FOSSIL-FREE ELECTRICITY USE IN NORDIC PUBLIC COMPANIES

Analysis of selected factors impacting decarbonization of electricity use

Lappeenranta–Lahti University of Technology LUT

Bachelor’s Programme in LUT Business school, Bachelor's thesis

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Examiner: Junior Researcher Essi Janhunen

ABSTRACT

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Bachelor’s thesis

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36 pages, 12 figures, 4 tables and 7 appendices

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Keywords: fossil-free electricity, logistic regression, carbon dioxide emission reduction

This Bachelor’s thesis investigates the factors influencing the adoption of fossil-free electricity by Nordic public listed companies headquartered in Norway, Sweden, Denmark, and Finland. The study applies a logistic regression model to analyse the relationship between various company-specific factors and the likelihood of purchasing fossil-free electricity.

The final model providing the best result to describe companies’ decision to purchase fossil-free electricity included five variables, which were the country of headquarter, industrial sector, total direct CO_2e emissions, market capitalization, and own produced electricity. Not all these variables were statistically significant, yet they were important to the model. Certain industrial sectors and own produced electricity did not show a strong statistical correlation with the likelihood of purchasing fossil-free electricity. Nonetheless, the inclusion of these variables was justified based on previous research, which generally supports their relevance.

The results of the quantitative analysis revealed notable trends that were mainly supported by previous research. Companies headquartered in Finland were the most likely to purchase fossil-free electricity, while those based in Norway were the least likely. Additionally, a negative correlation was found between a company's direct CO_2 emissions and its likelihood of purchasing fossil-free electricity; companies with higher emissions were less likely to opt for fossil-free electricity. Conversely, a positive relationship was observed between market capitalization and the likelihood of purchasing fossil-free electricity; larger companies were more inclined to make such purchases.

TIIVISTELMÄ

Lappeenrannan–Lahden teknillinen yliopisto LUT

LUT-kauppakorkeakoulu

Kauppatieteet

Henni Suvanto

Fossiilivapaan sähkön käyttö Pohjoismaisissa listayhtiöissä, Analyysi valittujen muuttujien vaikutuksesta sähkön käytöstä hiilidioksidipäästövähennyksissä

Kauppatieteiden kandidaatintyö

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36 sivua, 12 kuvaa, 4 taulukkoa ja 7 liitettä

Tarkastaja: Nuorempi Tutkija Essi Janhunen

Avainsanat: Fossiilivapaa sähkö, logistinen regressio, hiilidioksidipäästövähennykset

Tässä kandidaatintyössä tutkitaan, mitkä tekijät vaikuttavat Pohjoismaisten listayhtiöiden, joiden pääkonttorit ovat Norjassa, Ruotsissa, Suomessa tai Tanskassa, valintaan hankkia fossiilivapaata sähköä. Työssä hyödynnetään logististа regressioanalyysiä ja tarkastellaan erilaisten yritysspesifisten muuttujien suhdetta ja niiden todennäköisyyttä vaikuttaa päätökseen fossiilivapaan sähkön hankintaan.

Lopulliseen malliin, joka tuotti parhaan tuloksen ennustaa yrityksen päätöstä fossiilivapaan sähkön hankintaan, päätyi viisi muuttujaa, jotka olivat yrityksen pääkonttorin sijainti, toimiala, yrityksen suorat hiilidioksidipäästöt, markkina-arvo ja oman sähkön tuotanto. Näistä muuttujista kaikki eivät olleet tilastollisesti merkittäviä, mutta ne olivat mallin kannalta tärkeitä pitää mukana. Erityisesti jotkin toimialat ja oma sähkön tuotanto eivät osoittaneet merkittävää yhteyttä todennäköisyyteen hankkia fossiilivapaata sähköä. Kuitenkin muuttujien pitäminen mukana oli perusteltua myös aiemman tutkimuksen mukaisesti.

Kvantitatiivisen analyysin perusteella löydettiin huomionarvioisia trendejä, joita aiempi tutkimus pääosin tuki. Yritysten pääkonttorin ollessa Suomessa havaittiin tuovan suuremman todennäköisyyden fossiilivapaan sähkön hankintaan, kun taas norjalaiset yritykset hankkivat vähiten todennäköisesti fossiilivapaata sähköä. Sen lisäksi löydettiin negatiivinen suhde yrityksen hiilidioksidipäästöjen määrälle, eli yritykset, joiden hiilidioksidipäästöt olivat suurimmat, eivät todennäköisimmin hanki fossiilivapaata sähköä. Sitä vastoin havaittiin positiivinen yhteys markkina-arvon ja fossiilivapaan sähkön hankkimisen todennäköisyyden välillä; suuremmat yritykset olivat todennäköisemmin valmiita tekemään tällaisia hankintoja.

ABBREVIATIONS

AFOLU	Agriculture, Forestry and Other Land Use
CDP	Carbon Disclosure Project
CH_4	methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CSR	Corporate Social Responsibility
ESG	Environmental and Social Governance
ETS	Emission trading system
GHG	Greenhouse Gas
GoO	Guarantee of Origin
Gt	Gigatonnes
HFC	Hydrofluorocarbon
IPCC	Intergovernmental Panel on Climate Change
MWh	Megawatt hour
NF_3	Nitrogen triflouride
N_2O	nitrous oxide
PFC	Perfluorocarbon
PPA	Power purchase agreement
ROC	Receiver operating characteristic
SBTi	Science-Based Targets initiative
SF_6	sulphur hexafluoride
TWh	Terawatt hour

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1 Introduction

The urgency to mitigate climate change, coupled with the growing use of energy as a geopolitical tool, is putting increasing pressure on companies, public institutions, and consumers to accelerate the green transition. The shift away from a fossil fuel-based economy is gaining momentum, with businesses leveraging sustainability initiatives to appeal to both customers and investors. However, this transition requires substantial financial investment, as moving from oil-, coal-, and gas-based energy systems to fossil free alternatives involves significant cost. Electrification, as a major global trend, has been recognized as a key strategy for reducing reliance on fossil fuels and mitigating greenhouse gas (GHG) emissions, which are a primary driver of global warming. As Gaurav Sharma notes in Forbes (2024), the challenge to "electrify everything and do more with less" necessitates the collaboration of all stakeholders to secure sufficient funding. At the same time, electricity production remains one of the largest sources of GHG emissions globally, creating urgent demand for the installation of fossil-free electricity production.

Electricity producers are actively promoting their fossil-free electricity offerings, allowing both public and private customers to choose the source and origin of their electricity, even though the grid is interconnected, and electricity is mixed in the transmission network. However, there is limited clear data on which companies choose to buy fossil-free electricity and their motivations, instead of simply choosing the cheapest option without considering the source. On the other hand, emission reduction efforts, their effectiveness, and the challenges they face have been widely studied. The largest reductions in emissions have been achieved by energy-intensive companies, but research shows that the purchase of fully fossil-free electricity purchase is more common in less energy-intensive sectors, such as services and light industry (Ruiz Manuel & Blok 2023).

Understanding the distribution of companies' emissions and their sources is becoming increasingly accessible, thanks to growing reporting requirements for both companies as energy users and energy producers. Extensive amount of data is collected and made available for analysis, particularly concerning public companies' GHG emissions. The Carbon Disclosure Project (CDP), for example, annually gathers information on corporate environmental performance, which is widely used by capital markets and researchers.

(CDP 2023) Additionally, GHG reporting has become standardised, with one of the most widely used frameworks globally being the Greenhouse Gas Protocol, which is further discussed in Chapter 2.2.

Purchase of fossil free electricity or is not always the first action the companies will do to reduce their GHG emissions. The emission reduction should be considered as long-term action and the short- and long-term cost may be impacted by for example political decisions. (Gillingham & Stock 2018) Some other action might be more favourable to implement in the first phase and it can be more appealing for companies to wait with lower fossil-free electricity costs.

Research shows that reducing the impacts of climate change require urgent action, and it can be questioned if the traditional economical approaches for investment timing fits in the time of crisis. To follow up and support the progress of reducing emissions, substantial amount of research and data collection is needed. Identifying both local and global factors that impact decision making helps to focus resources where they are most needed. This study takes limited approach aiming to investigate the development of Nordic companies, and especially Finnish companies, emission reduction actions focusing on investigating the fossil-free electricity use.

1.1 Objectives and research questions

The objective of this study is to examine the role and significance of different factors and if they are influencing fossil-free electricity consumption among publicly listed companies in the Nordic countries of Sweden, Finland, Denmark, and Norway. The study aims to answer the following research questions:

1. Which selected factors affect the public company’s use of fossil free electricity?
2. Is it more likely that public company utilizes fully fossil free electricity if they have own electricity production?

To address these questions, a quantitative analysis will be conducted using a logistic regression model based on cross-sectional data from 2023. The logistic regression model is chosen because the primary interest is in determining whether a company uses 100% fossil-free electricity or not. Variables are selected based on previous research and data availability, which also provide insights into the expected direction of each factor's impact on fossil-free electricity consumption. Data is sourced from the LSEG database and the most recent sustainability or annual reports of publicly listed companies.

The result of the research aims to give indication about the progress of electrification and highlight the points which should be considered when planning further high-level strategies for emission reduction and the role of electricity in it. Information may be useful for political decision-makers, business executives, investors and electricity producers.

1.2 Limitations

The study focuses on the most recent financial year (2023) data from companies headquartered in Nodic countries, excluding Iceland. The inclusion of Norway, Sweden, Finland and Denmark ensures enough observations while maintaining regional proximity to Finland. These countries share several similarities, including a widely interconnected electricity grid and market through the Nordpool exchange. Additionally, they experience cold winters and mild summers, resulting in similar annual variations in energy consumption. The period is chosen, because the GHG emission reporting has developed heavily in recent years. The most recent year provides the widest data set compared to previous years, and the aim is to focus on the period illustrating the todays situation the best.

All the companies investigated in this study have publicly committed to reducing their greenhouse gas emissions, either by setting absolute reduction targets or by committing to net zero emissions. The study does not consider that the company might have significant operational areas outside of the company's headquarters country, nor does it limit the analysis to electricity consumed solely within the headquarters country. This study includes both renewable and nuclear electricity consumption, as the focus is on limiting greenhouse gas emissions. This approach aligns with the GHG Protocol, even though nuclear energy is often debated due to its other environmental impacts.

Energy cost is also an important aspect in companies’ decisions. Electricity cost aspect has not been included in the study, as it is highly volatile and region dependent. As we limit to companies who have committed to reduce emissions, it is expected that the decision to purchase fossil-free electricity is not a onetime action but a long term commitment not dependent on the cost.

1.3 Report structure

Chapter 2 will introduce the theoretical framework, explaining the concept of fossil-free electricity, its significance, and its role in greenhouse gas emission reduction targets. It will also review the factors identified in previous research that may influence companies' decisions to utilize fossil-free electricity. The chapter will conclude with the presentation of the study's hypotheses and an expected model of the relationships between the variables.

Chapter 3 will cover the data collection methods, the formation and modification of variables, and the analytical methods used. It will also discuss the methods how the reliability of the model can be assessed. Chapter 4 will present the analysis results and evaluate the goodness of fit of the regression model. Chapter 5 will provide the conclusions, compare the findings with previous studies, and offer proposals for further research in this area.

2 Theoretical framework

This chapter outlines the theoretical framework of the study, with a focus on previous research in the field. It provides background information and justification for the variables selected for analysis. The chapter begins with an overview of the dependent variable, fossil-free electricity, and introduces the context of greenhouse gas emission reduction targets, which serve as the criteria for selecting companies in this study. It then presents the key factors recognized in prior research, highlighting their relevance to this study. The chapter concludes by discussing the expected relationships between the variables.

2.1 Fossil-free electricity

Fossil free electricity is important from the climate change point of view, because energy production is one of the world's main GHG emitters. According to Climate Watch and illustrated in Figure 1, since year 1990 when the first joint agreement to reduce GHG emissions Kyoto protocol was signed, the emissions from electricity and heat have been increasing. This trend has not truly decreased even after signing the Paris agreement, where both developed and developing countries committed to limit global temperature rise to well below 2°C above pre-industrial levels through reducing the GHG emissions. (United Nations 2024)

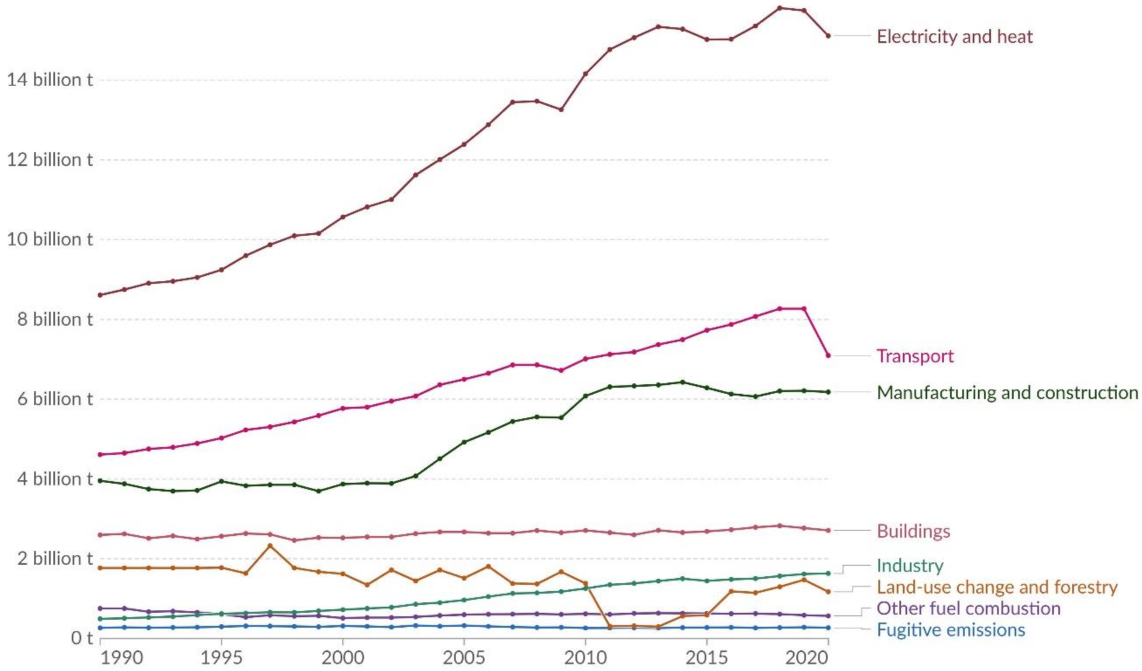

Figure 1 CO_2e emissions by sector, World (Climate Watch 2024)

Fossil-free electricity is defined as electricity produced from sources other than fossil fuels. Fossil fuels include coal, oil products, peat, manufactured gases, natural gas, and non-renewable waste. In this research, fossil-free electricity encompasses energy generated from renewable sources such as wind, hydro, solar, and biomass, as well as nuclear power (Eurostat 2023). Although the classification of nuclear energy has evolved over time, it is not considered renewable due to the use of uranium. However, because nuclear power does not produce GHG emissions that contribute to global warming in the same way as fossil fuels, it is included in this study (Sine & David 2010). In this study, GHG emissions are expressed as carbon dioxide equivalents (CO_2e). This metric standardizes various greenhouse gases based on their global warming potential, allowing for a unified measurement of their impact on climate change (Sotos 2014).

To reduce GHG emissions from electricity, it is essential to increase the share of electricity generated from fossil-free sources. According to the Intergovernmental Panel on Climate Change (IPCC), key strategies for achieving net-zero GHG emissions include enhancing energy efficiency and expanding the production of electricity from fossil-free sources (Lee & Romero 2023). Both markets and governments play a crucial role in driving demand for and facilitating the transition to fossil-free electricity. This transition requires substantial investment in new technologies to replace fossil-based energy production.

Figure 2 illustrates the evolution of electricity sources as a percentage of total production in various countries since 2015, highlighting an increase in wind and solar energy. The figure includes global and European Union statistics for comparison, demonstrating that Nordic countries have made significant strides in reducing their dependence on coal and gas.

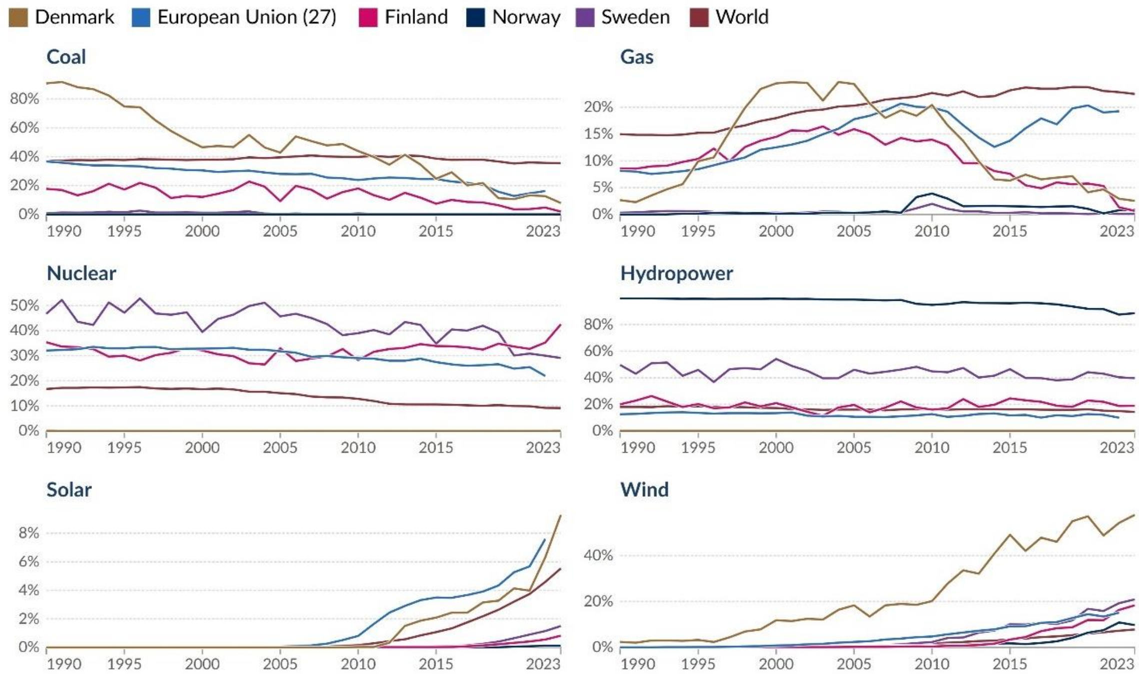

Figure 2 Share of electricity production by source, World (Ember 2024a)

Electricity from biomass is notably absent from the charts, yet it is a significant source of electricity in 2021 for several Nordic countries. In Finland, biomass accounted for 15% of electricity production; in Denmark, 18%; and in Sweden, 10%. In contrast, Norway had minimal biomass-based electricity production during the same period. (Pelkmans 2021)

2.2 Greenhouse gas emission reduction targets and reporting

Companies committed to reducing their GHG emissions typically make public pledges, set specific reduction goals, and report their emissions data to platforms like the CDP, adhering to the widely used GHG Protocol for accurate and standardized reporting. The GHG Protocol is the most commonly applied method for calculating and disclosing greenhouse gas emissions, and is the standard referenced in this study (Balderas, Luna, Voora & Lattea 2024).

The number of companies engaging in these voluntary initiatives has grown rapidly. By the end of 2023, over 8,100 companies had registered with the Science-Based Targets initiative (SBTi), with 5,348 of these setting science-based targets to help limit global warming (SBTi 2024). In comparison, in 2016, only 168 companies were involved, with just 17 having approved targets by SBTi experts (SBTi 2016). Consistent calculation and transparent reporting of emissions are essential to ensure accountability and prevent greenwashing. Initiatives like the SBTi and CDP rely on the GHG Protocol's rigorous accounting standards to measure and disclose climate action, with CDP now housing one of the world’s largest environmental datasets. (Balderas et al. 2024)

Emission reporting in line with the GHG Protocol covers greenhouse gas (GHG) emissions in accordance with the United Nations Framework Convention on Climate Change (UNFCCC). These emissions should be reported alongside information about energy consumption. The GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and nitrogen triflouride (NF_3). CO_2, CH_4 and N_2O are non-fluorinated gases, and are reported as CO_2-equivalents based on their global warming potential. (Sotos 2014) Consequently, GHG emissions are often simplified as "CO2 emissions" in literature and communication, including in this study. The GHG Protocol does not specify the time frame for the reporting period, but emissions are typically reported and monitored on an annual basis.

2.3 Recognized factors impacting fossil free electricity use

This chapter describes the theoretical framework for the factors recognized in previous research, which have potential impact on the companies' decision to reduce GHG emissions by purchasing fossil-free electricity.

2.3.1 Headquarter

Many Nordic public companies are multinational, with electricity consumption and operations spread across the globe. A study by Barkemeyer and Figge (2014) explored the impact of a multinational company's headquarter location on Corporate Social Responsibility (CSR), introducing the concept of the "headquarter effect." The study concluded that the location of a company's headquarters influences its CSR behavior, including how it extends environmental responsibilities to the societies in which it operates. Additionally, the political environment of the headquarter location significantly affects the company's CSR performance (Fatemi, Fooladi, Sy & Zaman 2024).

The location of a company's headquarters can be significant, as different countries have varying approaches to reducing emissions, which can influence corporate strategies. Depending on the industry, a company might prioritize reducing fossil fuel use in industrial steam or heating systems rather than focusing solely on renewable electricity. Marginal abatement cost curve is a widely known tool, where the cost of emission reductions is presented from smallest to highest. Rational decision makers reduce the emissions first where it is the least expensive. (Gillingham & Stock 2018)

Tax policies may also favor the use of renewable energy, influencing strategic decisions. Moreover, the national climate and public pressure toward environmental leadership can impact a company's approach, even if its operations are primarily in other countries. Governments may incentivize the green transition through for example tax reductions, green bonds, or direct subsidies for new renewable electricity production. Some countries might still be even incentivizing fossil fuels, which hinders the economic sense of using renewable energy. (Qadir, Al-Motairi, Tahir & Al-Fagih 2021) Table 1 illustrates the differences between Nordic countries in terms of electricity cost, emission intensity, and targets for reducing emissions.

Table 1 Countries average electricity cost and CO_2 emission factors year 2023 and commitment to emission reductions by 2030 (Krisinformation 2023, Finland's Ministry of the Environment 2023, Government.no 2022, Klimarådet 2023, Ember 2024b. & Eurostat 2024)

Country	Electricity cost €/kWh	Electricity emission factor gCO_2e/kWh	Target emission reduction by 2030 compared to 1990 level
Finland	0,1713	79	-60%
Sweden	0,1407	41	-63%
Norway	0,1521	30	-55%
Denmark	0,1846	152	-70%

Norway produces least CO_2e-emissions per produced kilowatt hour (kWh) of electricity and has smallest emission reduction target by 2030. In contrast, Denmark has the highest GHG emissions but is aiming for the most ambitious relative reduction by 2030.

2.3.2 Industry

Sectors and industries within them have varying energy consumption profiles. The IPCC monitors emissions by sector, categorizing them into Buildings, Transport, Agriculture, Forestry and Other Land Use (AFOLU), Industry and Other energy sectors. In 2019, total GHG emissions amounted to 59 $GtCO_2$-e, distributed among these sectors as shown in Figure 3.

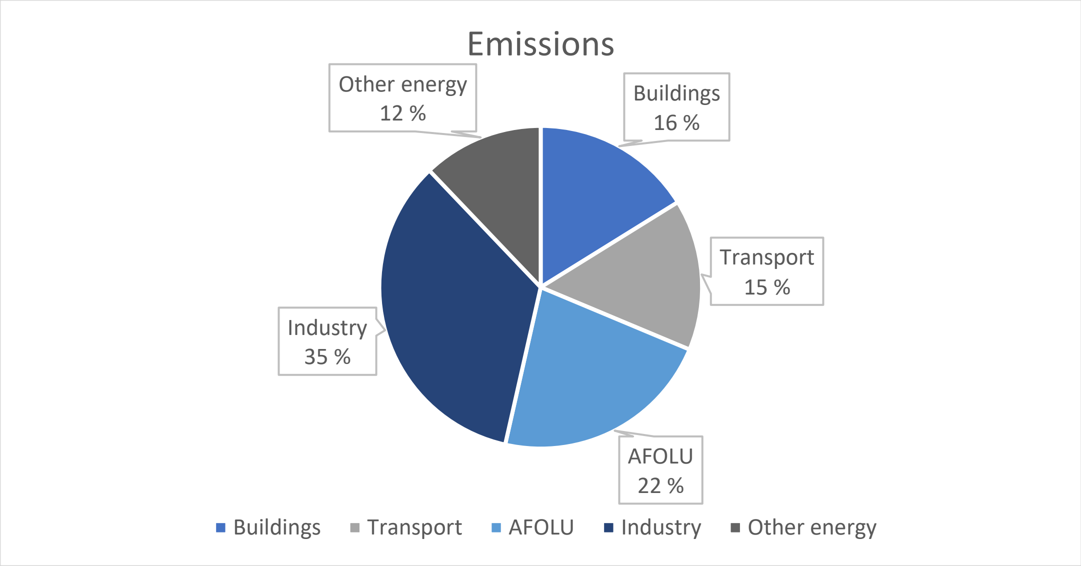

Figure 3 Direct and indirect emissions by sector (adapted from Dhakal & al 2022)

Emissions from the Buildings sector primarily result from heating and electricity consumption, both from onsite generation and purchased energy. The Transport sector's energy use remains predominantly oil-based, accounting for 92% of its consumption. In the AFOLU sector, emissions mainly stem from land use, land-use change, and forestry (LULUCF), enteric fermentation, and managed soils and pasture, with minimal direct emissions from electricity. The industry sector, as categorized by the IPCC, includes energy-intensive industries such as cement, waste management, chemicals, metals, and other manufacturing. Approximately one-third of these emissions are from purchased energy. The 'Other Energy' sector includes emissions such as fugitive emissions from fossil fuel processing. (Dhakal & al. 2022)

Launched in 2005, the EU's Emission Trading System (ETS) is designed to combat climate change by setting a cap on GHG emissions for certain energy-intensive industries, including the energy sector, manufacturing, and aircraft operators across all EU member states and European Free Trade Association countries, including Norway. The ETS operates as a 'cap and trade' system, where polluters pay for their emissions, and the cap is reduced annually to ensure a gradual decrease in emissions over time. This creates incentives for companies to invest in clean technologies and generates funding for the EU's green transition through the sale of emission allowances. Starting in 2024, the transport sector will also be included in the ETS. (European Commission 2024)

The electrification megatrend is transforming sectors such as transportation, energy production, manufacturing, and buildings. To reduce dependency on fossil fuels, key initiatives include electrifying thermal processes with technologies like heat pumps, producing hydrogen using renewable electricity, establishing battery storage systems, and strengthening power grids. The emissions impact of electrification depends on the source of electricity and necessitates significant investments in fossil-free electricity production. (Sharma 2024)

Companies are also using emission reduction as part of their marketing activities. A study by Lewadonski (2017) argues that companies from low emission sectors, such as service and finance sectors benefit from emission reduction more than they actually provide positive climate impact. The same study identifies, that some of the sectors with high emissions are not taking action, even if there would be potential to reduce emissions with minimal or no cost.

2.3.3 Market cap and revenue

Market capitalization (market cap) and revenue were reviewed as key financial metrics for evaluating the size and value of public companies. Market cap estimates a company's value based on its share price in the stock market, while revenue represents the earnings generated from business operations. A company can have a high market cap but low revenue, which is why both metrics are considered in this study. (Boyte-White 2021)

Public listed companies have their shares traded on the stock market, where share prices are determined. Private individuals, companies, and institutions buy and sell these shares, becoming owners of the company. Shareholders, particularly institutional investors who own a significant portion of the shares, have influence over the company’s decision-making. Many large investors adhere to Environmental, Social and Governance (ESG) policies when making investment decisions. For example, pension funds, which are long-term investments, consider climate change as a potential risk to the future value of their investments. (Silver 2017)

Most public companies now include sustainability reports as part of their annual reporting. A significant number of investors are willing to pay a premium if a company can demonstrate a clear link between its financial performance and ESG efforts. These investors are sophisticated, long-term oriented, and focused on sustainable competitive advantage. Additionally, investors prioritize different ESG areas depending on the sector and may even reduce or divest their holdings in industries that lack a strong ESG strategy. For example, in the energy sector, investors typically prioritize environmental performance. (Gelb, McCarthy, Rehm & Voronin 2023)

Revenue and sustainability are increasingly linked through customer preferences for sustainable products. Research indicates a positive correlation between revenue and companies' sustainability reporting. (Henisz, Koller, & Nuttall 2019; ISO 2024; Khaveh1, Nikhashemi, Yousefi & Haque 2012) While transparency about ESG risks and issues might initially lead to a decline in sales, it generally fosters increased transparency and demonstrates the company's commitment to sustainability in the long run. Additionally, sustainability efforts can reduce operational costs in areas such as energy, water, and waste (Henisz et al. 2019), potentially allowing for lower prices and increased sales. Opposite views have also been presented for example by Lewandonski (2017), who argues that companies who emit high level of CO_2 might face penalties from investors while making emission reduction actions.

2.3.4 Companies' total greenhouse gas emissions

There are three generally recognized scopes of GHG emissions: Scope 1, Scope 2, and Scope 3. Scope 1 emissions refer to direct emissions from operations, including energy produced by the company itself. Typically, if a company generates its own electricity using renewable or nuclear energy, these emissions can be reported as zero under Scope 1. Scope 2 emissions are indirect emissions from purchased energy, which can be reported either as location-based or market-based. Location-based reporting reflects average emissions from the grid, influenced over time by consumer choices and regulations. Market-based reporting, on the other hand, is based on specific purchase contracts and verified sources of energy (Sotos 2014). Scope 1 and Scope 2 emissions are those over which companies have direct control. Scope 3 emissions, which encompass the value chain, are also important but often lack the same level of detailed reporting and science-based reduction targets as Scope 1 and 2 emissions.

2.3.5 Consumed electricity

Companies can meet their electricity demand through own production, purchasing from power producers or traders, or entering into power purchase agreements (PPAs) with wind or solar parks to support new installations. The Guarantee of Origin (GoO) system, established by the EU Renewable Energy Directive 2001/77/EC and revised multiple times, aims to promote renewable electricity by ensuring that purchased quantities are not resold. The latest revision, Directive (EU) 2023/2413, expands the scope of GoOs to include other energy sources beyond electricity and allows their trade between EU member states. GoOs must be utilized within twelve months of the energy production date.

In the medium term, GoOs are crucial for decarbonizing operations. The issuance of GoOs increased from 373 TWh in 2015 to 747 TWh in 2021, while their price surged more than tenfold, rising from €1 to €10 per GoO by 2022. This market is expected to continue growing due to new sustainability reporting requirements. However, predicting future demand is challenging as it depends on various factors, including the willingness to pay, regional preferences, and the locality of production. (Diessen 2024)

Electricity production can be either fossil-based or renewable. For companies aiming to reduce emissions, renewable electricity production is preferred. Nuclear energy, while highly regulated and capital-intensive, can offer opportunities for co-ownership, such as through Finland's 'Mankala principle,' where multiple shareholders share the electricity based on its actual production costs (Tieteen Termipankki 2024). Own electricity production is common in energy-intensive industries, like the forest industry, which can utilize by-products as fuel. Rising electricity costs, stringent emission reduction targets, and technological advancements are making investments in self-generated electricity more attractive. Both own electricity production and distributed energy generation are on the rise, supported by the EU and individual countries. Electrification is a megatrend, with fossil fuel-based heating and industrial processes increasingly being replaced by electricity. The European Commission (2018) projects that electricity production will need to increase by up to 2.5 times by 2050 to achieve decarbonization goals.

2.4 Hypotheses

Based on the theoretical study, several variables potentially influencing a company's decision to choose fossil-free electricity have been identified. Figure 4 illustrates the expected relationships and the direction of their impact. Higher values in continuous variables can have positive or negative impact to the explanatory variable.

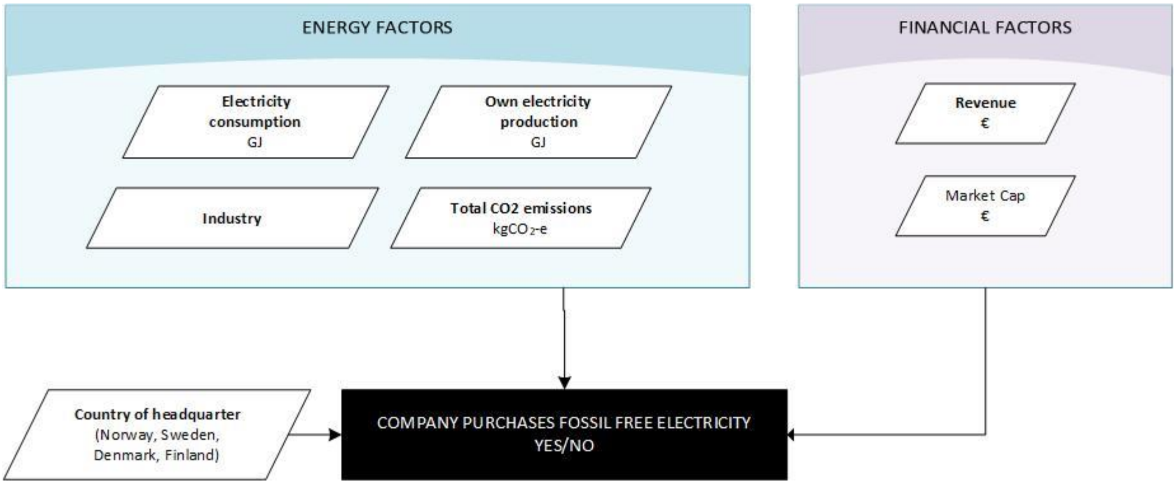

Figure 4 Illustration of the theoretical framework

3 Research methods

This chapter outlines the data collection methods, variable formation, and necessary modifications to ensure statistically significant results. It also introduces the principles of logistic regression, which will be the primary analysis method used. Additionally, the chapter presents basic functions to assess the model's goodness-of-fit. The analysis is conducted using Stata version 18.0.

3.1 Data collection

Data for this research was collected from the LSEG financial database in the spring of 2024. The dataset includes companies that meet the following criteria:

1. The company must be publicly listed.
2. The company headquarters must be located in Norway, Denmark, Finland, or Sweden.
3. The company must have established a target for emission reduction.
4. The company must have complete data for all relevant variables or sufficient data to perform the analysis.
5. The data analysis covers the previous financial year (2023).

While this study focuses on companies meeting the specified criteria, other companies outside this group may also use fossil-free electricity. This research aims to connect fossil-free electricity consumption with progress reporting on GHG emission reduction targets in sustainability reports.

Total CO_2 emissions, market capitalization, industry, and electricity production data were retrieved from the database. Information on whether a company uses only fossil-free electricity was gathered from each company's annual or sustainability reports. Companies for which fossil-free electricity consumption exceeded 90% of total electricity use were considered to meet the fossil-free criteria for this study, ensuring sufficient reliability. Achieving more than 90% fossil-free electricity indicates significant efforts toward decarbonization in Nordic countries. Companies lacking complete data for key variables were excluded from the analysis, resulting in a final sample of N=129. Many of the companies reported as their target to move to renewable electricity by year 2025 or 2030.

3.2 Variable forming and modifications

The dataset includes continuous, categorical, and dichotomous variables. Modifications were made to the variables to fit the model, such as applying logarithmic transformations to achieve normal distribution for continuous variables. Table 2 provides a summary of all variables.

Table 2 Summary of variables and their description

Variable	Stata name	Description
Fossilfree electricity use	fossilfree	Company uses fossilfree electricity 1=yes 0=no
Market capitalization	ln_marketcap	Market cap (logarithmic transformation) in €
Reported CO_2e Emissions (Scope 1+2)	ln_co2total	CO_2e emissions from own operations (logarithmic transformation) in tCO_2e
Consumed electricity	ln_elconsumed	Consumed electricity (logarithmic transformation) in MWh
Revenue	ln_revenue	Revenue (logarithmic transformation) in €
Electricity production	elproduced1	Produced own electricity (recoded) 1=no 0=yes
Industry sector	ind_sec	Industry sector (recoded) 1 = Industry and Manufacturing 2 = Consumer Products 3 = Finance and Insurance 4 = Real Estate and Construction 5 = Energy and Natural Resources 6 = Services 7 = Technology and Media
Country of headquarter	maa	Country of headquarter 1 = Norway 2= Sweden 3= Denmark 4= Finland

Initially, own electricity production in the dataset was recorded in megawatt hours (MWh). However, this limited the dataset to too few observations, so it was recoded into a dichotomous variable. 28 of the 129 companies were producing own electricity. The distributions of consumed electricity, reported CO_2e emissions, market capitalization, and revenue were highly skewed, so additional variables were created by applying logarithmic transformations to these variables.

This study includes companies from 54 different industries. To manage the high number of industries relative to the dataset size and observations within each industry, they were grouped into broader sectors using artificial intelligence (ChatGPT), with the final list reviewed and refined through expert judgment. The detailed industry groupings are presented in Appendix 1. The seven sectors used in the industry variable are: Industry and Manufacturing, Consumer Products, Finance and Insurance, Real Estate and Construction, Energy and Natural Resources, Services, and Technology and Media, as illustrated in Figure 5. Figure 6 presents the histogram for distribution of country of headquarters.

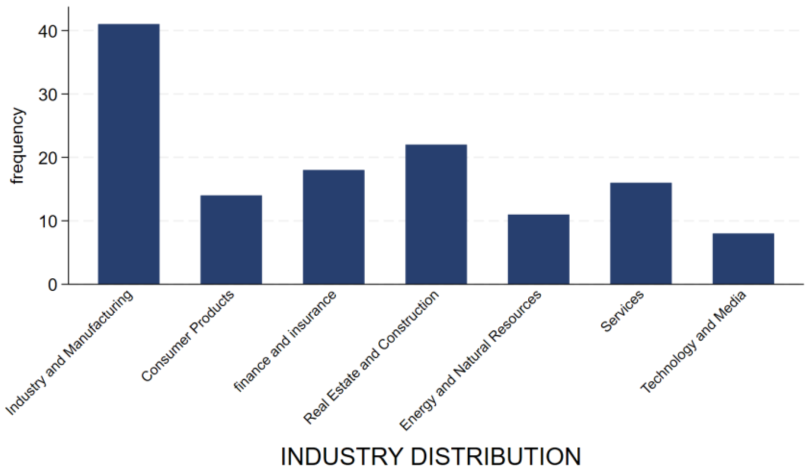

Figure 5 Histogram, industry

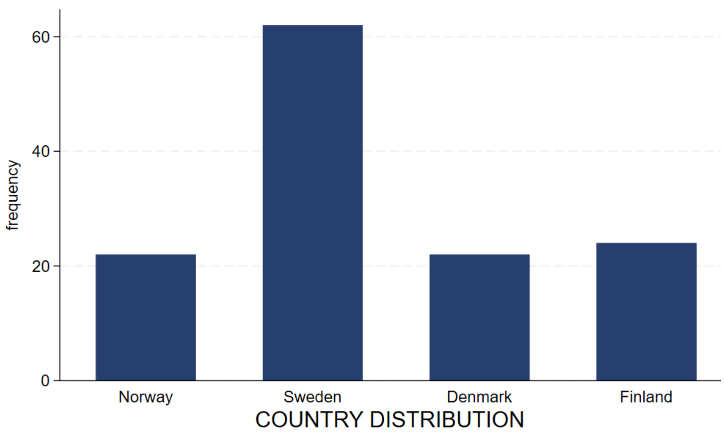

Figure 6 Histogram, country of headquarter

Observations from Sweden were dominant, representing nearly three times as many companies as those from the other countries. Norway, Denmark, and Finland each had approximately equal numbers of companies in the dataset.

The testing process begins by assessing the correlation among the identified variables. Based on this analysis, revenue and total electricity consumption were excluded from the model due to high correlations with other variables, as detailed in Appendix 2. The remaining five variables were tested, with four selected based on a literature review and previous research, which suggested they might be significant factors. These variables are the country of headquarters, industry sector, market capitalization, and reported total CO_2e emissions. The fifth variable, own electricity production, was included to explore its potential impact in relation to the second research question. Correlation coefficients and key statistics for the variables included in the model are presented in Table 3.

Table 3 Key figures and pairwise correlation matrix of key variables 1-5

	Min-Max	Mean	SD	**1.**	**2.**	**3.**	**4.**	**5.**
1. Total CO_2e (ln)	0 - 15.96	9.68	2.73	1				
2. Market cap (ln)	0 - 7.17	21.43	1.63	0.35*	1			
3. Electricity production	0 – 1	0.78	0.41	-0.21*	-0.20*	1		
4. Country of headquarter	1 – 4	2.37	0.97	0.15	0.10	-0.18*	1	
5. Industry sector	1 – 6	3.22	1.99	-0.19*	-0.25*	0.16	-0.13	1

* correlation coefficient significant in 5% level

Originally, linear relationship between the logit of the dependent variable (fossil-free) and the independent variables “market cap”, “total CO_2e”, “consumed electricity”, and “revenue” was not observed. Therefore, these variables were transformed using the natural logarithm. Examples of this transformation are illustrated in Figure 7 and Figure 8, which show CO_2e emissions and market capitalization, respectively, as included in the final model.

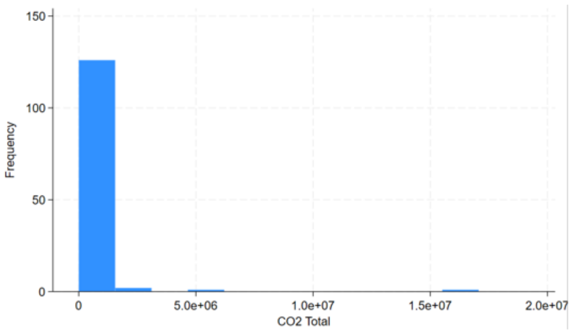

Figure 7 Histogram of reported CO2-e emissions and its logarithmic conversion

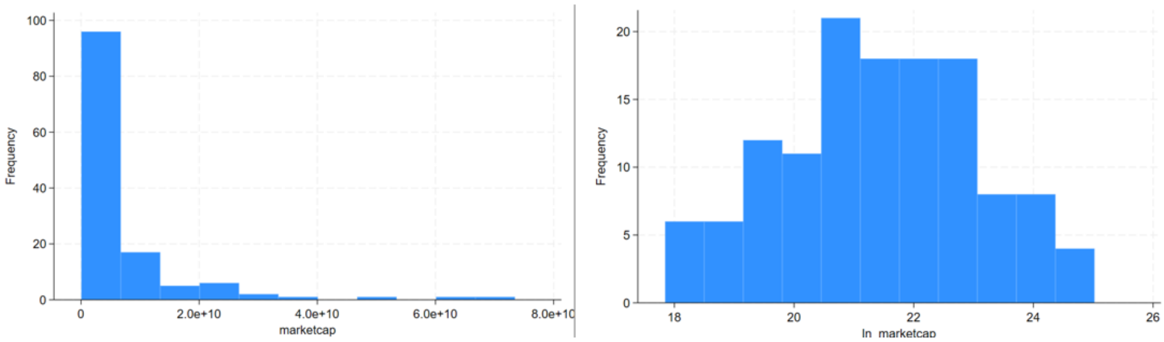

Figure 8 Histogram of market capitalization and its logarithmic conversion

3.3 Analysis methods

Since the research question focuses on determining whether a company uses fossil-free electricity, logistic regression was chosen for this study. Unlike traditional regression analysis, which is used for continuous outcome variables, logistic regression is suited for cases where the dependent variable is binary, taking only values of 0 or 1. This binary variable is also referred to as a dichotomous variable. Logistic regression predicts probabilities rather than quantities, making it suitable for this type of analysis. (Kaakinen & Ellonen 2024)

The formula for logistic regression is presented below:

$$\text{odds} = \frac{P(y=1)}{1-P(y=1)} = \frac{p}{1-p} \quad (1)$$

The probability *p*, that the explanatory variable will get value 1 is *P(Y=1)* in the formula. We will obtain logit (also called log odds) by taking natural logarithm from odds. The formula turns into following form:

$$logit_i = \ln\left(\frac{p_i}{1-p_i}\right) = \ln\left[\frac{P(y_i=1)}{1-P(y_i=1)}\right] = \beta_0 + \beta_1 x_{1i} + \beta_{2i} x_{2i} + \beta_k x_{ki} \quad (2)$$

The estimated probability for an event $\hat{p_i}$ observation *i y=1* can be iterated with maximum likelihood method using the estimated unknown parameters β_0 (intercept term) to β_k (predictor terms) according to following formula:

$$\hat{p}_i = \frac{1}{1+e^{-logit}} \quad (3)$$

Another key difference between traditional regression models and logistic regression is that the relationship between the independent variable *x* and the probability *p* follows an S-shaped curve rather than a linear relationship. In logistic regression, the probability of the outcome changes more significantly around the midpoint of the curve, making the interpretation of results more complex. This S-curve implies that small changes in *x* can lead to larger changes in probability when *x* is near the midpoint of the curve. Conversely, when *x* is at the extreme ends of the range, changes in *x* have a smaller impact on the probability (Kaakinen & Ellonen 2024; Hujala 2023). Example of S-curve idea is presented in Figure 9.

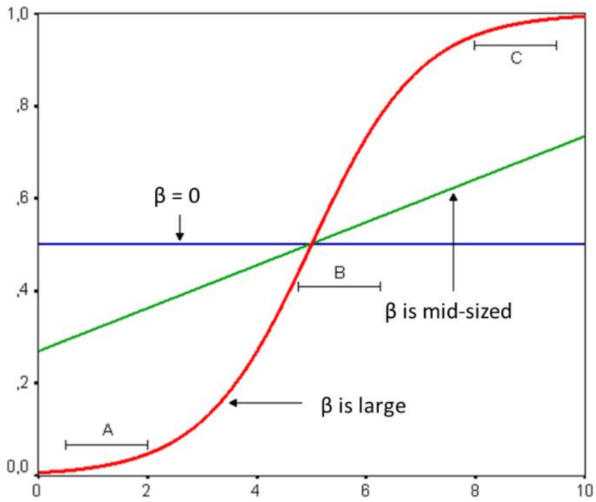

Figure 9 Example of logistic S-curve (adapted from Kaakinen & Ellonen 2024)

Interpretation of the coefficients β_k estimated for variable x_k depends on whether it is positive or negative. Positive coefficient mean, that increasing the value of x_k raises the probability of event *y=1*. Negative coefficient β_k decreases the probability of the event. This relationship between the coefficient and event probability is not linear. The significance of the coefficient can be tested with Wald's test normal distribution approximation, also called as *z-test*, where *H0:* $\beta_k = 0$.

$$z = \frac{\beta_k}{\hat{\sigma}_{b_k}} \quad (4)$$

where z is the test statistic and $\hat{\sigma}_{b_k}$ is the standard error of the parameter estimate β_k.

3.4 Assessing goodness of the model

In logistic regression analysis, several key assumptions must be met: the model should be correctly specified, essential variables must be included, observations need to be independent, and multicollinearity should be absent (Hujala 2023). Additionally, there must be a linear relationship between the logit of the dependent variable (fossil-free) and the independent variables. Hosmer & Lemeshown test is used to assess, whether the essential variables are included in the model. Test reviews, if observations are independent from each other and if there is multicollinearity between variables. Outliers can be checked for example with Preigbon delta-beta test.

4 Results

The logistic regression model predicts the probability that a company is purchasing fossil-free electricity. Prior to implementing the actual logistic regression, potential model specification errors were assessed using Stata's linktest, with results presented in Appendix 3. The test indicated that the model was correctly specified: the coefficient for _hat was statistically significant, while the coefficient for _hatsq was not significant. Additionally, the Hosmer & Lemeshow test confirmed that the model fits the data well. The analysis also verified that the observations are independent and that no multicollinearity between variables was present. Detailed results can be found in Appendix 4. One observation was dropped based on Pregibon's delta-beta test, which reveals if there exist any significant outliers in the model. Pregibon's delta-beta test results are presented in Appendix 5.

Results of the logistic regression model are presented in Table 4. The model's goodness-of-fit was tested both with and without the inclusion of the variable "produced electricity". Although this variable is not statistically significant at the 95% confidence level, retaining it in the model slightly improves the McFadden Pseudo R^2 value, making the model more suitable than the null model, which only includes the intercept term β_0. as the explanatory variable.

Table 4 Results of logistic regression for fossil free electricity use

Observations	129				
P	0.0001				
$\chi^2(12)$	38.87				
Pseudo R^2	0.2485				
	Coefficient	**Std. Error**	**z-value**	**p>z**	**Odds ratio* [95% confidence interval]**
Constant	-9.589	4.011	-2.39	0.0170**	
Country					
Norway	(base)				
Sweden	2.072	0.915	2.26	0.0240**	7.940 [0.279-3.87]
Denmark	1.901	1.080	1.76	0.0780***	6.692 [-0.216-4.018]
Finland	2.777	1.023	2.72	0.0070*	16.079 [0.773 -4.782]
Industrial sector					
Industry and Manufacturing	(base)				
Consumer Products	-1.561	1.171	-1.33	0.1830	0.210 [-3.856-0.735]
Finance and insurance	0.564	0.986	0.57	0.5670	1.758 [-1.368-2.496]
Real Estate and Construction	1.452	0.709	2.05	0.0410**	4.270 [0.062 -2.842]
Energy and Natural Resources	-0.052	1.193	-0.04	0.9650	0.950 [-2.389 -2.286]
Services	-0.254	0.865	-0.29	0.7700	0.776 [-1.949-1.442]
Technology and Media	0.590	0.889	0.66	0.5070	1.803 [-1.152-2.332]
Total CO_2	-0.341	0.139	-2.45	0.0140**	0.711[-0.613-0.068]
Market cap	0.472	0.210	2.25	0.0250**	0.060 [0.883-1.602]
Produced electricity	-0.542	0.578	-0.94	0.3480	0.581[-1.675-0.590]

odds ratio e^{logit}, Signifigance of 1%, 5% and 10% represented with *, ** and *** respectively

Based on these results, companies headquartered in Finland odds ratio to purchase fossil-free electricity compared to Norway is 16, meaning that Finnish companies are more likely to purchase fossil-free electricity compared to those in Norway. Among the countries investigated, Norwegian companies are the least likely to purchase fossil-free electricity. Denmark was the only country, which showed results with significance level of 10% compared to the base category, Norway.

In terms of “industrial sector”, only the Real Estate and Construction sector showed statistically significant results, with companies in this sector being more likely to purchase fossil-free electricity compared to those in the Industry and Manufacturing sector. Although the statistical significance of the other sectors was not strong, the variable was still an important component of the model.

Both “total CO_2” and “market cap” were statistically significant. Companies with higher CO_2 emissions are less likely to purchase fully fossil-free electricity, while companies with larger market capitalizations are more likely to do so.

The model’s classification accuracy, using a cut-off value of 0.5, was 80.62%, indicating strong performance. Specificity was high at 94.51%, reflecting the model's effectiveness in correctly identifying fossil-free cases. However, sensitivity was lower at 47.37%, suggesting the model is less effective at correctly identifying fossil-free cases. While the model excels in minimizing false positives, it may miss a significant number of true positives. Detailed results are presented in Appendix 6, Classification Table. The Receiver operating characteristic curve (ROC), shown in Figure 10, covers 0.825 of the area under the curve, which indicates good model performance.

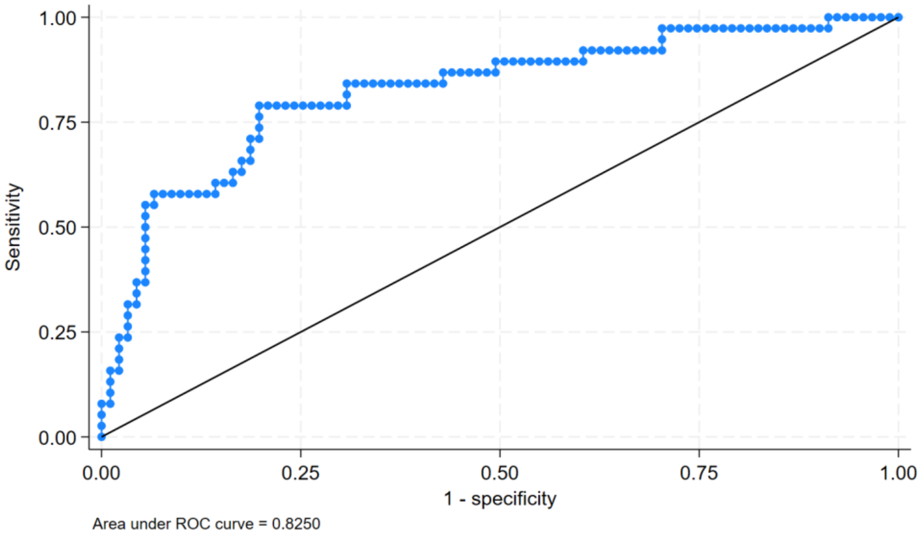

Figure 10 ROC-curve of the logistic regression model

Predictive margins were plotted to compare the effects of the "industrial sector" variable against "market cap" and "total CO_2" as shown in Figure 11, and similarly, for the "country of headquarters" variable against "market cap" and "total CO_2" as presented in Figure 12. Predictive margins illustrate how the predicted probabilities change with different levels of the predictor variables. These visualizations are also included in Appendix 7.

For the statistically significant "industrial sector" variable, specifically within the Real Estate and Construction sector, an increase in logarithmic market cap corresponds to a higher likelihood of consuming fossil-free electricity. However, there is also greater variation in observations within the higher market cap range. Regarding total CO_2 emissions, lower emissions are associated with a higher likelihood of the Real Estate and Construction sector consuming fossil-free electricity.

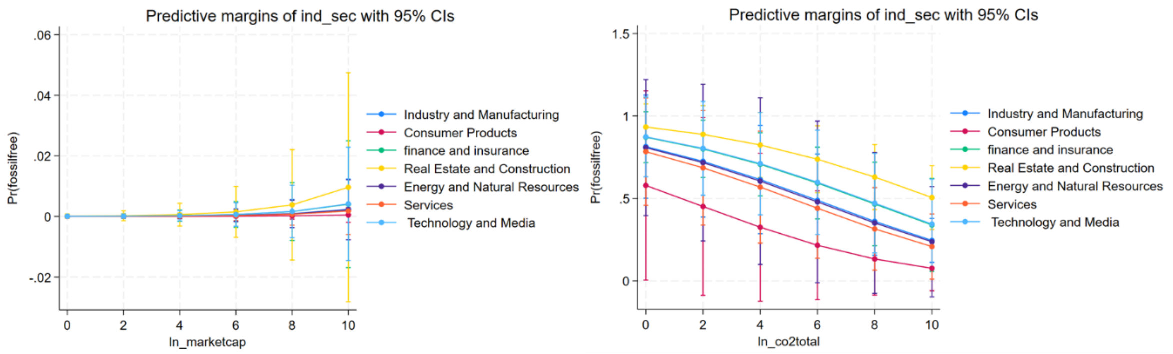

Figure 11 Predictive margins for industry sector and significant continuous variables

For the "country of headquarters" variable, the most variation in observations occurs at the midpoints of the logarithmic market cap values. Across all countries, the likelihood of consuming fossil-free electricity is lower at the lowest market cap values and higher at the highest values, showing a consistent pattern. However, Norwegian companies are consistently the least likely to consume fossil-free electricity throughout the scale, and they also exhibit the most variation in observations.

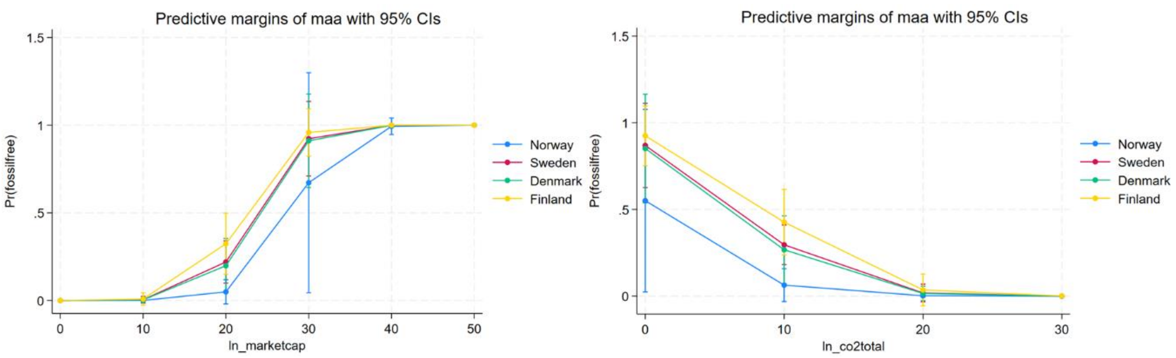

Figure 12 Predictive margins for maa and statistically significant continuous variables

Regarding “total CO_2”, Norwegian companies are again the least likely to purchase fossil-free electricity when their logarithmic emissions are low. As emissions increase, the differences between countries become less pronounced, but in no Nordic country does it seem very likely that fossil-free energy will be consumed when emissions are high.

5 Summary and conclusions

This study aimed to explore the factors influencing a company's likelihood of purchasing fossil-free electricity, with a particular focus on industry sector, market capitalization, total CO_2 emissions from own operations, and the country of headquarters. These key variables were identified through literature review and previous research, which focused on identifying the variables what might impact on the fossil-free electricity use and statistical background on the CO_2 emission development between different countries and industries. A logistic regression model was developed to predict the variables impact probabilities, providing insights into the dynamics of corporate energy sourcing in the Nordic region. The analysis results partially support previous research findings, as it was expected that market cap would have positive impact on the companies' decision to purchase fossil-free electricity and the amount of total CO_2 emissions would have negative impact. The results on industry were surprising as only one sector provided statistically significant results, unlike expected based on previous research. Next chapter will discuss these findings in more detail and make comparison to the theory.

5.1 Factors impacting fossil-free electricity use in Nordic countries

The first research question aimed to identify, which selected factors affect the public company's use of fossil free electricity. The analysis revealed that companies headquartered in Finland are much more likely to purchase fossil-free electricity compared to those in Norway. While it is consistent with theoretical expectations that the country of headquarters is a statistically significant variable, the specific ranking—Finland being the most likely and Norway the least likely to purchase fossil-free electricity—does not have clear support from existing literature. One possible explanation for Norway's status could be the "headquarter effect" described by Barkemeyer and Figge (2014). Norway, which generates most of its electricity from hydropower, might face less political or public pressure to focus on electricity for emissions reductions. Additionally, as Norway is not a member of the European Union, it is not bound by the EU's climate targets, which could further influence its lower likelihood of purchasing fossil-free electricity.

The industrial sector, while important for the model, showed that only one of the seven industries within it was statistically significant compared to the base category. The Real Estate and Construction sector emerged as a statistically significant predictor, with companies in this sector being more likely to purchase fossil-free electricity than those in the Industry and Manufacturing sector. While the statistical significance of other sectors was less pronounced, their inclusion in the model remained important for overall explanatory power. Expected results based on theory, in accordance with Lewandowski (2017) and Ruiz Manuel & Blok (2023), suggested that low-emission sectors such as Services, Technology & Media, and Finance & Insurance would be more likely to purchase fossil-free electricity. However, this was not reflected in the actual results.

From financial perspective and size of the company, there is a positive relationship between market capitalization and the likelihood of purchasing fossil-free electricity. As the logarithmic value of market cap increases, so does the probability of consuming renewable energy. However, this trend is accompanied by greater variation in observations at higher market cap levels. This observation is supported by previous research as introduced in Chapter 2.3.3, as investors require increasingly results in sustainability from their investments.

Companies with higher CO_2 emissions are less likely to purchase fossil-free electricity. The findings suggest that as emissions increase, the likelihood of adopting fossil free electricity increases. This could be explained with higher abatement cost for fossil-free electricity as a tool for emission reduction compared to other methods, as explained by Gillingham & Stock (2018). At higher emission levels, the differences between countries become less pronounced, yet the overall probability of consuming fossil-free electricity remains low.

The study did not provide a definitive answer to the second research question “Is it more likely that public company utilizes fully fossil free electricity if they have own electricity production?” While this factor slightly improved the overall model, it was not statistically significant as an individual variable. Given that many companies have publicly announced plans to purchase renewable electricity in the future, reassessing this question in a few years could be valuable. Future studies might also benefit from considering the amount of electricity produced by these companies, rather than treating it as a simple dichotomous variable.

5.2 Limitations and reliability of the analysis

The sample size of the companies was sufficient to conduct a robust analysis. However, it is important to note that the companies included in this study have already committed to reducing their emissions, meaning the findings represent only a subset of publicly listed companies in Nordic countries. Many companies are setting targets for renewable electricity, considering not only GHG emission reduction but also broader environmental goals and reputational risks. The fossil-free electricity included, in addition to renewable electricity, nuclear energy, which is widely used in Sweden and Finland. Nuclear energy is broadly accepted by politicians and citizens in these countries and is considered a CO_2 emission-free energy source (World Nuclear Association 2024a,b). Excluding nuclear energy from the analysis would have reduced the number of observations and potentially impacted the results.

The company’s operations and energy consumption might also be significantly focused outside the country of its headquarters. This aspect was not included in the study but could have a significant impact on the companies’ ability to verify the origin of their electricity, especially if they rely on methods different from the Guarantees of Origin system used in Europe. Additionally, reclassification of the industrial sector may have reduced the reliability of the results.

5.3 Recommendations for further research

Overall, the study highlights the significant influence of both economic and environmental factors on corporate energy decisions. Companies with larger market capitalizations and lower emissions are more likely to adopt fossil-free electricity, while country of headquarter and industry sector also play important roles. These findings enhance our understanding of the drivers behind fossil-free electricity demand. However, further research could provide deeper insights through more detailed assessments of specific industrial sectors, such as surveys exploring factors influencing companies' motivations to purchase fossil-free electricity, including their willingness to pay. Additionally, reviewing the impact of self-generated electricity after a few years could be valuable. The incentivized and rapid growth of wind and solar energy might also increase companies' willingness to invest in electricity security. Investigating the most appropriate statistical model for this analysis is recommended.

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Appendices

Appendix 1 List of industry sector grouping

1. **Industry and Manufacturing**
   Industrial Machinery & Equipment
   Heavy Machinery & Vehicles
   Auto, Truck & Motorcycle Parts
   Auto & Truck Manufacturers
   Electrical Components & Equipment
   Semiconductor Equipment & Testing
   Industry and manufacturing
   Tires & Rubber Products
   Paper Products
   Paper Packaging
   Electric Utilities
   Food Processing
   Brewers
   Distillers & Wineries
2. **Consumer Products**
   Appliances, Tools & Housewares
   Apparel & Accessories
   Consumer Goods Conglomerates
   Miscellaneous Specialty Retailers
   Food Retail & Distribution
   Pharmaceuticals
   Medical Equipment, Supplies & Distribution
3. **Finance and Insurance**
   Banks
   Investment Banking & Brokerage Services
   Investment Management & Fund Operators
   Investment Holding Companies
   Property & Casualty Insurance
4. **Real Estate and Construction**
   Real Estate Rental, Development & Operations
   Homebuilding
   Construction Supplies & Fixtures
   Construction Materials
   Construction & Engineering
5. **Energy and Natural Resources**
   Specialty Mining & Metals
   Oil Related Services and Equipment
   Oil & Gas Exploration and Production
   Specialty Chemicals
   Commodity Chemicals

Diversified Chemicals
Aluminum
Fishing & Farming

6. Services

Business Support Services
Business Support Supplies
IT Services & Consulting
Online Services
Courier, Postal, Air Freight & Land-based Logistics
Ground Freight & Logistics
Passenger Transportation, Ground & Sea
Airport Operators & Services
Casinos & Gaming
Hotels, Motels & Cruise Lines
Leisure & Recreation
Healthcare Facilities & Services

7. Technology and Media

Computer Hardware
Integrated Hardware & Software
Software
Communications & Networking
Wireless Telecommunications Services
Integrated Telecommunications Services
Integrated Technology and Media & Technology and Media

Appendix 2 Correlation matrix of all variables

	fossilfree	ln_scope1	ln_elconsumed	ln_revenue	ln_marketcap	ln_co2total	maa	ind_sec	elproduced1
fossilfree	1								
ln_scope1	**-0.2247**	1							
ln_elconsumed	**-0.0656**	0.6887	1						
ln_revenue	**-0.0099**	0.6048	0.5654	1					
ln_marketcap	**0.1769**	**0.3219**	**0.3886**	0.7613	1				
ln_co2total	**-0.202**	0.9243	0.7563	0.6395	0.4016	1			
Maa	**0.156**	**0.0843**	**0.1547**	**0.1398**	**0.1317**	**0.1162**	1		
ind_sec	**0.0555**	**-0.3092**	**-0.1862**	**-0.1656**	**-0.2471**	**-0.2354**	**-0.1694**	1	
elproduced1	**-0.0675**	**-0.1911**	**-0.1832**	**-0.1035**	**-0.2057**	**-0.206**	**-0.2066**	**0.1464**	1

Appendix 3. Results of linktest

```
. linktest

Iteration 0:  Log likelihood = -78.199311
Iteration 1:  Log likelihood = -59.420228
Iteration 2:  Log likelihood = -58.759816
Iteration 3:  Log likelihood = -58.726663
Iteration 4:  Log likelihood = -58.726633
Iteration 5:  Log likelihood = -58.726633

Logistic regression                                   Number of obs =    129
                                                      LR chi2(2)    =  38.95
                                                      Prob > chi2   = 0.0000
Log likelihood = -58.726633                           Pseudo R2     = 0.2490
```

fossilfree	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
_hat	1.042544	.2595368	4.02	0.000	.5338617	1.551227
_hatsq	.0320007	.1157861	0.28	0.782	-.1949359	.2589372
_cons	-.027609	.2866042	-0.10	0.923	-.5893428	.5341249

Appendix 4 Results of Hosmer & Lemeshow test

```
. * Oletus: kaikki oleelliset muuttujat selittäjinä
. * Hosmer-Lemeshow -testi
. estat gof, group(10)
note: obs collapsed on 10 quantiles of estimated probabilities.

Goodness-of-fit test after logistic model
Variable: fossilfree

 Number of observations =    130
       Number of groups =     10
Hosmer–Lemeshow chi2(8) =   5.40
            Prob > chi2 = 0.7144

. *prob>chi tulisi olla yli 0.05 jotta voidaan sanoa että malli sopiva. tämä tosi
```

Appendix 5. Classification table

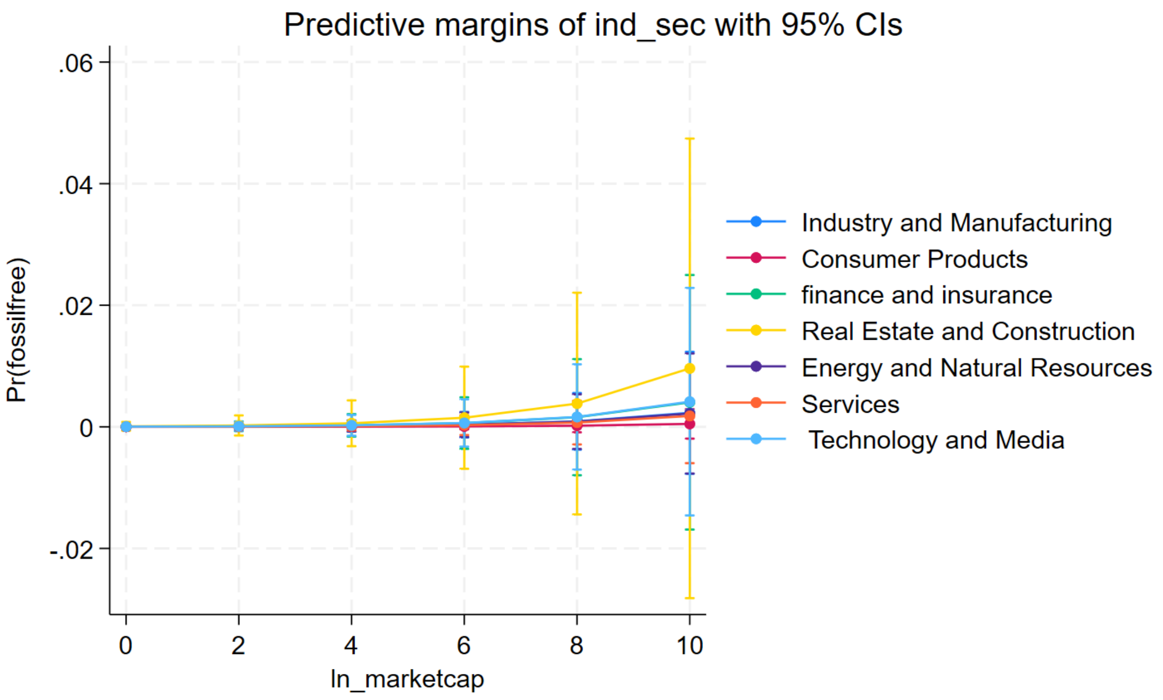
Logistic model for fossilfree

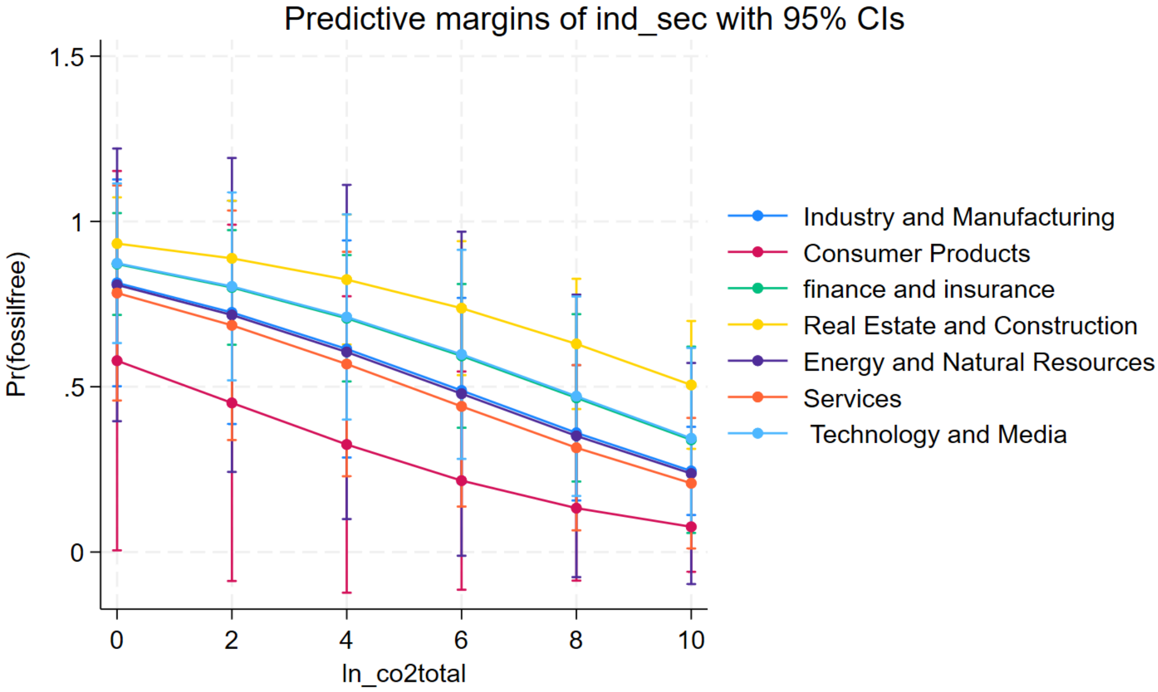
Classified	True D	True ~D	Total
+	18	5	23
-	20	86	106
Total	38	91	129

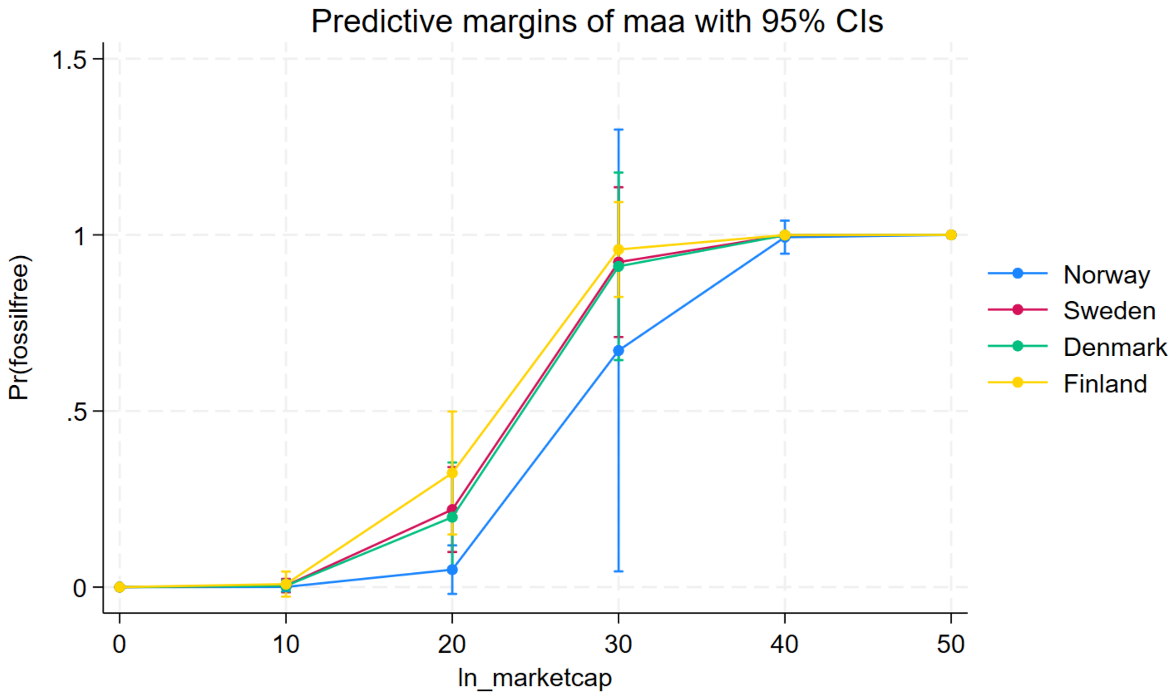
Classified + if predicted Pr(D) >= .5
True D defined as fossilfree != 0

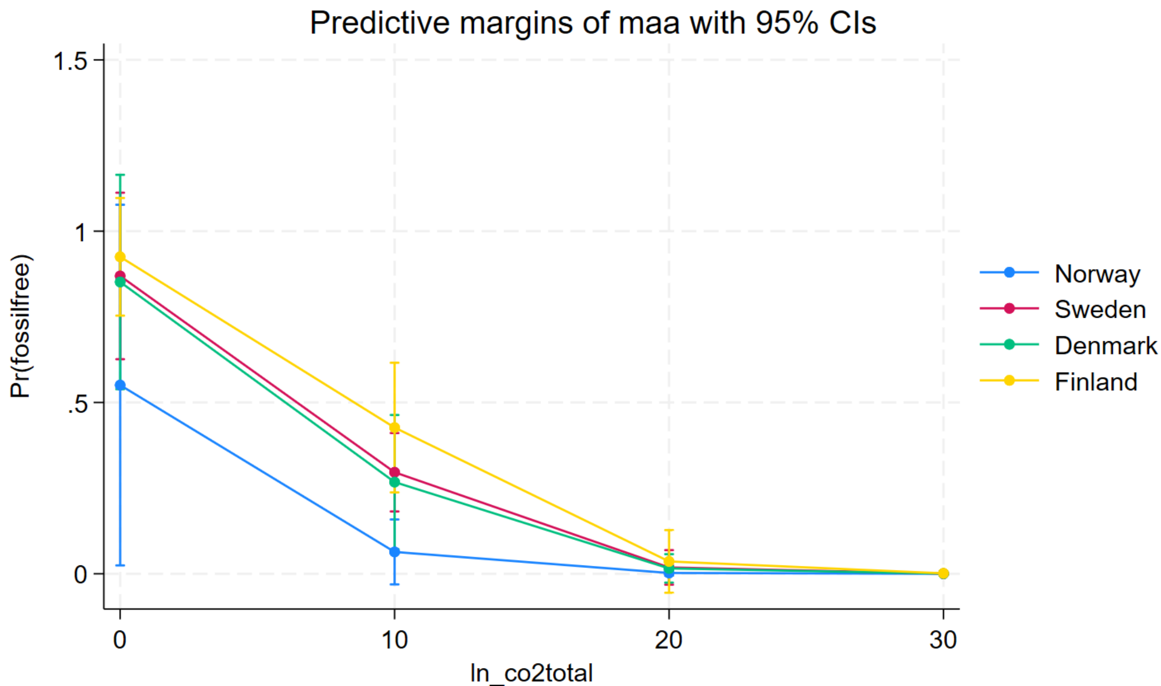
Sensitivity	Pr(+| D)	47.37%
Specificity	Pr(-|~D)	94.51%
Positive predictive value	Pr(D| +)	78.26%
Negative predictive value	Pr(~D| -)	81.13%
False + rate for true ~D	Pr(+|~D)	5.49%
False - rate for true D	Pr(-| D)	52.63%
False + rate for classified +	Pr(~D| +)	21.74%
False - rate for classified -	Pr(D| -)	18.87%
Correctly classified		80.62%

Appendix 6. Predictive margins visualization




Predictive margins of ind_sec with 95% CIs
1.5
1
.5
0
Pr(fossilfree)
0
2
4
6
8
10
ln_co2total
Industry and Manufacturing
Consumer Products
finance and insurance
Real Estate and Construction
Energy and Natural Resources
Services
Technology and Media


Predictive margins of maa with 95% CIs
Pr(fossilfree)
1.5
1
.5
0
0
10
20
30
40
50
ln_marketcap
Norway
Sweden
Denmark
Finland


Predictive margins of maa with 95% CIs
Pr(fossilfree)
1.5
1
.5
0
0
10
20
30
ln_co2total
Norway
Sweden
Denmark
Finland

Appendix 7. Pregibon's dbeta