured as the rate of growth of GDP per capita), and finally $g_{T,t}$ measures the growth rate of carbon intensity. For example, if the population is rising at 2% and affluence is rising at 6%, then carbon intensity has to decrease more than 8% for emissions to start falling. Note that carbon intensity could decline over time; however, this does not mean that emissions are decreasing. A declining carbon intensity can be caused by GDP rising faster than emissions are increasing. China has carbon intensity targets allowing it to increase emissions, but at a rate that is slower than its fast-growing economy, since it currently pledges to reduce CO_2 emissions per unit of GDP by over 65% from 2005 levels, by the target year of 2030 in alignment with its Paris Agreement goals. As of 2020, China had cut its CO_2 intensity by 48.4% below 2005 levels, thereby surpassing its "40-45%" pledge announced towards the Copenhagen Accord at the 2009 UN Climate Summit (Liu & You, 2021). However, after an economic rebound from the COVID-19 pandemic during the first quarter of 2021, China's emissions grew by 14.5%, the most rapid pace in a decade, primarily due to ramped up fossil fuel and cement production (Myllyvirta, 2021).

A reformulation of the IPAT is the ImPACT by Waggoner and Ausubel (2002), which attempts to associate the driving forces of impact *I* to population *P* and affluence *A* just as the earlier version, measured using GDP per capita. However, it breaks the technology part from carbon intensity (i.e., CO_2 per $ of GDP) with the dematerialization or intensity of energy use *C*, measured by energy used per $ of GDP, and efficiency *T*, which is the carbon intensity of energy used. Expressed as:

$$I = P * A * C * T$$

The ImPACT, like the IPAT, has been applied at the aggregate level rather than at the organizational level. Different combinations of these four factors yield results pertaining to the sustainability challenges of an increasing *PA* using two sustainability levers *CT* to regulate the economic expansion. ImPACT shows a need to slow population growth P and raise A, encourage successful conservation efforts in *C*, and regulate pollution in *T*. In terms of CO_2, it would be expressed as follows:

$$CO_{2,t} = P_t \frac{GDP}{P}_t \frac{FE}{GDP_t} \frac{CO_2}{FE}_t$$

where, for example, energy use is expressed in terms of British thermal unit (Btu) used in a given period. Waggoner and Ausubel (2002) examined GHG emissions for the world during the 1990-1997 period, which was prior to the Kyoto Protocol, and compared it to the 1950-

1990 period examined by Hoffert et al. (1998) using the IPACT. During 1950-1990, the latter authors found that world energy intensity of producing a $ of world GDP declined by 0.3% per year on average, and carbon intensity of energy improved by 0.4% per year, which in a fast-growing world economy at the rate of 3.7% moderated the increase in emissions to about 3% per year. For the 1990s, Waggoner and Ausubel (2002) estimated the slowdown of income growth, with the continued reduction in the intensity of use to produce a $ of GDP as well as faster efficiency. These changes kept emissions to 0.5% per year from the 3% per year during 1950-1990.

Waggoner and Ausubel (2002) speculated that an ImPACT analysis could relay some foresight about the Kyoto Protocol's targets for the first commitment period because the ImPACT can gauge the practicability of targets and timetables identifying how forces must change to achieve a goal. Since Kyoto endeavored for industrialized nations to reduce their emissions by 5% compared to 1990 levels in the first commitment period of 2008-2012 (UNFCCC, 2021f), Waggoner and Ausubel (2002) started their analysis by comparing the aspirations of two countries: France and the United States, firstly during the 1980-1990 period, to understand the emissions situation Kyoto negotiators would have assessed for that decade. While population *P* grew slowly in both nations, income *A* rose rapidly. Moreover, both nations had also lowered their energy intensity use *C*, meaning per capita use was left almost unaltered, implying an income elasticity near zero. As a result, efficiency *T* of carbon emission per energy had mildly improved in the U.S., but France saw remarkable improvement, as the latter moved to nuclear energy power. This driving force resulted in national emissions in France falling by 2.8% per year with expanding affluence, while emissions were on a slow rise of 0.5% in the U.S. As for what was required by Kyoto, the U.S. needed a national emissions decline of 1.4% to reach its target of 93% of 1990 emissions for the 1997-2010 period. For the same period, France also needed a 0.8% decline to meet its 92% target of 1990 emissions levels. To calculate how these declines would follow through in light of the four forces of the ImPACT model, the authors found that the U.S. would have had to match France's efficiency *T* of carbon emissions per energy from its 1980s levels, while France would simply have had to continue pursuing its trend of drastic improvement.

In reality, the 1990-2000 period saw the following actual changes: Income *A* grew mainly in the U.S. while both nations experienced a moderate growth in population *P*. Intensity of energy use *C* declined in the U.S., thus implying income elasticity of 0.3, but *C* did not decline in

France, implying a full elasticity of 1. While efficiency *T*, measured as carbon emissions per energy, was seeing improvements in both countries, it was slower compared to France's 1980s performance and even slower still for both nations to meet their Kyoto targets (Waggoner & Ausubel, 2002).

After the Kyoto agreements reached in Bonn and Marrakech in 2002, targets were relaxed. From this point on, Waggoner and Ausubel (2002, p.7864) were using the ImPACT for predicting the changes in performances needed by France and the U.S., wherein they anticipated that reaching either actual or relaxed Kyoto targets demanded "unlikely behavior" from both countries. In terms of meeting even the relaxed targets, they proposed that the U.S. would have to apply its sustainability levers to bring down $C + T$ from the annual declines of 1.8% in the 1990s to 4.3%. Meanwhile, France would also need to push its 0.9% decline of the 1990s to 3.2%. Waggoner and Ausubel (2002) showed that therefore, ImPACT is a swift and transparent tool for evaluating the changes required for accomplishing environmental goals and testing their practicability.

As discussed previously, le Quere et al. (2019) explored the drivers of declining CO_2 emissions in 18 developed economies by focusing on the decomposition of technology into four compartments. First, total final energy use, FE. Second, the fossil fuel share of final energy use, $\frac{FE_{ff}}{FE}$. Third, the fossil fuel utilization rate, $\frac{PE_{ff}}{FE_{ff}}$, where primary fossil energy is PE_{ff} and fossil final energy use is FE_{ff}, meaning the energy used and lost from extracting fossils and converting them into fuels for providing heat or electricity for final consumption. Finally, the fossil fuel intensity is represented by $\frac{CO_2}{PE_{ff}}$, which indicates the amount of CO_2 from a unit of primary energy. Their formulation is as follows:

$$CO_{2,t} = GDP_t \left(\frac{FE}{GDP}\right)_t \left(\frac{FE_{ff}}{FE}\right)_t \left(\frac{PE_{ff}}{FE_{ff}}\right)_t \left(\frac{CO_2}{PE_{ff_t}}\right)$$

With the corresponding growth rates, their evidence indicates that the largest contributor to the reduction in CO_2 emissions is energy use FE, followed by fossil share, while the fossil utilization rate and fossil CO_2 intensity have an insignificant role in reducing emissions. Le Quéré et al. (2019) highlight that between the 2005-2015 period, carbon emissions sourced from fossils fuels and industries worldwide saw an annual increase of 2.2% on average. Among the group of eighteen industrialized countries analyzed by le Quéré et al. (2019), decarbonization and falling emissions are explained by displacing fossil fuels through renewable energy. However, the decrease in energy use can partly be attributed to slower GDP growth. While renewable energy policies seem to bolster emissions reductions and fossil fuel displacement, such results were only found in these 18 countries and not anywhere else. Still, policies that support energy efficiency seem to be dropping energy use worldwide, not just in these 18 countries. Results from le Quéré et al.'s (2019) paper are expanded on in the *Paris Agreement* section of this thesis.

Recent research advocates adding another driver to the IPAT to account for factor input substitution by reformulating the IPAT to an 'IPAST' model (Bretschger, 2021).

$$I = P * A * S * T$$

where for impact *I*, Bretschger (2021) uses fossil fuels *FF* instead of GHG emissions, arguing that combustion of these natural resources is the source of emissions. Hence reducing the use of fossil fuels will reduce emissions. Instead of population, Bretschger (2021) uses the labor force *L*, highlighting the role of the workforce instead of the population in producing fossil fuels. This reformulation of the population force is essential for applying the IPAT to corporations. In terms of affluence, it is replaced with labor productivity. This change is also an important element for the application of IPAT to corporations. Finally, technology is represented by the intensity of inputs *FF/GDP*, equating to how much fossil fuel usage per $ of GDP, which is the inverse of the productivity of fossil fuels, namely how much GDP a unit of fossil fuel (i.e., barrel of oil) produces. The IPAT is then:

$$FF_t = L_t \frac{GDP}{L}_t \frac{FF}{GDP_t}$$

And in growth rates expressed as follows:

$$g_{FF,t} = g_{L,t} + g_{A,t} + g_{T,t}$$

To arrive at the PAST, Bretschger (2021) added a substitution force as a "driver" of resource use and extending the IPAT identity by an additional term *K*, representing production inputs other than fossil fuels, such as a "broad (real) capital" (e.g., human capital, equipment, buildings, dams, and windmills to produce renewable energy). The substitution force *S* is measured by fossil fuels used per capital unit. For example, a reduction in *FF* can be achieved by increasing human capital and reducing fossil fuels to generate GDP. Technology in this model is measured by the amount of the broad capital excluding fossil fuels per $ of GDP produced. This factor could be falling because GDP increases slower than *K* increases. The

IPAT then is:

$$FF_t = L_t \frac{GDP}{L}_t \frac{FF}{K}_t \frac{K}{GDP_t}$$

With the equivalent expression in growth rates.

IPAT Framework at the Corporate Level

The IPAT model reformulated and adopted at the company level can provide information on corporate environmental impact in driving forces and facilitate decision-making to achieve future targets with a growing demand for the corporations' products and services. However, can these formulations be applied at the organizational level? What would the sustainability challenges be at the organizational level, and what levers would be needed to control the challenges?

As the determinants of ICP, technological progress and innovation in the IPAT offer critical insights into the valuation of carbon and its reduction. As per the da Silva et al. (2019) study, 'technology' was computed by focusing on emissions, water consumption, energy consumption, generation of effluents, and waste production relative to the company's production levels. Apart from technology, they used 'production' as the second factor, replacing GDP (i.e., *PA*). Thus, their IPAT-e rendition of the IPAT model replaced certain original factors more relevant to business calculations and formulated it as Impact = Production x Technology, which essentially measures the carbon intensity of firms over time. When applied to contemporary organizations, their IPAT-e model was additionally able to analyze which particular area(s) of the technology factor they could improve their performance in, such as Vale Company's inefficiencies in atmospheric emissions, water consumption, and solid waste, or Fibria's weakness in energy consumption.

In this thesis, the simple IPAT is formulated as follows:

$$CO_{2e,t} = R_t \left(\frac{E}{R}\right)_t \left(\frac{CO_2}{E}\right)_t$$

At the corporate level, the forces of emissions include firstly the size of the firm, as determined by revenue per year to capture the equivalent of the size of the economy as per GDP, and secondly technology, captured from the ImPACT – a reformulation of the original IPAT by Waggoner and Ausubel (2002). Technology is broken down to energy per unit of revenue, which measures energy efficiency and emissions per unit of energy, thus measuring technological changes.

In **Table 1**, “I” stands for environmental impact, which is what we aim to assess. “P” is for population and “A” is for affluence, which both represent the size of the firm. “C” denotes intensity of energy use, and is levered by the organizations or producers themselves, since the extent of their energy consumption is in their hands. “T” represents technology and sheds light on the sources of energy that firms or producers rely on for their operations. For example, the carbon intensity of energy would matter here as it is the organization’s choice to choose either renewable sources of energy or fossil-based ones. See Column 2.

Table 1: Symbols for environmental impacts at the firm level

Category	IPAT Symbol	Corporate Symbol	Actors	Dimension
Impact	I	$CO_{2e,t}$	All	Emissions
Revenue	P*A	R_t	Consumers	Size of the firm
Energy intensity of revenue	C	$\left(\frac{E}{R}\right)_t$	Consumers and Firms	Energy efficiency
Carbon intensity of energy	T	$\left(\frac{CO_2}{E}\right)_t$	Firms	Sources of energy
Consumer and producers challenge	R*T	$R_t\left(\frac{CO_2}{E}\right)_t$	All	Size and technology
Technology challenge	R*C	$R_t\left(\frac{E}{R}\right)_t$	Firms/Producers	Energy
Sustainability challenge	P*A	R_t	All	Revenue
Sustainability levers	C*T	$\left(\frac{E}{R}\right)_t\left(\frac{CO_2}{E}\right)_t$	Firms/Producers	Emissions per unit of revenue

The actors drive these forces of change, suggested Waggoner and Ausubel (2002), who designated four actors. Namely, parents being responsible for population (P), workers for affluence (A), consumers for intensity of use (C), and producers for efficiency (T). At the firm level, there are only two actors. Consumers determine the revenue of the firm and the intensity of revenue, while firms control the intensity of energy and carbon (C and T). See Column 4.

Thus, we can understand the three challenges; firstly of the consumers and producers, then of technology, and finally sustainability. These challenges can be controlled using the sustainability levers (C*T). The challenges that consumer and producers jointly face is revenue and technological challenges. The sustainability challenge is to keep revenue growing using the levers to meet target reductions. The technology challenge is in terms of energy use.

Consumers ultimately can exercise their power over corporations by influencing demand for sustainable products and services from companies that show less environmental responsibility, while favoring those that are achieving or directing resources towards sustainable goals. Companies have to embrace innovation, accept responsibility for the environmental impact they cause, and adopt greener practices and technologies, without bearing losses. In the next chapters, the thesis proves how accomplishing this is a real, lucrative possibility for organizations.

CHAPTER 5: METHODOLOGY

You cannot manage what you do not measure. Since carbon emissions account for 81% of overall GHG emissions (US EPA, 2022b), businesses need to start monitoring their carbon emissions if they want to reduce or even eliminate them. The GHG Protocol's corporate standard classifies companies' GHG emissions into three scopes, out of which Scopes 1 and 2 are mandatory to report (Bernoville, 2022). Under Scope 1 are direct GHG emissions, caused by the company's controlled or owned resources, such as fuel combustion occurring in boilers, furnaces, and vehicles, or also emissions released through industrial processes and manufacturing. Scope 2 includes indirect emissions that are the result of energy purchased from a utility provider, such as electricity, cooling, heating, or steam (US EPA, 2022c; Bernoville, 2022). Scope 3 emissions are also indirect emissions, which are generated by resources not owned or controlled by the reporting company, but are still associated with the company's operations and indirectly impact its value chain (US EPA, 2022a). Although these are often the biggest source of emissions for companies, Scope 3 emissions are notoriously hard to monitor and also only voluntary to report. There are several high-emitting activities that companies commit regularly which count as Scope 3 emissions, such as waste generation, transport and distribution, leased assets, franchises, capital goods like buildings and machinery, and usage of sold products over time by consumers (Bernoville, 2022; US EPA, 2022a).

For analyzing company scope 1 and 2 emissions data in this thesis, 102 large corporations have been chosen from the United States and Europe, of which 50 are in the U.S. and 52 are spread across the European countries of Denmark, Finland, France, Germany, Norway, Sweden, and the United Kingdom. Although many of our chosen companies are well-known brands that have worldwide operations, we have selected only one country where each operates (e.g. Coca-Cola's operations in the U.S., Adidas' in Germany, Carrefour's in France, etc.). A complete list of these 102 corporations is provided in Appendix 1. The period investigated was from 2017-2020 with 2017-2019 the post-Paris Agreement and pre-COVID period, while the 2020 year was the COVID period. Data came from the Carbon Disclosure [CDP] database, which is discussed in the next section.

We aimed to choose five companies per industry from each region; i.e. five from Europe and five from the United States, to include a maximum of ten companies per industry. The final 102 corporations are distributed among the eleven industries listed below, including one example from Europe and the U.S. respectively, in brackets:

1. Apparel [Burberry, Nike];
2. Biotech & Big Pharma [GlaxoSmithKline, Pfizer];
3. Food, Beverage and Agriculture [Danone, Dr. Pepper];
4. Fossil Fuels [Equinor, ConocoPhillips];
5. Manufacturing (Automobiles) [BMW, Ford];
6. Manufacturing (Electronics) [Nokia, Apple];
7. Materials (Chemicals, Personal Care, & Household Products) [Unilever, Proctor & Gamble];
8. Power Generation [Ørsted, Duke Energy];
9. Retail (Hypermarkets and Department Stores) [Marks & Spencer Group, Walmart];
10. Services (Banks) [HSBC, Morgan Stanley];
11. Transportation Services (Airlines) [Lufthansa, American Airlines].

Energy is the highest-emitting industry globally as it includes pollution from electricity, heat, and transport, thus, it alone accounts for 73.2% of GHG emissions. The next biggest offenders are agriculture, forestry, and land use, accounting for 18.4%, then industrial processes involving chemicals and cement, which contribute 5.2%, and also waste, which generates 3.2% of worldwide GHG emissions (Richie & Roser, 2020). As mentioned earlier, retail is also among the top ten most carbon intensive industries (Ferreira et al., 2019). Therefore, this thesis analyzes Scope 1 and 2 emissions in companies from some of the highest-emitting industries, such as power generation, transport (aviation and automobiles), fossil fuels, chemicals, food and agriculture, retail, apparel, financial services, and manufacturing.

Carbon Disclosure Project [CDP]

Founded in 2000, the CDP is a not-for-profit charity that operates a worldwide disclosure system aiming to create sustainable economies by helping companies, investors, cities, nations, states, and regions spanning over 90 countries to measure and manage their environmental impacts. The CDP is heralded for being a rich source of environmental reporting, with its extensive datasets about the climate action and planning that cities, countries, and corporations are undertaking (CDP, 2021a). As of 2020, the CDP is receiving carbon pricing data reported by 5,900 companies globally (CDP, 2021b). Companies that disseminate GHG emissions data voluntarily through the CDP are inclined to perform better on the environmental and CSR front (Ferreira et al., 2019).

The CDP also works in collaboration with the Carbon Accountability Institute [CAI], an organization dedicated towards researching anthropogenic climate change, hazardous interferences with nature's systems, and the involvement of fossil fuel producers in generating carbon to atmospheric carbon dioxide content (CAI, 2019). While large-scale data on GHG emissions is usually gathered at the country-level, the Carbon Majors Database, established by researcher Richard Heede from the CAI, traces emissions to a smaller set of commercial decision-makers (CDP, 2017). Heede's (2013) work finds that the brunt of anthropogenic climate change, which is about two-thirds of the carbon dioxide released since the year 1750, can be attributed to the world's 90 largest cement and fossil fuel producers, the majority of which are still in operation as of today (CAI, 2020). Additionally, over 50% of worldwide industrial GHG emissions since 1988 are attributable to only 25 corporate and state producers. Heede's (2013) research also identified the top 20 companies on the list, including Saudi Aramco, Chevron, Exxon, and Shell, to be responsible for 35% of the world's total carbon emissions, equaling more than 529 billion tons of CO_2 since 1965 (Taylor & Watts, 2019). Most of these companies have since accepted responsibility and commented on the efforts and technological innovations they will be investing in to reduce their future impact on environmental degradation (Taylor, 2019).

The Kyoto Protocol and Paris Agreement may lead to the implementation of national policies and regulations, which will affect corporations and the countries in which they are based. This regulatory action by nations may create new risks, challenges, and opportunities for companies that could eventually influence their governance. Risks and governance are what formulate the company's strategy, both of which influence corporate actions towards environmental sustainability, through initiatives such as more robust engagement with their suppliers and consumer base regarding their sustainability strategy, setting stricter targets, and techniques like ICP – provided there is no national pricing of GHGs (CDP, 2021b). Finally, the results of these initiatives will show emissions levels and energy use of the companies. This thesis will use the CDP database to examine corporate strategies that lead to emissions and energy use reductions, as depicted in Figure 5.

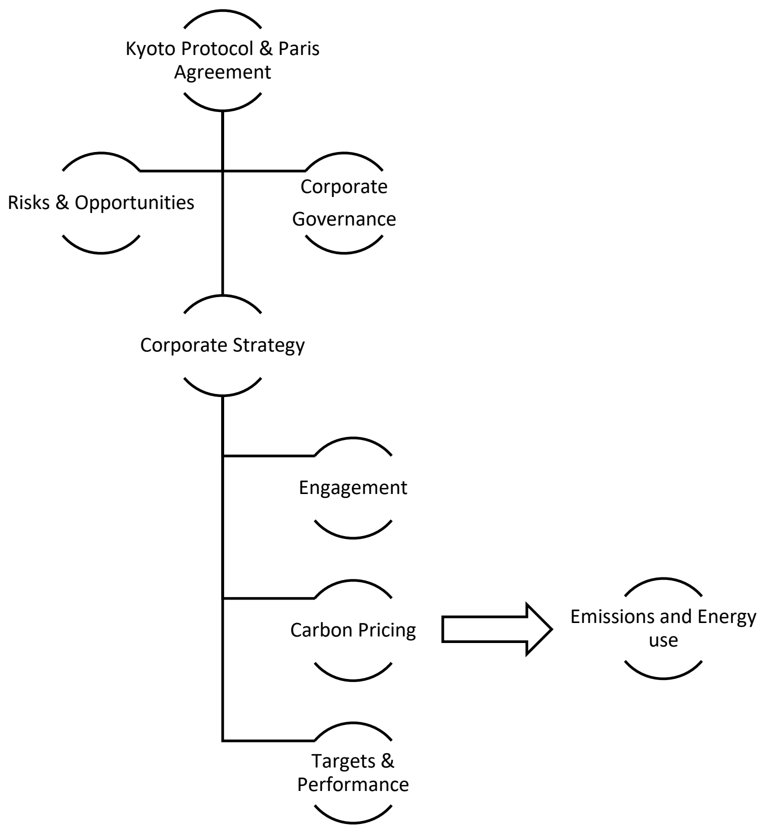

Figure 5: Potential impact of the agreements

Data for Analysis

The data can be found in sheets C6.10 of the CDP Excel workbook, in which the firms describe their gross global combined Scope 1 and 2 emissions for the reporting year in metric tons CO_{2e} per unit currency total revenue and provide any additional intensity metrics that are appropriate to your business operations. The emissions intensity per unit of revenue is reported in C1 (column L) and was crossed checked with the following two variables. A few inconsistencies were found and were corrected by cross checking the sustainability reports of the companies.

$CO_{2e,t}$ is located in C2 (column M) reported in gross global combined Scope 1 and 2 emissions in metric tons of CO_{2e}. Sometimes reporting values were in megatonnes.

Total revenue in local currency, R_t is located in C4 (column N). Sometimes reporting values were in millions of the currency unit (i.e., $s in millions)

C6 (column Q) in sheet C6.10 also reported gross global combined Scope 1 and 2 emissions as a % change from the previous year and C7 (column R) reports the direction of change of emissions.

Energy usage was reported in sheet C8.2a in megawatt hours (MWh). The questionnaire states: “Report your organization’s energy consumption totals (excluding feedstocks) in MWh”, with C2 (column M) from renewable sources, C3 (column N) from non-renewable sources, and C4 (column O) reporting total (renewable and non-renewable) MWh. Once the above variables were retrieved for the 2017-2020 period, energy per unit of revenue, $\left(\frac{E}{R}\right)_t$, which represents energy efficiency, and emissions per unit of energy, $\left(\frac{CO_2}{E}\right)_t$, representing technology, were computed. The rate of change (growth rates) of emissions and the three forces (i.e., size of the firm, energy efficiency, and technology) as shown next:

$$g_{i,pre-Covid} = \frac{Y_{2019} - Y_{2017}}{Y_{2017}} * 100$$

$$g_{i,Covid} = \frac{Y_{2020} - Y_{2019}}{Y_{2019}} * 100$$

These were averaged across each sector as well as in total. These values were reported terms of growth rates to satisfy the IPAT in growth rates and to determine which of the three forces played the most significant effect on emissions.

$$g_{e,t} = g_{R,t} + g_{E/R,t} + g_{T,t}$$

CHAPTER 6: IPACT RESULTS AND DISCUSSION

Initial Descriptive Data Exploration

Table 2 and **Table 3** show industry-wide emissions and energy data for companies in their respective regions of Europe and the U.S. during the 2017-2020 period. In total, these 102 companies for the period 2017-2020 emitted approximately 1.98 gigatonnes (giga=billions) of scope 1 and 2 GHG emissions. To put this figure into perspective, global CO_2 emissions from energy combustion and industrial processes hit 36.3 gigatonnes in 2021, rebounding from the 2020 lockdowns and worldwide economic meltdown arising from the COVID-19 pandemic (IEA, 2022). Thus, over the four-year period of 2017-2020, these 102 European and U.S. companies represented 5.5% of the 2021 global CO_2 emissions.

At a glance, we can see that the U.S. companies together generate almost double the amount of carbon emissions than Europe's in the same time period, despite also having two fewer companies than Europe in this study. Moreover, U.S. corporations are using roughly only half the amount of renewable energy, as well as almost twice the amount of non-renewable energy that the European corporations use.

Table 2: Emissions & Energy Data for 52 European Companies, sorted industry-wise for the period of 2017-2020.

Industry	Number of firms	CO_{2e} Emissions	Renewable Energy (MWh)	Non-Renewable Energy (MWh)	Total Energy (MWh)	Emissions per firm
Apparel	5	1,344,441	2,399,869	3,242,731	5,642,600	268,888
Biotech & Big Pharma	4	10,493,086	6,038,780	36,406,367	42,445,146	2,623,272
Food, Beverage, & Agriculture	5	11,629,925	12,787,236	43,265,939	56,055,176	2,325,985
Fossil Fuels	5	80,588,078	25,691,779	313,979,299	339,734,076	16,117,616
Manufacturing (Automobiles)	4	39,911,755	34,384,671	130,347,139	164,731,812	9,977,939
Manufacturing (Electronics)	5	5,277,164	2,815,199	12,316,749	15,131,946	1,055,433
Materials	5	6,675,662	12,624,239	24,221,445	36,845,684	1,335,132
Power Generation	5	264,018,815	235,671,635	1,130,717,737	1,366,389,372	52,803,763
Retail	5	20,203,719	9,418,882	51,656,552	61,063,004	4,040,744
Financial Services (Banks)	5	3,705,620	4,048,975	7,723,298	11,772,525	741,124
Transportation Services (Airlines)	4	228,087,949	637,625	721,965,839	726,756,938	57,021,987
Total	**52**	**671,936,214**	**346,518,889**	**2,475,843,095**	**2,826,568,279**	**12,921,850**

For both regions, the three highest-emitting industries are in exactly the same order: first is Power Generation, with 264 million metric tons in Europe and 623.1 million metric tons in the U.S., which means that only five American utility providers are responsible for 1.7% of 2021's global GHG emissions, and along with the five European companies, this becomes almost 2.4% of the global figure. In second place is Transportation Services, which is the airlines industry, accounting for 228 million metric tons in Europe and 357.7 million metric tons in the U.S.; do note that we are looking at only three American airlines versus four airlines in Europe. Still, these 7 airlines together made 1.61% of global 2021 emissions. The third highest emitter, which should probably come as no surprise, is the Fossil Fuel industry, generating 80.5 million metric tons in Europe and 146.5 million metric tons in the States; again, in this study there were four Fossil Fuel companies in the U.S., versus five in Europe, and altogether they generated 0.62% of 2021's worldwide emissions.

Table 3: Emissions & Energy Data for 50 U.S. Companies, sorted industry-wise for the period of 2017-2020.

Industry	Number of firms	CO_{2e} Emissions	Renewable Energy (MWh)	Non-Renewable Energy (MWh)	Total Energy (MWh)	Emissions per firm
Apparel	5	2,469,454	3,284,115	9,645,925	12,930,040	493,891
Biotech & Big Pharma	5	17,934,981	5,002,543	67,799,994	72,802,546	3,586,996
Food, Beverage, & Agriculture	4	11,209,298	1,581,540	31,352,571	32,934,111	2,802,324
Fossil Fuels	4	146,582,662	2,274,944	483,370,801	485,645,746	36,645,666
Manufacturing (Automobiles)	4	40,790,878	8,881,107	130,615,237	139,492,340	10,197,720
Manufacturing (Electronics)	5	1,218,886	9,927,417	3,020,257	12,947,943	243,777
Materials	5	19,397,726	10,794,301	72,182,544	82,688,132	3,879,545
Power Generation	5	623,157,420	126,966,974	2,401,662,399	2,511,077,505	124,631,484
Retail	5	84,240,666	14,467,225	195,442,937	209,910,158	16,848,133
Services (Banks)	5	7,331,253	10,930,851	9,722,874	20,653,767	1,466,251
Transportation Services (Airlines)	3	357,754,411	391,900	1,398,226,543	1,225,486,729	119,251,470
Total	**50**	**1,312,087,635**	**194,502,917**	**4,803,042,082**	**4,806,569,017**	**2,624,175**

The highest energy consumption was also by the same three industries, in exactly that order, for both regions. The three lowest emissions- and energy-intensive industries are also the same in both regions, although not in the same exact order: Apparel, Financial Services (Banks), and Manufacturing (Electronics). The ten apparel companies from Europe and America thus caused 0.01% of 2021's global emissions, 10 banks caused 0.03%, and 10 electronics manufacturers caused 0.017%. In terms of both emissions and total energy, the overall rankings from highest to lowest look very similar for both the Europe and U.S. tables.

Some examples of renewable sources of energy that companies reported using are biogas, biodiesel, landfill gas, wood waste, ethanol, etc. In Europe, the three industries using renewable sources of energy are Power Generation, Manufacturing, and Fossil Fuels in absolute terms (Table 2). In the U.S., Power Generation is also at the top, along with Retail and Services (Banks) in absolute terms (Table 3).

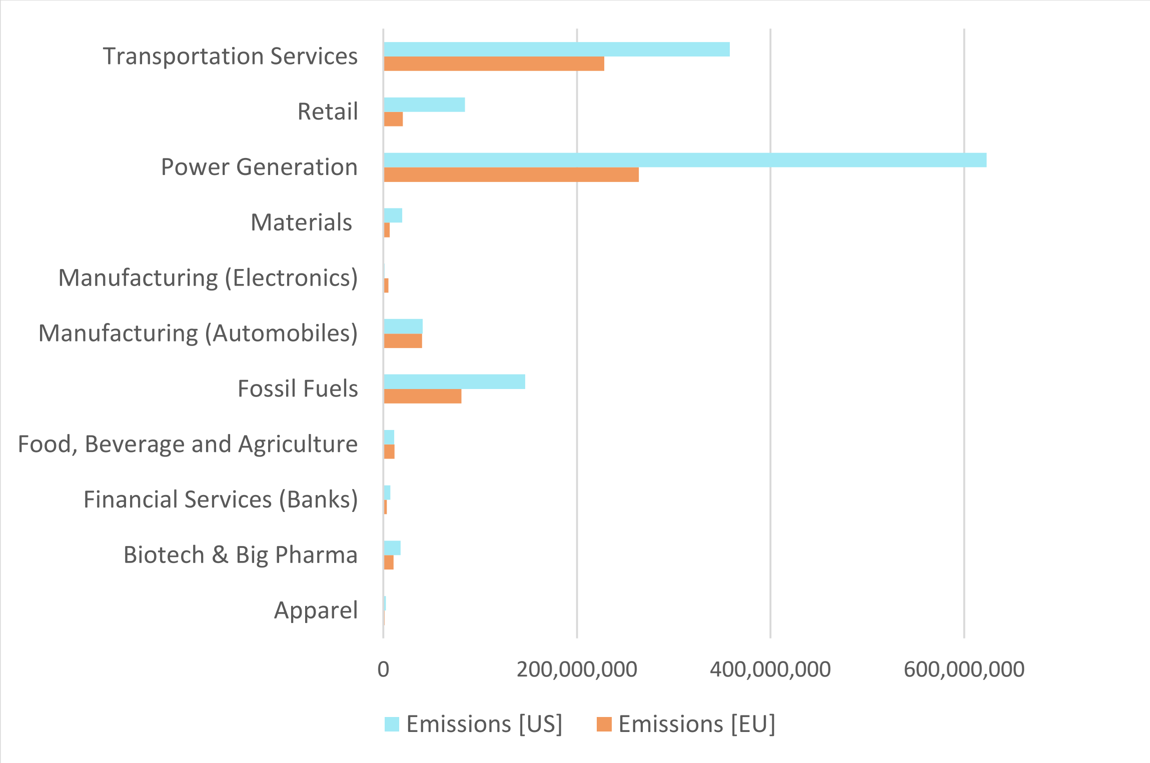

Figure 6: Emissions distribution industry-wise, Europe VS U.S.

Interestingly, in relative to total energy, the U.S. Fossil Fuel industry is among the three least renewable energy-friendly industries in the region, with Food, Beverage, and Agriculture in 2nd place and Transportation Services (Airlines) being the least inclined to using renewable sources (Figure 8). The three U.S. airline companies, namely Delta, United, and American Airlines, used only 391,900 units of renewable energy compared to 1.39 billion MWh units of non-renewable energy. European airlines, namely Finnair, Air France, Lufthansa, and SAS, were also the worst in that regard, using 637,625 units of renewable versus 721.9 million units of non-renewable energy. According to a study by Klöwer et al. (2021), the aviation industry makes up 4% of human-induced global warming, and if allowed to grow at pre-pandemic rates, aviation is expected to trigger almost 0.1℃ (or 0.2℉) of warming by the year 2050.

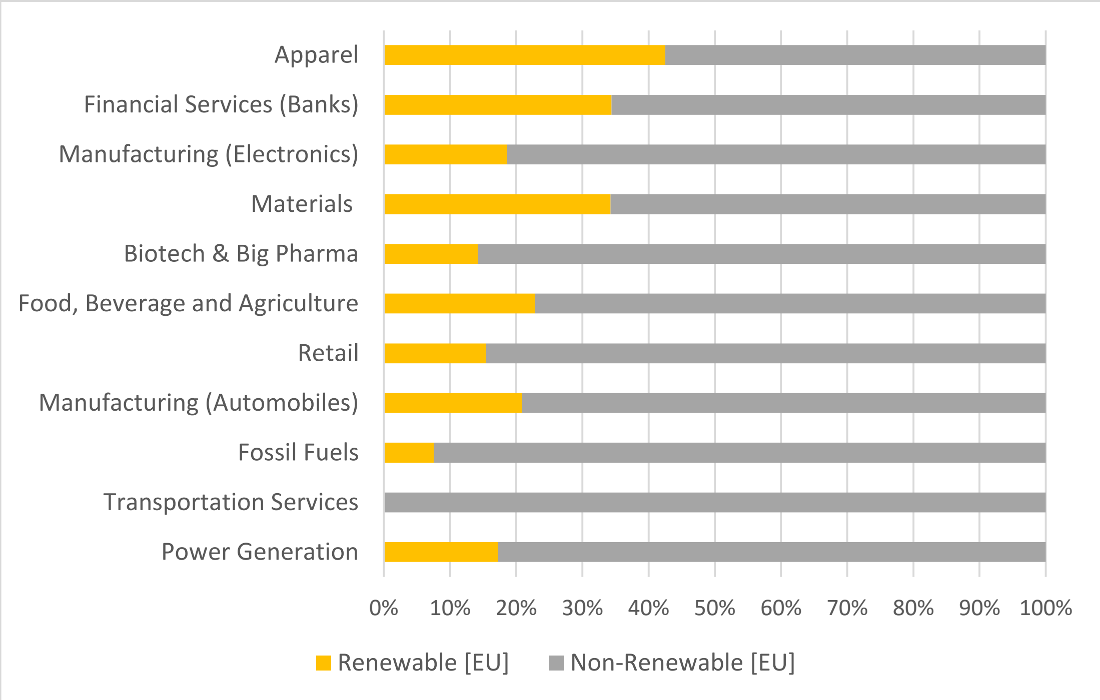

Figure 7: Europe's distribution of Renewable versus Non-Renewable sources of Energy

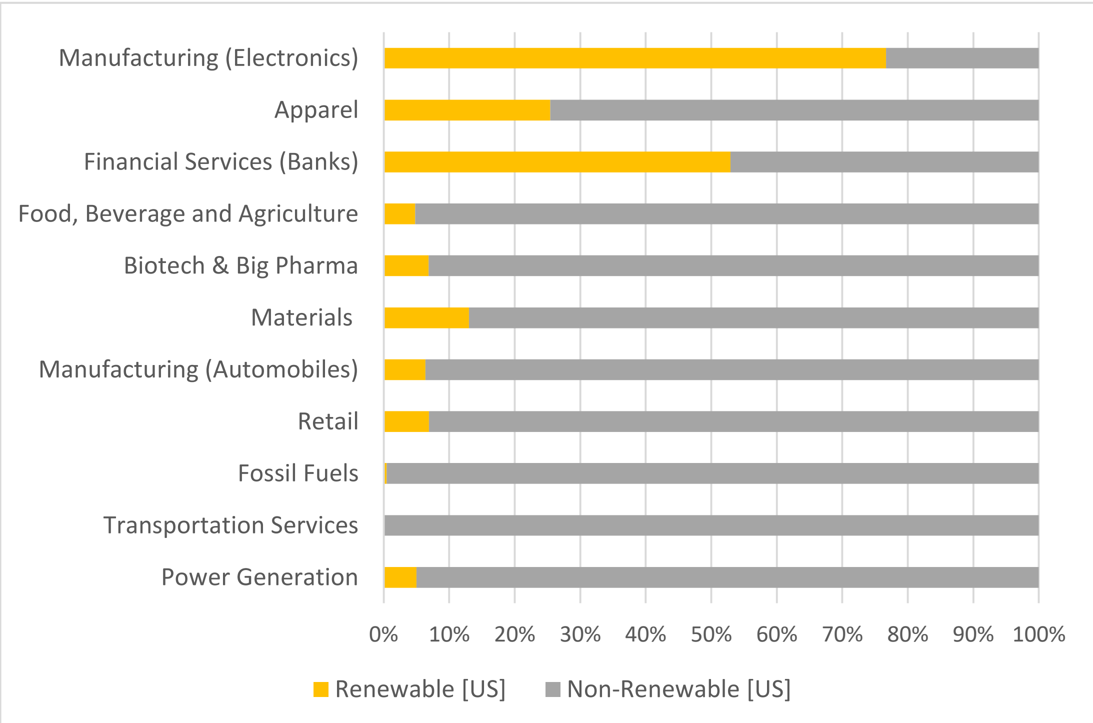

Figure 8: U.S. distribution of Renewable versus Non-Renewable sources of Energy

Although Apparel is in 2nd place in Europe for using the least amount of renewable sources in absolute terms, it is worth noting that 42% of all their energy used is renewable, thus showing a much better ratio of energy sources when compared to other low-performing industries in both regions (**Figure 7**). The European apparel companies are Burberry, Puma, Adidas, LVMH, and Kering. In 3rd place in Europe is the Manufacturing (Electronics) industry, which includes brands based in Nordic countries like Ericsson, Nokia, and Assa Abloy.

Results from the Simple Corporate IPAT Framework: Pre-COVID 2017-19 period

The results below show the growth rate of emissions, revenue, energy per unit of revenue, and GHGs per unit of energy used over the pre-COVID (2017-2019) period for Europe and the USA, industry-wise. These values are reported in terms of growth rates to satisfy the IPAT and to determine which of the three forces played the most significant effect on emissions. The association is as follows:

$$g_{e,t} = g_{R,t} + g_{E/R,t} + g_{T,t}$$

Observe Table 4 below. On average, emissions in pre-COVID Europe fell by 16.9%. This was driven by energy efficiency that dropped by 6.1%, but mostly by technology away from fossil fuels by 13.9% and these emission reductions were done with revenue rising at the rate of 3.1%. Total energy in Europe fell by almost 3% over this period. Industry-wise emissions in pre-COVID Europe fell in all 11 sectors except transportation (airlines), which rose by 5.8%. The highest reductions were in Apparel at the rate of 41%, followed by Materials at 29%, while the lowest drops were that of fossil fuel companies at a 4.2% reduction, along with Biotech and Big Pharma at a 6.8% reduction.

Interestingly, we observe a significant reduction in Power Generation emissions at the rate of 24.2%, due to the strong force of revenue reduction by 12.1%, which thus enabled a 7.2% reduction in total energy use. As a result, energy per revenue increased, making the sector less efficient, due to revenue falling at a faster rate than the energy was reduced. Emissions per unit of energy fell by 17% because emissions fell more than energy dropped.

Revenue increased in all sectors except for Power Generation and Retail, with comparatively the lowest losses in Materials, indicating that in most industries, emissions could fall without hurting the companies' revenue streams. Apparel's revenue increased by 11.7% and emissions dropped by 41%; in comparison, Fossil Fuel revenue increased by a similar rate but emissions fell only by 4.2%.

Table 4: Europe IPAT calculations, industry-wise, Pre-COVID (2017-2019)

Industry	CO_{2e} Emissions	Revenue	Energy per Revenue	Emissions per Energy	Total Energy (MWh)
Apparel	-41.02%	11.70%	-18.31%	-34.41%	-6.61%
Biotech & Big Pharma	-6.81%	8.15%	-13.53%	-1.43%	-5.37%
Food, Beverage, & Agriculture	-10.26%	4.11%	3.65%	-18.02%	7.76%
Fossil Fuels	-4.23%	11.55%	-12.25%	-3.54%	-0.70%
Manufacturing (Automobiles)	-9.55%	3.09%	-3.90%	-8.74%	-0.81%
Manufacturing (Electronics)	-10.35%	9.19%	-13.52%	-6.02%	-4.33%
Materials	-29.22%	-1.55%	-4.09%	-23.58%	-5.64%
Power Generation	-24.20%	-12.07%	4.86%	-16.99%	-7.21%
Retail	-13.77%	-3.94%	5.45%	-15.28%	1.51%
Services (Banks)	-25.19%	0.29%	-12.11%	-13.38%	-11.81%
Transportation Services (Airlines)	5.83%	7.37%	-2.03%	0.49%	5.34%
Total	**-16.90%**	**3.12%**	**-6.11%**	**-13.92%**	**-2.98%**

The most efficient sector in terms of energy per unit of revenue is Apparel, where energy per $ of revenue fell by 18.3%, and the least efficient sectors are Retail, Power Generation, and Food, Beverage, & Agriculture, which actually increased their energy per unit of revenue by 5.45%, 4.9%, and 3.65% respectively. In the cases of both Retail and Food, Beverage, & Agriculture, the industries' increase was caused by energy use increasing faster than revenue increasing, while in Power Generation it was driven by revenue falling faster than energy falling.

Additionally, the most technologically-efficient industries in pre-COVID Europe include Apparel, with a 34.4% fall in emissions per unit of energy, as well as Materials showing a 23.5% decrease, followed by Food, Beverage, & Agriculture with an 18% decrease. These findings are quite consistent with what we have seen in Figure 7, indicating that more technologically-advanced companies are using more renewable sources along with greener technology. The least efficient companies hail from the Airlines, Big Pharma, and Fossil Fuels sectors, showing an actual 0.4% increase, and only 1.4% and 3.5% decrease respectively. Meanwhile, pre-COVID emissions in the U.S. fell by only 9.53% on average compared to

Europe's 16.9% (Table 5). Revenue increased by 9.9%, while Europe's did so by only 3.1%. Total energy use saw only a 0.75% reduction in the U.S., compared to a 2.9% reduction in Europe. Similar to Europe's, industry-wise emissions fell in every U.S. industry except for airlines as well, which saw a 4% increase – but somehow, the American Food, Beverage, and Agriculture sector also had an 8% increase in emissions, with a 20.8% rise in revenue and a whopping 16.52% increase in total energy used. While three industries lost revenue in pre-COVID Europe, only the fossil fuels industry suffered so in the U.S., with a 10.5% reduction in revenue resulting in a 9.9% reduction in emissions. Less revenue reduced total energy use by 20.3%, which resulted in energy per revenue to drop 9.81%, offset by an increase in emissions per energy, which in turn was due to a 10.4% increase from inefficiencies in technology. The increase in the growth rate of emissions per energy was caused by emissions falling at a much slower rate than energy use fell.

Table 5: U.S. IPAT calculations, industry-wise, Pre-COVID (2017-2019)

Industry	CO_{2e} Emissions	Revenue	Energy per Revenue	Emissions per Energy	Total Energy (MWh)
Apparel	-15.94%	6.09%	1.02%	-23.05%	7.11%
Biotech & Big Pharma	-12.59%	13.26%	-16.80%	-9.05%	-3.54%
Food, Beverage, & Agriculture	8.03%	20.81%	-4.28%	-8.49%	16.52%
Fossil Fuels	-9.92%	-10.55%	-9.81%	10.45%	-20.36%
Manufacturing (Automobiles)	-4.39%	16.09%	-21.95%	1.47%	-5.86%
Manufacturing (Electronics)	-20.14%	22.09%	-11.82%	-30.41%	10.27%
Materials	-8.02%	8.47%	-9.80%	-6.69%	-1.33%
Power Generation	-2.01%	9.14%	-4.38%	-6.76%	4.76%
Retail	-14.43%	5.08%	-9.28%	-10.23%	-4.20%
Services (Banks)	-20.19%	9.42%	-11.30%	-18.31%	-1.88%
Transportation Services (Airlines)	4.03%	7.15%	0.10%	-3.23%	7.26%
Total	**-9.53%**	**9.92%**	**-9.17%**	**-10.28%**	**0.75%**

Speaking of technology, the most efficient industries in the U.S. are Electronics Manufacturing, with a 30.4% decrease in emissions per unit of energy, followed by the Apparel sector with a 23% decrease, and Banks with an 18.3% decrease, thus meaning that these three industries are using more renewable sources and/or greener technology than the others, which is also observable in Figure 8. Thus, the Apparel industry in both Europe and the U.S. is among the top two most technologically-efficient industries. The least efficient U.S. industries include Fossil Fuels, as we noted earlier, with a ghastly 10.4% increase in emissions per unit of revenue, Automobiles Manufacturing that also has a 1.4% increase, and Airlines with only a 3.2% decrease. This is quite similar to the case of Europe, where we also noted that the fossil fuel and airlines industries were the worst at using renewable or greener sources.

In terms of energy efficiency per $ of revenue in the U.S., Apparel and Airlines are the worst performers with a 1% and 0.1% increase, unlike in Europe, where Apparel was the best performer. Apparel and Airlines in the U.S. both also show a 7% increase in total energy use. The most energy-efficient industries in the U.S. are instead Automobiles Manufacturing and Big Pharma with decreases of almost 22% and 16.8% respectively. Surprisingly, Electronics Manufacturing also had a 10.2% increase in total energy use, but still is the third most energy-efficient and first most technologically-efficient industry in this group. Food, Beverage, and Agriculture enjoyed the highest total energy use with a 16.5% increase as well as a 20.8% boost in revenue, thus making it the most profitable but also the third least energy-efficient.

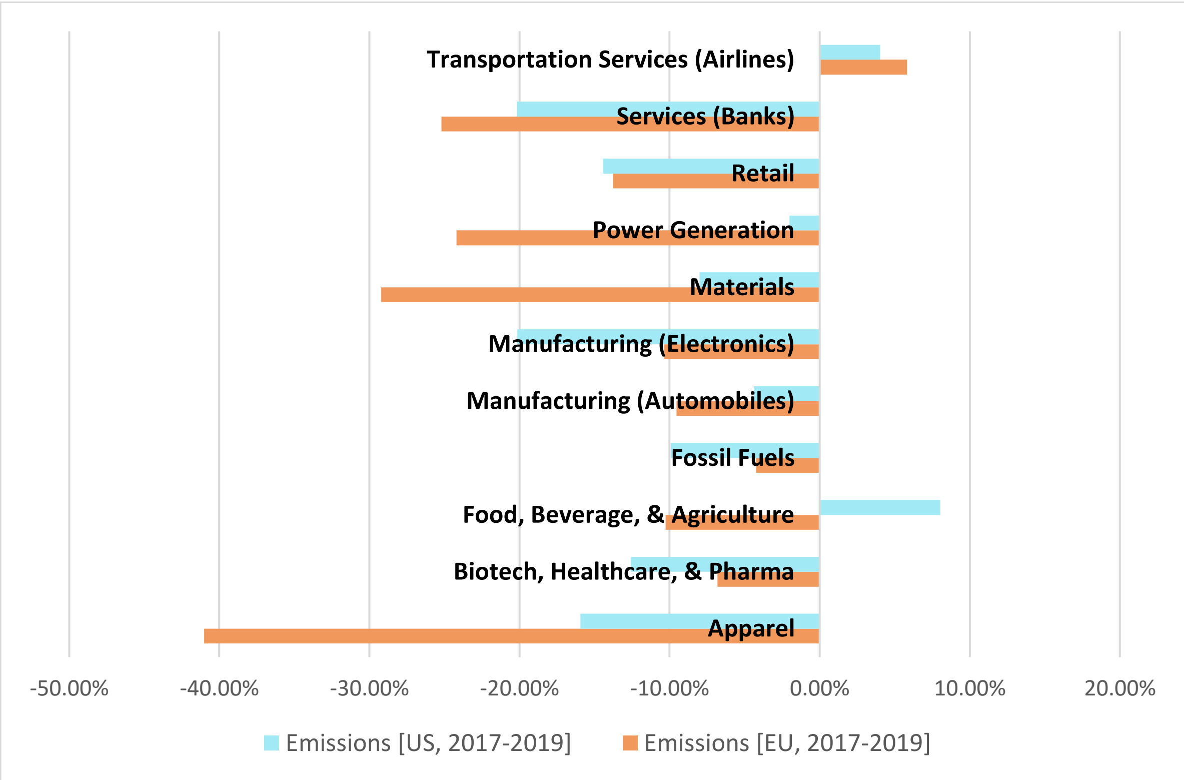

Figure 9: Europe VS U.S. Pre-COVID (2017-2019) Emissions distribution, industry-wise

Looking at **Figure 9** and **Figure 10**, we are further able to compare emissions distribution across the same eleven industries in the different regions of Europe and the U.S., with **Figure**

9 highlighting the pre-COVID era, and **Figure 10** offering a glimpse in the post-COVID year of 2020. Next, we are analyzing energy and technology efficiency in the two regions, COVID, through **Table 6** and **Table 7**.

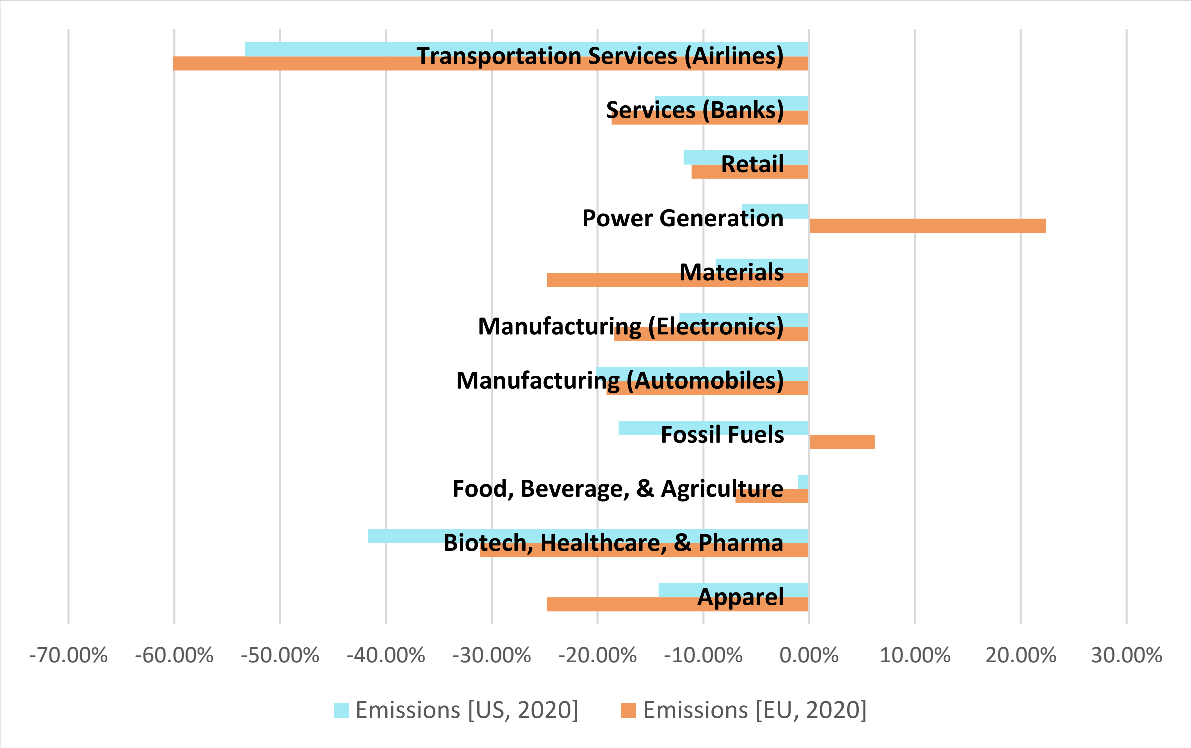

Figure 10: Europe VS U.S. COVID (2020) Emissions distribution, industry-wise

Notice in **Figure 10** how the European Fossil Fuels and Power Generation industries showed stark emissions increases of 6% and 22.3% respectively, despite being in the COVID era, while every other industry in each region had emissions falling. We investigated why Power Generation had precisely a 22.3% rise (**Table 6**) in emissions, and one big reason for this was the Finnish company Fortum Oyj being part of our five selected corporations in this industry and region. In March 2020, Fortum became the majority stakeholder of German energy company Uniper, thus making Uniper its subsidiary (Ulfves, 2020), and rendering Fortum the second-largest producer of nuclear power, third-largest producer of carbon-free electricity, and one of the largest gas companies in Europe (Fortum, 2022).

Unsurprisingly, Europe's sharpest drop in emissions, which was a 60% decrease (**Table 6**), occurred in the transportation services (airlines) sector, naturally due to pandemic-induced worldwide lockdowns. The industry also had a 53.3% cut in emissions in the U.S. (**Table 7**), along with a 63.2% loss in revenue and 53% lower total energy use. The European airline companies also utilized about 61% lower total energy, and suffered a 62.8% loss in revenue. Biotech and Big Pharma had the second largest drop in emissions in both regions, with a 31% reduction in Europe and 41.2% reduction in the U.S., but also gained revenues of 3.47% and 16.9% in both Europe and the U.S. respectively. This may be due to Big Pharma becoming the most technologically efficient industry in both regions, as it shows 29.6% lower emissions per unit of energy in Europe, and 39.1% lower in the U.S. This, once again, highlights a relationship between technology efficiency and revenue, that being more environmentally sustainable also reaps higher profits.

Table 6: Europe IPAT calculations, industry-wise, COVID (2020)

Industry	CO_{2e} Emissions	Revenue	Energy per Revenue	Emissions per Energy	Total Energy (MWh)
Apparel	-24.75%	-13.25%	10.28%	-21.78%	-2.97%
Biotech & Big Pharma	-31.15%	3.47%	-4.93%	-29.69%	-1.46%
Food, Beverage, & Agriculture	-6.97%	-7.29%	3.87%	-3.55%	-3.42%
Fossil Fuels	6.20%	-19.26%	15.79%	9.66%	-3.47%
Manufacturing (Automobiles)	-19.15%	-12.29%	0.14%	-7.00%	-12.15%
Manufacturing (Electronics)	-18.44%	-1.45%	-11.65%	-5.34%	-13.09%
Materials	-24.75%	-6.71%	-2.35%	-15.69%	-9.06%
Power Generation	22.37%	-8.57%	22.48%	8.46%	13.91%
Retail	-11.11%	-5.68%	5.98%	-11.41%	0.30%
Services (Banks)	-18.66%	-11.40%	-1.36%	-5.90%	-12.77%
Transportation Services (Airlines)	-60.14%	-62.81%	1.82%	0.86%	-60.99%
Total	**-15.81%**	**-12.59%**	**3.91%**	**-7.14%**	**-8.68%**

Unlike in the pre-COVID years, many industries in both Europe and the U.S. seem to be performing poorly at energy per $ of revenue, with Europe's Power Generation and America's Food, Beverage, & Agriculture leading the way through roughly a 22% increase in both cases respectively, also seconded by Fossil Fuels in both regions showing about a 15% increase.

Overall for the year 2020, the average of emissions across all industries in Europe was roughly the same as the three years before COVID, with the 2020 figure being a 15.8% decrease and the pre-COVID figure being a 16.8% decrease. Seemingly, emissions were slightly lower pre-COVID in Europe; this figure may be due to the Apparel sector almost doubling its emissions, since they had a 41% decrease until 2019, and only a 24% decrease in 2020. Strong surges in online shopping appear to have led Apparel companies to increase production and international shipping, while also sidelining sustainability practices (Vladimirova et al., 2022). In the U.S. however, Apparel's emissions remained the same both before and during the pandemic. More notably, overall emissions in the U.S. decreased nearly two-fold, going from a 9.5% fall in the pre-COVID era to a 17.5% drop in 2020.

While America's technology efficiency remains the same at 10% lower emissions per MWh of energy, Europe's has roughly halved, rising from a 13.9% low to only 7.1%. On the bright side, both the U.S. and Europe observed an overall decrease in total energy use, with Europe shifting from a 2.9% to 8.6% decrease, and the U.S. showing even better progress with a 7% decrease in energy use compared to a 0.7% increase in the pre-COVID era. However, energy efficiency also seems to have taken a backseat in both Europe and America during the pandemic year, since the figures for energy being utilized per $ of revenue have gone up from -6.1% and -9.1% respectively to a 3.9% and 0.8% high. Revenue additionally suffered heavy blows in both regions, with Europe's diminishing from an overall 3.1% to -12.5%, and the U.S,' plummeting from 9.9% to -7.9%. See **Figure 11** and **Figure 12** for observing Revenue pre-2020 and during 2020.

Table 7: U.S. IPAT calculations, industry-wise, COVID (2020)

Industry	CO_{2e} Emissions	Revenue	Energy per Revenue	Emissions per Energy	Total Energy (MWh)
Apparel	-14.22%	-14.82%	11.34%	-10.74%	-3.48%
Biotech & Big Pharma	-41.70%	16.90%	-19.50%	-39.10%	-2.61%
Food, Beverage, & Agriculture	-1.08%	1.90%	21.48%	-24.46%	23.38%
Fossil Fuels	-18.02%	-24.68%	14.94%	-8.27%	-9.74%
Manufacturing (Automobiles)	-20.17%	-24.77%	6.58%	-1.98%	-18.19%
Manufacturing (Electronics)	-12.27%	-0.32%	-1.93%	-10.02%	-2.25%
Materials	-8.85%	9.34%	-9.30%	-8.89%	0.04%
Power Generation	-6.32%	0.83%	-6.89%	-0.26%	-6.06%
Retail	-11.88%	-10.48%	1.55%	-2.94%	-8.93%
Services (Banks)	-14.57%	-2.85%	-8.94%	-2.78%	-11.79%
Transportation Services (Airlines)	-53.31%	-63.42%	10.33%	-0.22%	-53.09%
Total	**-17.54%**	**-7.92%**	**0.85%**	**-10.47%**	**-7.08%**

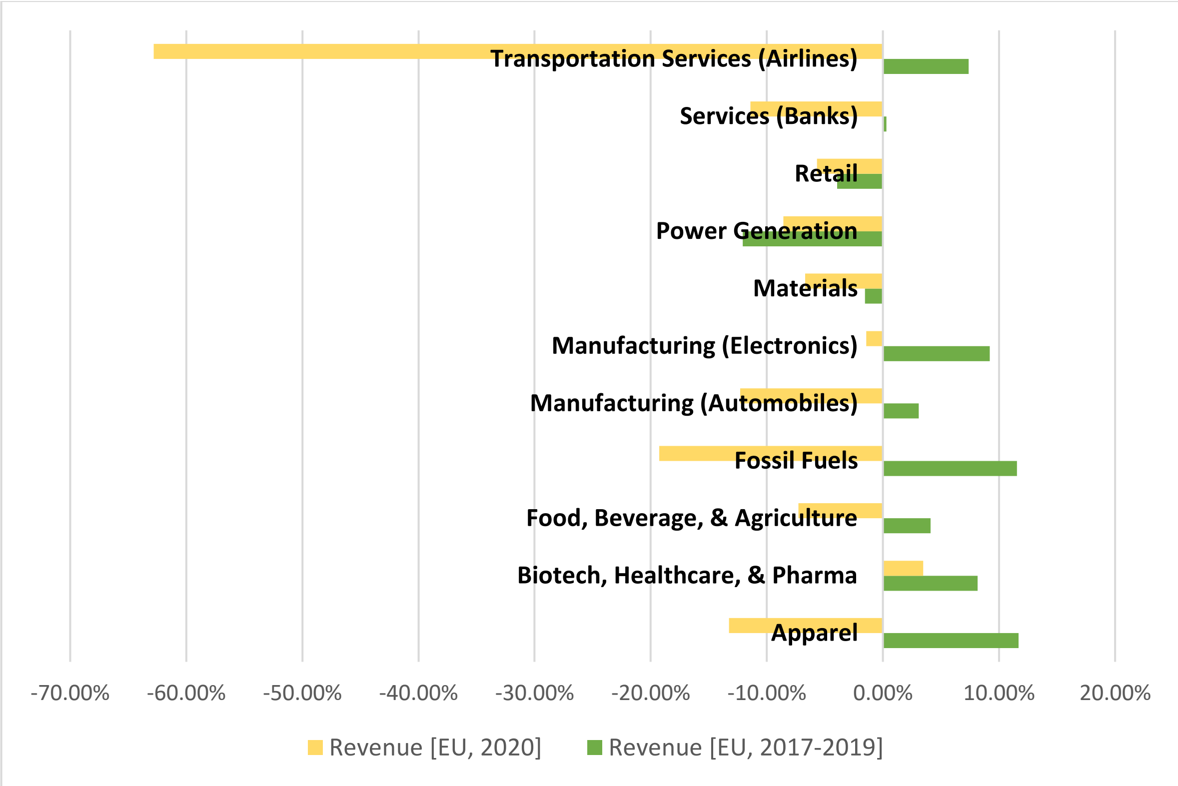

Figure 11: Europe Revenue distribution, industry-wise, Pre-COVID (2017-2019) VS COVID (2020)

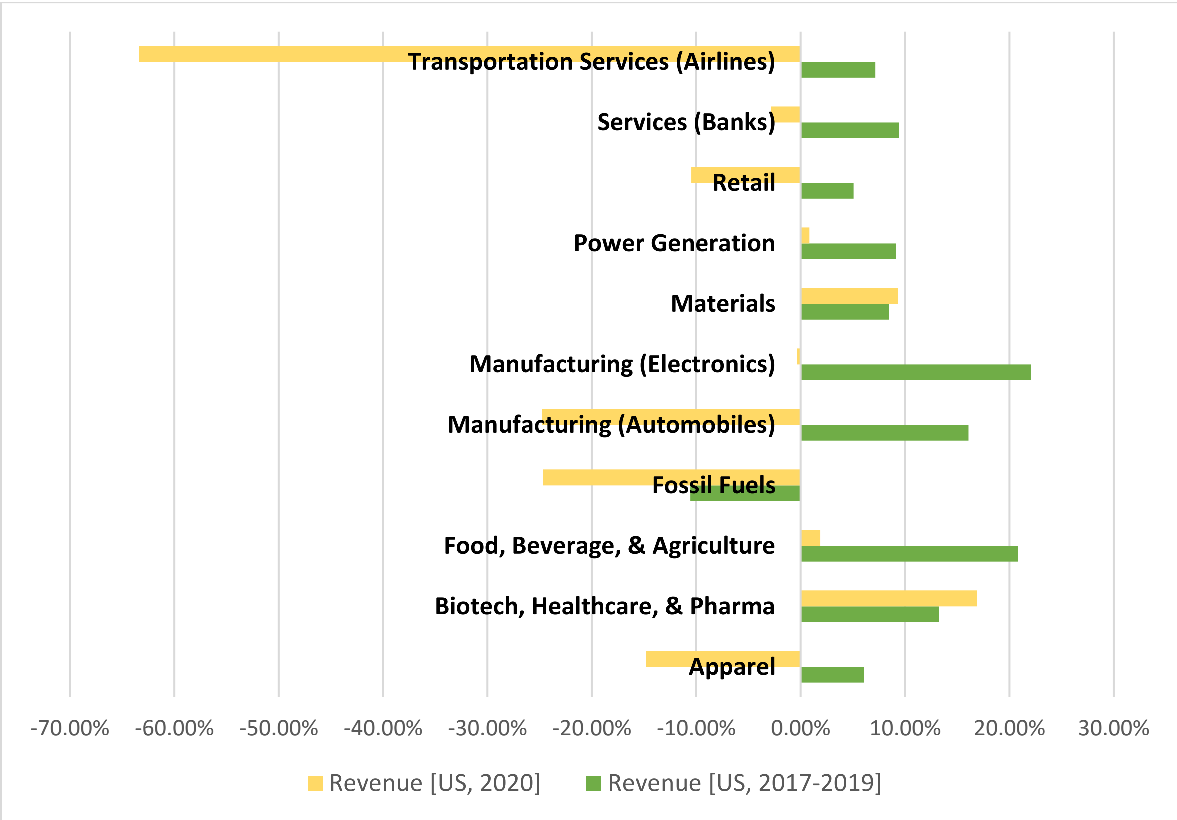

Figure 12: U.S. Revenue distribution, industry-wise, Pre-COVID (2017-2019) VS COVID (2020)

IPACT Results: Concluding Remarks

Over the four-year period of 2017-2020, these 102 European and U.S. companies represented 5.5% of the 2021 global CO_2 emissions. The 50 U.S. companies together generated almost double the amount of carbon emissions than Europe's 52, in the same 4-year time period. American corporations are using only half the amount of renewable energy, and also almost twice the non-renewable energy that the European corporations use. For both regions, the highest-emitting industry is Power Generation. At 264 million metric tons in Europe and 623.1 million metric tons in the U.S., the ten utility companies in this study are responsible for almost 2.4% of 2021's global GHG emissions.

In the pre-COVID period, total energy use fell in Europe, while it increased in the U.S. In 2020, both regions observed an overall decrease in total energy use. However, unlike in the pre-COVID years, energy efficiency seems to have taken a backseat in both Europe and America during 2020. Revenue additionally suffered heavy blows in both regions from the pandemic.

In the four-year period, emissions dropped in both regions due to a joint improvement in energy and carbon efficiency. Interestingly, emissions in both regions fell more than revenue did in 2020. Europe's emission reductions were achieved more through renewable energy, than through energy efficiency. Overall emissions in the U.S. decreased nearly two-fold, going from a 9.5% fall in the pre-COVID era to a 17.5% drop in 2020. While America's technology efficiency remains the same at 10% lower emissions per MWh of energy, Europe's has roughly halved, rising from a 13.9% low to only 7.1%.

Emissions' growth rate across all industries in Europe was roughly the same as the three years before COVID (went from -16.9% to -15.8% in 2020). Seemingly, emissions were slightly lower during the pre-COVID era in Europe. This may be due to the Apparel industry doubling production and transportation from a surge in online shopping during the pandemic.

A key finding was that COVID-19 lockdowns reduced emissions significantly more in the U.S. than policies and business strategies could before the pandemic year of 2020. In Europe, emissions during COVID-19 fell at a similar rate.

In the next chapter, we set out to estimate the impact the forces would have on emissions if we were not assuming the IPACT framework, and instead, a different, stochastic model.

CHAPTER 7: THE STIRPAT FRAMEWORK

The STIRPAT Framework at the National Level

Dietz and Rosa (1994, 1997) recognized the limitations in the IPAT model, the first being that it is an identity and thus would not allow hypothesis testing, and the second about how the model assumes proportionality in the relationship between factors, meaning that a doubling of population *P* would automatically double the impact *I*, with everything else held constant (i.e., a unitary elasticity of emissions with respect to population). They argued that socio-ecological theory necessitates hypotheses regarding the relationships between anthropogenic factors and impacts be falsifiable with empirical evidence, in lieu of simple assumptions. Endeavoring to counter these limitations, Dietz and Rosa (1997) formulated the model STIRPAT, standing for "Stochastic Impacts by Regression on Population, Affluence, and Technology" to disaggregate *P*, *A*, and *T*, thus being able to use regression methods for empirical hypothesis testing and estimation (Chertow, 2000; York et al., 2003). Dietz and Rosa (1997) estimated the following model for CO_2 emissions across 111 nations for the year 1989.

$$CO_{2,i} = \beta_0 P_i^{\beta_1} A_i^{\beta_2} \varepsilon_i$$

where β_i are parameters estimated using statistical techniques. The β_1 parameter represents the percentage change in the CO_2 emissions for a 1% change in population (i.e., the elasticity of emissions concerning population), while β_2 represents the elasticity of emissions to affluence *A*. The parameter β_0 (a scaling factor) and the residual ε_i attempt to capture technology. According to Dietz and Rosa (1997), technology is considered broader than a black box labeled "carbon intensity", and includes institutions, culture, policies, and other variables that affect the emissions.

Dietz and Rosa (1997, p. 177) found the peak income level, after which emissions start falling with affluence, was at $10,000. The result is very pessimistic, and they stated the following: *"Seventy-five percent of the 111 nations in our sample have GDPs below $5000. Thus, our results suggest that, for the overwhelming majority of nations, economic growth that can be anticipated for the next quarter century or so will produce increasing, rather than declining,* CO_2 *emissions."*

The sample was drawn before the Kyoto Protocol in 1989. If this non-linear association still holds today, the decline would occur at $32,000, assuming a 3.5% growth in affluence per year on average. Given that the current world income per capita is $14,000 (World Bank in PPP Int$) this suggests that the world has yet to reach a turning point, and time is of the essence to hit the ambitious 2030 targets set by nations.

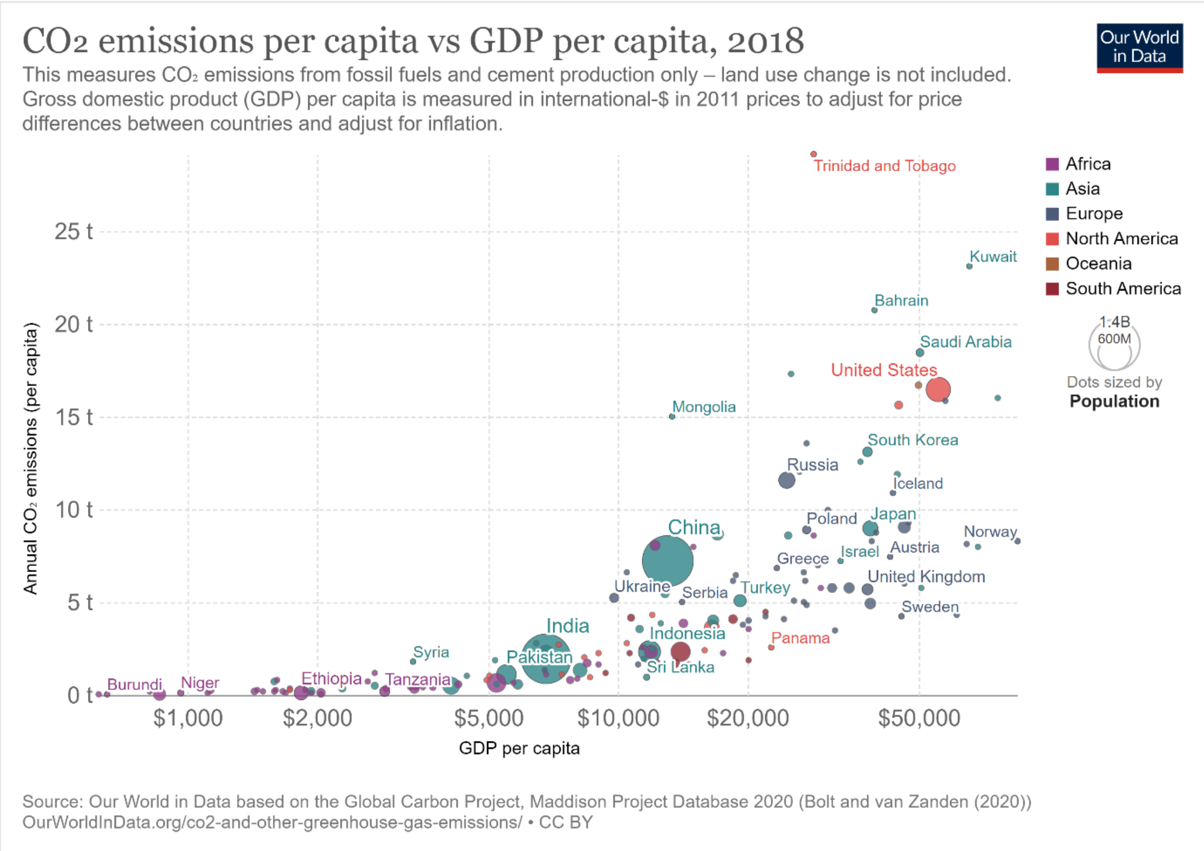

Figure 13: CO_2 per capita and GDP per capita

For the elasticity of emissions concerning population, Dietz and Rosa (1997) found it to increase with population at an increasing rate when China and India were included in the sample. Otherwise, the population had a unitary elasticity. Either result indicates that population growth plays a significant role in the environmental degradation we observe today and into the future.

York et al. (2003) expanded the above model to incorporate technology explicitly into the STIRPAT with additional factors including percentage of the population that is non-dependent, percentage of GDP that is the industrial sector, degree of urbanization, whether or not the nation is in the tropics, and quadratic terms to capture non-linearities. As a result, the estimated relationship (ignoring the quadratic terms) and generalizing can be expressed as:

$$I_i = \beta_0 P_i^{\beta_1} A_i^{\beta_2} T_i^{\beta_3} \varepsilon_i$$

Where environmental impact I_i was measured using the national CO_2 emissions of 146 nations for the year 1996, and the national energy footprint of 138 nations for 1999. York et al. (2003) found a CO_2 turning point for affluence, but for the national energy footprint, the elasticity was increasing with the footprint indicating a sobering result of no turning point yet. As for CO_2, the turning point was at $61,000. York et al. (2003, p.362) state: *"This result, in light of the highest observed value for affluence, $27,765, for the US in 1996 provides a sober and challenging warning: if there is an Environmental Kuznets Curve [EKC] for CO_2 emissions, the turning point is clearly unreachable by any nation in the near future."*

The STIRPAT Framework at the Corporate Level

In addition to the simple corporate framework discussed previously, a simple corporate STIRPAT framework will be estimated. The IPAT model sets the elasticities of each force equal to unity, but this may not be the case. In order to estimate the elasticities of emissions with respect to revenue and with respect to energy efficiency, the model is similar to Dietz and Rosa's (1997) as well as Yale et al.'s (2003), but applied to firms rather than to nations:

$$I_i = \beta_0 R_i^{\beta_1} (\frac{E}{R_i})^{\beta_2} \varepsilon_i$$

Where β_1 is the elasticity of emissions with respect to revenue, and $\beta_2$the elasticity of emissions with respect to energy intensity. The error terms capture technology and other institutional factors that have been omitted.

As stated previously, in the original IPAT, the elasticities are assumed to equal one, implying that a 1% change in population leads to a 1% change in emissions and the same with respect to affluence and technology. In the above expanded model, the elasticity is estimated with the sample drawn instead of assuming it is unitary. Dietz and Rosa (1997) also included a quadratic term for affluence and population so that the elasticity varies with affluence and population. They found that the elasticity of emissions falls as affluence increases and thus is neither unitary nor constant. This result implies an income level after which emissions will start falling with income per capita rising. This inverted U shape result is the outcome that is expected from the literature on the EKC (Grossman and Krueger, 1995; Stern, 2017; Halkos and Managi, 2017). Although observed with other local pollutants, it has not yet occurred with GHGs worldwide (Figure 13).

In this thesis, revenue might have a quadratic term impacting emissions. In order for the EKC model to operate at the firm level, revenue should be increasing at a decreasing rate and eventually falling with revenue increases. This implies that elasticity of emissions with respect to revenue is greater than unity for small firms, and as firms increase in size the elasticity falls, peaks, and then becomes negative, making emissions a normal good from inferior good.

Two effects explain why emissions follow an inverted U shape pattern with revenue; rising initially, reaching a peak, and then falling with emissions. First, emissions should be falling with revenue of an affluent organization. The effects are based on the interactions of production and technology. On the production side, there are the scale effects. Emissions initially increase with production as revenue expands. The technology depends on input substitution, the energy intensity of production, and carbon energy intensity. Reduction in emissions with expanding revenue may result from a nation's environmental regulations or innovation policies than revenue itself. Although the EKC has been studied extensively at the national level, it has not been applied at the firm level yet (Stern, 2017; Halkos and Managi, 2017).

CHAPTER 8: STIRPAT RESULTS AND DISCUSSION

Results from the STIRPAT Estimations

Table 8: Effects of Revenue and Energy Efficiency on 2019 CO_2 emissions of 99 companies in Europe and the United States.*

	Log-polynomial model				Log-linear model			
	Coefficient	Standard Error	95% Confidence Interval		Coefficient	Standard Error	95% Confidence Interval	
Revenue	6.663	1.399	3.884	9.441	1.182	0.163	0.858	1.507
Revenue^2	-0.119	0.030	-0.179	-0.060				
Energy Efficiency	1.019	0.034	0.950	1.088	1.007	0.048	0.910	1.103
Intercept	-67.960	16.300	-100.321	-35.599	-5.767	4.238	-14.180	2.646
R-Squared	0.9348				0.8805			

*99 companies instead of the 102, because three companies (ADVA Optical, Dr. Pepper, and Church & Dwight) did not have data for 2019; they only did for 2017, 2018, and 2020.

For the log-linear model, the elasticity of emissions with respect to revenue is 1.2 with a 95% confidence interval [0.86, 1.51] and the elasticity of emissions with respect to energy efficiency is 1.0 with a 95% confidence interval [0.91, 2.65]. This supports the IPACT, because in that model, the elasticities are unitary. The implication is that emissions are relatively sensitive to the two forces with the remaining force indicated by the residual. For example, a firm can reduce emissions by 10% if its energy efficiency increases by 10%, holding revenue constant. Revenue can increase by 10% with emissions falling, if energy efficiency improves by 20%.

For the log-polynomial model, the energy efficiency elasticity remains similar to the log-linear model around the unitary elasticity, but the revenue force surprisingly has an elasticity that varies with size of the firm, as determined by revenue. Firms with high revenue have a lower elasticity than firms with a low revenue, since the revenue elasticity is not constant and decreases with revenue increasing. This has implications that very large firms can increase their revenue while reducing emissions, holding energy efficiency constant; most likely through utilizing better technology from the technology multiplier. As highlighted in the previous chapter, this scenario of falling emissions with rising revenue was strongly observable in the Big Pharma industry throughout the 2017-2020 period, in both Europe and the U.S. (**Table 5**, **Table 6**, **Table 7**).

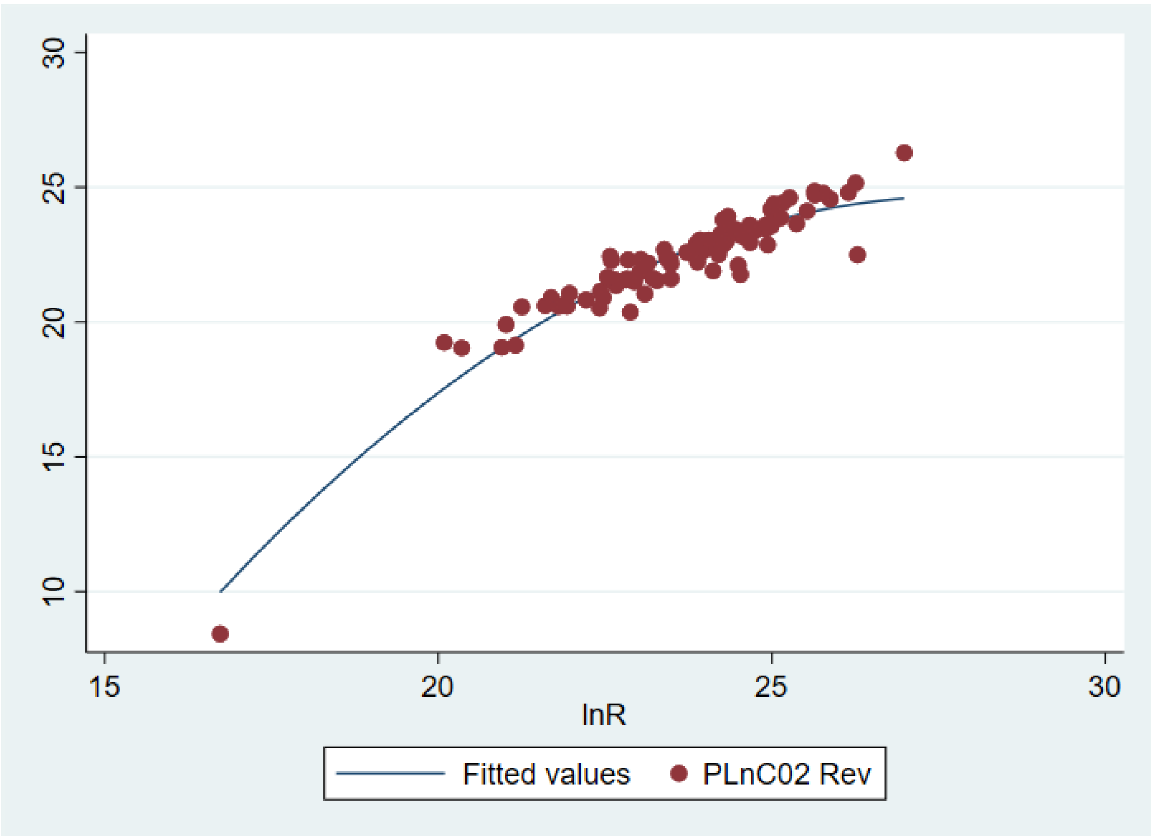

Figure 14: Effects of Revenue on CO_2 emissions in 2019. Data points plotted for the 99 companies in Table 10.

In **Figure 14**, the American company All Access Apparel is an influential variable with a $PLnCO_2$ Rev value of 8.43.

Table 9: Effects of Revenue on CO_2 emissions of 99 companies in 2019. For convenience, the 11 industries were sorted into the five groups listed below.*

Technology Multiplier	Coefficient	Standard Error	95% Confidence Interval	
Energy	1.228	0.169	0.891	1.565
Services	1.045	0.133	0.780	1.310
Manufacturing	1.539	0.266	1.010	2.069
Personal Care	1.019	0.117	0.786	1.253
Consumer Goods	1.166	0.186	0.796	1.537

*"Energy" includes Fossil Fuels and Power Generation, "Services" includes Banks and Airlines, "Manufacturing" includes both the Electronics and Automobile manufacturing industries, "Personal Care" comprises Materials and Big Pharma, and "Consumer Goods" consists of Retail, Apparel, and Food, Beverage, & Agriculture.

In both the original IPAT formula and its stochastic reformulation, the STIRPAT, recall that "T" stands for "technology", which is modeled as a residual term in the formulation. "Technology" here embodies not only technology in terms of non-renewable versus renewable sources of energy but also institutions, culture, governance and power, and other internal and external factors. Similar to the IPAT, the STIRPAT integrates the multiple factors that contribute to "technology" into a single multiplier (Dietz & Rosa, 1997). The technology multiplier is the antilog of the residual from the log–polynomial regression reported in **Table 8** earlier.

Technology multipliers corresponding to the CO_2 emissions of 99 companies in the pre-COVID year of 2019 can be observed in **Table 10** below. **Table 9** provides sectorial technology multipliers by averaging the individual multipliers within each sector. Note that the higher the multiplier, the more responsive is the force of technology in influencing either emissions reductions, or increases in the force of CO_2 per unit of energy. For example, if the multiplier is greater than 1, such as 1.2, it would indicate a 1% increase in CO_2 per unit of energy, resulting in a more than 1% increase in emissions, i.e. 1.2%.

In **Table 10**, we can observe that Walmart, a large American retailer, has a very high technology multiplier of 5.443, which can lead to big reductions in emissions from reducing the carbon intensity of energy. A 1% reduction in carbon intensity of energy, i.e. employing natural gas trucks instead of diesel or gasoline, will reduce emissions by 5.4%. Also, in the U.S., electronics manufacturer ADTRAN has a multiplier above 5 as well.

However, Apple Inc., one of the most prominent American corporations in the world that is also in the electronics manufacturing industry, has the lowest multiplier of all 99 companies listed in the table, at 0.15. This is most likely because Apple has already achieved major reductions, thus making it more difficult to use T to reduce emissions further. From 2017 to 2019, Apple's T was reduced by almost 70%. Other companies with technology multipliers below 0.5 are L'Oreal, Nordea and Danske Banks, Ørsted, and Kering in Europe, along with American Express in the U.S.

While most Power Generation companies in Europe have a multiplier below 1, two of America's have a multiplier of 1.6 and 2.8. The Apparel industry in both regions seems to have emissions less responsive to T than others, with the exception of Burberry Group in Europe and Nike Inc. in the U.S., both having technology multipliers above 1. All European electronics manufacturers have multipliers above 1, and the same is true for all automobile manufacturers in the U.S.

Examining **Table 9**, in which firms have been placed in their respective sectors, the technology multipliers of these sectors hover around the unitary elasticity, consistent with the IPAT formulation. 'Manufacturing' has a higher multiplier than the other sectors.

Table 10: Technology Multiplier for 99 companies' CO_2 emissions, for both regions of Europe and the United States, sorted by industry, for the pre-COVID year of 2019.*

ORGANIZATION	COUNTRY	INDUSTRY	TECHNOLOGY MULTIPLIER
ADIDAS AG	Germany	Apparel	**0.548**
KERING	France	Apparel	**0.435**
LVMH	France	Apparel	**0.956**
PUMA SE	Germany	Apparel	**0.934**
BURBERRY GROUP	United Kingdom	Apparel	**2.044**
CARREFOUR	France	Retail	**1.584**
KESKO CORPORATION	Finland	Retail	**0.380**
J SAINSBURY PLC	United Kingdom	Retail	**0.544**
CASINO GUICHARD-PERRACHON	France	Retail	**1.869**
MARKS AND SPENCER GROUP PLC	United Kingdom	Retail	**1.456**
DANONE	France	Food, beverage & agriculture	**0.823**
BRITVIC	United Kingdom	Food, beverage & agriculture	**0.791**
DIAGEO PLC	United Kingdom	Food, beverage & agriculture	**0.509**
PERNOD RICARD	France	Food, beverage & agriculture	**0.709**
CARLSBERG BREWERIES A/S	Denmark	Food, beverage & agriculture	**0.812**

ORGANIZATION	COUNTRY	INDUSTRY	TECHNOLOGY MULTIPLIER
EQUINOR	Norway	Fossil Fuels	**0.908**
TULLOW OIL	United Kingdom	Fossil Fuels	**2.812**
LUNDIN ENERGY AB	Sweden	Fossil Fuels	**1.252**
NESTE OYJ	Finland	Fossil Fuels	**0.764**
AKER BP ASA	Norway	Fossil Fuels	**1.055**
ERICSSON	Sweden	Manufacturing (Electronics)	**1.590**
ADVA OPTICAL NETWORKING SE	Germany	Manufacturing (Electronics)	
NOKIA GROUP	Finland	Manufacturing (Electronics)	**1.105**
ASSA ABLOY	Sweden	Manufacturing (Electronics)	**2.040**
APTIV	United Kingdom	Manufacturing (Electronics)	**1.423**
FINNAIR	Finland	Transportation services	**1.227**
AIR FRANCE – KLM	France	Transportation services	**0.856**
DEUTSCHE LUFTHANSA AG	Germany	Transportation services	**0.870**
SAS	Sweden	Transportation services	**0.878**
GLAXOSMITHKLINE	United Kingdom	Biotech, health care & pharma	**1.143**
NOVO NORDISK A/S	Denmark	Biotech, health care & pharma	**1.073**
SANOFI	France	Biotech, health care & pharma	**0.793**
ASTRAZENECA	United Kingdom	Biotech, health care & pharma	**0.833**
HENKEL AG & CO. KGAA	Germany	Materials	**0.916**
L'ORÉAL	France	Materials	**0.318**
ORIFLAME HOLDING LTD	Sweden	Materials	**1.017**
PZ CUSSONS	United Kingdom	Materials	**2.797**
UNILEVER PLC	United Kingdom	Materials	**0.579**
RENAULT GROUP	France	Manufacturing (Automobiles)	**0.849**
BMW AG	Germany	Manufacturing (Automobiles)	**0.736**
VOLKSWAGEN AG	Germany	Manufacturing (Automobiles)	**2.171**
DAIMLER AG	Germany	Manufacturing (Automobiles)	**1.403**
ØRSTED	Denmark	Power generation	**0.440**
SSE	United Kingdom	Power generation	**1.102**
FORTUM OYJ	Finland	Power generation	**0.512**
EDF	France	Power generation	**0.857**
CENTRICA	United Kingdom	Power generation	**0.753**
BNP PARIBAS	France	Financial Services	**0.939**
HSBC HOLDINGS PLC	United Kingdom	Financial Services	**1.603**
DANSKE BANK A/S	Denmark	Financial Services	**0.198**

ORGANIZATION	COUNTRY	INDUSTRY	TECHNOLOGY MULTIPLIER
NORDEA BANK ABP	Sweden	Financial Services	**0.249**
NATWEST GROUP PLC	United Kingdom	Financial Services	**2.134**
NIKE INC.	United States of America	Apparel	**1.093**
PVH CORP	United States of America	Apparel	**0.917**
HANESBRANDS INC.	United States of America	Apparel	**0.868**
LEVI STRAUSS & CO.	United States of America	Apparel	**0.700**
ALL ACCESS APPAREL, INC.	United States of America	Apparel	**0.214**
WALMART, INC.	United States of America	Retail	**5.443**
WALGREENS BOOTS ALLIANCE	United States of America	Retail	**2.108**
BEST BUY CO., INC.	United States of America	Retail	**0.933**
MACY'S, INC.	United States of America	Retail	**1.205**
NORDSTROM, INC.	United States of America	Retail	**0.893**
THE COCA-COLA COMPANY	United States of America	Food, beverage & agriculture	**1.981**
KEURIG DR PEPPER	United States of America	Food, beverage & agriculture	
CONSTELLATION BRANDS, INC.	United States of America	Food, beverage & agriculture	**0.891**
MOLSON COORS BREWING COMPANY	United States of America	Food, beverage & agriculture	**1.033**
DEVON ENERGY CORPORATION	United States of America	Fossil Fuels	**1.256**
CONOCOPHILLIPS	United States of America	Fossil Fuels	**1.042**
WILLIAMS COMPANIES, INC.	United States of America	Fossil Fuels	**0.907**
HESS CORPORATION	United States of America	Fossil Fuels	**2.377**
APPLE INC.	United States of America	Manufacturing (Electronics)	**0.150**
COMMSCOPE, INC.	United States of America	Manufacturing (Electronics)	**1.796**
ARISTA NETWORKS	United States of America	Manufacturing (Electronics)	**1.733**
JUNIPER NETWORKS, INC.	United States of America	Manufacturing (Electronics)	**0.907**
ADTRAN INC	United States of America	Manufacturing (Electronics)	**5.500**
AMERICAN AIRLINES GROUP INC	United States of America	Transportation services	**0.954**
DELTA AIR LINES	United States of America	Transportation services	**0.879**
UNITED AIRLINES HOLDINGS	United States of America	Transportation services	**0.905**
PFIZER INC.	United States of America	Biotech, health care & pharma	**1.114**
ABBVIE INC	United States of America	Biotech, health care & pharma	**0.891**
BRISTOL-MYERS SQUIBB	United States of America	Biotech, health care & pharma	**0.778**
JOHNSON & JOHNSON	United States of America	Biotech, health care & pharma	**1.054**

ORGANIZATION	COUNTRY	INDUSTRY	TECHNOLOGY MULTIPLIER
MERCK & CO., INC.	United States of America	Biotech, health care & pharma	**0.787**
PROCTER & GAMBLE COMPANY	United States of America	Materials	**0.954**
COLGATE PALMOLIVE COMPANY	United States of America	Materials	**0.901**
ESTEE LAUDER COMPANIES INC.	United States of America	Materials	**1.019**
CLOROX COMPANY	United States of America	Materials	**1.387**
CHURCH & DWIGHT CO., INC	United States of America	Materials	
FORD MOTOR COMPANY	United States of America	Manufacturing (Automobiles)	**1.830**
GENERAL MOTORS COMPANY	United States of America	Manufacturing (Automobiles)	**1.842**
NAVISTAR INTERNATIONAL CORPORATION	United States of America	Manufacturing (Automobiles)	**1.131**
PACCAR INC	United States of America	Manufacturing (Automobiles)	**1.068**
EXELON CORPORATION	United States of America	Power generation	**0.730**
CMS ENERGY CORPORATION	United States of America	Power generation	**2.847**
DOMINION ENERGY	United States of America	Power generation	**0.587**
PINNACLE WEST CAPITAL CORPORATION	United States of America	Power generation	**1.606**
DUKE ENERGY CORPORATION	United States of America	Power generation	**0.751**
AMERICAN EXPRESS	United States of America	Financial Services	**0.286**
MORGAN STANLEY	United States of America	Financial Services	**1.142**
U.S. BANCORP	United States of America	Financial Services	**0.979**
WELLS FARGO & COMPANY	United States of America	Financial Services	**1.793**
CITIGROUP INC.	United States of America	Financial Services	**1.884**

*99 companies instead of the 102, because 3 companies (ADVA Optical, Dr. Pepper, and Church & Dwight) did not have data for 2019; they only did for 2017, 2018, and 2020.

STIRPAT Results: Concluding Remarks

In summary, the findings from the STIRPAT estimations are consistent with those of the IPACT model. **Table 8**'s log-linear calculations show unitary elasticities of emissions just like in the IPACT model, signifying that emissions are relatively sensitive to revenue and energy efficiency. The log-polynomial exhibits a difference in the revenue force, which has an elasticity that varies with size of the firm, as determined by revenue. In this case, revenue elasticity is not constant and decreases with revenue increasing, violating the IPACT formulation that has a constant unitary elasticity. This implies that very large firms can increase their revenue while reducing emissions, holding energy efficiency constant; most likely through utilizing better technology from the technology multiplier. Smaller firms have more difficulty and may be focusing more on energy efficiency than switching to renewable energy sources.

Furthermore, similar to the IPACT, the STIRPAT integrates the multiple factors that contribute to “technology” into a single multiplier, which is the antilog of the residual from the log–polynomial regression reported in **Table 8**. The higher the technology multiplier, the more responsive is the force of technology in influencing either emissions reductions or increases. **Table 9** shows that the technology multipliers of the sectors hover around the unitary elasticity, consistent with the IPACT formulation.

CHAPTER 9: TARGETS AND EMISSION REDUCTIONS

Introduction: Targets at the Corporate Level

According to the United Nations Principles for Responsible Investment [UN PRI], setting carbon neutrality and net-zero GHG commitments for attaining specified future emissions levels by a target year is starting to become the norm for both businesses and governments. The question today is not so much about whether companies will ever set targets, but rather how they plan to meet them (Geck, 2021).

Although the term '"carbon-neutral" is sometimes used interchangeably with "net-zero," the two are not the same. When a company claims to be carbon-neutral, it typically offsets its carbon emissions by paying carbon tax or buying carbon credits, but essentially does not reduce emissions by an amount that reaches net-zero at the global or sector level. This may mask the need for further emissions cuts, consistent with science calling for limiting global warming to 1.5°C. Also, the carbon-neutral claim does not necessarily cover any GHGs other than CO_2 (Tarrant, 2021).

Net-zero, on the other hand, involves overall GHG reductions throughout the organization’s entire supply chain. Net-zero means emissions are offset by the removal of an equivalent amount of CO_2 from the atmosphere. It can be implemented through investment in renewable energy, planting trees, or processes like carbon capture and storage. In order to limit global warming to 1.5 °C and prevent the worst effects of climate change, anthropogenic emissions must be net-zero by the year of 2050 (ISO, 2022; Tarrant, 2021).

As per the 2021 Corporate Sustainability Assessment conducted by S&P Global, almost 60% of European companies had declared plans to reduce their direct emissions as well as those generated from their purchased energy. Meanwhile, only 35% companies in North America, 31% in South America, and 29% in the Asia-Pacific region had announced Scope 1 and/or Scope 2 emissions targets (Whieldon & Almtoft, 2022).

A recent report by Accenture highlights that 93% of companies will fail to meet their net-zero commitments if they do not double their rate of emissions reductions by 2030. In spite of the fact that more businesses in every region are setting clear, publicly visible decarbonization goals, with a record number of corporate targets validated by the Science-Based Targets Initiative [SBTi] this year alone, and despite 84% of businesses planning to increase investments in their sustainability initiatives before the end of 2022, the study finds that rising energy price inflation and supply insecurity are pushing commitments out of reach (Aizenberg & Luu, 2022).

Despite the pledges made, just 7% of businesses are on track to meet their net-zero goals for Scope 1 and 2 emissions at the observed rates of change by 2030, and the remaining most likely will move their targets to 2050. Assuming that corporations accelerated emissions reductions to twice the existing levels in the years leading up to 2030, and then three times after that, 59% would still fail by 2050, the timeframe deemed necessary to avert the most catastrophic and long-lasting effects of climate change (Aizenberg & Luu, 2022).

The Accenture report recommends that companies will need to create several 'carbon intelligence' capabilities at the same time to operate at the pace and scale demanded by science and economics. This entails integrating carbon data and insights that are ready for decision-making across their systems and processes, enabling efficient use of financial and non-financial resources, as well as sound risk management when deploying the digital, biological, and industrial technologies that will be required to achieve net-zero (Aizenberg & Luu, 2022).

The next sections in this chapter will compare the nature of targets set by the 102 companies in this thesis. Additionally, using past performance as an indicator, case studies will be observed on two companies from each region to assess whether they are on track to meet their targets. Finally, we will also conduct the IPAT case study at the national level on one country.

Targets from European and American Firms

Absolute targets refer to reductions in CO_2 emissions while intensity targets refer to carbon emissions in relation to a benchmark like total energy, size of the operation, the firm's revenues, etc. With intensity targets, emissions can increase; but as long as they increase at a slower rate than the benchmark, their target can be achieved. For example, emissions currently may be 60% of energy. The target could be to reduce intensity to 30% of energy. This target can be hit even if emissions increase as long as they increase at a slower rate than energy rises.

Table 11: Pre-COVID growth rate of CO_2 and type of control for 65 companies across Europe and the U.S.

Type of control	Target: All	Target: 2030*	Coefficient	Standard Error	95% Confidence Interval	
Absolute	46	22	-0.139	0.045	-0.229	-0.049
Intensity**	17	17	-0.082	0.051	-0.184	0.019
Both	39	26	-0.148	0.041	-0.231	-0.065
Total	**102**	**65**				

*"Target: 2030" tells the number of companies that have or include an emissions target for the year of 2030. However, other than ConocoPhillips, none of the 14 companies with intensity targets had provided any detail about their target year, base year, progress, etc. But for the sake of comparison, we have still included those 13 companies in the intensity row. **For convenience, the "Intensity" row includes the 3 companies which had not set a target at all. 14 companies had set an actual intensity target.

Table 11 assesses the 65 companies across both the U.S. and Europe that have emissions targets for the year of 2030, since it is a common target for companies, plus not as soon as 2025 and not as far away as 2040 or 2050. Out of the 65 companies, 33.8% have absolute targets. The "Intensity" target row includes the three companies which had not set a target at all, and represents 26.2% of the total. The remaining 40% had both absolute and intensity targets. In the Pre-COVID era, companies with absolute targets reduced emissions on average by 13.9%, with a 95% confidence interval [-22.9%, -4.9%]. Those with intensity targets reduced the least by 8.2%, but is not statistically significant and thus inconclusive if they reduced or not. Those with both control types reduced by 14.8% with a 95% confidence interval [-23.1%, -6.5%],

Table 12: Pre-COVID growth rate of CO_2 and type of control for 37 companies in Europe.

Type of Control [EU]	Target: 2030	Coefficient	Standard Error	95% Confidence Interval	
Absolute	11	-0.187	0.070	-0.331	-0.043
Intensity	6	-0.089	0.021	-0.134	-0.045
Both	20	-0.201	0.053	-0.309	-0.092
Total	**37**				

Table 13: Pre-COVID growth rate of CO_2 and type of control for 28 companies in the U.S.

Type of Control [US]	Target: 2030	Coefficient	Standard Error	95% Confidence Interval	
Absolute	11	-0.090	0.044	-0.183	0.001
Intensity*	11	-0.078	0.075	-0.233	0.076
Both	6	0.026	0.022	-0.020	0.073
Total	**28**				

*For convenience, the "Intensity" row includes the 3 companies which had not set a target at all. Only 8 U.S. companies had set an actual intensity target.

Table 12 and **Table 13** convey **Table 11**'s statistics separately by regions, i.e. Europe and the U.S. respectively, but only taking the target year of 2030 into account. This shows that there are significant differences between the two regions. European companies with absolute targets reduced emissions by 18.7% relative to U.S. companies that reduced emissions only by 9%. In Europe, companies with intensity targets reduced emissions by 8.9%, but in the U.S., emissions fell by 7.8%. However, this is not statistically significant and hence inconclusive to show if intensity targets achieve reductions on average. For European companies with both targets, emissions fell by 20.1%, while in the U.S. emissions increased by 2.6%, although not significant and hence inconclusive to make any claims.

Case Studies: IPAT Framework to Hit Targets at the Corporate Level

Table 14: Target details of companies Nokia Group, Apple Inc., Ørsted, & Nike Inc.

Organization	Nokia Group	Apple Inc.	Ørsted	NIKE Inc.
Country	Finland	USA	Denmark	USA
Base Year [BY]	2014	2019	2018	2015
Target year	2030	2030	2032	2030
BY Emissions	710,000	25,100,000	29,200,000	264,394
Targeted reduction from BY (%)	41.00	61.70	50.0	65.00
Emissions in TY	418,900	9,613,300	14,600,000	92,538
Emissions in 2019	452,238	25,100,000	25,333,000	255,779
Emissions growth (-decline)	-23.4%	-38.1%	-54.3%	1.99%
Revenue growth	0.7%	13.5%	13.6%	13.83%
Energy efficiency	-10.3%	16.2%	-45.2%	11.66%
Technology	-13.8%	-67.8%	-22.7%	-23.50%
Energy growth	-9.6%	29.7%	-31.6%	25.49%

Note: Growth rates are pre-COVID-19, so that the pandemic does not influence endogenous decisions.

Can a firm meet its target given past performances and future expected revenue growth? The following application of IPAT illustrates the effort of meeting the targets for reducing CO_2 emissions with respect to three companies that had absolute targets – namely Nokia Group, Apple Inc., Ørsted, and Nike Inc. Details about these companies can be observed in **Table 14**.

I. Apple Inc.

Founded in 1976 by Steve Jobs, Steve Wozniak and Ronald Wayne, Apple Inc. is a multinational technology company based in Cupertino, California. It is considered one of the Big Four technology companies, alongside Amazon, Google, and Microsoft. Apple reached $1 trillion in value in 2018, ranking 3rd worldwide in Fortune 500 companies (Fortune, 2019).

After going public in 1980, Apple Inc. is now considered to be one of the largest companies in the world, and has tremendous influence within the U.S. and global economies. According to data from the World Bank, Apple Inc. is worth more than Canada's $1.7 trillion economy, leaving only seven countries in the world with a GDP higher than Apple's market value. As of March 15, 2021, Apple's market cap increased to $2.08 trillion, making it the first publicly traded U.S. company to surpass $2 trillion, and the first company in the world to reach a market capitalization of $1 trillion (Kolakowski, 2021).

Now, let us conduct the IPAT experiment to see whether Apple will meet its target, which is for its GHG emissions to be 61.7% below 2019 levels by 2030. From 2017 to 2019, Apple had the following growth rates – revenue grew at an average rate of 4.5% per year during this period, while energy use grew at the rate of 9.9% per year (derived from the three-year figures in **Table 14**). Thus, energy per unit of revenue grew at the rate of 5.4% per year (i.e., the difference in the growth rate of energy and revenue). In order to hit the target, assuming revenue and energy efficiency continue to grow at the same rates, carbon intensity has to fall to a certain level in 2030 relative to 2019 levels. Using the IPAT equations:

$$CO_{2_{2030}} = (R_{2030})(\frac{E}{R}_{2030})(\frac{CO_2}{E}_{2030})$$

$$CO_{2_{2019}} = (R_{2019})(\frac{E}{R}_{2019})(\frac{CO_2}{E}_{2019})$$

And taking the ratio of these two relationships yields:

$$\frac{CO_{2_{2030}}}{CO_{2_{2019}}} = \frac{\left(R_{2030}\right)(\frac{E}{R_{2030}})\left(\frac{CO_2}{E}_{2030}\right)}{\left(R_{2019}\right)\left(\frac{E}{R_{2019}}\right)\left(\frac{CO_2}{E}_{2019}\right)}$$

On average, if the above rates of growth are maintained, then in 2030, revenue will be 1.62

times higher at the average growth rate of 4.5% per year, and energy per unit of revenue will be 1.78 times higher than energy in 2019 at the average annual growth rate of 5.4%. This results in:

$$\frac{CO_{2_{2030}}}{CO_{2_{2019}}} = 1.62 * 1.78 \frac{(\frac{CO_2}{E}_{2030})}{(\frac{CO_2}{E}_{2019})}$$

Since the target for CO_2 is to be 61.7% below 2019 levels:

$$CO_{2_{2030}} = CO_{2_{2019}} - 0.617 CO_{2_{2019}} = 0.383 CO_{2_{2019}}.$$

Substituting these values into the ratio of the two equations and solving for carbon intensity, we get approximately:

$$\left(\frac{CO_2}{E}_{2030}\right) = \frac{0.383}{1.62 * 1.78}\left(\frac{CO_2}{E}_{2019}\right) = 0.133\left(\frac{CO_2}{E}_{2019}\right)$$

Thus, carbon intensity in 2030 has to be 13.3% of that in 2019, in order to hit the target of 61.7% below 2019 levels by 2030. The reason it has to be way below 61.7% of the 2019 level, i.e. 13.3% of 2019 level, is because revenue and energy used per unit of revenue are expected to rise in the future if the same trend continues until 2030.

How fast do carbon emissions have to fall in the future to hit the target requires a growth rate of carbon intensity that will bring it in 2030 to 0.133, its 2019 level. Carbon intensity should be falling by g percent per year as follows:

$$T_{2030} = T_{2019}(1 + g)^{11}$$

Where for simplicity, $T_{2030} = \frac{CO_2}{E}_{2030}$ is carbon intensity in 2030, and $T_{2019} = \frac{CO_2}{E}_{2019}$ is carbon intensity in 2019. But we also want $T_{2030} = 0.133T_{2019}$ to hit the target. Equating the last two equations, we get: $0.133 = (1 + g)^{11}$. Solving for g yields:

$$g = 0.133^{1/11} - 1 = -0.167$$

Meaning 16.7% reduction per year in carbon intensity. Since energy grew at 9.9% per year, and if it continues at this rate in the future, carbon emissions will need to fall by 6.8% per year over the next 11 years. The company can compare the past growth rate of emissions with 6.8% reduction per year to see if it is on target or not. Apple Inc.'s emissions fell by 11.4% per year in the 2017-2019 period, which shows that Apple is on the right track to hit its 2030 target. Even in the case of revenue and energy efficiency not changing over the next 11 years, emissions have to fall at a rate of 8.4% per year to hit the target of 9,613,300 in 2030 from 25,100,000 in 2019, as per **Table 14** above.

II. Nokia Group

Nokia is a telecommunication and IT firm based in Finland. Nearly 88,000 people work for the corporation, which was founded in 1865, and has its headquarters in Espoo. Nokia has ventured into different markets throughout the years. The company dominated the mobile market as a global leader in the early days of the cell phone and smartphone era. However, beginning in 2011, Nokia's mobile business started to lose money as a result of its slow adoption of advances in smartphone technology, which allowed rivals like Samsung and Apple to gradually overtake it as the market leader. Microsoft purchased Nokia's phone division in 2013 (Alsop, 2022).

Since then, Nokia has concentrated on data networking services and telecommunications equipment through its subsidiary, Nokia Networks. As of 2021, this subsidiary has become its highest-earning business segment. Additionally, the technology company has branched out to providing solutions for cloud computing and mapping applications. The most significant markets for Nokia globally are those in North America and Europe, where it has emerged among the leading telecom infrastructure industry. The Nokia brand today is worth roughly US $28 billion (Alsop, 2022; Financial Times, 2023).

Now, we perform the IPAT experiment on Nokia Group, to see if the company is on track to meet its target of reducing GHG emissions to be 41% below 2014 levels by 2030. From 2017 to 2019, Nokia had the following growth rates – revenue grew at a rate of 0.23% per year during this period, while energy use fell at the rate of -3.2% per year. Thus, energy per unit of revenue fell at the rate of -3.0% per year. Assuming these rates continue into the future and were present in the past three years (i.e., 2014-2016) on average, carbon intensity has to fall to a certain level in 2030 relative to 2014 levels. Using the IPAT equations:

$$CO_{2_{2030}} = (R_{2030})(\frac{E}{R}_{2030})(\frac{CO_2}{E}_{2030})$$

$$CO_{2_{2014}} = (R_{2014})(\frac{E}{R}_{2014})(\frac{CO_2}{E}_{2014})$$

On average, if the above rates of change are maintained, then revenue in 2030 will be 1.04 times higher than in 2014, at the assumed average growth rate of 0.23% per year. Energy per unit of revenue in 2030 will decrease to 0.614 compared to the 2014 figure, at the average annual decline rate of -3%. Since the target for CO_2 is to be 41% below 2014 levels:

$$CO_{2_{2030}} = CO_{2_{2014}} \text{-} 0.41 CO_{2_{2014}} = 0.59 CO_{2_{2014}}.$$

Substituting these values into the ratio of the two equations and solving for carbon intensity, we get approximately:

$$\left(\frac{CO_2}{E}_{2030}\right) = \frac{0.59}{1.04 * 0.614}\left(\frac{CO_2}{E}_{2014}\right) = 0.92\left(\frac{CO_2}{E}_{2014}\right)$$

Thus, carbon intensity in 2030 has to be 92% of that in 2014, in order to hit the target of 41% below 2014 levels by 2030. The reason carbon intensity does not need to drop by a lot is because revenue is unchanged but energy per unit of revenue is falling at a very fast rate and is assumed to continue to drop reaching 61.4% by 2019 relative to 2014. How fast do carbon emissions have to fall in the future to hit the target requires a growth rate of carbon intensity that will bring it in 2030 to 0.92, its 2014 level. Carbon intensity should be falling by g percent per year as follows:

$$T_{2030} = T_{2014}(1 + g)^{16}$$

Where for simplicity, $T_{2030} = \frac{CO_2}{E}_{2030}$ is carbon intensity in 2030, and $T_{2014} = \frac{CO_2}{E}_{2014}$ is carbon intensity in 2014. But we also want $T_{2030} = 0.92T_{2014}$ to hit the target. Equating the last two equations, we get $0.92 = (1 + g)^{16}$. Solving for g yields:

$$g = 0.92^{1/16} - 1 = -0.0052$$

Meaning 0.5% reduction per year in carbon intensity. Since energy fell at 3% per year during the past on average, carbon emissions will have to fall by 3.5% per year over the 16 years. The company can compare the past growth rate of emissions with 3.5% reduction per year to see if it is on target or not. Nokia's emissions fell by 7.3% per year over the 2017-2019 period, which shows that Nokia is on the right track to hit its 2030 target. In fact, since Nokia's emissions fell much faster than 3.5% per year from 2017-2019, its emissions need to fall only by 0.7% over the next 11 years, even if revenue and energy intensity remain unchanged. This is because emissions in 2030 have to be 418,900 tonnes, and in 2019 were 452,238 tonnes (see **Table 14**).

III. Ørsted

To mitigate climate change, companies in every industry must swiftly reduce their GHG emissions. Although it is not an easy undertaking, a few companies exemplify that it can be done. Ørsted, an energy company based in Denmark, leads the way in doing so. When it was still known as DONG Energy twelve years ago, the company generated the majority of its income from the sale of heat and power, 85% of which was derived from coal (Tryggestad & Rosenfield, 2020).

In 2009, the corporation then declared a significant strategy shift, aiming to instead produce 85% of its heat and electricity from renewable sources by 2040. Eventually, Ørsted phased out coal and invested aggressively in offshore wind. By 2019, it had risen to become as the world's biggest generator of offshore wind energy. The corporation increased its share of renewable generation to 86 percent, exceeding its target 21 years earlier than expected. As of today, Ørsted employs 8,000 people and has a market cap of roughly US$37 billion (Tryggestad & Rosenfield, 2020; The Wall Street Journal, 2023).

Moving on to conducting the IPAT experiment on Ørsted, which has a target of reducing GHG emissions to be 50% below 2018 levels by the target year of 2032. From 2017 to 2019, Ørsted had the following growth rates – revenue grew at a rate of 4.5% per year during this period, while energy use fell at the rate of -10.5% per year. Thus, energy per unit of revenue fell at the rate of -15.1% per year. In order to hit the target, assuming revenue and energy efficiency continue to grow at the same rates, carbon intensity has to fall to a certain level in 2032 relative to 2018 levels. Using the IPAT equations:

$$CO_{2_{2032}} = (R_{2032})(\frac{E}{R_{2032}})(\frac{CO_2}{E}_{2032})$$

$$CO_{2_{2018}} = (R_{2018})(\frac{E}{R_{2018}})(\frac{CO_2}{E}_{2018})$$

On average, if the above rates of change are maintained, then in 2032, revenue will be 1.75 times higher at the average growth rate of 4.53% per year, and energy per unit of revenue will be 0.135 times lower than energy in 2018 at the average annual decline rate of -15.06%. Since the target for CO_2 is to be 50% below 2018 levels:

$$CO_{2_{2032}} = CO_{2_{2018}} - 0.5CO_{2_{2018}} = 0.5CO_{2_{2018}}.$$

Substituting these values into the ratio of the two equations and solving for carbon intensity, we get approximately:

$$\left(\frac{CO_2}{E}_{2032}\right) = \frac{0.50}{1.75 * 0.135}\left(\frac{CO_2}{E}_{2018}\right) = 2.1\left(\frac{CO_2}{E}_{2018}\right)$$

Thus, carbon intensity in 2032 can be 210% of that in 2018, in order to hit the target of 50% below 2018 levels by 2032. This is because of the assumption that energy efficiency continues to drop significantly, reaching 13.5% of 2018 in 2032, even with revenue rising. Carbon intensity should be g percent per year:

$$T_{2032} = T_{2018}(1 + g)^{14}$$

But we also want carbon intensity to be 2.1 times the 2018 level by 2032, namely, $T_{2032} = 2.1T_{2018}$ to hit the target. Equating the last two equations, we get $2.1 = (1 + g)^{14}$. Solving for g yields:

$$g = 2.1^{1/14} - 1 = 0.054$$

Meaning 5.4% increase per year in carbon intensity. Since energy fell at 10.5% per year, carbon emissions will need to fall by 5.1% per year over the next 14 years. Ørsted's emissions fell by 23% per year which shows that Ørsted will hit its 2032 target. If revenue and energy efficiency remain unchanged during this period, emissions can fall at the rate of 3.8% per year and Ørsted will still hit the target (see **Table 14**).

IV. Nike Inc.

Nike Inc. is a multinational company from the United States that specializes in making and selling athletic shoes, clothing, and sports equipment. It is the largest producer and supplier in the industry, and competes with other major players like Adidas, Puma, and Under Armour. Nike owns several brands, including Converse and Jordan, and its headquarters are located in Beaverton, Oregon (Tighe, 2022).

As of 2022, Nike Inc. has 80,000 employees around the world, with a significant number located in North America. Despite significant growth in non-U.S. markets, the United States remains Nike's primary market, as it generates approximately 40 percent of the company's total global revenue. Additionally, Nike provides sponsorship to numerous well-known athletes worldwide, including Cristiano Ronaldo, Rory McIlroy, LeBron James, and Rafael Nadal. The company also sponsors sports teams such as Barcelona, RB Leipzig, and Paris Saint-Germain. In 2022, Nike's brand value was estimated to be over US$33 billion, which represents a growth of almost $3 billion compared to the previous year (Tighe, 2022).

Being the final company in this case study¸ we now perform the IPAT experiment on Nike, which has a target of reducing GHG emissions to be 65% below 2015 levels by the target year of 2030. From 2017 to 2019, Nike had the following growth rates – revenue grew at a rate of 4.61% per year during this period, while energy use grew at the rate of 8.5% per year. Thus, energy per unit of revenue grew at the rate of 3.88% per year. In order to hit the target, assuming revenue and energy efficiency continue to grow at the same rates, carbon intensity has to fall to a certain level in 2030 relative to 2015 levels. Using the IPAT equations:

$$CO_{2_{2030}} = (R_{2030})(\frac{E}{R}_{2030})(\frac{CO_2}{E}_{2030})$$

$$CO_{2_{2015}} = (R_{2015})(\frac{E}{R}_{2015})(\frac{CO_2}{E}_{2015})$$

On average, if the above rates of change are maintained, then in 2030, revenue will be 1.76 times higher at the average growth rate of 4.61% per year, and energy per unit of revenue will be 0.63 times the 2015 figure, at the average annual growth rate of 3.88%. Since the target for CO_2 is to be 65% below 2015 levels:

$$CO_{2_{2030}} = CO_{2_{2015}} \text{-} 0.65CO_{2_{2015}} = 0.35CO_{2_{2015}}.$$

Substituting these values into the ratio of the two equations and solving for carbon intensity, we get approximately:

$$\left(\frac{CO_2}{E}_{2030}\right) = \frac{0.35}{1.76 * 0.63}\left(\frac{CO_2}{E}_{2015}\right) = 0.315\left(\frac{CO_2}{E}_{2015}\right)$$

Thus, carbon intensity in 2030 has to be 31.5% of that in 2015, in order to hit the target of 65% below 2015 levels by 2030. Carbon intensity should be falling by g percent per year as follows:

$$T_{2030} = T_{2015}(1 + g)^{15}$$

But we also want $T_{2030} = 0.315T_{2015}$ to hit the target. Equating the last two equations, we get $0.315 = (1+g)^{15}$. Solving for g yields:

$$g = 0.315^{1/15} - 1 = -0.071$$

Meaning 7.1% reduction per year in carbon intensity. Since energy grew at 8.5% per year, carbon emissions will need to fall by 1.4% per year over the next 15 years. Nike's emissions fell by 0.66% per year, which shows that with double the effort, Nike would be on the right track to hit its 2030 target. Assuming no growth in revenue and no improvements in energy efficiency, emissions have to fall even faster at the rate of 3.9% per year, since emissions in 2030 have to be 92,538 tonnes. In 2019, they were at 255,779 tonnes (see **Table 14**).

Introduction: Targets at the National Level

Using a fully statistically based probabilistic framework, Liu and Raftery (2021) determine that the chances of the top emitting countries achieving their NDCs are low, e.g. 2% for the U.S. and 16% for China. On the basis of present trends, the likelihood of keeping global warming below 2°C is only 5%; however, if all nations meet their NDCs and keep reducing emissions at the same rate until 2030, the likelihood increases to 26%. If the U.S. alone fails to reach its NDC, it drops to 18%. Therefore, for a fair chance at maintaining the temperature rise below 2°C, the average rate of decline in emissions would need to go up from the yearly 1% required for meeting the NDCs, to 1.8%.

The expansion of net-zero emission goals illustrates a substantial surge in ambition after the Paris Agreement. But net-zero is perhaps still in its early stages as a consolidating principle for climate action. In order to achieve climate goals, these targets must be increased not only in quantity, but also in quality, and ultimately in execution. All entities must seek to make their long-term targets clearer, binding, comprehensive, and largely resilient, combined with near-term targets and initiatives that follow a credible pathway to long-term goals, given that NDCs have been developed to get progressively more ambitious over time. Thus, further work is needed to operationalize this concept effectively in policy and practice for all entities (Hale et al., 2021).

Case Study: IPAT Framework to Hit Targets at the National Level

Canada's target is for GHGs to be 40-45% below 2005 levels by 2030. Can Canada meet its target given past performances and future expected economic growth? The following application of IPAT illustrates the difficulty of meeting the targets for reducing CO_2 emissions.

Past population, affluence, and technology growth rates from 1997 to 2021 including COVID-19 were as follows: the population of Canada grew at a rate of 1.02% per year, GDP grew at 2.12%, GDP per person grew at the rate of 1.1% per year on average, CO_2 emissions (from burning fossil fuels) grew at 0.56% per year, and carbon intensity fell at the rate of 1.55% per year on average. Note that carbon intensity in this case is CO2 emissions per $ of GDP.

Note that carbon intensity fell not because emissions fell, but because the GDP grew faster than CO_2 emissions. CO_2 emissions are increasing on average at about the same rate as the population. Hence CO_2 emissions per person have remained relatively constant over the period, even though GDP per person has been increasing at 1.1% per year.

In order to hit the target, assuming population and GDP per person continue to grow at the same rates, carbon intensity has to fall to some level in 2030 relative to 2005 levels. Using the IPAT equations:

$$CO_{2_{2030}} = (P_{2030})(\frac{GDP}{P}_{2030})(\frac{CO_2}{GDP_{2030}})$$

$$CO_{2_{2005}} = (P_{2005})(\frac{GDP}{P}_{2005})(\frac{CO_2}{GDP_{2005}})$$

Since the population in 2030 will be 1.29 times higher at the historical average growth rate of 1% per year over this decade and GDP per capita in 2030 will be 1.30 times higher than GDP per capita in 2005 at the average annual growth rate of 1.1%. While the target is for CO_2 is to be 40% below 2005 levels:

$$CO_{2_{2030}} = CO_{2_{2005}} - 0.40 CO_{2_{2005}} = 0.60 CO_{2_{2005}}.$$

Substituting these values into the ratio of the two equations and solving for carbon intensity, we get approximately

$$\left(\frac{CO_2}{GDP_{2030}}\right) = \frac{0.60}{1.29 * 1.30}\left(\frac{CO_2}{GDP_{2005}}\right) = 0.355\left(\frac{CO_2}{GDP_{2005}}\right)$$

Carbon intensity in 2030 has to be 35.5% of that of 2005 to hit the target of 40% below 2005 levels by 2030. Carbon intensity would be 60% of that of 2005 levels in 2030 if population and affluence remained unchanged. Now it has to be much lower to accommodate a higher population and affluence level in the future until 2030.

Next, we need to find the growth rate of carbon intensity that will bring it in 2030 to 0.355 its 2005 level. The growth rate is g (negative number to fall) and carbon intensity should be falling by $T_{2030} = T_{2005}e^{g25}$, where for simplicity, let $T_{2030} = \frac{CO_2}{GDP}_{2030}$ be carbon intensity in 2030, and let $T_{2005} = \frac{CO_2}{GDP}_{2005}$ be carbon intensity in 2005. But we also want $T_{2030} = 0.355T_{2005}$ to hit the target. Equating the last two equations we get $0.355 = e^{g25}$. Solving for g by taking the natural log on both sides and using the logarithmic exponent rule we get:

$$g = \frac{\ln(0.355)}{25} = -0.041$$

Meaning 4.1% per year reduction in carbon intensity. Carbon intensity has to decline at a growth rate that is more than double the 40-year period decline of 1.87% per year on average.

In reality, from 2005 to 2021, carbon intensity has been falling at 1.55% per year, similar to the historical average. Hence at the beginning of 2022 carbon intensity is $T_{2021} = T_{2005}e^{-0.0155*15}$, or alternatively $T_{2021} = 0.775T_{2005}$.

In 2021, carbon intensity is only 0.78 of the 2005 level, and we need to get to 0.355 of the 2005 levels by 2030. We need to get to 35.5% of the 2005 level, and we are only at 78% in 2021 relative to the 2005 level. Hence, we need to reduce carbon intensity faster than 4.1% to catch up with the slower pace in the past. We need carbon intensity over the following decade to be growing at the rate of $T_{2030} = T_{2021}e^{g*10}$, but we know that $T_{2021} = 0.775\ T_{2005}$. Substituting this into the above equation, we have 2030 in terms of 2005 as follows:

$$T_{2030} = 0.78\ T_{2005}e^{g*9}$$

In order to arrive at the solution, we need to keep in mind that $T_{2030} = 0.355T_{2005}$ to hit the target. Combining the two equations above yields:

$$0.355\ T_{2005} = 0.78\ T_{2005}e^{g*9}$$

Solving for g:

$$g = \frac{\ln(0.355/0.78)}{9} = -0.087$$

Meaning carbon intensity has to fall by 8.7% per year over the next 9 years. If the target was for emissions to be 45% below 2005 levels by 2030, then carbon intensity would have to fall even more than 8.7% per year. The probability that this will happen is extremely low, indicating a sobering result from an affluent society like Canada.

To summarize, if carbon intensity should have fallen by 4.1% per year for 25 years, it fell only by 1.55% per year in the first 15 years. Now it has to fall at 8.7% for the remaining years to make up the difference. **Figure 15** shows what pathways the world would have to take to hit 2℃ (Hope, 2015). Canada should hit 300 million tonnes, and currently emissions are just below 700. Planned policies would bring emissions to roughly 500 million tonnes. Current policies and actions have emissions slightly above 600 million tonnes. This analysis corresponds to the previous analysis, which would require unprecedented reductions in emissions to hit the 2030 target. These projections are also available in Canada's 4th Biennial report on Climate Change, submitted to the UNFCCC in 2019. **Table 15** below shows a summary of the above analysis for Canada.

Table 15: IPAT summary of targets scenarios in Canada

Trends	**Period**	**i**	**a**	**p**	**t**
Historical	1997-2021	0.56	1.09	1.02	-1.55
Target for 2030	2005-2030	-2.04	1.09	1.02	-4.15
Observed within target period	2005 - 2021	0.10	0.54	1.06	-1.50
To hit target in 2030 from 2022	2022-2030	-6.56	1.09	1.06	-8.71

Note: a and p are assumed to grow at their historical averages.

Table 16 below illustrates Canada's performance in reducing emissions after signing the Kyoto Protocol in 1997 and the 2015 Paris Agreement until 2021, with two scenarios: including the pandemic, and assuming there was no pandemic. The last row of the table suggests that Canada faces an insurmountable challenge relative to the previous period with agreements in place. The objective of analyzing Canada's performance is to demonstrate that a top-down approach may not be capable of achieving targets, due to political and socio-economic factors. Instead, a bottom-up approach, as seen earlier in this chapter with the four large companies, may instigate a change in behavior.

Table 16: IPAT summary of targets performance in Canada after international agreements

Agreements	Period	CO_2	Population	Affluence	Technology
Post-Kyoto	1998-2014	0.96	1.00	1.49	-1.53
Post-Paris Agreement, with pandemic	2015-2021	-0.41	1.09	0.10	-1.60
Post Paris Agreement, assuming no pandemic	2015-2021	1.00	1.08	1.20	-1.28
What is needed to hit the target	2022 -2030	-6.56	1.09	1.06	-8.71

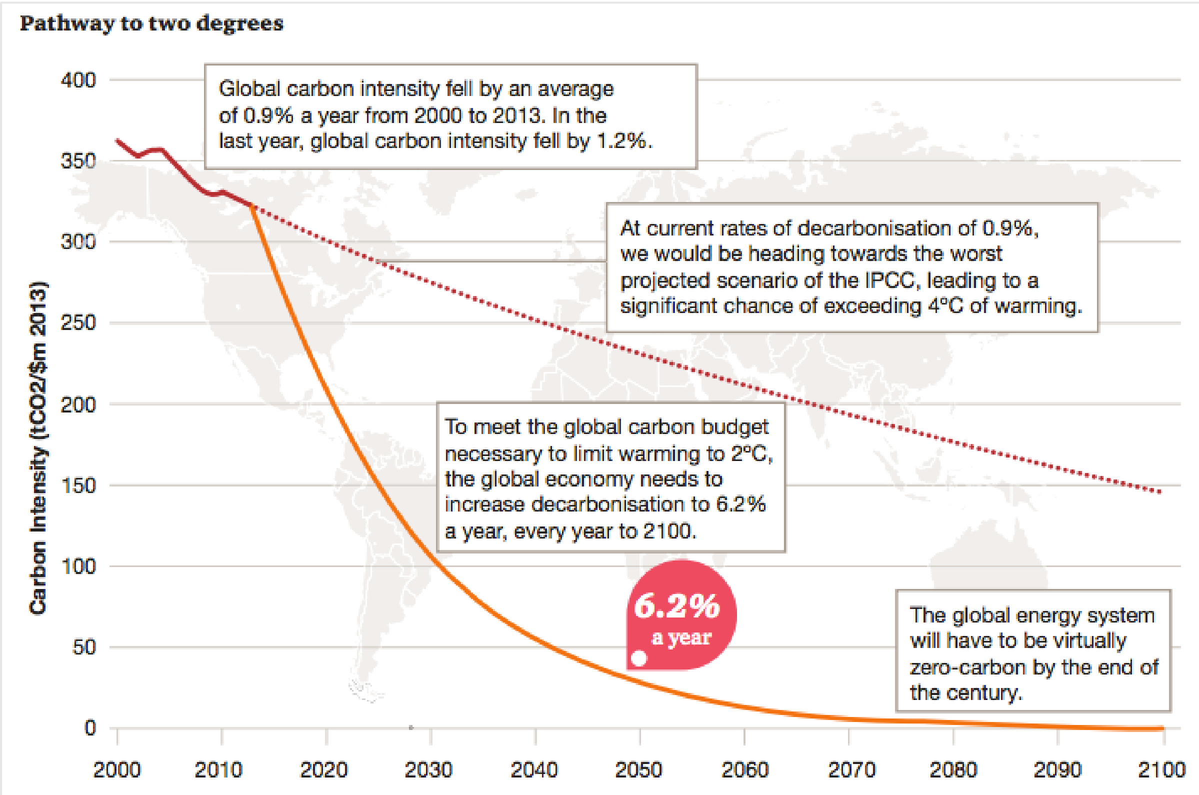

Figure 15: Historical global carbon intensity and projections, from 2000 to 2100.

Global Emissions

In 2020, global CO_2 emissions were 34.8 billion tonnes. CO_2 emissions falling by 30% relative to 2020 would lead to 24.4 billion tonnes per year by 2030. This reduction would require emissions to fall by 3.5% per year over the next decade, but this does not include that population and affluence will be higher. Adding population growth of 1% per year and GDP per capita by 2.5%, carbon intensity would need to fall by 7.5% per year. With intergenerational equity issues of climate change, the developed world would have to decrease carbon intensity by more than 7.5% per year while the rest would by less than 7.5% per year, so the path to 2°C is highly improbable to occur. This is in line with **Figure 15** above, from PwC's 6th Low Carbon Economy Index Report (Hope, 2015).

Targets: Concluding Remarks

An Accenture report suggested that 93% of companies will fail to meet their net-zero commitments if they do not double their rate of emissions reductions by 2030. Assuming that corporations accelerated emissions reductions to twice the existing levels in the years leading up to 2030, and then three times after that, 59% would still fail by 2050, the timeframe deemed necessary to avert the most catastrophic and long-lasting effects of climate change.

In the pre-COVID era, out of the 65 companies from our study with a 2030 target, the firms with absolute targets reduced emissions on average by 13.9%. Those with intensity targets reduced the least by 8.2%, but is not statistically significant and thus inconclusive if they reduced or not. Those with both absolute and intensity targets reduced by 14.8%. See **Table 11**.

European companies with absolute targets reduced emissions by 18.7% relative to U.S. companies that reduced emissions only by 9%. In Europe, companies with intensity targets reduced emissions by 8.9%, but in the U.S., emissions fell by 7.8%. However, this is not statistically significant and hence inconclusive to show if intensity targets achieve reductions on average. For European companies with both targets, emissions fell by 20.1%, while in the U.S. emissions increased by 2.6%, although not significant and hence inconclusive to make any claims. See **Table 12** and **Table 13**.

Next, by applying the IPAT formula and using past performance as an indicator, we conducted case studies on Apple Inc., Nokia, Ørsted, and Nike Inc. to assess whether they were on track to meet their targets by 2030, and 2032 in the case of Ørsted. While Apple, Nokia, and Ørsted are showing positive signs of reaching their goals, Nike needs to double its efforts in order to achieve its target of reducing GHGs to 65% below 2015 levels by 2030.

Finally, we also conducted the IPAT case study at the national level, on Canada, and we found that unfortunately the nation is not on track to meet its target, which is to reduce GHGs to 40-

45% below 2005 levels by 2030.

For both organizations and nations to meet climate goals, it is necessary to enhance the quality, quantity, and execution of targets. All parties need to make their long-term objectives more explicit, binding, comprehensive, and resilient. In addition to this, they need to set up near-term targets and initiatives that lead towards the long-term goals. Therefore, further work is required to operationalize this concept effectively into practice and policy for all entities.

CHAPTER 10: CONCLUSION

Discussion

Being the world's most powerful economic force as well as a key agent in causing anthropogenic climate change, businesses play a pivotal role in addressing the issues of climate risk and keeping the global temperature rise below 1.5°C. Corporations are tasked with the urgent need for instigating transformative action by reducing their GHG emissions and using renewable energy sources. By empowering global collaboration on combatting the threat of climate change, international climate treaties such as the landmark Kyoto Protocol and more recent Paris Agreement may have affected and executed considerable change in the business-as-usual scenarios. Many industrialized and developing nations are preparing to meet their GHG emissions reductions targets. However, as Figure 16 shows, only a few nations have committed to being net-zero carbon by 2050 in law, China and India do not yet have such a target in law, and Russia and the USA have only pledged to be net-zero by 2050. Only a handful of small nations have achieved net-zero carbon emissions.

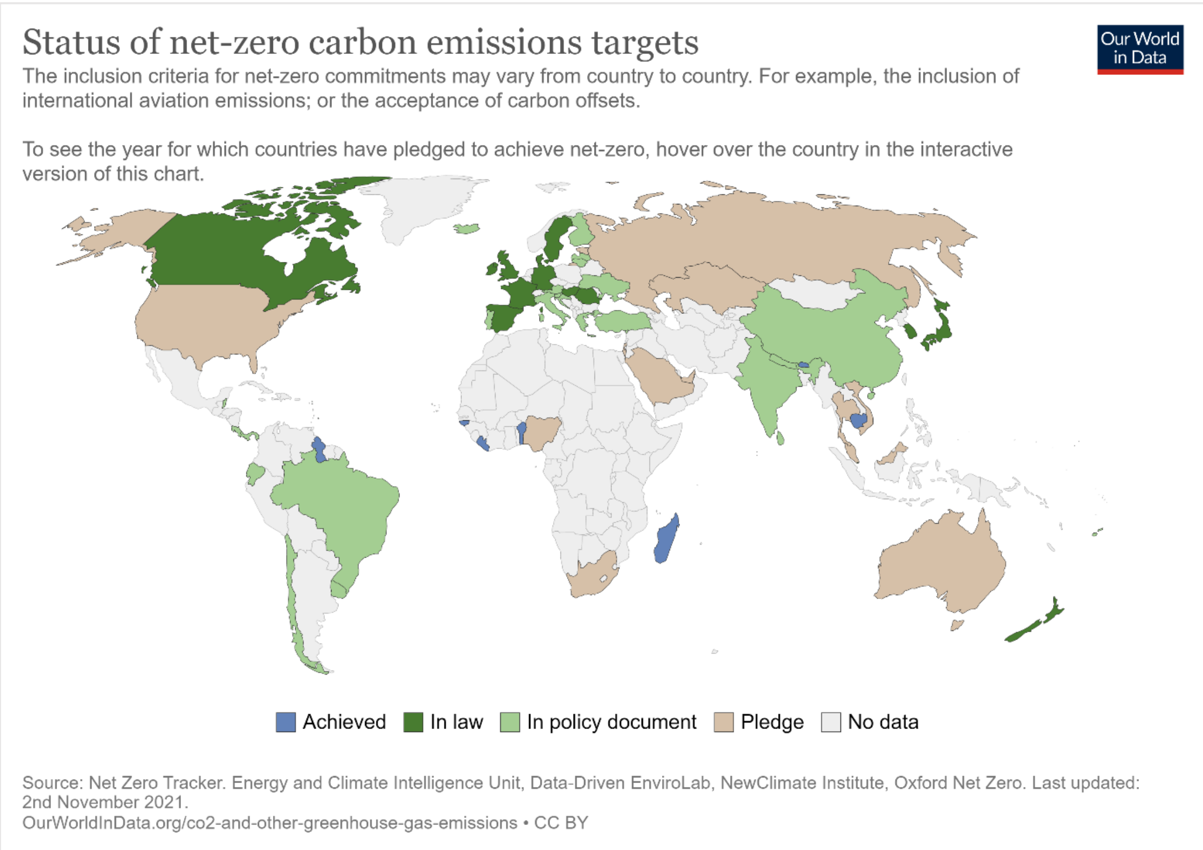

Figure 16: Net-Zero Carbon in 2050

Using data from environmental reporting organizations such as the CDP, in addition to dynamic frameworks like the STIRPAT, this thesis aimed to recognize the influence of climate treaties like the Kyoto Protocol and Paris Agreement towards the drivers of environmental impact in high-emitting corporations, and how changes to corporate strategy and governance can result in improved risk management, enhanced engagement with suppliers and consumers towards green initiatives, and optimized targets and performance for lowered GHG emissions and intensity reductions.

Naturally, the policies set by these nations due to the signing of international agreements could be absorbed and incorporated by a large portion of the organizations operating in these countries, driving the world closer to meeting the goals set by these climate treaties and paving a path towards a more sustainable future. Nevertheless, many discrepancies and gaps still exist, between companies and even more so between nations and different regions of the world, thus impeding progress.

Key Findings

Our research question aimed to assess whether the Kyoto Protocol and Paris Agreement have yielded any measurable impact on corporations, leading them to transform their business strategy, governance, and energy use towards lowering GHG emissions and becoming more environmentally responsible.

We applied the IPACT, a modified version of the IPAT model, at the corporate level to assess drivers of environmental impact and identify areas needing change. The IPACT helped track changes in emissions, revenue, and use of renewable versus non-renewable energy in 100+ corporations spanning Europe and the USA, both before and after the COVID-19 pandemic came into play. The 102 companies operate in some of the highest-emitting industries, such as power generation, transport (aviation and automobiles), fossil fuels, chemicals, food and agriculture, retail, apparel, financial services, and manufacturing. Over the four-year period of 2017-2020, these 102 European and U.S. companies represented 5.5% of the 2021 global CO_2 emissions.

At a glance, we found that the U.S. companies together generate almost double the amount of carbon emissions than Europe's in the same time period, despite also having two fewer companies than Europe in this study. Moreover, U.S. corporations are using roughly only half the amount of renewable energy, as well as almost twice the amount of non-renewable energy that the European corporations use. Stricter regulations in Europe relative to those in the U.S. can explain this observation.

For both regions, the highest-emitting industries are in exactly the same order: first is Power Generation, with 264 million metric tons in Europe and 623.1 million metric tons in the U.S., which means that only five American utility providers are responsible for 1.7% of 2021's global GHG emissions, and along with the five European companies, this becomes almost 2.4% of the global figure. In second place is Transportation Services, which is the airlines industry, and these 7 airlines together made 1.61% of global 2021 emissions. The third highest emitter, which should probably come as no surprise, is the Fossil Fuel industry. In this study there were four Fossil Fuel companies in the U.S., versus five in Europe, and altogether they generated 0.62% of 2021's worldwide emissions.

In the pre-COVID period, total energy use fell in Europe, while it increased in the U.S. In 2020, both regions observed an overall decrease in total energy use. However, unlike in the pre-COVID years, energy efficiency seems to have deteriorated in both Europe and America during 2020. Revenue additionally suffered heavy blows in both regions from the pandemic.

In the four-year period of 2017-2020, emissions dropped in both regions due to a joint improvement in energy and carbon efficiency. Moreover, the pandemic year's impact was just as significant as that of technology's impact over three years. Interestingly, emissions in both regions fell more than revenue did in 2020. Europe's emission reductions were achieved more through renewable energy, than through energy efficiency. Overall emissions in the U.S. decreased nearly two-fold, going from a 9.5% fall in the pre-COVID era to a 17.5% drop in 2020. While America's technology efficiency remains the same at 10% lower emissions per MWh of energy, Europe's has roughly halved, rising from a 13.9% low to only 7.1%.

A notable finding was that COVID-19 lockdowns reduced emissions significantly more in the U.S. than policies and business strategies could before the pandemic year of 2020. In Europe, emissions during COVID-19 fell at a similar rate.

Interestingly, the research also saw that emissions can be reduced with increasing revenue and possible profitability, depending on cost increases.

Next, we applied a stochastic version of the IPAT model, called the STIRPAT. The findings from the STIRPAT estimations were consistent with those of the IPACT model in the log-linear model, which we discussed above. The STIRPAT's log-linear assessment showed unitary elasticities of emissions just like in the IPACT, signifying that emissions are relatively sensitive to revenue and energy efficiency. The log-polynomial exhibited a difference in the revenue force, which has an elasticity that varies with size of the firm, as determined by revenue. In this case, revenue elasticity is not constant and decreases with revenue increasing. This implied that large firms are capable of increasing their revenue while reducing emissions, holding energy efficiency constant; most likely through utilizing better technology from the technology multiplier.

In the final chapter, we used the IPAT formula to analyze the past performance of four companies to determine whether they were on track to achieve their targets by. While three of them are making good progress towards their goals, one needs to double its efforts to achieve its target of reducing GHGs to 65% below 2015 levels by 2030. Additionally, we conducted an IPAT case study on Canada and found that the nation is not on track to meet its goal of reducing GHGs to 40-45% below 2005 levels by 2030.

To achieve climate objectives, it is necessary to improve the quality, quantity, and execution of targets for both organizations and nations. They need to make their long-term objectives more explicit, binding, comprehensive, and resilient, and establish near-term targets and initiatives that are aligned with long-term goals. Therefore, more work is needed to effectively implement this concept into practice and policy for all entities.

Limitations

Following are some limitations to the study. First, data may not be completely error-free as statistical institutions have not verified them. Second, there is a gap in research at the micro-level to evaluate the progress of the Paris Agreement. This gap is also true regarding the progress on the Doha Amendment, the second commitment period of the Kyoto Protocol, implemented for 2013-2020. Also, information prior to 2008 cannot be used as a control period to examine the impact of agreements. Lastly, due to confounding factors, it is difficult to pinpoint with precision the contribution of the agreements towards change in corporate strategic behavior. Effects such as the COVID-19 pandemic from 2020 to 2022 must be controlled.

Future Research

Since the themes in this study contribute to a new and developing area of climate research, there are a number of ideas that can be incorporated into future work.

First, it is possible to explore the effects of additional factors that influence emissions in the STIRPAT framework, such as institutional elements comprising the culture of an organization, its governance, composition of board of directors, profitability, regulations, and equality, diversity, and inclusivity. Additionally, financial and industry data from FactSet at www.factset.com can be used for supplementing CDP data. Hence, future research can attempt to incorporate revisions into the IPAT framework such as the improved stochastic nature, STIRPAT, to account for more determinants such as the industry, company size, energy usage, input substitution, gender and composition of board members, and the relative performance of private versus public ownership in reducing their impact.

Second, other IPAT formulations can be explored at the corporate level such as the le Quere et al. (2019) drivers of declining CO_2 emissions focusing on the decomposition of technology into four compartments. Namely, total final energy use, the fossil fuel share of final energy use, the fossil fuel utilization rate, and the fossil fuel intensity. Additionally, to account for factor input substitution, the IPAT model can be reformulated as an 'IPAST' model, as suggested by Bretschger (2021). In this model, fossil fuels (FF) are used instead of GHG emissions to represent impact (I), labor force (L) for population, and labor productivity for affluence. Plus, a substitution force (S) is introduced as a "driver" of resource use that measures fossil fuels used per capital unit. This substitution force represents production inputs other than fossil fuels, such as "broad (real) capital". For instance, firms may reduce FF by increasing human capital to generate revenue, and technology can be measured by the amount of the broad capital, excluding fossil fuels, per dollar of revenue generated.

Third, future research could also investigate the potential impact of the circular economy concept on corporate emissions reduction and environmental sustainability. This could involve exploring how circular economy strategies, such as closed-loop production systems and product design for reuse and recycling (Tse et al., 2016), can be incorporated into the IPAT framework to assess their effectiveness in reducing emissions. Additionally, case studies of companies that have successfully implemented circular economy practices or have started to incorporate it, such as Michelin, Dell, and Nike (Atasu, 2021; Tse et al., 2016), could provide valuable insights and best practices for other organizations to follow.

Fourth, to circumvent the limitations of our research, future studies may also utilize data verified from the SEC in the U.S., or equivalent regulatory bodies subject to respective regions. Towards that end, it would also be fruitful to analyze different regions and countries around the world that were not included in this study, such as developing countries globally, the Asia-Pacific region, the remaining countries in Europe and North America, and so on.

Finally, access to data after COVID can show the impact of COVID before and after, possibly in the form of an event study. Future research could investigate whether COVID played a role in the future trajectory of emissions for particular firms, or if they went back to old-school methods.

Final Concluding Remarks

The findings of this study prove that corporations have the capabilities to incorporate environmental responsibility into their modus operandi – in fact, they have additional incentive to do so. Through embracing innovation, adopting newer, greener technologies, and using more renewable sources of energy, corporations can earn higher revenues while simultaneously decreasing emissions.

As observed in the case of many European countries participating in the Emissions Trading System, organizations globally should be encouraged to reap the rewards of being sustainable. Governments should continue to enforce more stringent environmental laws and regulations, like the landmark proposal launched by the SEC in the U.S. in March 2022 for mandating public companies to report all emissions and climate risk data.

Businesses around the world can and should take concrete steps for setting and meeting emissions reduction targets by investing in more novel and efficient technologies, products, and practices.

In the words of Sir David Attenborough (2020), “We humans have come this far because we are the smartest creatures to have ever lived. But to continue, we require more than intelligence. We require wisdom.”

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Appendix: Complete List of 102 Corporations in this Thesis Sample

I. Europe: 52 Companies [Graph]

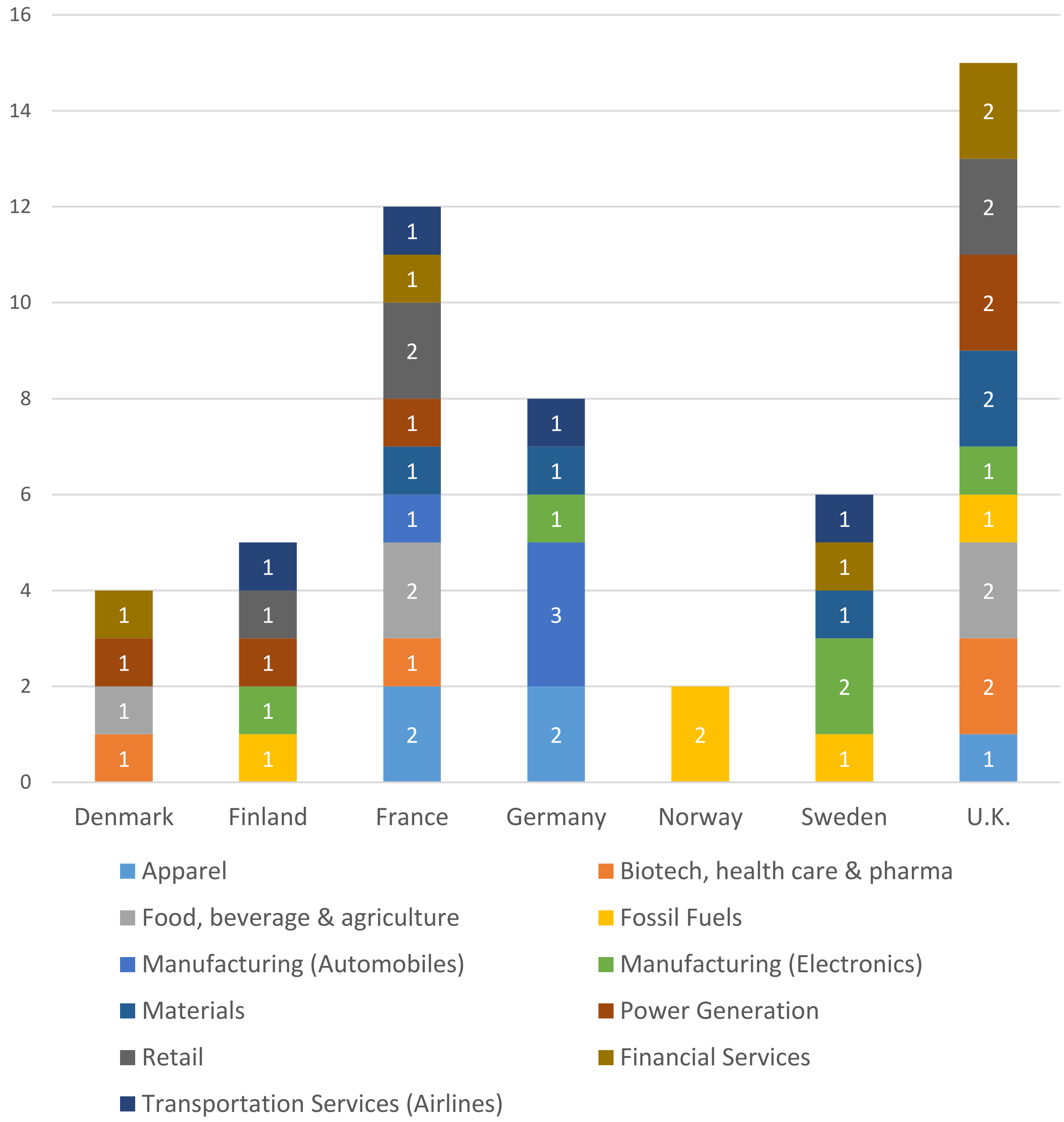

Figure 17: Distribution of Firms in Europe by Country & Industry

Europe: 52 Companies [Sorted Alphabetically by Industry]

ORGANIZATION	COUNTRY	PRIMARY INDUSTRY	PRIMARY SECTOR	PRIMARY ACTIVITY
KERING	France	Apparel	Apparel design	Apparel & footwear design
LVMH	France	Apparel	Apparel design	Apparel & footwear design
ADIDAS AG	Germany	Apparel	Textiles & fabric goods	Apparel & footwear
PUMA SE	Germany	Apparel	Textiles & fabric goods	Apparel & footwear
BURBERRY GROUP	United Kingdom	Apparel	Textiles & fabric goods	Apparel & footwear
NOVO NORDISK A/S	Denmark	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
SANOFI	France	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
GLAXOSMITHKLINE	United Kingdom	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
ASTRAZENECA	United Kingdom	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
CARLSBERG BREWERIES A/S	Denmark	Food, beverage & agriculture	Food & beverage processing	Alcoholic beverages
DANONE	France	Food, beverage & agriculture	Food & beverage processing	Dairy & egg products
PERNOD RICARD	France	Food, beverage & agriculture	Food & beverage processing	Alcoholic beverages
BRITVIC	United Kingdom	Food, beverage & agriculture	Food & beverage processing	Non-alcoholic beverages
DIAGEO PLC	United Kingdom	Food, beverage & agriculture	Food & beverage processing	Alcoholic beverages
NESTE OYJ	Finland	Fossil Fuels	Oil & gas processing	Oil & gas refining
EQUINOR	Norway	Fossil Fuels	Oil & gas processing	Oil & gas refining
AKER BP ASA	Norway	Fossil Fuels	Oil & gas extraction & production	Oil & gas extraction
LUNDIN ENERGY AB	Sweden	Fossil Fuels	Oil & gas extraction & production	Oil & gas extraction
TULLOW OIL	United Kingdom	Fossil Fuels	Oil & gas extraction & production	Oil & gas extraction
RENAULT GROUP	France	Manufacturing	Transportation equipment	Automobiles
BMW AG	Germany	Manufacturing	Transportation equipment	Automobiles
VOLKSWAGEN AG	Germany	Manufacturing	Transportation equipment	Automobiles
DAIMLER AG	Germany	Manufacturing	Transportation equipment	Automobiles

ORGANIZATION	COUNTRY	PRIMARY INDUSTRY	PRIMARY SECTOR	PRIMARY ACTIVITY
ERICSSON	Sweden	Manufacturing	Electrical & electronic equipment	Communications equipment
ADVA OPTICAL NETWORKING SE	Germany	Manufacturing	Electrical & electronic equipment	Communications equipment
NOKIA GROUP	Finland	Manufacturing	Electrical & electronic equipment	Communications equipment
ASSA ABLOY	Sweden	Manufacturing	Electrical & electronic equipment	Electrical equipment
APTIV	United Kingdom	Manufacturing	Electrical & electronic equipment	Electrical equipment
L'ORÉAL	France	Materials	Chemicals	Personal care & household products
HENKEL AG & CO. KGAA	Germany	Materials	Chemicals	Personal care & household products
ORIFLAME HOLDING LTD	Sweden	Materials	Chemicals	Personal care & household products
PZ CUSSONS	United Kingdom	Materials	Chemicals	Personal care & household products
UNILEVER PLC	United Kingdom	Materials	Chemicals	Personal care & household products
ØRSTED	Denmark	Power generation	Energy utility networks	Electricity networks
FORTUM OYJ	Finland	Power generation	Thermal power generation	CCGT generation
EDF	France	Power generation	Nuclear power generation	Nuclear generation
SSE	United Kingdom	Power generation	Renewable power generation	Other renewable generation
CENTRICA	United Kingdom	Power generation	Thermal power generation	CCGT generation
KESKO CORPORATION	Finland	Retail	Convenience retail	Supermarkets, food & drugstores
CARREFOUR	France	Retail	Convenience retail	Supermarkets, food & drugstores
CASINO GUICHARD-PERRACHON	France	Retail	Convenience retail	Supermarkets, food & drugstores
J SAINSBURY PLC	United Kingdom	Retail	Convenience retail	Supermarkets, food & drugstores
MARKS AND SPENCER GROUP PLC	United Kingdom	Retail	Convenience retail	Supermarkets, food & drugstores

ORGANIZATION	COUNTRY	PRIMARY INDUSTRY	PRIMARY SECTOR	PRIMARY ACTIVITY
DANSKE BANK A/S	Denmark	Services	Financial services	Banks
BNP PARIBAS	France	Services	Financial services	Banks
NORDEA BANK ABP	Sweden	Services	Financial services	Banks
HSBC HOLDINGS PLC	United Kingdom	Services	Financial services	Banks
NATWEST GROUP PLC	United Kingdom	Services	Financial services	Banks
FINNAIR	Finland	Transportation services	Air transport	Passenger airlines
AIR FRANCE - KLM	France	Transportation services	Air transport	Passenger airlines
DEUTSCHE LUFTHANSA AG	Germany	Transportation services	Air transport	Passenger airlines
SAS	Sweden	Transportation services	Air transport	Passenger airlines

II. United States of America: 50 Companies [Sorted Alphabetically by Industry]

ORGANIZATION	PRIMARY INDUSTRY	PRIMARY SECTOR	PRIMARY ACTIVITY
NIKE INC.	Apparel	Textiles & fabric goods	Apparel & footwear
PVH CORP	Apparel	Apparel design	Apparel & footwear design
HANESBRANDS INC.	Apparel	Textiles & fabric goods	Apparel & footwear
LEVI STRAUSS & CO.	Apparel	Apparel design	Apparel & footwear design
ALL ACCESS APPAREL, INC.	Apparel	Apparel design	Apparel & footwear design
PFIZER INC.	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
ABBVIE INC	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
BRISTOL-MYERS SQUIBB	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
JOHNSON & JOHNSON	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
MERCK & CO., INC.	Biotech, health care & pharma	Biotech & pharma	Pharmaceuticals
THE COCA-COLA COMPANY	Food, beverage & agriculture	Food & beverage processing	Non-alcoholic beverages
CONSTELLATION BRANDS, INC.	Food, beverage & agriculture	Food & beverage processing	Alcoholic beverages
KEURIG DR PEPPER	Food, beverage & agriculture	Food & beverage processing	Non-alcoholic beverages
MOLSON COORS BREWING COMPANY	Food, beverage & agriculture	Food & beverage processing	Alcoholic beverages
DEVON ENERGY CORPORATION	Fossil Fuels	Oil & gas extraction & production	Oil & gas extraction
CONOCOPHILLIPS	Fossil Fuels	Oil & gas extraction & production	Oil & gas extraction
WILLIAMS COMPANIES, INC.	Fossil Fuels	Oil & gas storage & transportation	Oil & gas pipelines & storage
HESS CORPORATION	Fossil Fuels	Oil & gas extraction & production	Oil & gas extraction
APPLE INC.	Manufacturing	Electrical & electronic equipment	Communications equipment
COMMSCOPE, INC.	Manufacturing	Electrical & electronic equipment	Communications equipment
ARISTA NETWORKS	Manufacturing	Electrical & electronic equipment	Communications equipment
JUNIPER NETWORKS, INC.	Manufacturing	Electrical & electronic equipment	Communications equipment
ADTRAN INC	Manufacturing	Electrical & electronic equipment	Communications equipment
GENERAL MOTORS COMPANY	Manufacturing	Transportation equipment	Automobiles

ORGANIZATION	PRIMARY INDUSTRY	PRIMARY SECTOR	PRIMARY ACTIVITY
FORD MOTOR COMPANY	Manufacturing	Transportation equipment	Automobiles
NAVISTAR INTERNATIONAL CORPORATION	Manufacturing	Transportation equipment	Automobiles
PACCAR INC	Manufacturing	Transportation equipment	Automobiles
PROCTER & GAMBLE COMPANY	Materials	Chemicals	Personal care & household products
COLGATE PALMOLIVE COMPANY	Materials	Chemicals	Personal care & household products
ESTEE LAUDER COMPANIES INC.	Materials	Chemicals	Personal care & household products
CLOROX COMPANY	Materials	Chemicals	Personal care & household products
CHURCH & DWIGHT CO., INC	Materials	Chemicals	Personal care & household products
EXELON CORPORATION	Power generation	Nuclear power generation	Nuclear generation
CMS ENERGY CORPORATION	Power generation	Thermal power generation	CCGT generation
DOMINION ENERGY	Power generation	Thermal power generation	CCGT generation
PINNACLE WEST CAPITAL CORPORATION	Power generation	Thermal power generation	CCGT generation
DUKE ENERGY CORPORATION	Power generation	Thermal power generation	CCGT generation
WALMART, INC.	Retail	Convenience retail	Hypermarkets & superstores
WALGREENS BOOTS ALLIANCE	Retail	Convenience retail	Supermarkets, food & drugstores
BEST BUY CO., INC.	Retail	Discretionary retail	Specialist retail
MACY'S, INC.	Retail	Discretionary retail	Department stores
NORDSTROM, INC.	Retail	Discretionary retail	Department stores
AMERICAN EXPRESS	Services	Financial services	Banks
MORGAN STANLEY	Services	Financial services	Banks
U.S. BANCORP	Services	Financial services	Banks
WELLS FARGO & COMPANY	Services	Financial services	Banks
CITIGROUP INC.	Services	Financial services	Banks
AMERICAN AIRLINES GROUP INC	Transportation services	Air transport	Passenger airlines
DELTA AIR LINES	Transportation services	Air transport	Passenger airlines
UNITED AIRLINES HOLDINGS	Transportation services	Air transport	Passenger airlines