VILNIUS UNIVERSITY

FACULTY OF ECONOMICS AND BUSINESS ADMINISTRATION

FINANCE AND BANKING PROGRAMME

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MASTER THESIS

ŽALIŲJŲ FINANSŲ POVEIKIO VERTINIMAS DARNAUS VYSTYMOSI TIKSLAMS PASIEKTI	**ASSESSMENT OF THE IMPACT OF GREEN FINANCE ON ACHIEVING THE SUSTAINABLE DEVELOPMENT GOALS**

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Vilnius, 2025

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INTRODUCTION

In 2015, Sustainable Development Goals (SDGs) were established to ensure that the planet is preserved for future generations (United Nations Development Programme, 2023). It was brought to the attention that 50% of advancement towards achieving SDGs is insufficient and slow-paced. Furthermore, 30% of goals stopped advancing or even had reverse progress due to several challenges, such as the COVID-19 crisis, the effects of climate change, and the worldwide economic cost-of-living challenges (United Nations, 2023). International financial institutions have a vital role in promoting financial instruments that enable the achievement of SDGs. Traditional finances are based on a narrow set of values, do not consider social and environmental issues, and are unsuitable for accomplishing SDGs (Fullwiler, 2016). Thus, there is an urgent need to mature green financing and increase investment in green projects (Li, Tang, Wu, Zhang & Lv, 2020). Green bond is one of the most used green financial instruments for achieving a carbon economy. The green bond market has undergone substantial expansion in the last decade. As a result, the significance of analyzing the link between green finance and its effects on achieving SDGs is gaining increasing attention among scholars. This influenced the choice of this topic and encouraged the investigation of the link between green bonds and their impact on achieving SDG 13, which is dedicated to implementing immediate measures to tackle climate change and its effects.

The level of exploration of the topic includes several studies that investigated aspects associated with green bonds and their environmental effects, particularly focusing on carbon dioxide emissions and renewable energy. Alamgir and Cheng (2023) explored the link between renewable energy exhibits and green bonds, as well as the relationship between carbon dioxide emission and green bonds across 67 countries. Using the same method, Saha and Maji (2023) explored the effect of green bonds on carbon dioxide emissions globally. Arshad, Parveen & Mir (2024) examined the relationship between green bonds and carbon dioxide emission in developing countries.

The novelty of the thesis: several articles were published focusing on the impact of green bonds on SDG 13 in developing countries or countries around the world, which does not consider regional differences. There are no publications available on this subject that focus on the Nordic region. As a result, the Nordic region is selected to address the research gap. Published studies established a basis for understanding the scope of research already conducted in this field. The analysis within this thesis builds upon these foundational studies, advancing the dialogue by focusing on the development of a green bond market in the Nordic region between 2017 and 2023 and its impact on SDG 13.

The main problem addressed in this thesis is the relationship between green finance and SDGs, specifically evaluating how green bonds impact greenhouse gas emissions in Nordic countries.

The aim is to determine the impact of green bonds on achieving Sustainable Development Goal 13 in Nordic countries (Denmark, Finland, Norway, and Sweden) between 2017 and 2023.

The objectives established to achieve the aim of the thesis are outlined below:

- Review existing literature of published research on green finance and the Sustainable Development Goals.
- Build a methodology to perform research on the impact of green bonds on achieving Sustainable Development Goal 13.
- Investigate the correlation between the amount of green bonds issued and greenhouse gas emissions in Denmark, Finland, Norway, and Sweden.
- Examine the impact of green bonds on achieving Sustainable Development Goal 13 in Denmark, Finland, Norway, and Sweden and summarize the obtained results.

The methods deployed by the thesis: existing literature, including academic articles, books, and reports on the topic of green finance and SDGs, was identified, summarized, and reviewed. Also, bibliometric analysis was conducted on published research on green finance, green bonds, and the SDGs. A literature gap was identified using these methods. In the empirical section, the secondary data was collected from Statista, Bloomberg Terminal, and Global Economy. The descriptive statistics method was employed to describe the position of Nordics in the global and European green bonds market, summarize the collected data of green bonds and greenhouse gas emissions dataset, present it visually, and examine its characteristics, key features, and insights. Furthermore, correlation analysis was used to select variables for the regression analysis and to measure the degree and direction of relationships between selected variables. A redundant fixed effect test was completed to check if ordinary least squares regression was the best method for this research. The ordinary least squares method was used to explore the influence between selected variables and show if the results were statistically significant. Breusch-Godfrey test was performed to identify if autocorrelation exists in the residuals of regression analysis. Breusch-Pagan test and White test were used to detect if heteroskedasticity is present in the regression model. These selected methods, tools, and techniques provide needed outcomes to understand the impact of green bonds on achieving SDG 13 in the Nordic region.

The structure of this thesis is organized into five chapters that contribute to the achievement of the aim of the study. The first chapter focuses on the introduction, which outlines the thesis topic's relevance, the aim and problem of the study, its objectives, and the methods deployed. The second chapter covers the analysis of scientific literature that summarizes published

academic literature written on SDGs, green finance, and green bonds and identifies the gap. The third chapter includes methods used to conduct research in the empirical part. The fourth chapter demonstrates the empirical results analysis. The fifth chapter contains conclusions and recommendations, which summarize key findings, mention limitations, and offer suggestions for further investigation.

The importance of the thesis lies in its contribution to the exploration of the relatively new field of study and offering new insights into the impact of green bonds on achieving SDG 13 in the Nordic region. Moreover, the research explores key characteristics and features of the green bond market and greenhouse gas emissions in Nordic countries.

1. THEORETICAL FRAMEWORK OF SUSTAINABLE DEVELOPMENT GOALS AND GREEN FINANCE

In this chapter, the literature review will provide a comprehensive analysis of existing research related to green finance and SDGs. This section aims to identify and analyze the literature surrounding the concept of SDGs, sustainable financial systems, green finance, green financial products, and green bonds. Also, bibliometric analysis will be conducted to further explore published literature on green finance, green bonds, and SDGs to identify gaps and areas that require further investigation. This chapter will create the foundation and demonstrate how this thesis contributes to the academic work in this field.

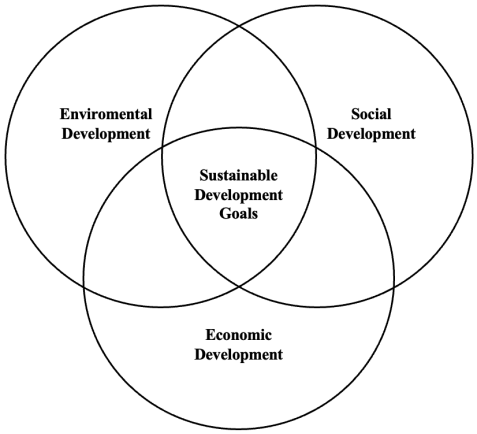
1.1 The concept of Sustainable Development Goals and sustainable financial system

The UN World Commission on Environment and Development created the Brundtland Report, which mentioned the sustainability development concept for the first time in 1987. Furthermore, the first group of sustainability targets, which are referred to as Millennium Development Goals (MDGs), were created in 2020 (Dhahri, Slimani & Omri, 2021). MDGs were replaced by seventeen universal goals called Sustainable Development Goals (SDGs), which were created by the United Nations in 2015. SDGs indicate the need to make efforts to preserve the Earth for generations to come, to end poverty, and to promote progress toward peace and equal human rights (United Nations Development Programme, 2023). The objective is to reach Sustainable Development Goals by 2030. Targets of achieving SDGs are relevant to all nations, irrespective of the degree of sustainable development, challenges, and economic growth. The annex includes an overview of seventeen SDGs. This overview demonstrates that SDGs are complex concepts as goals cover various range of fields, such as social development, environmental sustainability, economic development, and global partnership, and have different types of criteria.

Furthermore, SDGs are categorized into three measurements of sustainable development: environmental, economic, and social (Dhahri et al., 2021). In 1999, John Elkington presented the triple bottom line concept and emphasized that society, economy, and ecological health worldwide are interlinked and serve as a foundation to accomplish long-term success *(*Elkington, 1999). Thus, to achieve SDGs, all nations must perform in all three: economic, social, and environmental areas (Figure 1).

Figure 1.

Sustainable Development Goals: triple bottom line concept



Source: Compiled by the author, based on Elkington's (1999) triple bottom line concept.

In 2015, the Sustainable Development Goals Index (SDGI) was created to evaluate each Organization for Economic Co-operation and Development (OECD) country's performance on the SDGs. The first performed assessment was based on thirty-four individual indicators. Results of the "stress test" showed that Denmark, Finland, Norway, and Sweden had the highest performance scores and had the highest chance to achieve targets by 2030 (Kroll, 2015). SDGI provides each country with the possibility to evaluate progress and compare its performance with other countries. (Schmidt-Traub, Kroll, Teksoz, Durand-Delacre & Sachs, 2017).

The Sustainable Development Goals Report 2023 showed that 50% of goals' progress is insufficient and slow-paced, and 30% of goals stopped advancing or even had reverse progress due to several different challenges. First and foremost, the world did not fully recover from the COVID-19 pandemic impacts, due to which global health, education, poverty reduction, and economics had reversal progress. Carbon emission continues to rise and worsen the climate change crisis. The frequency of floods, heat waves, wildfires, and droughts continues to increase. Thus, it is crucial to take action to achieve SDGs. Otherwise, the capability of upcoming generations to fulfill their necessities will be compromised (United Nations, 2023). Furthermore, Sinha, Sengupta & Alvarado (2020) highlighted the importance of having policies that would take into consideration the objectives of SDGs to achieve the set targets by 2030.

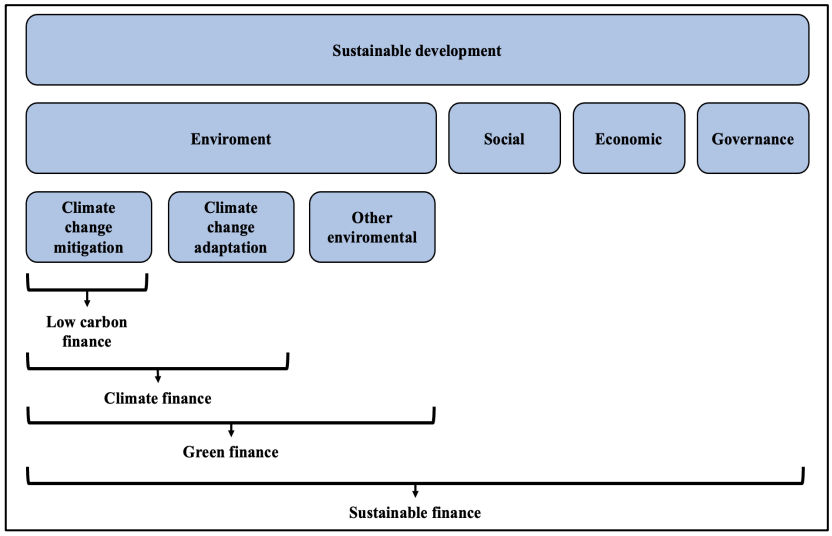
Financial resources have a critical role in initiating the change and the progress (United Nations Development Programme, 2023). Sustainable finance enables the achievement of SDGs as this type of funding mechanism considers environmental, economic, and social outlooks. Sustainable finance includes different types of finance, such as carbon finance, development

finance, microfinance, responsible finance, environmental finance, and green finance (Ziolo et al., 2019).

Furthermore, ‘sustainable finance,’ ‘green finance,’ ‘low carbon finance,’ and ‘climate finance’ terminology is widely applied and misused in the literature. Thus, the United Nations Environment Programme created a scheme, which is illustrated in Figure 2, to minimize complexity and enhance knowledge and clarity of extensive terminology. Sustainable finance encompasses green finance, climate finance, and low carbon finance and covers a broad range of categories, such as social, economic, governance, and environmental categories. Green finance is focused on different types of environmental issues. Climate finance and low carbon finance cover climate change issues and have the narrowest spectrum. These terms are interrelated as one type of finance generates different types of outcomes, which would impact different categories (United Nations Environment Programme, 2016).

Figure 2

Scheme for understanding the terminology



Source: United Nations Environment Programme, 2016.

To sum up, seventeen SDGs were created to ensure the preservation of the Earth for generations to come, and the objective was set to achieve targets by 2030. SDGs are categorized into three dimensions such as economic, social, and environmental. It is crucial to perform in all categories to achieve sustainable development. Furthermore, SDGs were created to evaluate each country’s performance towards the achievement of set targets. However, it was identified that humanity faced several different challenges in recent years that slowed the pace or even reversed the progress made toward the achievements of SDGs. Thus, the number of different types of

financial resources, such as ‘sustainable finance,’ ‘green finance,’ ‘low carbon finance,’ and ‘climate finance,’ were indicated as these financial resources have a critical role in initiating the progress towards achieving SDGs.

1.2 The concept of green finance

The financial sector has been a strong enabler of the growth of humanity and rising quality of life since the Industrial Revolution (Meo & Karim, 2022). Previously, this sector did not pay attention to how allocated financial resources impact the ecosystem. Thus, the scale of environmental and social problems has increased over the years. Pollution and effects of climate change grew, biodiversity was reduced, and natural resources degraded (Scholtens, 2017). Traditional finances are based on a narrow set of values as it does not consider social and environmental issues. Thus, it is unsuitable for accomplishing SDGs (Fullwiler, 2016). The financial sector is key to creating financial innovations, such as benefit corporations, crowdfunding, and the social impact bond, that would have a beneficial effect on the environment and society (Shiller, 2013). Moreover, environmental issues and global climate change have been growing concerns in the past decade, and the underlying importance of the urgency of the need to mature green financing and increase investment into environmentally friendly projects (Li et al., 2020). The green finance concept emerged from 1998 to 2002 (Zhou and Xu, 2022). Therefore, it is a relatively new phenomenon that does not have one universally agreed definition. Factors such as cultural differences, diverse priorities to tackle economic and environmental issues, and different stages of economic growth accelerate the development of various green definitions across countries (Gilchrist, Yu & Zhong, 2021). Over the years, the green finance concept developed from environment finance. Environment finance has the same objective: to minimize the destructive effect on the environment. However, the description differentiates as environmental finance aims to achieve objectives through market-based environmental policy instruments (Bhatnagar and Sharma, 2022).

A bibliometric analysis performed by Zhang, Zhang & Managi (2019) showed rapidly increasing relevance and significant importance of green finance topics. Lee and Lee (2022) observed that green finance can be described in three main types of concepts. The first concept is focused on environmental finances, which are known as financial services aimed at tackling environmental issues (Cowan, 1999; Gray, 2002; Salazar, 1998). The second concept is focused on innovative financial products aimed at the prevention and mitigation of environmental risks (Labatt and White, 2002). The third concept is described as a new form of finance that raises society’s awareness of ecology through the encouragement of the usage of green financial

instruments and investments that are environmentally friendly (He, Liu, Zhong, Wang & Xia, 2019; Hu, Wang & Wang, 2021; Liu, Wang, Zhang & Zhang, 2019). In another study, Wang and Zhi (2016) stated that the main aspect, which differentiates green finance from traditional financial activities, is the focus on protecting the environment and producing ecological environmental benefits. Furthermore, green finance has a narrower scope in comparison to sustainable finance, as green finance covers only one (environmental) pillar out of three sustainable development pillars (Ziolo et al., 2019). As indicated by Bakry, Mallik, Nghiem, Sinha & Vo (2023), the main aim of green finance is the mitigation of global warming and raising the quality of the environment through financial resources. Meanwhile, Srivastava, Dharwal & Sharma (2022) stated that to achieve sustainable economic development, green finance is key to guiding the allocation of financial resources. Moreover, the authors outlined that the green finance phenomenon does not have a direct influence on the environment as environmental quality is improved through the support that green finance provides through the financial resources allocated to different organizations (Zhou, Tang & Zhang, 2020).

Bhatnagar and Sharma (2022) reviewed green finance literature available from 2018 to 2021. The authors identified that the political environment, macroeconomic drivers, conductive investment environment, regulatory structure development, financial policies and regulations, technology and technological advancement, capital building, developed capital market, financial instruments, and institutional engagement increase are the main enablers of green finance. Thus, collaboration between different stakeholders, such as government, financial institutions, private institutions, etc., is a key to success in enabling green finance.

In conclusion, traditional finances are based on a narrow set of values as it does not consider social and environmental issues. Thus, it is unsuitable for accomplishing SDGs. As a result, there is an urgent necessity to mature green finance and increase investment into environmentally friendly projects. Various definitions exist due to cultural differences, diverse priorities to address economic and environmental challenges and different stages of economic development. Thus, green finance could be described as a financial resource that aims to enable organizations to positively impact the environment. In addition, collaboration between different stakeholders was identified as an important factor that is needed to succeed in enabling green finance.

1.3 Green financial instruments

International financial institutions have a vital role in promoting financial instruments that enable the achievement of SDGs. The United Nations Global Compact and KPMG International

introduced the SDG Industry Matrix, which aims to inform about the actions that the private sector could take to drive sustainable development. Opportunities to create shared value were presented and categorized into four categories such as financial inclusion, investment into infrastructure and renewable energy products, influencing customer behavior by leveraging risk expertise, and having a positive effect on corporate clients' and investment companies' social, environmental, and governance practices. Actions, such as raising capital through debt and equity, facilitating secure payments, and developing sustainable and innovative pricing models that reflect social, environmental, and governance risks, were presented (United Nations Global Compact and KPMG, 2016).

Financial products have a critical role in the application of the green finance concept (Wang and Zhi, 2016). The promotion of green financial instruments and activities is crucial to influencing the greening of the financial systems (Gilchrist et al., 2021). Table 1 includes a combined overview of different types of green financial products/instruments, such as green loans, green investment funds, green bancassurance, green bond, green stock indexes, and green long-term investment accounts, and their definitions created by different authors.

Table 1

Green finance products and instruments

Green finance products and instruments	Definition
Green loan	Green loan is an investment lent by the bank that aims to contribute towards green economy transition though mitigation of global warming and environmentally friendly initiatives (Gilchrist et al., 2021).
Green investment fund	Green investment fund is a trust fund, investment company, which adheres to the principles of investing according to standards that are green and orientated towards protection of environment (Wang and Zhi, 2016).
Green bancassurance	Insurance that provides net zero underwriting coverage for green assets and liabilities, such as green buildings and cars etc. (Wang, Nie, Peng & Li, 2017).
Green bond	Fixed income security that differentiates from ordinary bond as it directs raised funds to be spent on environmentally friendly business activities, projects, and assets (Organization for Economic Co-operation and Development, 2017).
Green Stock Index	Green stock index is used for choosing stocks from listed companies based on specific requirements (Fu and Ng, 2021).
Green long-term investment account	Product that gives the ability for customers to accumulate money to invest in long duration environmental projects, such renewable energy investment projects etc. (He et al., 2019).

Source: Compiled by the author based on the research of scientific literature

Green financial products enable environmental protection and sustainable utilization of resources (Srivastava et al., 2022; Wang and Zhi, 2016). Xu and Li (2020) indicated that green credit lowers the debt financing cost of green firms in China. Furthermore, researchers identified that the impact of green credit is greater in significance in economically developed areas. Furthermore, green financing tools enable green economic growth through financial resources invested into green projects, which creates job places, reduces carbon emissions, and improves welfare (Xu, She, Gao & Sun, 2023).

To sum up, international financial institutions have a vital role in promoting green financial instruments to positively impact economic development, protection of the environment, and improvement of society's welfare and progress towards achievement of set targets. Also, the SDG Industry Matrix was described to inform on actions that the private sector could take to drive sustainable development.

1.4 Green bonds as a green financial tool

In 2007, the first bond, named the "green bond," was released by the European Investment Bank (Baker, Bergstresser, Serafeim & Wurgler, 2018). Since then, green bonds gained increased popularity and have become the most innovative tool (Maria, 2020). First of all, the main distinction between ordinary bonds and green bonds is that green bonds are securities, which raise funds that must be spent on environmentally friendly projects (Wang and Zhi, 2016), have longer investment payback periods (Li et al., 2020), higher risk and less certain returns (Chang, Taghizadeh-Hesary, Chen & Mohsin, 2022). In 2014, "Green Bond Principles" (GBP) were created by several investment banks to form voluntary guidelines for the market. GBP consists of components such as the project assessment process, proceeds management, the utilization of the bond issue proceeds, information revealing and reporting of proceeds, and financing projects. Green bond proceeds are used to create energy-efficient buildings in the education sector. Also, it is commonly used for public power, water projects, and transportation (Baker et al., 2018).

Gianfrate and Peri (2019) have analyzed that green bond is the tool used to accomplish a low-carbon economy by mobilizing financial resources. Projects that aim to reduce pollution and protect the environment are financed by green bonds (Meo and Karim, 2022). Flammer's (2021) study results showed that the release of corporate green bonds has great outcomes, such as the formulation of a positive image, which attracts investors, results in a favorable reaction from the stock market, reduced carbon emission, and higher environmental ratings. Furthermore, research showed that green bond is not a tool for greenwashing and do not have a cost of capital benefit as it is not a source of cheaper financing. Zhao et al. (2022) research findings demonstrated that green

bond financing policy is enhancing economic growth. On the other hand, Larcker and Watts (2020) study results showed that municipal investors are reluctant to give up returns to invest in green securities in the United States. Also, the green bonds market faces several different barriers and challenges. The scope of low-carbon investments is too narrow and needs to be expanded. Also, there is a lack of green bonds market expansion and international standards (Sartzetakis, 2021).

In conclusion, the green bond was identified as an extensively used green financial instrument that attracts investors, enhances economic growth, has a beneficial effect on the environment, and is one of the main tools used to achieve a carbon-neutral economy. However, green bonds have a few drawbacks, such as a lack of green bond market expansion and internationally agreed standards. Furthermore, GBP was created to provide voluntary guidelines for the market.

1.5 The role of green finance in economic growth, environmental improvement, and Sustainable Development Goals.

The theoretical literature suggests that green finance contributes to green economic growth (Jiakui, Abbas, Najam, Liu & Abbas, 2023). Furthermore, Xu et al. (2023) analyzed the connection between green economic growth rates and green financial instruments, such as green bonds, by using the Panel Vector Autoregressive method. Research results indicated that the issuance of green bonds accelerated the green economic growth rate in the agricultural sector. In addition, financial resources invested into green projects created job places, reduced carbon emissions, and improved welfare (Xu et al., 2023). Moreover, Zhao et al. (2022) research findings demonstrated that green bond financing policy enhanced economic growth. Additionally, Zhou et al. (2020) used the environmental Kuznets curve to demonstrate that green finance promotes economic growth and reduces environmental damage in China.

According to Srivastava et al. (2022), Wang and Zhi (2016), green financial products enable environmental protection and sustainable utilization of resources. Also, Meo and Karim (2022) performed a study in which data from the top ten economies was used. The overall results of the study showed that green finance is reducing carbon emissions. Thus, it is a great financial strategy as it reduces environmental degradation. Moreover, Li, Faridi & Nazar (2023) concluded that green finance contributes to improving environmental quality by reducing greenhouse gas emissions in most studied countries. Also, Gilchrist et al. (2021) discovered that environmentally responsible practices contribute positively to the growth of shareholders' and non-financial stakeholder's value.

Taghizadeh-Hesary and Yoshino (2019) discovered that SDGs have a direct and indirect relationship with green finance and can be achieved by investing in green energy projects. Furthermore, SDGs can be achieved by increasing the level of cooperation between resources, environmental development, and the economy by implementing green finance practices (Jiakui et al., 2023).

To sum up, green finance is a great financial strategy that contributes to economic growth and improves the quality of the environment. Progress towards reaching SDGs can be accomplished by the utilization of green financial resources that are invested in green energy projects. An increase in cooperation between the economy, resources, and environmental development is crucial to implementing green finance practices.

1.6 Bibliometric analysis of Sustainable Development Goals and green finance

A bibliometric analysis of publications using tools such as Web of Science, Google Scholars, and VOSViewer will be conducted to gain additional insights into the relevance of green finance, green bonds, and SDGs topics and emerging themes in the literature. The analysis will provide a data-driven overview of how the research field of these topics evolved and enable the identification of areas for future studies. Furthermore, a review of different bibliometric analyses of published papers conducted by various authors will be completed.

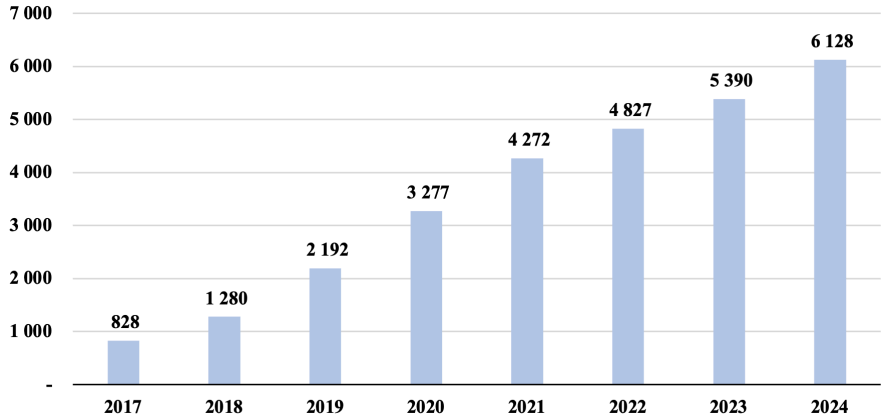
Bennich, Weitz & Carlsen (2020) reviewed the scientific literature on SDGs and created an overview, which includes the number of annually published peer-reviewed scientific articles. The author identified that 'Deciphering the Scientific Literature on SDGs Interactions: A Review and Reading Guide' was the first paper published on this topic in 2015. Since 2015, the number of papers published on SDGs has consistently increased. In 2018, the total number of published peer-reviewed scientific articles reached 21, indicating the rapid evolution of the field.

First and foremost, the Web of Science (2024) database was used to search "Sustainable Development Goals" publications. The selection of articles for the period between 2017 and 2024 was made. In total, 28194 publications were published on this topic, which consists of 3003 reviewed articles. Figure 3 shows a significant rise in the quantity of publications across the years. 828 articles were published in 2017, the number further grew to 1280 papers in 2018, followed by a further increase to 2192 articles in 2019. In 2020, the number rose to 3277 and accelerated further in 2021, reaching 4272 publications. By 2022, the number of publications increased to 4827 and continued to grow, reaching 5390 released publications in 2023. In 2024, total number of articles published was 6128. The data demonstrates a consistent increase, indicating an expanding research field. In addition, many scholars have written extensively on SDGs topics between 2017 and 2024.

Kumar A. has emerged as the leading author in terms of publication output, reaching 82, while Liu Y. has also made a significant contribution, publishing 65 papers. Other authors, such as Kumar S. with 60 articles, Kumar R. with 56 articles, and Leal W. with 55 articles, have also made valuable contributions. The consistent work of researchers emphasized the rising interest in SDGs topic.

Figure 3

The total count of publications on the Sustainable Development Goals topic

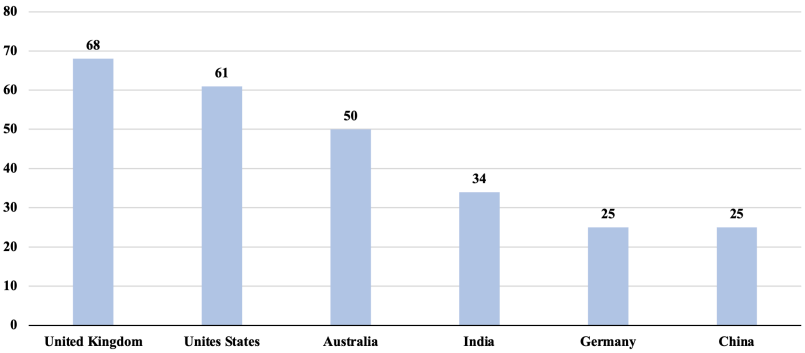


Source: Compiled by the author, based on the data extracted from the Web of Science (2024) database.

A bibliometric analysis performed by Yamaguchi et al. (2023) identified that the United Kingdom (68 articles), the United States (61 articles), Australia (50 articles), India (34 articles), Germany (25 articles) and China (25 articles) published the largest number of articles on SDGs from 2015 to 2021 and had the biggest contribution in scientific production (Figure 4).

Figure 4

Top six countries by volume of publication on Sustainable Development Goals



Source: Yamaguchi et al., 2023.

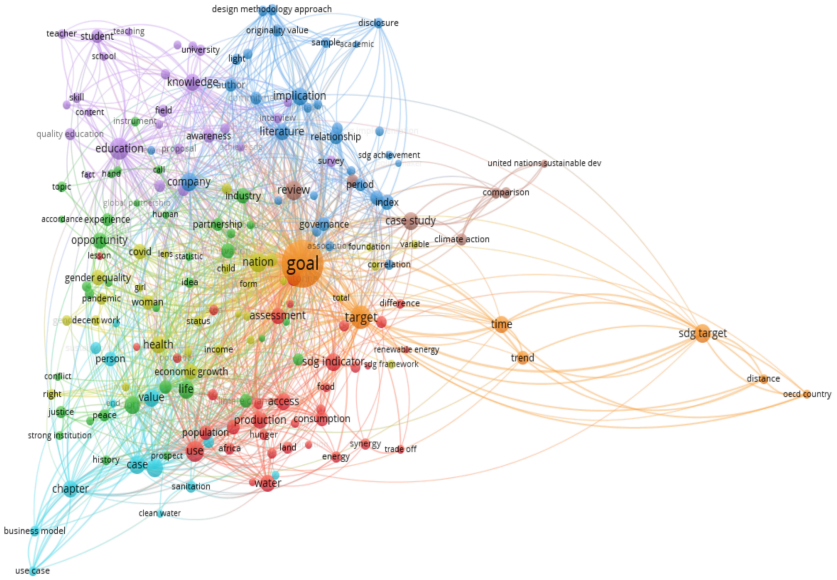
In addition, a bibliometric analysis of SDGs literature performed by Yamaguchi et al. (2023) showed rapid growth of research in the SDGs field. The author identified disproportion in the academic research as many SDGs, such as Goal 5, Goal 10, Goal 14, and Goal 16, were explored the least. Thus, future research should address this gap for the SDGs research area to be considered as consolidated. The concept of SDGs is complex as goals cover a range of fields and have different types of criteria.

Furthermore, data from authors who published on the topic of "SDG" (2022 and 2023 data) is applied to create a bibliographic map of the most often repeated words used by the authors, which are demonstrated in Figure 5 and Figure 6. Circles shown in the map have different colors to categorize the results into different types of clusters. The size of the circles demonstrates the importance of the word. The words that were cited the most frequently have larger circles. The lines between the words indicate that there is a relationship between keywords, and the distance indicates the intensity of the interference. The interference is greater when circles are closer to each other. Circles have different colors, which are distinguished between various clusters.

Figure 5 shows an "SDG" keyword network visualization map that consists of eight clusters: the red cluster contains 35 keywords, the green cluster includes 34 keywords, the blue cluster contains 31 keywords, the yellow cluster consists of 29 keywords, the purple cluster includes 26 keywords, the bright blue cluster contains 14 keywords, orange cluster consists of 8 keywords, light brown cluster includes 7 keywords.

Figure 5

Findings from bibliometric analysis of the SDG topic

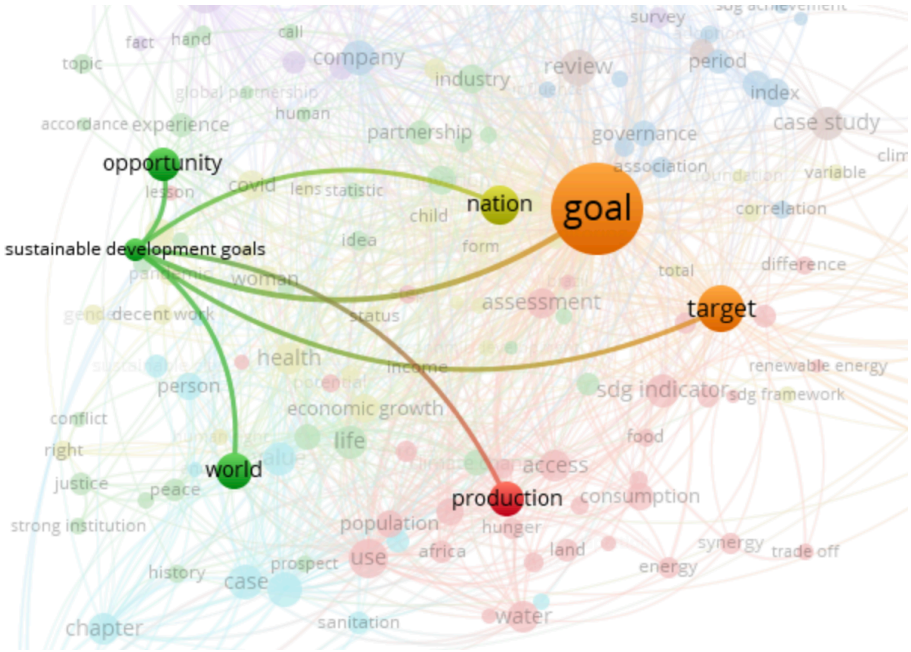


Source: Compiled by the author using the VOSviewer program (van Eck and Waltman, 2022).

The first cluster includes words such as “use,” “production,” and “access.” The word “use” is the most cited keyword and has 167 links, 86 occurrences, and the strength of the link is 863. The second most cited word is “production,” which has 150 links and 57 occurrences, and the strength of the link is 550. The second cluster consists of keywords such as “world,” “opportunity,” “life,” “climate change,” and “sustainable development.” The most frequently cited keyword is “world,” which has 153 links and 59 occurrences, and the strength of the link is 556. The second most often cited word is “opportunity,” which has 155 links, 52 occurrences, and strength of the link 519. Also, “sustainable development” was used in the literature. This word has 108 links, 22 occurrences, and the strength of the link is 224 (Figure 6).

Figure 6

Findings from bibliometric analysis of the SDG topic: the second cluster



Source: Compiled by the author using the VOSviewer program (van Eck and Waltman, 2022).

The third cluster consists of keywords such as “company,” “implication,” and “literature.” The most popular cited keyword is “company,” which has 155 links and 65 occurrences, and the strength of the link is 674. The second most frequently used word is “implication,” which has 148 links, 58 occurrences, and strength of the link 600. The fourth cluster consists of the words “nation,” “health,” and “economic growth.” The most frequently cited word in this cluster is “nation,” which has 166 links with 71 occurrences, and the strength of the link is 650. One of the other popular keywords is “health,” which has 157 links, 54 occurrences, and strength of link 498, and “economic growth,” which has 137 links, 46 occurrences, and strength of the link 390. The

fifth cluster has the keywords “education,” “knowledge,” and “awareness.” The most frequently cited word in this cluster is “education,” which has 170 links and 91 occurrences, and the strength of the link is 842. The second most often used word is “knowledge,” which has 162 links and 57 occurrences, and the strength of the link is 586. The sixth cluster has the keywords “technology,” “value,” and “case.” The most popular word in this cluster is “technology,” which has 156 links and 64 occurrences, and the strength of the link is 675. The second most important word is “value,” which has 156 links, 60 occurrences, and the strength of the link is 633. The seventh cluster has keywords such as “goal,” “target, “and “time. “The most widely used word in this cluster is “goal,” which has 183 links, 412 occurrences, and the strength of the link is 3331. The second most frequently used word is “target,” which has 175 links and 103 occurrences, and the strength of the link is 902. The eighth cluster has the keywords “review,” “case study,” and “response.” The most utilized word in this cluster is “review,” which has 161 links and 72 occurrences, and the strength of the link is 562. The second most used word is “case study,” which has 150 links and 61 occurrences, and the strength of the link is 439. To sum up, the findings from the “SDG” keyword network visualization map provided a holistic overview of the current academic work on the topic of SDGs published in the years 2022 and 2023. The results of the analysis showed that the link between green finance and SDG is absent.

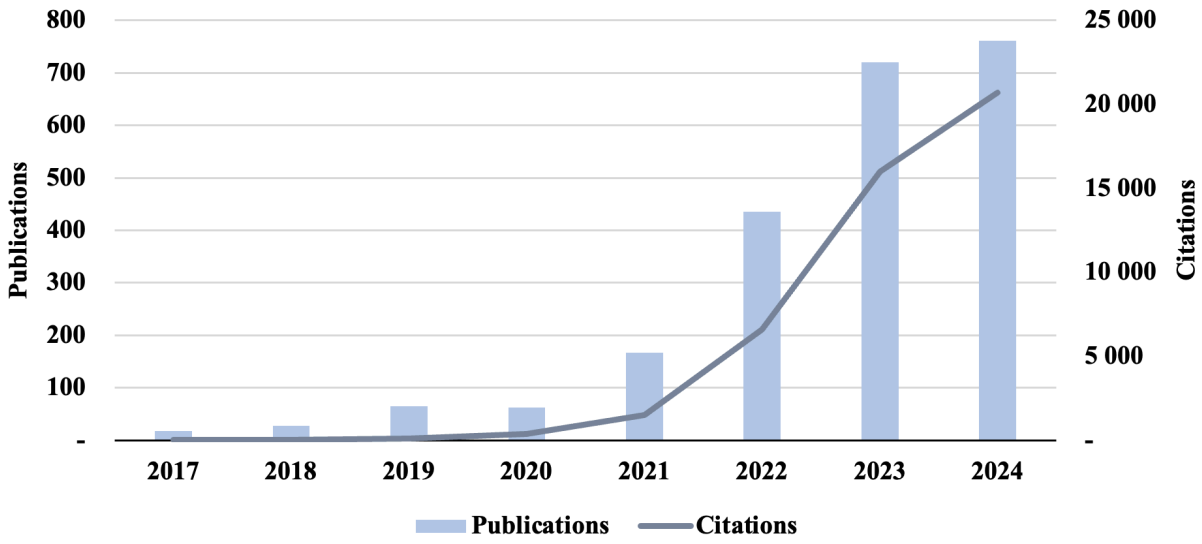
In addition, Akomea-Frimpong, Adeabah, Ofosu & Tenakwah (2022) analyzed the number of annually published papers on green finance of banks topic from 1997 to 2019. Bibliometric analysis results showed that from 1997 to 2013, the number of publications on this topic was low, as only one article was published per year in 1997, 2004, 2009, 2012, and 2013. In 2014, this number increased to four articles being published, followed by two articles published per year in 2015, 2016, and 2017. The number of publications significantly increased in 2018, and this upward trend continued in 2019, with a total of 22 articles published. Bibliometric analysis completed by Akomea-Frimpong et al. (2022) indicated a growing academic interest in green finance of banks topic.

Moreover, the Web of Science (2024) database was used to search “green finance” publications. The selection of articles for the period between 2017 and 2024 was made. In total, 2255 publications were published on this topic, which consists of 64 reviewed articles. Figure 7 demonstrates a steady growth in the number of publications through the years, with more significant growth occurring after 2020. In 2017, 18 papers were published on green finance topics, and this number steadily increased to 27 in 2018. In 2019, the number rose to 65 publications. The number accelerated significantly, with 167 papers in 2021. In 2022, number of publications reached 435 and continued to grow to 720 in 2023. In 2024, total number of articles published was 761, indicating significantly growing academic interest in this field. Furthermore,

Figure 7 demonstrates the frequency of citations. The largest number of citations, 20704, took place in the year 2024, and the lowest number of citations, 7, occurred in 2017. The consistent growth in the number of citations each year indicates academic engagement and acknowledgment of this topic. Moreover, many authors wrote on green finance topics between 2017 and 2024. Taghizadeh-history F. had the highest level of activity in publishing 33 articles on this topic, followed by Wang Y., who published 22 articles, and Lee C. C., who published 21 papers. In addition, several other authors have contributed, including Liu Y. with 19 publications and Zhang Y. with 17 publications between 2017 and 2024. To sum up, the ongoing contribution from the authors to research this topic highlighted the growing academic engagement within green finance topic.

Figure 7

The total publication counts on the green finance topic

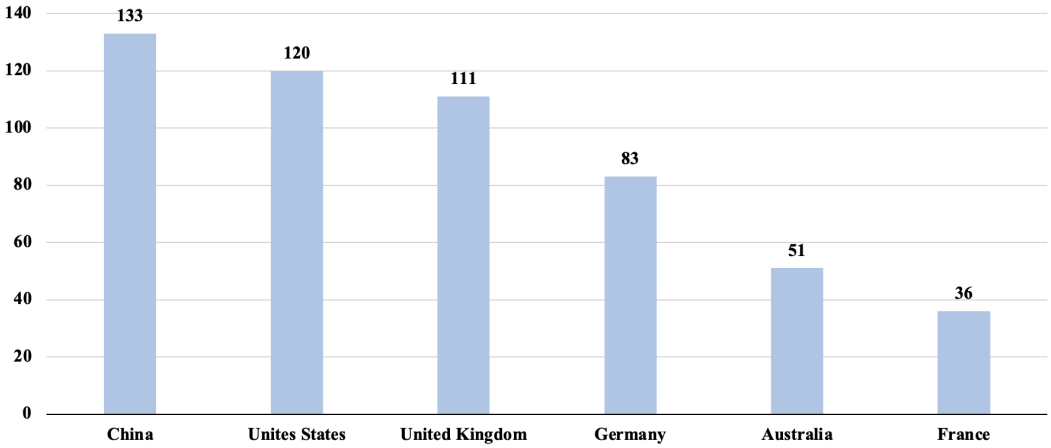


Source: Compiled by the author, based on the data extracted from the Web of Science (2024) database.

A bibliometric analysis performed by Bhatnagar and Sharma (2022) identified that China (133 articles), the United States (120 articles), the United Kingdom (111 articles), Germany (83 articles), Australia (51 articles), and France (36 articles) published the largest number of articles on green finance from 2018 to 2021 and had the biggest contribution in scientific production (Figure 8).

Figure 8

Top 6 countries of publication on green finance

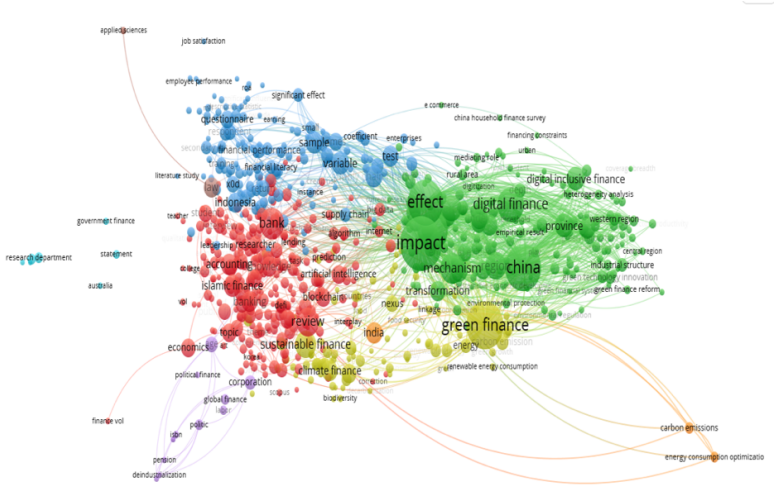


Source: Bhatnagar and Sharma, 2022.

Furthermore, data from authors who published on the topic of "Finance" (2023 data) was applied to create a bibliographic map of the most often repeated words used by the authors, which are demonstrated in Figure 9 and Figure 10. Additionally, Figure 9 demonstrates the "Finance" keyword network visualization map that consists of eight clusters: the red cluster consists of 285 keywords, the green cluster contains 181 keywords, the blue cluster includes 137 keywords, the yellow cluster consists of 94 keywords, purple cluster contains 12 keywords, bright blue cluster includes 7 keywords, orange cluster consist of 3 keywords, light brown cluster contains 3 keywords.

Figure 9

Findings from bibliometric analysis of the finance topic

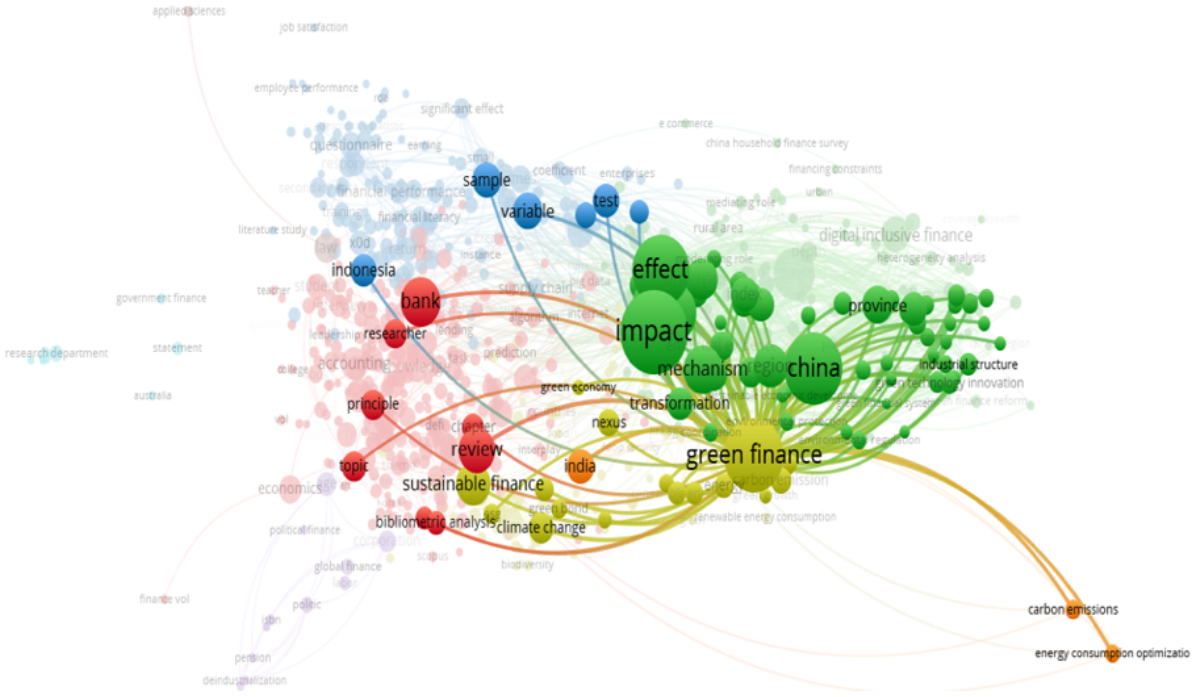


Source: Compiled by the author using the VOSviewer program (van Eck and Waltman, 2022).

The first cluster includes words such as “bank,” “review,” and “knowledge.” The word “bank” is the most cited keyword and has 540 links, 285 occurrences, and the strength of the link is 2199. The second most cited word is “review,” which has 492 links and 236 occurrences, and the strength of the link is 1732. The second cluster consists of keywords such as “impact,” “effect,” and “China.” The most frequently cited keyword is “impact,” which has 678 links and 814 occurrences, and the strength of the link is 7291. The second most often cited word is “effect,” which has 664 links and 584 occurrences, and the strength of the link is 5840. The third cluster includes keywords such as “sample,” “variable,” and “test.” The most popular cited keyword is “sample,” which has 472 links with 141 occurrences, and the strength of the link is 1632. The second most frequently used word is “variable,” which has 473 links and 149 occurrences, and the strength of the link is 1613. The fourth cluster is demonstrated in Figure 10 and consists of the words “green finance,” “climate change,” “sustainable finance,” “carbon emission,” “energy,” “climate finance,” and “SDGs.” Figure 10 illustrates the fourth cluster. The most frequently cited word in this cluster is “green finance,” which has 532 links and 632 occurrences, and the strength of the link is 4031. One other widely used keyword is “sustainable finance,” which has 348 links, 214 occurrences, and the strength of the link is 909, and “SDGs,” which has 292 links, 58 occurrences, and the strength of the link is 607.

Figure 10

Findings from bibliometric analysis of the finance topic: fourth cluster



Source: Compiled by the author using the VOSviewer program (van Eck and Waltman, 2022).

The fifth cluster has the keywords “age,” “corporation,” and “politics.” The most frequently cited word in this cluster is “age,” which has 260 links and 69 occurrences, and the strength of the link is 530. The second most often used word is “corporation,” which has 261 links and 58 occurrences, and the strength of the link is 466. The sixth cluster has the keywords “statement,” “research department,” and “finance section.” The most popular word in this cluster is “statement,” which has 124 links and 22 occurrences, and the strength of the link is 174. The second most important word is “research department,” which has 18 links and 34 occurrences, and the strength of the link is 100. The seventh cluster has keywords “India,” “carbon emission, “and “energy consumption. “The most frequently used word in this cluster is “India,” which has 326 links and 130 occurrences, and the strength of the link is 811. The second most adopted word is “carbon emission,” which has 58 links and 38 occurrences, and the strength of the link is 249. The eighth cluster has keywords “law,” “applied sciences,” and “Eurasian journal.” The most popular word in this cluster is “law,” which has 347 links and 112 occurrences, and the strength of the link is 789. The second most used word is “applied sciences,” which has 12 links and 15 occurrences, and the strength of the link is 40. To conclude, the findings from the “Finance” keyword network visualization map provided an extensive overview of the current research landscape on the topic of finance published in the year 2023. The fourth cluster indicated the high usage of green finance, SDGs, and carbon emissions keywords by authors in the literature. This suggested that these topics are highly discussed and are interconnected with other topics. The field of research is growing and gaining importance in academic discussions. Other keywords related to the topic of this thesis were not found.

In addition, table 2 demonstrates an overview of published books on green finance and/or SDGs topics per year from 2015 to 2023. ‘Sustainable Development Goals’ and ‘Green Finance’ words were used to perform this analysis and find the number of books released on these topics; a search was conducted using Google Scholar’s (2023) search engine. In total, 46 books were published. The results show that books on these topics were not published in 2015. However, the largest number of books were published in 2023. Furthermore, 2017, 2018, 2019, and 2022 years had the same number of publications. Moreover, data indicates that the popularity of this topic significantly decreased in the year 2020 and regained interest in 2022. Overall, the number of published books increased since 2015.

Table 2

Data of published books on green finance and/ or Sustainable Development Goals

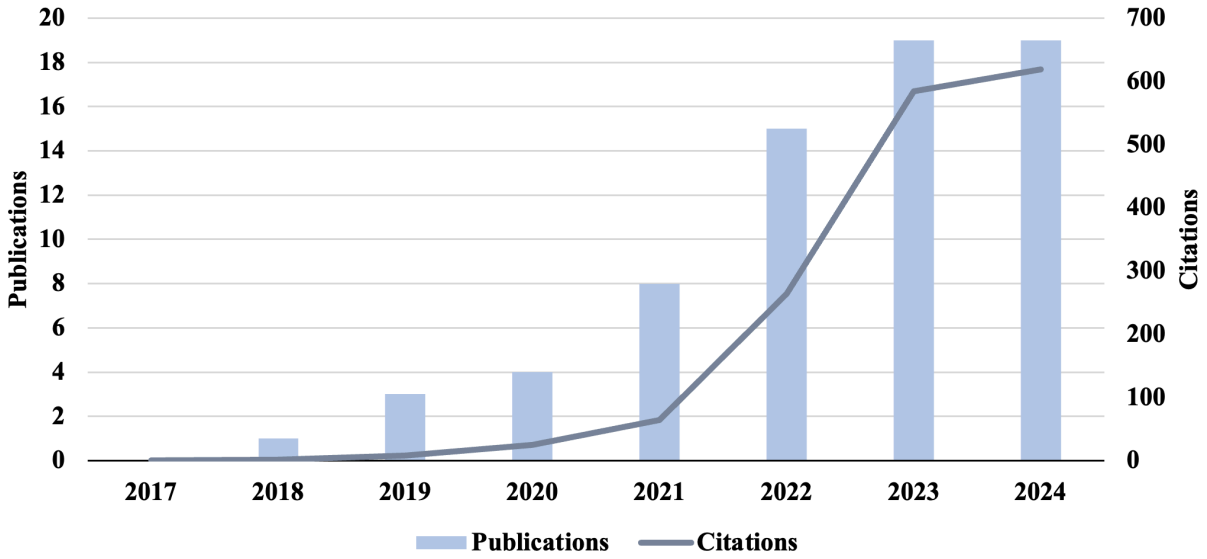
Year	Green Finance and Sustainable Development Goals
2023	8
2022	7
2021	3
2020	2
2019	7
2018	7
2017	7
2016	5
2015	0

Source: Compiled by the author, based on the data extracted from the Google Scholar (2023) database.

Furthermore, the bibliometric analysis was performed to identify emerging trends and changes by comprising publications that focus on green bonds and SDGs. The selection of articles for the period between 2017 and 2024 was made. Web of Science (2024) database was used to search "green bond" or "green bonds" and "Sustainable Development Goal" or "SDGs" publications. In total, 69 papers were published on this topic, which consists of 9 reviewed articles. Figure 11 demonstrates a gradual and modest increase in research output over the years. No publications were identified for the year 2017. In 2018, 1 article was published, the number grew to 3 publications in 2019 and 4 papers in 2020. In 2021, the number increased more significantly to 8 articles, followed by a modest rise to 15 articles in 2022. This number grew to 19 articles in 2023 and was maintained in 2024. Furthermore, Figure 11 demonstrates the frequency of citations. The largest number of citations, 619, took place in the year 2024, and the lowest number of citations, 1, occurred in 2018. There were no citations in 2017. The number of citations is consistently growing each year. In addition, the green bond and SDGs topic has attracted contributions from several different scholars from 2017 to 2024. To conclude, the steady increase in the frequency of citations and the number of published articles indicated a growing academic interest in green bonds and SDGs topic. Also, raising citations demonstrated academic involvement and recognition of this topic as an important field of study by scholars. However, the number of publications is significantly lower in comparison to bibliometric analysis completed only on SDGs publications and on green finance publications. This indicated that SDGs and green bonds are a relatively new field of study.

Figure 11

The frequency of citations and the total publication counts on green bonds and Sustainable Development Goals



Source: Compiled by the author, based on the data extracted from the Web of Science (2024) database.

Moreover, additional bibliometric analysis was performed to narrow down the scope of the research. Web of Science (2024) database was used to search “green bond” or “green bonds,” “Sustainable Development Goals” or “SDGs,” and “Climate action” or “carbon dioxide” or “greenhouse gas.” In total, seven publications were released on this topic. Data indicated a limited and fluctuating trend of publications. The first and only one article was published in 2019. In 2020, there were no publications. In 2021 and 2022, 1 article was published, following an increase of 3 papers published in 2023. In 2024, this number decreased to 1. Overall, publication volume remains low, suggesting the early stage of the research area. Results indicate an under-explored field and research gap that would investigate green bonds and Sustainable Development Goal 13, which is focused on addressing climate change. Moreover, data on the frequency of the citations was analyzed. In 2019, the publication was cited 4 times. Since then, the number of citations has steadily increased over time, with notable growth observed from 2021 onwards. The frequency of citations increased from 17 citations in 2021 to 72 citations in 2024, indicating growing recognition and interest within the academic community. To conclude, a low number of publications suggested that the quantity of articles is limited. However, the frequency of citations pointed out that the quality and influence of existing articles are strong and gaining increased attention and validation of this topic over time.

To sum up, the steady increase in several published articles on green finance, SDGs, and green bonds indicated a growing academic interest in these topics. Also, raising citations of publications demonstrated academic involvement and recognition of these topics as important fields of study by scholars. Furthermore, bibliometric analysis of the individual SDG and green finance topics and keyword network visualization maps showed a greater volume of publications than the combined bibliometric analysis of SDGs and green bonds. This indicated that SDGs and green finance as separate topics have been explored extensively and suggested that these topics are highly discussed and are interconnected with other topics. The field of research is growing and gaining importance in academic discussions. However, SDG and green bonds as a unified research area is a relatively new emerging field of study. Furthermore, it was identified that the number of books published on green finance and SDGs topics is noticeably smaller than the number of published papers. Moreover, China and the United States were identified as the biggest contributors to the scientific production of green finance topics, while the United Kingdom and the United States were the largest contributors to the scientific production of SDG topics.

1.7. The relationship between green bonds, Sustainable Development Goal 13, and greenhouse gas emissions

Several authors researched the impact of green bonds on achieving SDG 13 across different geographical regions by studying the relations between the amount of green bonds issued and carbon dioxide emission levels. Alamgir and Cheng (2023) performed research in 67 countries around the world and focused on researching the impact of green bonds on SDG 13 and SDG 7. Results of the study showed that green bonds and carbon dioxide emission have a negative relationship, indicating that once the amount of green bonds issued increases, the carbon dioxide emission decreases. Similarly, Saha and Maji (2023) studied 44 countries covering different regions and found that green bonds exhibit a significant negative impact on carbon dioxide emissions. Arshad et al. (2024) conducted a study on developing countries and indicated that green bonds reduce carbon dioxide emissions in these countries. Further, Dill (2024) performed research that covered 150 countries. The results showed that the issuance of green bonds is linked to an average 14% decrease in carbon dioxide emissions. In addition, Nguyen, Luu, Hoang & Nguyen (2023) conducted a study in 171 countries. The findings validated that the issuance of green bonds leads to positive environmental outcomes, such as the reduction of carbon dioxide emissions and greenhouse gas emissions, and partially enables the advancement of the achievement of SDGs. Countries that issued green bonds demonstrated great environmental performance compared to those that did not. Moreover, Rasoulinezhad and Taghizadeh-Hesary (2022) examined the

connection between green finance, carbon emission, energy efficiency, and green energy index. Research results showed that green bonds reduce carbon emissions in the long term and are the right method used to raise awareness of green energy projects. To conclude, several articles were published focusing on green bonds impact on SDG 13 or the reduction of greenhouse gas emissions in developing countries or countries around the world, which does not consider regional differences. There were no publications available on this subject that focused on the Nordic region. As a result, the Nordic region was selected to address the research gap.

1.8 Conclusions of the chapter

Seventeen SDGs were created to ensure that the planet is preserved for future generations, and the objective was set to achieve targets by 2030. However, it was identified that humanity faced several different challenges in recent years that slowed the pace or even reversed the progress made toward the achievements of SDGs. Traditional finances are based on a narrow set of values and do not consider social and environmental issues. As a result, it is unsuitable for accomplishing SDGs. Immediate action is required to mature green finance and increase investment into environmentally friendly projects. Green finance is a great financial strategy as it contributes to economic growth and has a positive impact on the environment. Green bonds were identified as one of the most used green financial instruments, which attracts investors, enhances economic growth, has a positive impact on the environment, and is one of the main tools used to achieve a low-carbon economy. Furthermore, the results of the conducted bibliometric analysis using the VOSviewer database showed that the link between green finance and SDGs was absent in the papers on the topic of SDGs published in the years 2022 and 2023. Hence, additional bibliometric analysis using the Web of Science (2024) database was completed, and results indicated that the relevance of green finance and the SDGs concept is rapidly increasing among academics. It was noticed that the number of publications was significantly lower for bibliometric analysis that combined green bonds and SDG topics in comparison to bibliometric analysis that focused solely on SDG and green finance topics. This indicates that SDGs and green finance as separate topics have been explored extensively. However, SDG and green bonds as a unified research area is a relatively new emerging field of study. Additional analysis was done on articles that cover the topic of green bonds and SDG 13, which is dedicated to addressing climate change issues. The results showed that publication volume remains low on this topic, suggesting the early stage of the research area. Few articles were published focusing on developing countries or global views that do not consider regional differences. There were no publications available on this subject that focused on the Nordic region. As a result, the Nordic region was selected to address

the research gap. There is a need for a more focused study that examines how green bonds impact SDG13 in the Nordic region. Thus, this thesis assesses the impact of green bonds on achieving SDG 13 in the Nordic region to contribute to academic research.

2. THE METHODOLOGY FOR RESEARCHING THE IMPACT OF GREEN FINANCE ON ACHIEVING THE SUSTAINABLE DEVELOPMENT GOAL 13 IN NORDIC COUNTRIES

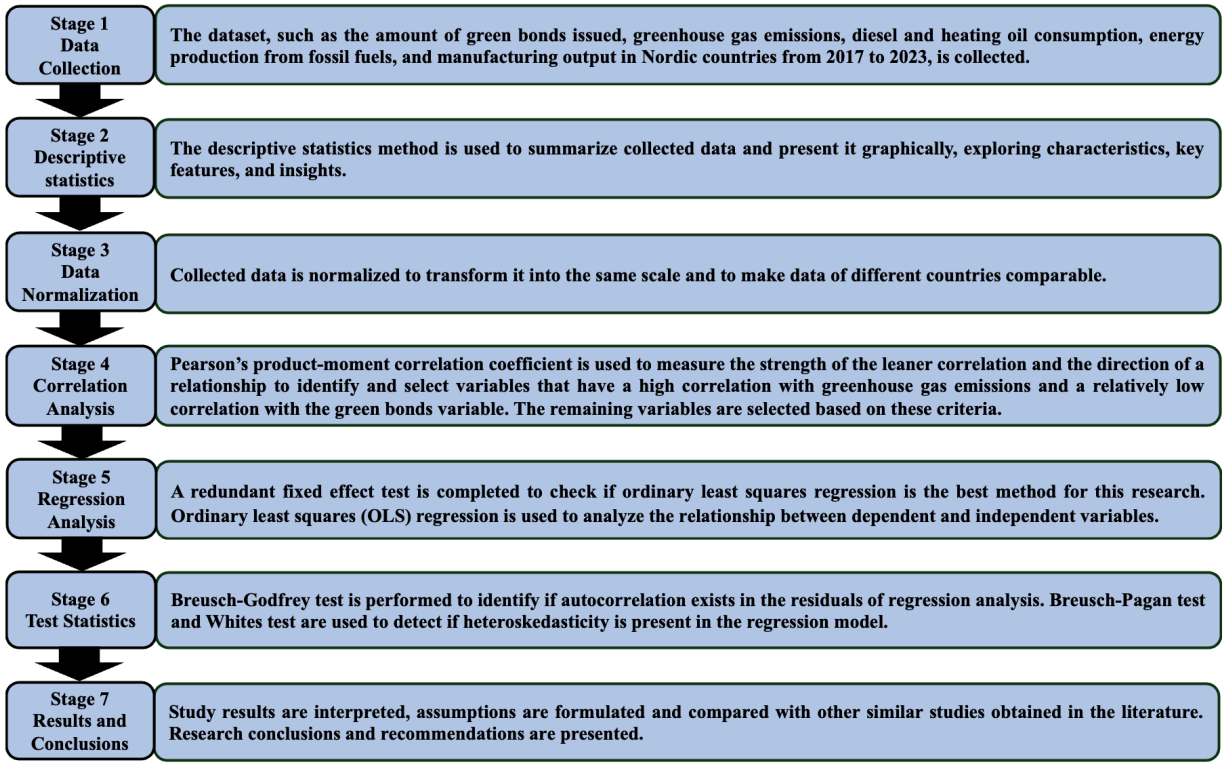
In this chapter, the aim, research questions, and stages of the thesis will be covered. Data samples, data sources, and variables will be indicated. Methodologies used to investigate the impact of green finance on achieving SDGs will be explored. Through this exploration, data analysis methods, tools, and techniques will be selected and described to achieve the aim of the thesis.

The thesis aims to determine the impact of green finance on achieving the Sustainable Development Goals. To accomplish this, the following research questions were formulated:

- Has there been a difference in greenhouse gas emissions and the amount of green bonds issued in Nordic countries from 2017 to 2023?
- How green bonds impact greenhouse gas emissions in Nordic countries from 2017 to 2023?

Figure 12

Stages of the research



Source: Compiled by the author.

Figure 12 demonstrates seven stages of the research. In the first stage, data from dependent variables, such as the amount of green bonds issued, and data from independent variables, such as greenhouse gas emissions, consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output, in Nordic countries from 2017 to 2023, are collected. In the second stage, the descriptive statistics method is used to summarize collected data and present it graphically, exploring characteristics, key features, and insights. In the third stage, collected data is normalized to standardize the variables, bringing them to a consistent scale and making sure that data from different countries is comparable. In the fourth stage, correlation analysis is performed to measure the strength and direction of relationships between the selected variables. The aim is to identify which variables have a high correlation with the greenhouse gas emissions variable and a relatively low correlation with the green bond variable. The remaining variables are selected based on these criteria. In the fifth stage, a redundant fixed effect test is completed to check if ordinary least squares regression is the best option for this research. Ordinary least squares regression is used to analyze the relationship between dependent and independent variables. In the sixth stage, test statistics are performed to detect if autocorrelation occurs in the residuals of regression analysis and if heteroscedasticity is present. Study results are interpreted, assumptions are formulated and compared with other similar studies obtained in the literature, and research conclusions and recommendations are presented in the final stage of the research.

2.1 Data selection and description

This research is based on a sample of 4 countries such as Denmark, Sweden, Norway, and Finland. This group of countries is referred to as Nordic countries in the remainder of this thesis. Iceland issued significantly smaller amounts of green bonds in comparison to Denmark, Norway, Sweden, and Finland. Therefore, Iceland is excluded from this research. Also, the Faroe Islands, Greenland, and Aland are excluded from this study. Regional differences in green bond market development are removed by comparing countries in the same region. All four countries have issued green bonds. The Nordic region is not entirely homogeneous. However, Nordic countries are the leaders in the green energy transition and are vanguards in the carbon pricing field. Norway, Finland, and Sweden are ranked among the countries that have the highest carbon tax rates worldwide (Alves, 2024). Results of the “stress test” showed that Sweden, Norway, Denmark, and Finland had the highest performance scores and had the greatest chance to reach the ambitious set by the United Nations to achieve goals by 2030 (Kroll, 2015). Furthermore, SDGs and the Paris Agreement were created in 2015, which led to increased environmental protection actions across the world and an increased number of green bond initiatives that would enable the achievement of

set targets. However, the agreement came into effect at the end of 2016. Accordingly, this study covers a period of 6 years, starting from 2017 to 2023. Moreover, this research focuses on assessing the impact of achieving SDG13, which has the target of reducing greenhouse gas emissions. This goal is mainly focused on resolving environmental problems and is at the center of the SDGs agenda.

Three different sources are used to collect the data. Firstly, the dataset of the value of green bonds issued each year by Nordic countries is retrieved from Bloomberg Terminal using the SRCH function. A fixed-income search is performed to find issued green bonds. Filters are applied to find active bonds in Norway, Finland, Denmark, and Sweden from 2017 to 2023. A green instrument indicator filter is added to ensure that data includes green bonds. Furthermore, data on greenhouse gas emissions in a million metric tons of CO2 equivalent in Nordic countries is extracted from Statista. Greenhouse gas emissions include carbon dioxide (fossil only), methane, nitrous oxide, and fluorinated gases. Data is aggregated using Global Warming Potential values from the Intergovernmental Panel on Climate Change Fifth Assessment Report (Global Warming Potential over a 100-year time horizon). Moreover, the dataset of diesel and heating oil consumption in thousand barrels per day in Nordic countries is collected from The Global Economy. This data is based on annual consumption of distillate fuel oils, which consist of two main categories such as diesel fuel and heating oil. The source is The U.S. Energy Information Administration. In addition, the dataset of energy production from fossil fuels in billion kilowatt-hours in Nordic countries is extracted from Statista. The fossil fuel market consists of natural gas, oil, and coal. Extracted data includes oil and petroleum products, manufactured gases and waste, natural gas-fired power plants, hard coal, lignite, and co-firing. Also, data includes energy components, such as ethane, propane, butane, isobutene, and pentane. Furthermore, the dataset of manufacturing output in billion euro in Nordic countries is collected from Statista. Manufacturing output is based on physical and chemical transformations of materials, substances, or components into new products.

Table 3 provides a summary and description of selected variables used in this thesis to complete the analysis. This research aims to assess the impact of green bonds on achieving SDG 13. This goal aims to tackle the climate change crisis. As a result, greenhouse gas emission is selected as a variable. Furthermore, the amount of green bonds issued is selected as a variable as it is a financial instrument known for raising funds that must be spent on environmentally friendly projects and is used to accomplish a low-carbon economy (Gianfrate and Peri 2019, Wang and Zhi 2016). Several different factors impact greenhouse emissions. Thus, additional variables, such as consumption of diesel, heating, and oil, energy production by using fossil fuels, and manufacturing output, are selected due to their contribution to climate change.

Table 3

Summary of study variables

Short name	Variable Name	Category	Description
GHGpc	Greenhouse gas emissions in million metric tons of CO_2 equivalent	Dependent variable	Greenhouse gas emissions include carbon dioxide (fossil only), methane, nitrous oxide and fluorinated gases.
GBVpc	Green bonds	Independent variable	Amount of green bonds issued in euro.
DHOC	Diesel and heating oil consumption, thousand barrels per day	Independent variable	This data is based on annual consumption of distillate fuel oils, which consist of two main categories, such as diesel fuel and heating oil.
FFpc	Energy Production from Fossil Fuels in billion Kilowatt-hours.	Independent variable	Extracted data includes oil and petroleum products, manufactured gases and waste, natural gas-fired power plants, hard coal, lignite and co-firing. Also, data includes energy components, such as ethane, propane, butane, isobutene, and pentane.
MNF	Manufacturing output in billion euro	Independent variable	Manufacturing output is based on physical, chemical transformations of materials, substances, or components into new products.

Source: Compiled by author, based on the current research.

Furthermore, table 3 summarizes selected variables. The greenhouse gas emissions variable is selected as the dependent variable. Green bonds, manufacturing output, energy production from fossil fuels, consumption of diesel, and heating oil variables are selected as independent variables.

2.2 Research methods used by other authors

Methodologies used to investigate the impact of green and sustainable finance on achieving SDGs are explored to identify and select the best-suited method to achieve the aim of this thesis. Table 4 summarizes the methods and results.

Table 4

Summarized research completed by other authors on a similar topic

Author(s)	Year	Article	Summary of Methodology	Summary of Results
Alamgir, M., and Cheng, M. C.	2023	Do Green Bonds Play a Role in Achieving Sustainability?	One-step generalized method of moments model, Person's Correlation Matrix.	Renewable energy exhibits a significant positive relationship with green bonds. Green bonds and carbon dioxide emission have negative relationship.
Saha, R., and Maji, S. G.	2023	Do green bonds reduce CO2 emissions? Evidence from developed and developing nations	Generalized methods of moments, instrumental variables, descriptive statistics, generalized least squares regression model, Person's Correlation Matrix, sensitivity analysis.	Green bonds exhibit a significant negative impact on carbon dioxide emission globally.
Streimikiene, Mikalauskiene & Burbaite	2023	The Role of Sustainable Finance in Achieving Sustainable Development Goals	The method of standardized sum, correlation (Pearson's linear correlation and Kendall's correlation) and least-squares regression analyses.	Sustainable finance has an impact on the implementation of Sustainable Development Goals.
Arshad, A., et al.	2024	The role of green bonds in reducing CO2 emissions: a case of developing countries.	Pooled ordinary least squares, fixed effect and generalized method of moments.	Green bonds reduce carbon dioxide emission in developing countries.

Source: Compiled by author, based on the current research.

Three authors created Pearson's Correlation Matrix to measure the strength and direction of a relationship between selected variables. Three out of two authors used the generalized method of momentum, which is used to address the issues of the endogeneity of lagging dependent variables, serial correlation in residuals, heteroscedasticity, correlation, and examination of random effect (Alamgir and Cheng, 2023). Different methods of regression analysis, such as least-squares regression and generalized least-squares regression, were used by other authors to assess the impact of independent variables on dependent variables. As a result, Pearson's Product Moment Correlation Coefficient and regression analysis methods are selected to achieve the aim and objectives of this thesis.

2.3 Selected research methods

The descriptive statistics method is used to summarize collected data and present it graphically, exploring characteristics, key features, and insights to discover if there has been a difference in greenhouse gas emissions and the amount of green bonds issued in Nordic countries during the study period. Furthermore, the position of Nordics in the global and European green bonds market is evaluated.

Collected data is normalized to make data of different countries comparable. Collected data, which has different scales, is adjusted to have the common reference scale by applying the manual standardization method. The data is adjusted manually by converting values into a specific standardized format. Furthermore, the Z-score normalization method is applied. This method is selected as it is the most frequently used method. Mean and standard deviation are used to normalize the data. Mean is the quotient of the total value of the data set and the count of observations. Standard deviation is a statistical measure that indicates how values spread out around the mean the Z-score is calculated for each variable by subtracting the mean of the variable and dividing by the standard deviation (Newbold, Carlson, & Thorne 2013). The Z-score normalization method can be expressed in Equation 1:

$$Z_{score} = \frac{X-\mu}{\sigma} \quad (1)$$

Explanation of abbreviations:

X = the input of a model

μ and σ = the mean and the standard deviation calculated over X, respectively

Pearson's Product Moment Correlation Coefficient is used to measure the strength of the leaner correlation and direction of a relationship, such as positive or negative, between selected variables (Franzese and Iuliano, 2018). The aim is to identify variables that have a high correlation with the greenhouse gas emissions variable and a relatively low correlation with the variable of green bonds. The collected data is processed using the Microsoft Office Excel program. Pearson's Product Moment Correlation Coefficient can be expressed in Equation 2:

$$r = \frac{\Sigma\,(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\Sigma(x_i-\bar{x})^2\Sigma(y_i-\bar{y})^2}} \quad (2)$$

Explanation of abbreviations:

x_i and y_i = data of selected two variables

$\bar{x}$ = the mean of the *x*-values, and $\bar{y}$ is the mean of the *y*-values

Σ = the summation sign

Table 5

Interpretation of correlation strength

Correlation coefficient	Description
From 0,9 to 1,0 or from -0,9 to -1,0	Very strong correlation
From 0,7 to 0,9 or from -0,7 to -0,9	Strong correlation
From 0,5 to 0,7 or from -0,5 to -0,7	Average correlation
From 0,3 to 0,5 or form -0,3 to -0,5	Weak correlation
From 0,3 to – 0,3	Insignificant correlation

Source: Bileviciene and Jonusauskas, 2011.

Table 5 shows an interpretation of the correlation strength of values between -1 and 1. If the value of the correlation coefficient is from 0,9 to 1,0 or from -0,9 to -1,0, then the correlation is very strong. If the value is from 0,7 to 0,9 or from -0,7 to -0,9, then the correlation is strong. If the value is from 0,5 to 0,7 or from -0,5 to -0,7, then the correlation is average. If the value is from 0,3 to 0,5 or from -0,3 to -0,5, then the correlation is weak. If the value of the correlation coefficient is from 0,3 to – 0,3, the correlation is insignificant (Bileviciene and Jonusauskas, 2011).

A redundant fixed effect test is completed using the EViews program to determine whether the individual fixed effects are redundant or not needed in the model. This method is commonly used to analyze panel data. If the findings of the redundant fixed effect test lack contribution to explaining the variance in the dependent variables, then ordinary least squares regression will be used to answer research questions.

Analysis based on linear models developed using the ordinary least squares regression is used to analyze the relationship between the dependent variable GHGpc and independent variables, such as GBVpc, DHOC, FFpc, and MNF. The regression analysis reveals the p-value, which indicates if the results are statistically significant. This method reduces the total of all squares predictive errors for known dependent variables' scores in correlation analysis (Witte and Witte, 2017). The collected data is processed with a Python (Version 3.13.1) program. The relationship between selected variables can be expressed in ordinary least squares regression equations 3:

$$GHGpc = c + \beta_1 GBVpc + \beta_2 DHOC + \beta_3 FFpc + \beta_4 MNF + \varepsilon \quad (3)$$

Explanation of abbreviations:

GHGpc = greenhouse gas emissions.

c = *GHGpc* intercept.

GBVpc = amount of green bonds issued.

β_1 = the slope of the line, which represents the change in *GHGpc* for every unit change in *GBVpc.*

DHOC = diesel and heating oil consumption.

β_2 = the slope of the line, which represents the change in *GHGpc* for every unit change in *DHOC.*

FFpc = energy production from fossil fuels.

β_3 is the slope of the line, which represents the change in *GHGpc* for every unit change in *FFpc.*

MNF = manufacturing output.

β_4 = the slope of the line, which represents the change in *GHGpc* for every unit change in *MNF*.

ε = error term.

To examine the accuracy of the regression model, several tests are conducted to identify potential issues in the residuals. The Breusch-Godfrey test is performed to identify if autocorrelation exists in the residuals of regression analysis, intending to check the robustness and correctness of results. This test accommodates models where lagged dependent variables are allowed, and other explanatory variables may correlate with past errors. In the presence of serial correlation, ordinary least squares standard errors and test statistics are no longer accurate (Wooldridge, 2016). The p-value is used to perform the test of the null hypothesis, which is rejected if the significance level is 0,05. If the p-value is less than 0,05, then the null hypothesis indicates that there is no autocorrelation. Furthermore, the Breusch-Pagan test examines whether the residuals have a consistent variance across all observations and is used to detect if heteroskedasticity is present in the regression model (Wooldridge, 2016). If the p-value is less than 0,05, then heteroskedasticity is present. Moreover, the White test is used to further validate the results from the Breusch-Pagan test. The White test is used to indicate if there is heteroskedasticity where the squared residuals are regressed against both linear and non-linear transformations of the explanatory variables. Heteroskedasticity is not a stable variability of the error term given the explanatory variables (Wooldridge, 2016). If the p-value is less than 0,05,

then heteroskedasticity is present. The occurrence of heteroskedasticity would indicate unreliable estimates as the spread of the errors would vary. Absence of heteroskedasticity would indicate that research results are valid and reliable. Python (Version 3.13.1) program is used to complete Breusch-Godfrey, Breusch-Pagan, and White tests.

2.4 Conclusion of the chapter

To sum up, this thesis aims to determine the impact of green bonds on achieving SDG 13 in Nordic countries. This study covers a period starting from 2017 to 2023. The data is collected from Statista, Bloomberg Terminal, and Global Economy. The descriptive statistics method is used to summarize, graphically present the data, and provide key insights. Collected data is normalized to make data from Nordic countries comparable. Correlation analysis is used to measure the strength and direction of relationships between selected variables and to select variables for the regression analysis. A redundant fixed effect test is completed to determine whether the individual fixed effects are redundant or not needed in the model and if ordinary least squares regression is the best method for this research. Ordinary least squares regression analysis is used to explore the relationship between selected variables and show if the results are statistically significant. Breusch-Godfrey test is performed to identify if autocorrelation exists in the residuals of regression analysis. Breusch-Pagan test and White test are used to detect if heteroskedasticity is present in the regression model. These selected methods, tools, and techniques provide needed outcomes to understand the impact of green bonds on achieving sustainable development in the Nordic region.

3. ANALYSIS OF THE IMPACT OF GREEN BONDS ON ACHIEVING SUSTAINABLE DEVELOPMENT GOAL 13 IN NORDIC COUNTRIES

In this chapter, the impact of green bonds on achieving SDG 13 in Nordic countries from 2017 to 2023 will be explored. The chapter begins by providing a summary of collected data using the descriptive statistics method and presenting it graphically, exploring characteristics, key features, and insights to discover if there has been a difference in greenhouse gas emissions and the number of green bonds issued in Nordic countries during the study period. Furthermore, the Person's Correlation Matrix for variables under consideration will be presented, and least squares regression results of the relationship between the independent variable and dependent variable will be observed and analyzed to investigate how green bonds impact carbon dioxide emission in Nordic countries during the study period. In addition, several tests will be conducted to validate the robustness of the results. Breusch-Godfrey test will be performed to identify if autocorrelation exists in the residuals of regression analysis. Breusch-Pagan test and White test will be used to detect if heteroskedasticity is present in the regression model. The results of this chapter will provide valuable insights into how green bonds impact SDG 13.

3.1 Summary of collected data: descriptive statistics

In this section, the descriptive statistics method will be employed to present the position of Nordics in the global and European green bonds market, summarize the collected data of green bonds and greenhouse gas emissions dataset, present it visually, and examine its characteristics, key features, and insights to discover if there has been a difference in greenhouse gas emissions and amount of green bonds issued in Nordic countries during the study period. Furthermore, other factors, such as manufacturing outputs, fossil fuel energy production, diesel and heating oil consumption, the Compound Annual Growth Rate (CAGR), and year-to-year growth rates of these factors will be explored.

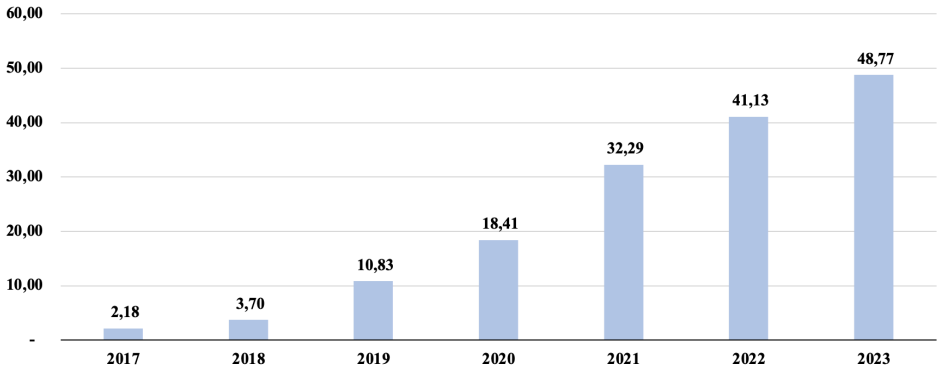
Green bonds are becoming a key instrument for financing environmental sustainability. According to global data, China led the world in green bond issuance value in 2023. Sweden ranked fourteenth, with Norway in fifteenth, Denmark in sixteenth, and Finland in twentieth place (Climate Bonds Initiative, 2024a). Europe was the region that issued the largest value of green bonds in 2023. 53% of green bonds were issued by Europe, 32% were issued by Asia-Pacific, while North America issued 11%. (Climate Bonds Initiative, 2024b). The energy sector issued the largest number of green bonds worldwide, accounting for 27%, while the building sector issued 20%, the water sector issued 18%, and the transport sector 17% (Climate Bonds Initiative, 2024c).

Corporations and governments are integrating green bonds at an increased rate as a crucial financial instrument in Europe. The cumulative value of green bonds issued in Europe from 2014 to 2023 indicates that Germany, France, and the Netherlands were the top three countries leading in the issuance of bonds. Sweden ranked seventh, followed by Norway in eighth, Denmark in ninth, and Finland in thirteenth (Climate Bonds Initiative, 2024d). In 2023, Sweden and Germany were the top countries in Europe based on the volume of green bond issuances, with both nations issuing 117 green bonds each. Norway was in third place with 57 green bonds issued, while Finland was ranked eighth with 27 green bonds. Denmark was in eleventh place and issued 25 green bonds (Climate Bonds Initiative, 2024e). Additionally, in terms of green bond issuance value in Europe in 2023, Germany, the United Kingdom, and Italy were the top three countries. Sweden ranked eighth, followed by Norway in ninth, Denmark in tenth, and Finland in twelfth (Climate Bonds Initiative, 2024f). In conclusion, both global and European data indicated that Sweden ranked highest among the Nordic countries in green bond issuance in 2023 and between 2014 and 2023, followed by Norway, Denmark, and Finland.

The Norwegian Agency for Local Governments, known as KBN Kommunalbanken AS, raised its first green bond in the Nordic market in 2010 in Norway. Sweden issued its first green bond in 2014, followed by Finland in 2016 and Denmark in 2017 (Climate Bonds Initiative, 2024g). The green bond market has experienced a notable expansion in the last seven years in Nordic countries. Figure 13 demonstrates a steady and significant increase in the amount of green bonds issued from 2017 to 2023.

Figure 13

Green bonds issued by Nordic countries per year (amount in billion euros)



Source: Compiled by the author, based on data extracted from Bloomberg (2024) terminal.

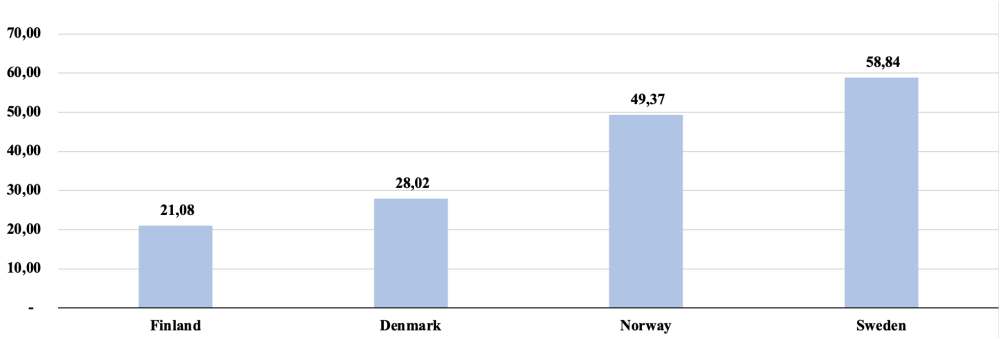
The Compound Annual Growth Rate (CAGR) is a measure that indicates the average growth rate over a period. CAGR was 56% between 2017 and 2023. The highest value of green

bonds, 48,77 billion euros, was issued in 2023. This increase was in parallel with the launch of SDGs and the Paris Agreement, which came into effect at the end of 2016. Furthermore, it was noted that the COVID-19 outbreak did not stop the further issuance of green bonds. The highest year-to-year growth rate was 198%, which occurred between 2018 and 2019, while the lowest year-to-year growth rate of 19% was observed between 2022 and 2023.

Figure 14 demonstrates the number of green bonds issued by the country. Sweden issued the largest amount of green bonds in Nordic countries, with 58,84 billion euros. Followed by Norway with 29,37 billion euros, Denmark with 28,02 billion euros, and Finland, which issued the smallest amount of 21,08 billion euros (Bloomberg, 2024). Sweden experienced the highest growth rate in green bond issuance, with a Compound Annual Growth Rate (CAGR) of 117%, followed by Norway at 82%, Finland at 42%, and Denmark at 34%. Investors' recognition of climate change risks is rising, and demand to invest in portfolios that adhere to environmental, social, and governance (ESG) principles is increasing. As a result, green bonds are predicted to remain at the core of financial strategy to achieve SDGs.

Figure 14

Green bonds released by countries between 2017 and 2023 (amount in billion euros)



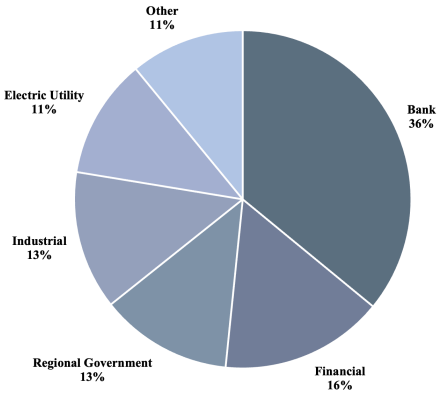
Source: Compiled by the author, based on data extracted from Bloomberg (2024) terminal.

Figure 15 demonstrates that banks were the largest issuers of green bonds in the Nordics, with 36%, followed by the financial industry with 16%, and both the industrial industry and regional governments, each with 13%. In the banking sector, DNB Bank ASA, Danske Bank A/S, and Nordea Bank Abp were the leading issuers of green bonds. In the financial sector, the largest issuers were Vasakronan AB, Nordea Kiinnitysluottopankki Oyj, and Entra ASA. Within the industrial sector, Stora Enso Oyj, Neste Oyj, and UPM-Kymmene Oyj issued the largest volume of green bonds. In the regional government sector, the top issuers included Kommuninvest i Sverige AB, Kommunekredit, and Kuntarahoitus Oyj. Furthermore, Ørsted AS, categorized under

the electric utility industry, was the largest issuer of green bonds across all sectors, with a total issuance amounting to 9,32 billion euro (Bloomberg, 2024).

Figure 15

Green bond releases by issuer industry in the Nordic countries (share of cumulative value from 2017 to 2023)

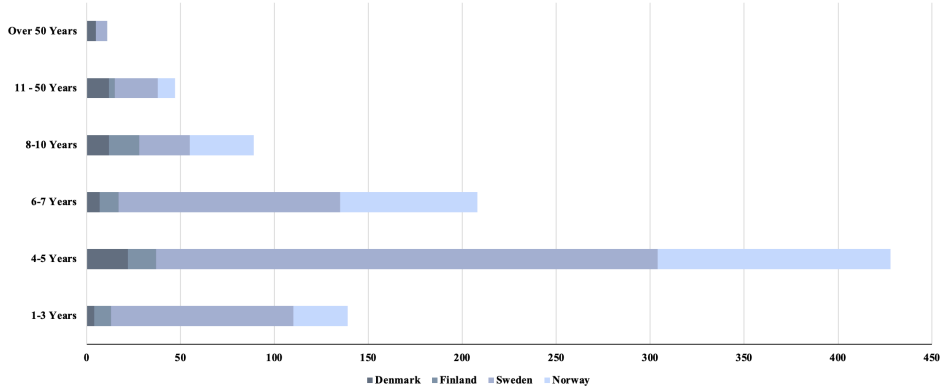


Source: Compiled by the author, based on data extracted from Bloomberg (2024) terminal.

Figure 16 illustrates the tenor of green bonds issued in Nordic countries from 2017 to 2023. The average tenors were 6,7 years for Finland, 6,2 years for Norway, 6,2 years for Sweden, and 88 years for Denmark. Denmark had a high average due to 4 green bonds issued by Orsted AS and one green bond issued by NKT A/S, which have a term of 1000 years. Long-term green bonds play a crucial role for local governments and corporations in financing long-term green infrastructure projects. Overall, the most common tenors were 4-5 years range in Denmark, Sweden, and Norway and 8-10 years range in Finland (Bloomberg, 2024).

Figure 16

The tenor of green bonds in the Nordic countries

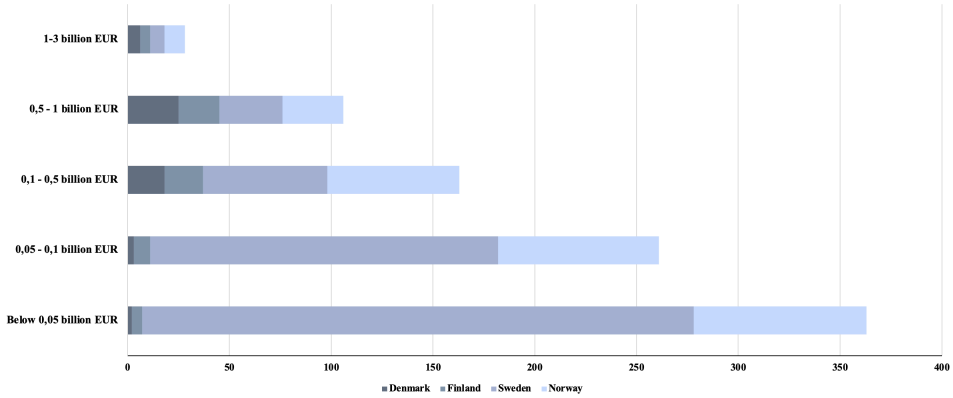


Source: Compiled by the author, based on data extracted from Bloomberg (2024) terminal.

Figure 17 illustrates the categorization of several green bonds in Nordic countries from 2017 to 2023 by bond size. During the study period, the Danish government issued the largest value green bond of 2,25 billion euros in 2023. The average value of bonds issued in Norway was 0,18 billion euros, in Sweden was 0,11 billion euros, in Finland was 0,37 billion euros, and in Denmark was 0,52 billion euros. Data shows that the largest number of green bonds issued in Denmark and Finland was in the range of 0,5 - 1 billion euros, while in Sweden and Norway, it was in the range below 0,05 billion euros (Bloomberg, 2024). To conclude, the size of green bonds is larger in Denmark and Finland, while the size of green bonds is smaller in Sweden and Norway.

Figure 17

Several green bonds are categorized in deal sizes.



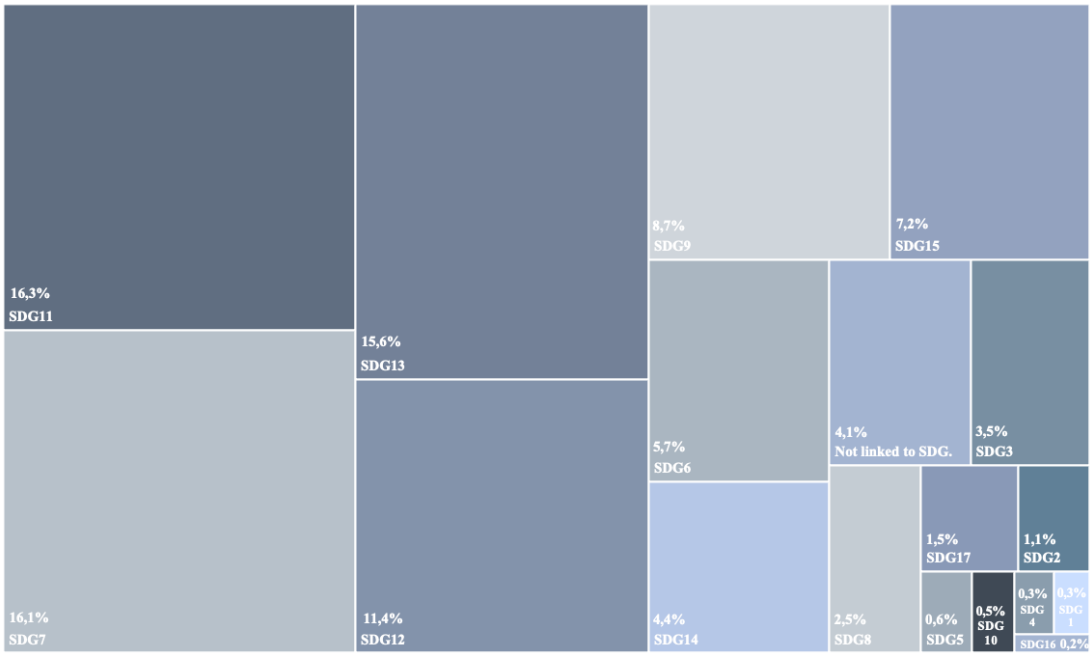
Source: Compiled by the author, based on data extracted from Bloomberg (2024) terminal.

Figure 18 illustrates the SDGs associated with the number of green bonds issued in Nordic countries from 2017 to 2023. 16,3% of the green bonds issued were mapped out to the SDG 11 - Sustainable Cities & Communities goal, while 16,1% were linked to the SDG 7 - Affordable & Clean Energy goal and 15,6% were mapped to the SDG 13 - Climate Action goal. Furthermore, 11,4% were directed towards the SDG 12 - Responsible Consumption & Production goal, while 8,7% were associated with the SDG 9 - Industry, Innovation & Infrastructure goal, and 7,2% were mapped to the SDG 15 - Life on Land goal. Moreover, 5,7% of green bonds were aligned to the SDG 6 - Clean Water & Sanitation goal, while 4,4% were directed to the SDG 14 - Life Below Water goal. 4,1% of issued green bonds were not mapped to the Sustainable Development Goals. 3,5% were linked to the SDG 3 - Good Health & Wellbeing goal, while 2,5% were associated with the SDG 8 - Decent Work & Economic Growth goal, 1,5% were directed towards the SDG 17 - Partnerships for the goal, and 1,1% were mapped to SDG 2 - Zero Hunger goal. Less than 1% of several issued green bonds were associated with SDG 5 - Gender Equality, SDG 10 - Decreased

Inequalities, SDG 4 - Quality Education, SDG 1- Ending poverty, and SDG 16 - Peace, Justice & Strong Institutions goals (Bloomberg 2024). In summary, most of the released bonds contributed to SDG 11, followed by SDG 7 and SDG 13.

Figure 18

The Sustainable Development Goals associated with number of green bonds issued in Nordic countries from 2017 to 2023



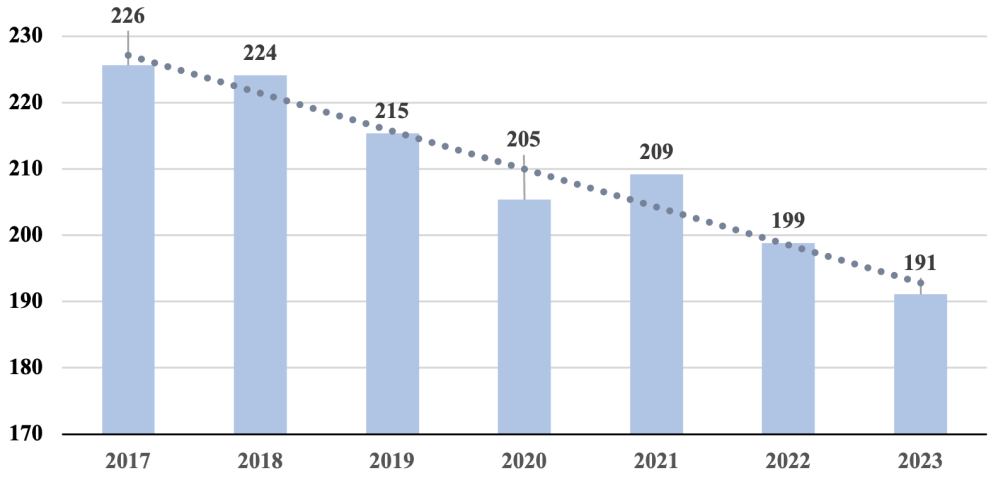
Source: Compiled by the author, based on data extracted from Bloomberg (2024) terminal.

From a global perspective, annual greenhouse gas emissions have been on the rise for decades. In 1970, emissions were 24 billion metric tons of carbon dioxide equivalent (CO2eq). By 2023, they reached a new record high of 52,96 billion metric tons of CO2eq (EDGAR/JRC, 2024a). In 2023, China was the largest emitter of greenhouse gases, then comes the United States, followed by India, the European Union, and Russia. Collectively, these five economies were responsible for 60% of global greenhouse gas emissions (EDGAR/JRC, 2024b).

Figure 19 exhibits the trend of greenhouse gas emissions in a million metric tons of CO2eq in Nordics by year and demonstrates a decline of emissions during the study period from 225,65 in 2017 to 191,12 in 2023. Further decrease in emissions in the year 2020 (to 205,39 million metric tons of CO2eq) could have been caused by the COVID-19 pandemic as economic activities slowed down due to lockdowns and other restrictions.

Figure 19

Greenhouse gas emissions by year in million metric tons of carbon dioxide equivalent in Nordics

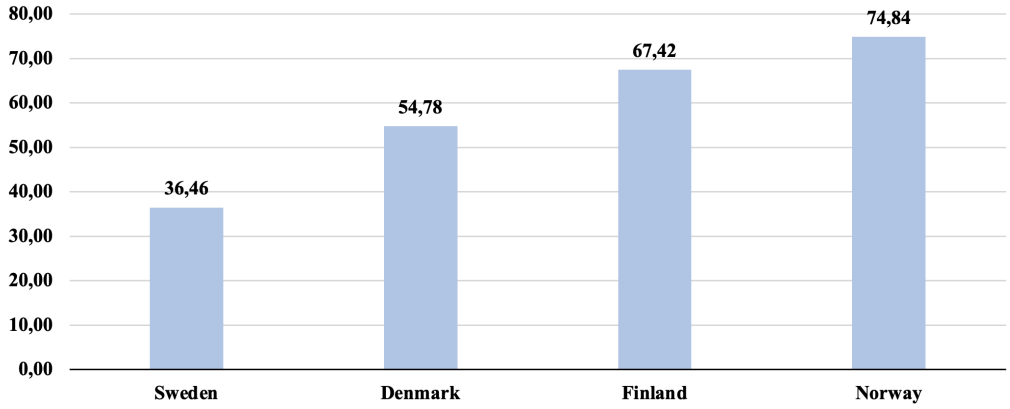


Source: Compiled by the author based on the data extracted from the Statista database (EDGAR/JRC, 2024c).

Figure 20 exhibits data on greenhouse gas emissions per capita by country, in tons of CO2eq per person per year from 2017 to 2023. Norway was the largest emitter of greenhouse gas emissions in Nordic countries, with 74,84, followed by Finland, with 67,42, while Sweden had the smallest emissions per capita, with 36,46, followed by Denmark, with 54,78. Furthermore, Finland had the biggest decrease in emissions during the study period.

Figure 20

Greenhouse gas emissions per capita by country, in tons of carbon dioxide equivalent per person per year



Source: Compiled by the author based on the data extracted from the Statista database (Crippa et al., 2024).

In 2023, the power industry emerged as the largest global emitter of carbon dioxide, contributing 38,24% of total emissions, followed by the transportation sector at 21,11% and industrial combustion at 16,42% (Statista, 2024). From 2017 to 2023, the transportation sector was the largest emitter in both Denmark and Sweden, while the fuel exploitation sector was the dominant emitter in Norway, and the power industry sector led emissions in Finland. In Nordic countries, the transportation sector was the largest emitter, accounting for 24,5% of total emissions, followed by the power industry sector at 14,6% and the agriculture sector at 12,8% (Crippa et al., 2024).

Manufacturing activities are a crucial part of the economy and influence innovation of technology, trade, employment, and pollution. Manufacturing is the process of altering materials, substances, or components through physical or chemical changes to create new products. Geopolitical instability, the COVID-19 pandemic disrupted the supply chain, caused the manufacturing market to experience challenges, and changed the behavior of consumers. On the other hand, the manufacturing market presents several opportunities for businesses to improve efficiency and productivity and decrease costs by utilizing advanced, automated, digitalized technology. Countries are manufacturing a wide variety of physical goods in different industries. The CAGR of manufacturing outputs of B2B production from 2018 to 2023 was 3,8% in Denmark, 2,8% in Finland, 1,5% in Sweden, and 1,1% in Norway. Consumer goods, such as food, beverages, furniture, electrical equipment, etc., accounted for 40% of total manufacturing output in Norway and 28% in Denmark. Material products, such as basic metals, chemicals, textiles, wood, etc., accounted for 40% of total manufacturing output in Sweden and 42% in Finland. Furthermore, it is forecasted that the CAGR of manufacturing outputs from 2024 to 2029 will be 0,8% in Sweden, 0,7% in Norway, 0,6% in Denmark, and 0,5% in Finland. Also, it is predicted that the changing needs of consumers and raising awareness about environmental issues will influence manufacturers and encourage them to adopt sustainability measures and develop eco-friendly products (Statista Market Insights, 2024a).

For over a century, governments and large corporations made large investments in fossil fuel energy, which had a major role in the energy market. This source of energy contributes heavily to the climate change. As a result, this market is predicted to experience major challenges and changes in the future. The usage of renewable energy sources is expected to grow due to a decrease in the cost of renewable energy technology, new policies, and regulations that demand from customers for clean energy to support green transition. The CAGR of energy production from fossil fuels from 2018 to 2023 was -9,73% in Denmark, -6,25% in Finland, -3,10% in Sweden and -4,16% in Norway. Fossil fuel energy market data consists of natural gas, oil, and coal. Oil is processed to produce gasoline, diesel, and kerosene. The road transportation sector had the largest

demand for oil in OECD (Organization for Economic Co-operation and Development) countries in 2022, accounting for 49,24%. Oil constituted 88% of fossil fuel energy in Sweden and 37% in Finland. Norway primarily consumed 68% of natural gasses, while Denmark mainly used coal, accounting for 61%. The growing world's population is raising energy demand, and countries may continue to use fossil fuels to meet this need. It is forecasted that the CAGR of energy production from fossil fuel from 2024 to 2029 will be 0,2% in Sweden, 0,3% in Norway, -1,0% in Denmark, and 0,6% in Finland. (Statista Market Insights, 2024b).

Diesel and heating oil consumption is another factor that affects the amount of greenhouse gases being released into the environment. In Nordic countries, the CAGR of diesel and heating oil consumption from 2017 to 2023 was -1,14% in Denmark, -2,37% in Finland, -0,3% in Sweden, and -1,18% in Norway (The U.S. Energy Information Administration, 2024). Also, it is forecasted that diesel consumption will decrease further in the upcoming decade due to rising diesel prices and the green transition pushing for the adoption of electric vehicles. From 2027, fuel suppliers will have to purchase allowances to offset their carbon dioxide emissions. There is a high probability that cost will be passed on to consumers and decrease diesel consumption (Hancock and Millard, 2024).

Table 6

Results after application of manual standardization and Z-score normalization

Year	Country	Greenhouse gas emissions (GHGpc)	Amount of green bonds issued (GBVpc)	Consumption of diesel and heating oil (DHOC)	Energy production from fossil fuels (FFpc)	Manufactoring output (MNF)
2017	Denmark	1,41	-0,73	0,80		
2018	Denmark	1,40	-0,87	1,27	1,92	-1,11
2019	Denmark	0,22	-0,40	1,21	-0,22	-0,43
2020	Denmark	-0,61	-0,81	-1,04	-1,02	-0,71
2021	Denmark	-0,21	-0,28	-0,40	0,09	-0,50
2022	Denmark	-0,84	1,55	-0,50	0,29	1,39
2023	Denmark	-1,37	1,55	-1,33	-1,07	1,37
2017	Finland	1,05	-1,00	0,80		
2018	Finland	1,28	-1,26	0,72	1,94	-0,84
2019	Finland	0,69	-0,59	0,58	0,65	-0,42
2020	Finland	-0,18	-0,11	-0,27	-0,86	-0,90
2021	Finland	-0,23	0,30	0,17	-0,70	-0,63
2022	Finland	-0,92	0,87	0,30	-0,36	1,40
2023	Finland	-1,69	1,79	-2,31	-0,67	1,39
2017	Norway	1,60	-1,29	0,94		
2018	Norway	1,25	-0,84	1,33	1,56	-0,11
2019	Norway	0,19	-0,84	0,45	1,13	0,52
2020	Norway	-0,61	-0,37	-0,65	-0,26	-1,44
2021	Norway	-0,32	1,00	-0,13	-0,71	-1,08
2022	Norway	-0,82	1,01	-0,01	-1,22	1,41
2023	Norway	-1,29	1,33	-1,93	-0,50	0,69
2017	Sweden	1,70	-1,31	1,44		
2018	Sweden	0,63	-1,26	-0,27	1,70	0,01
2019	Sweden	0,34	-0,65	0,29	0,74	0,06
2020	Sweden	-0,24	0,22	-0,62	-1,50	-1,37
2021	Sweden	0,20	0,78	1,22	-0,20	-1,08
2022	Sweden	-1,11	0,83	-0,42	-0,35	1,40
2023	Sweden	-1,51	1,39	-1,65	-0,39	0,99

Source: Compiled by the author using Microsoft Office Excel program (Microsoft Corporation, 2023).

Denmark, Finland, Norway, and Sweden vary in terms of size, population, and economic characteristics. As a result, collected data was normalized for comparison purposes. Two normalization methods were applied. First and foremost, the manual standardization method was used. Each year's collected data was normalized by dividing it by the country's population for that year to obtain per capita figures. Secondly, the Z-score normalization method was applied. Mean and standard deviation were used to normalize the data. The Z-score was calculated for each variable by subtracting the mean of the variable and dividing by the standard deviation. Table 6 illustrates the data following the application of manual standardization and Z-score normalization techniques.

Table 7

Statistical summary of the dependent variable

	GHGpc			
	Denmark	**Finland**	**Norway**	**Sweden**
Mean	-0,24	-0,18	-0,27	-0,28
Median	-0,41	-0,2	-0,47	-0,02
Maximum	1,4	1,28	1,25	0,63
Minimum	-1,37	-1,7	-1,3	-1,51
Standard Deviation	0,97	1,07	0,89	0,85
Skewness	0,66	-0,04	0,71	-0,46
Kurtosis	2,47	1,96	2,48	1,64
Jarque-Bera	0,51	0,28	0,57	0,67

Source: Compiled by the author using the Eviews 12 Student Version program (IHS Markit, 2022).

Table 7 shows descriptive statistics of normalized dependent variable greenhouse gas emissions in Nordic countries. Finland exhibits the highest mean, while Sweden shows the lowest mean. The median is known as the middle observation of the dataset (Newbold, Carlson, & Thorne 2013). Sweden has the greatest median, whereas Norway has the smallest. Moreover, Denmark has the highest maximum, in contrast to Sweden, which has the lowest. Norway presents the most significant minimum, while Finland has the smallest. Furthermore, Finland has the highest standard deviation, indicating that data points are the most spread out from the mean, while Sweden has the most insignificant standard deviation, having the smallest spread. Moreover, skewness shows the degree of asymmetry in the distribution of collected data, which can be skewed to the left if it is negative or to the right if it is positive (Newbold, Carlson, & Thorne

2013). Finland's skewness value is close to 0, which indicates that the data is nearly symmetrical and balanced, with minor leftward skew. On the other hand, Norway is most distant from 0 and indicates a positive skew. Furthermore, kurtosis indicates whether the data set is more concentrated near the mean or the tails relative to normal distribution (Newbold, Carlson, & Thorne 2013). If greenhouse gas emissions data is more concentrated near the tails, then that would indicate that greenhouse gas emissions strongly fluctuated in the past. Hence, it is distant from the mean. Norway's kurtosis figure is closest to 3, while Sweden's kurtosis figure is the furthest from 3. If kurtosis is less than 3, then the data set has light tails and fewer outliers compared to a normal distribution. Jarque-Bera test shows if the data sample is normally distributed. The p-value is used to perform the test of the null hypothesis, which is rejected if the significance level is 0,05 (Newbold, Carlson, & Thorne 2013). All countries have p-values greater than 0,05. This indicates that the data set does not significantly deviate from the normal distribution and suggests a failure to reject the null hypothesis.

Table 8

Statistical summary of normalized independent variables

		Mean	Median	Maximum	Minimum	Standard Deviation	Skewness	Kurtosis	Jarque-Bera
Denmark	**GBVpc**	0,12	-0,34	1,55	-0,87	1,13	0,58	1,5	0,9
	DHOC	-0,13	-0,45	1,27	-1,33	1,12	0,41	1,52	0,72
	FFpc	0	-0,06	1,92	-1,07	1,1	0,81	2,66	0,68
	MNF	0	-0,47	1,39	-1,11	1,1	0,55	1,53	0,85
Finland	**GBVpc**	0,17	0,09	1,79	-1,26	1,08	0,22	2,05	0,27
	DHOC	-0,13	0,24	0,72	-2,31	1,12	-1,43	3,54	2,13
	FFpc	0,00	-0,52	1,94	-0,86	1,1	1,05	2,57	1,14
	MNF	0,00	-0,53	1,4	-0,9	1,1	0,64	1,5	0,97
Norway	**GBVpc**	0,22	0,31	1,33	-0,84	1,01	-0,04	1,15	0,86
	DHOC	-0,16	-0,07	1,33	-1,93	1,09	-0,36	2,5	0,2
	FFpc	0,00	-0,38	1,56	-1,22	1,1	0,49	1,67	0,68
	MNF	0,00	0,21	1,41	-1,44	1,1	-0,16	1,66	0,48
Sweden	**GBVpc**	0,22	0,5	1,39	-1,256	0,99	-0,41	1,78	0,54
	DHOC	-0,24	-0,35	1,22	-1,65	0,96	0,11	2,46	0,09
	FFpc	0,00	-0,28	1,7	-1,5	1,1	0,3	2,29	0,22
	MNF	0,00	0,03	1,4	-1,37	1,1	-0,02	1,62	0,48

Source: Compiled by the author using the Eviews 12 Student Version program (IHS Markit, 2022).

Table 8 shows descriptive statistics of normalized independent variables, such as the amount of green bonds issued, consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output in Nordic countries. Norway and Sweden exhibit the highest GBVpc variable mean, while Denmark shows the lowest mean. Denmark and Finland have the biggest DHOC variable mean, while Sweden exhibits the smallest mean. Furthermore, Sweden presents the largest GBVpc variable median, Finland displays the highest DHOC variable median, whereas Denmark has the smallest. Denmark shows the largest FFpc variable median, and Norway exhibits the largest MNF variable median, while Finland has the lowest. Moreover, Finland has the highest maximum of GBVpc and FFpc variables, in contrast to Norway, which has the lowest. Norway presents the largest maximum of DHOC and MNF variables, while Finland has the smallest maximum of DHOC variables, and Denmark has the lowest of MNF variables. In addition, Norway presents the highest minimum of GBVpc variable, while Finland and Sweden have the least significant minimum. Denmark shows the highest minimum of variable DHOC, while Finland has the lowest. Finland has the highest minimum of FFpc and MNF variables, while Sweden has the smallest minimum variable for the FFpc variable, and Norway has the lowest minimum for MNF variables. The standard deviation is in the range from 0,96 to 1,13, indicating that the data set is spread moderately around the mean. Additionally, Sweden's skewness value of the MNF variable is closest to 0, which means that the data is nearly symmetrical and balanced, with a minor leftward skew. On the other hand, Finland's DHOC variable is the most distant from 0 and indicates a moderate negative skew. Furthermore, Finland's kurtosis figure of the DHOC variable is 3,54, which indicates that the distribution is more peaked and has a heavier tail in comparison to the normal distribution. Other variables have a kurtosis value which is less than 3. This indicates that the data set has light tails and fewer outliers compared to a normal distribution. Moreover, the Jarque-Bera test shows that all variables have a p-value greater than 0,05. This demonstrates that the data set does not significantly deviate from the normal distribution and suggests a failure to reject the null hypothesis.

To conclude, both global and European data indicated that Sweden ranked highest among the Nordic countries in green bond issuance during the study period. The green bond market has undergone impressive growth in the last seven years in Nordic countries. The banking industry was the largest issuer of green bonds in the Nordics. The most common tenors were in the 4-5 years range in Denmark, Sweden, and Norway and 8-10 years range in Finland. The size of green bonds is larger in Denmark and Finland, while it is smaller in Sweden and Norway. Most of the issued green bonds in Nordics were associated with SDG11 - Sustainable Cities & Communities goal, SDG7- Affordable & Clean Energy goal, and SDG13 - Climate Action goal. Also, data showed a decline in greenhouse gas emissions, diesel and heating oil consumption, fossil fuel

energy production, and an increase in manufacturing output in Nordic countries during the study period. In Nordic countries, the transportation sector was the largest emitter, accounting for 24,5% of total emissions. Norway was the largest emitter of greenhouse gas emissions in Nordic countries, while Denmark had the smallest emissions. However, Finland had the biggest decrease in emissions since 2017. Furthermore, the data was normalized for comparison purposes, and descriptive statistics were calculated for the dependent and independent variables.

3.2 Correlation, regression, and statistical tests

In this section, the Person's Correlation Matrix will be presented, a redundant fixed effect test will be completed, and least squares regression results of the relationship between the independent variable and dependent variables will be observed and analyzed to investigate how green bonds impact greenhouse gas emissions in Nordic countries during the study period. In addition, several statistical tests will be conducted to validate the robustness of the results. Breusch-Godfrey test will be performed to identify if autocorrelation exists in the residuals of regression analysis. Breusch-Pagan test and White test will be used to detect if heteroskedasticity is present in the regression model. Furthermore, the dynamics of the independent variable with each dependent variable over time will be illustrated.

Table 9 presents the Person's Correlation Matrix. Results show that the correlation coefficient between the amount of green bonds issued and greenhouse gas emissions is -0,866. This coefficient indicates a strong relationship between these variables and suggests that as the amount of green bonds issued increases, the amount of greenhouse gas emissions decreases. The correlation coefficient between greenhouse gas emissions and consumption of diesel and heating oil is 0,852, which is a positive correlation that indicates a strong relationship between these variables. This implies that as consumption of diesel and heating oil grows, greenhouse gas emission also rises. Moreover, the correlation coefficient between greenhouse gas emissions and energy production from fossil fuels is 0,767, which is a positive correlation that demonstrates a strong relationship between these variables. This shows that as energy production from fossil fuels increases, greenhouse gas emission also grows. Furthermore, the correlation coefficient between greenhouse gas emissions and manufacturing output is -0,607, which is a negative correlation that suggests an average strength relationship between these variables. This reveals that as manufacturing output increases, greenhouse gas emissions are reduced. The underlying assumption is that this measure may suggest that manufacturers are adopting technologies that lead to greater output with fewer emissions. In addition, the correlation coefficient between the amount of green bonds issued and consumption of diesel and heating oil is -0,664. This coefficient

shows a negative average strength relationship between these variables and suggests that as the amount of green bonds issued rises, the consumption of diesel and heating oil decreases. The correlation coefficient between the amount of green bonds issued and energy production from fossil fuels is -0,654, which is a negative correlation that demonstrates the average strength relationship between these variables. This implies that as the amount of green bonds issued increases, energy production from fossil fuels decreases. Moreover, the correlation coefficient between the amount of green bonds issued and manufacturing output is 0,601, which is a positive correlation that suggests an average strength relationship between these variables. This implies that as the amount of green bonds issued rises, manufacturing output also increases. The underlying assumption is that green bonds may be used to invest in new technology that produces less emission and more output. In addition, the correlation coefficient between the consumption of diesel and heating oil and energy production from fossil fuels is 0,545, which is a positive correlation that reveals an average strength relationship between these variables. This demonstrates that as consumption of diesel and heating oil increases, energy production from fossil fuels also grows. Furthermore, the correlation coefficient between the consumption of diesel and heating oil and manufacturing output is -0,42. This coefficient indicates a negative, weak relationship between these variables and suggests that as the consumption of diesel and heating oil slightly decreases, the manufacturing output slightly increases. The underlying assumption is that less diesel and heating oil are being used in manufacturing processes, with green technologies being adopted in production instead, thereby reducing emissions. Also, the correlation coefficient between energy production from fossil fuels and manufacturing output is -0,150. This coefficient indicates the insignificant relationship between these variables. To conclude, variables such as consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output were selected due to their strong correlation with the greenhouse gas emissions variable and average strength correlation with the green bonds variable.

Table 9

Pearson Correlation Matrix

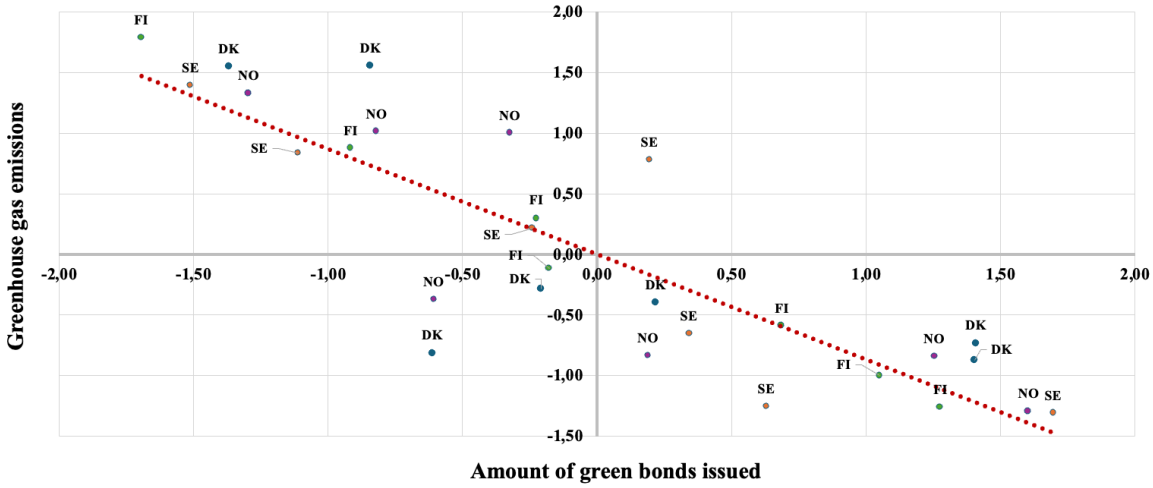
	GHGpc	GBVpc	DHOC	FFpc	MNF
GHGpc	1				
GBVpc	-0,866	1			
DHOC	0,852	-0,664	1		
FFpc	0,767	-0,654	0,545	1	
MNF	-0,607	0,601	-0,420	-0,150	1

Sources: Compiled by the author using Microsoft Office Excel program (Microsoft Corporation, 2023).

Pearson's negative correlation between the amount of green bonds issued and greenhouse gas emissions was the strongest. Hence, the scatter diagram was created to visualize the relationship between these two variables. Figure 21 demonstrates that the data points are tightly clustered around a downward-sloping line, suggesting a strong negative relationship between the two variables. A negative correlation is noticeable as the amount of green bonds issued increases, implying that greenhouse gas emissions decrease. On the other hand, dots are scattered around the trend line, indicating that variability in the relationship exists.

Figure 21

Scatter diagram between greenhouse gas emissions and amount of green bonds issued

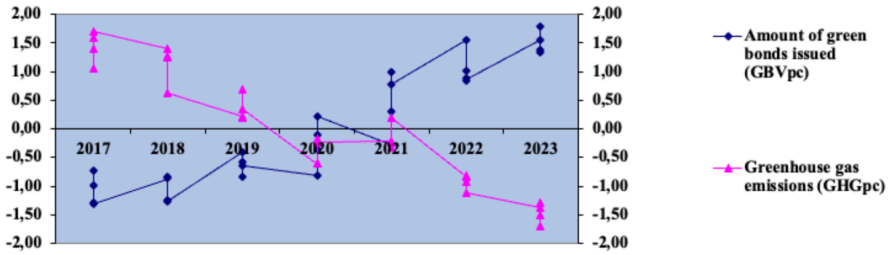


Source: Compiled by the author using Microsoft Office Excel program (Microsoft Corporation, 2023).

Figure 22 exhibits the relationship between issued green bonds and greenhouse gas emissions in Nordic countries during the short-term period and seven-year period. The graph demonstrates that as investment in green bonds increases, greenhouse gas emissions consistently decrease. It illustrates the strong negative correlation between variables, and it is noted that the COVID-19 outbreak did not stop further issuance of green bonds. However, it did cause greenhouse gas emissions to decrease in the year 2020 due to slowed-down economic activities, lockdowns, and other restrictions.

Figure 22

Trends in greenhouse gas emissions and amount of green bonds issued

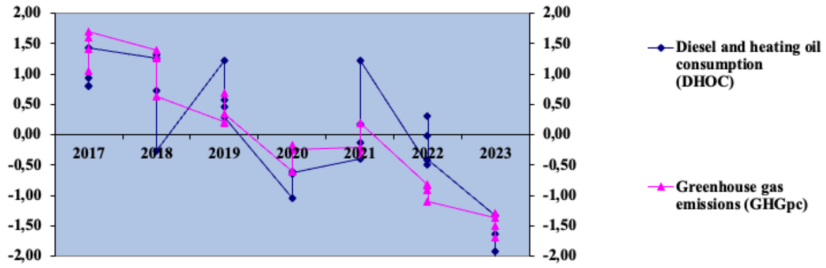


Source: Compiled by the author using Microsoft Office Excel program (Microsoft Corporation, 2023).

Figure 23 shows the connection between the consumption of diesel and heating oil and greenhouse gas emissions in Nordic countries during the short-term period and seven-year period. The graph reveals that as the consumption of diesel and heating oil decreases, greenhouse gas emissions also decrease. It presents a strong positive correlation between variables. It is noted that consumption of diesel and heating oil drastically decreased in 2020, which could have been caused by the COVID-19 outbreak. During a pandemic, lockdowns were introduced, economic activities slowed down, and other restrictions were imposed. Furthermore, consumption of diesel and heating oil experienced an increase in 2021, followed by a subsequent decline.

Figure 23

Trends in greenhouse gas emissions and consumption of diesel and heating oil



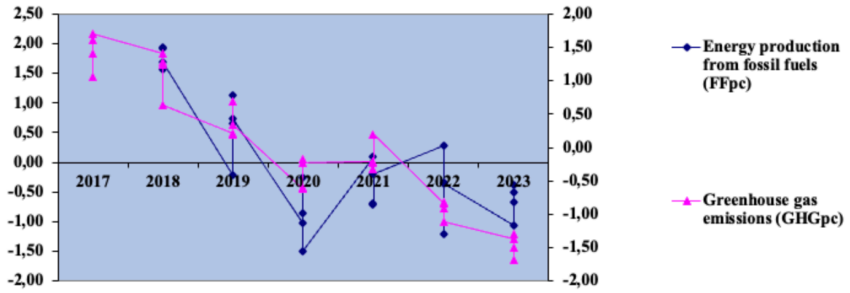
Source: Compiled by the author using Microsoft Office Excel program (Microsoft Corporation, 2023).

Figure 24 presents the link between energy production from fossil fuels and greenhouse gas emissions in Nordic countries during the short-term period and seven-year period. The graph indicates that as energy production from fossil fuels decreases, the greenhouse gas emissions also decrease. The graph illustrates the positive correlation between variables. It is observed that energy

production from fossil fuels was at a notably low point in 2020, which could have been caused by the COVID-19 outbreak. In 2021, it underwent an increase, which was later followed by a decline.

Figure 24

Trends in greenhouse gas emissions and energy production from fossil fuels

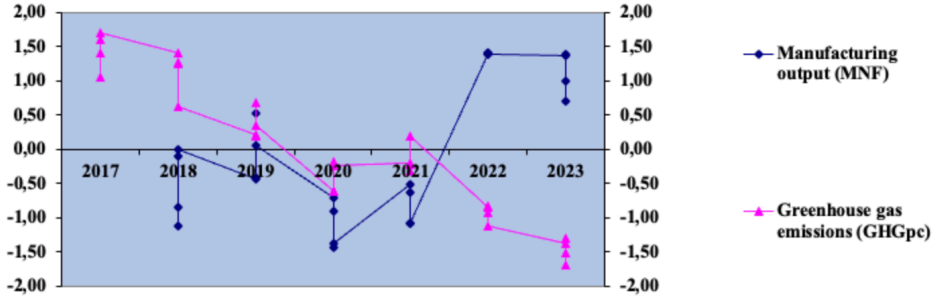


Source: Compiled by the author using Microsoft Office Excel program (Microsoft Corporation, 2023).

Figure 25 demonstrates the relationship between manufacturing output and greenhouse gas emissions in Nordic countries during the short-term period and seven-year period. The graph displays that as manufacturing output increases, greenhouse gas emissions consistently decrease. The graph illustrates the negative correlation between variables. In 2020, manufacturing output decreased, followed by a notable increase thereafter. The decrease could have been caused by the COVID-19 outbreak.

Figure 25

Trends in greenhouse gas emissions and manufacturing output



Source: Compiled by the author using Microsoft Office Excel program (Microsoft Corporation, 2023).

Table 10 shows the redundant fixed effect test results. The F-test result is 0,071, and the Chi-square test statistic result is 0,299. Both findings are low and indicate that the fixed effects model lacks contribution to explain the variance in the dependent variables. Furthermore, the F-test probability result is 0,974, and the Chi-square test probability result is 0,96. Both results are high and indicate a possible failure to reject the null hypothesis and suggest that fixed effects are redundant. The results of this test show that the ordinary least squares regression method should be used.

Table 10

Redundant fixed effect test results

	Statistic	**Degrees if freedom**	**Probability**
Cross section F	0,071195	(3,17)	0,9746
Cross section Chi – square	0,299652	3	0,9601

Sources: Compiled by the author using Python (Version 3.13.1) (Python Software Foundation, 2023).

Table 11 presents the findings of ordinary least squares regression. Relationships between the dependent variable GHGpc and independent variables, such as GBVpc, DHOC, FFpc, and MNF, are analyzed.

Table 11

Results of ordinary least squares regression

R square	**Adjusted R Square**	**F**	**Significance F**	**Durbin Watson**
0,915	0,893	40,48	7,22e-08	1,438
	Coefficients	**Standard Error**	**t Stat**	**p-value**
c	-0,2205	0,058	-3,783	0,002
$\beta 1$	-0,1677	0,089	-1,885	0,079
β_2	0,3547	0,065	5,448	0,000
β_3	0,2130	0,095	2,246	0,040
β_4	-0,2171	0,067	-3,231	0,006

Sources: Compiled by the author using Python (Version 3.13.1) (Python Software Foundation, 2023).

An adjusted R square value of 0,893 indicates that 89,3% of the variance in greenhouse gas emissions can be explained by variance in the amount of green bonds issued, consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output. 10,7% of the variability in greenhouse gas emissions cannot be explained by selected independent variables and shows that other factors are also affecting dependent variables. A high adjusted R square value demonstrates that the ordinary least squares regression model is suitable to examine the relationship between selected dependent variable and independent variables. Also, it indicates that independent variables are relevant predictors. The F statistic value is 40,48 and shows a strong relationship between collective independent variables and dependent variables. The p-values of consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output variables are less than 0,05. This indicates that these variables have a significant impact on greenhouse gas emissions. The p-value of the amount of green bonds issued variable is 0,079, which is more than 0,05. This indicates that the amount of green bonds issued with greenhouse gas emissions shows marginal significance. Least squares regression is shown in equation 4:

$$GHGpc = -0{,}22 - 0{,}17 * GBVpc + 0{,}35 * DHOC + 0{,}21 * FFpc - 0{,}22 * MNF + \varepsilon \quad (4)$$

Least squares regression results showed that most of the variance in greenhouse gas emissions can be explained by variance in the amount of green bonds issued, consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output. Other scholars, such as Saha and Maji (2023), Alamgir and Cheng (2023), and Meo and Abd Karim (2022), observed similar results that green bonds have a negative impact on greenhouse gas emissions in global and developing countries context.

Breusch-Godfrey Test is performed to identify if autocorrelation exists in the residuals of regression analysis. Furthermore, the Breusch-Pagan Test and White test are used to detect if heteroskedasticity is present in the regression model. Table 12 summarizes the results of these tests.

Table 12

Outcomes of statistical testing

	Test statistic	**p-value**
Breusch-Godfrey test results	-0,2205	0,058
Breusch-Pagan test results	-0,1677	0,089
White test results	0,3547	0,065

Sources: Compiled by the author using Python (Version 3.13.1) (Python Software Foundation, 2023).

Breusch-Godfrey test results show that the p-value is above 0,05. Hence, there is no indication of the existence of autocorrelation. Breusch-Pagan test and White test results indicate that high p-values, which are above 0,05, do not indicate significant heteroskedasticity.

To sum up, Person's Correlation Matrix showed multiple notable positive and negative relationships between variables, with the strongest negative correlation between the amount of green bonds issued and greenhouse gas emissions. The negative relationship between these two variables was demonstrated in the scatter diagram, where the data points are tightly clustered around a downward-sloping line. Furthermore, the dynamics of the independent variable with each dependent variable over time was illustrated and showed that the COVID-19 outbreak could have affected multiple variables during 2020 due to slowed-down economic activities, lockdowns, and other restrictions. Moreover, redundant fixed effect test results showed that the fixed effects model lacks contribution to explain the variance in the dependent variables. Hence, least squares regression results showed that most of the variance in greenhouse gas emissions could be explained by variance in the amount of green bonds issued, consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output. Breusch-Godfrey test, the Breusch-Pagan test, and the White test were completed and did not indicate the existence of autocorrelation and significant heteroskedasticity.

3.3. Conclusion of the chapter

To summarize, the green bond market has undergone impressive expansion between 2017 and 2023 in Nordic countries. The largest amount of green bonds was issued by Sweden, and the banking industry was the largest issuer of green bonds. The most common tenors were in the 4-5 years range in Denmark, Sweden, and Norway and 8-10 years range in Finland. Most of the issued green bonds in Nordics were associated with SDG 11, SDG 7, and SDG 13. Also, greenhouse gas emissions, diesel, and heating oil consumption, energy production from fossil fuel decreased, and manufacturing output increased in Nordic countries during the study period. The transportation sector was the largest emitter of greenhouse gas emissions. Norway was the largest emitter in Nordic countries, while Denmark had the smallest emissions. Furthermore, Person's Correlation Matrix demonstrated that the strongest negative correlation was between the amount of green bonds issued and greenhouse gas emissions. Furthermore, the dynamics of the independent variable with each dependent variable over time was illustrated and showed that the COVID-19 outbreak could have affected multiple variables during 2020. During a pandemic, lockdowns were introduced, economic activities slowed down, and other restrictions were imposed. Least squares regression results showed that most of the variance in greenhouse gas emissions can be explained

by variance in the amount of green bonds issued, consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output. The Breusch-Godfrey test, the Breusch-Pagan test, and the White test were completed and did not indicate the existence of autocorrelation and significant heteroskedasticity. The research results indicated that green bonds have an impact on reducing greenhouse gas emissions in Nordic countries, which contributes to the achievement of SDG 13, which is aimed at tackling climate change.

CONCLUSIONS AND RECOMMENDATIONS

1. Conducted bibliometric analysis indicated that the relevance of green finance and SDGs concept is rapidly increasing among academics. It was noticed that the number of publications was significantly lower for bibliometric analysis that combined green bonds and SDG topics in comparison to bibliometric analysis that focused solely on SDG and green finance topics. This indicates that SDGs and green finance as separate topics have been explored extensively. However, SDG and green bonds as a unified research area is a relatively new emerging field of study.
2. The review of existing literature of published research on green bonds and SDG13 showed that publication volume remains low on this topic, suggesting the early stage of the research area. Few articles were published focusing on developing countries or global views that do not consider regional differences. There were no publications available on this subject that focused on the Nordic region. As a result, the Nordic region was selected to address the research gap. There is a need for a more focused study that examines how green bonds impact SDG13 in the Nordic region.
3. This thesis aimed to determine the impact of green bonds on achieving Sustainable Development Goal 13 in Nordic countries. This research was based on a sample of 4 countries such as Denmark, Sweden, Norway, and Finland. This study covered a period starting from 2017 to 2023. The data was collected from Statista, Bloomberg Terminal, and Global Economy. The descriptive statistics method was used to summarize, graphically present the data, and provide key insights. Collected data was normalized to make data of Nordic countries comparable. Correlation analysis was used to measure the strength and direction of relationships between selected variables and to select variables for the regression analysis. A redundant fixed effect test was used to determine whether the individual fixed effects are redundant or not needed in the model. Ordinary least squares regression analysis was used to explore the relationship between selected variables and show if the results were statistically significant. The greenhouse gas emissions variable was selected as the dependent variable. Green bonds, manufacturing output, energy production from fossil fuels, consumption of diesel, and heating oil variables were selected as independent variables. Breusch-Godfrey test was performed to identify if autocorrelation exists in the residuals of regression analysis. Breusch-Pagan test and White test were used to detect if heteroskedasticity is present in the regression model.
4. The descriptive statistics method showed that the green bond market had experienced a notable expansion in the last seven years in Nordic countries. The banking industry is the

largest issuer of green bonds. The most common tenors are in the 4-5 years range in Denmark, Sweden, and Norway and 8-10 years range in Finland. The size of green bonds is larger in Denmark and Finland, while it is smaller in Sweden and Norway. Most of the issued green bonds in Nordics are associated with SDG11 - Sustainable Cities & Communities goal, SDG7- Affordable & Clean Energy goal, and SDG13 - Climate Action goal. Also, data shows a decline in greenhouse gas emissions, diesel and heating oil consumption, fossil fuel energy production, and an increase in manufacturing output in Nordic countries during the study period. Norway is the largest emitter of greenhouse gas emissions in Nordic countries, while Denmark has the smallest emission. However, Finland had the biggest decrease in emissions since 2017.

5. Pearson's correlation analysis showed notable positive and negative relationships between variables, with the strongest negative correlation between the amount of green bonds issued and greenhouse gas emissions, which suggests that as the amount of green bonds issued increases, the amount of greenhouse gas emissions decreases. Furthermore, the dynamics of the independent variable with each dependent variable over time was illustrated and showed that the COVID-19 outbreak could have affected multiple variables during 2020 due to slowed-down economic activities, lockdowns, and other restrictions.
6. Least squares regression results showed that most of the variance in greenhouse gas emissions can be explained by variance in the amount of green bonds issued, consumption of diesel and heating oil, energy production from fossil fuels, and manufacturing output. The Breusch-Godfrey test, the Breusch-Pagan test, and the White test were completed and did not indicate the existence of autocorrelation and significant heteroskedasticity. The research results demonstrated that green bonds have an impact on reducing greenhouse gas emissions in Nordic countries and contribute to the achievement of SDG 13, which is aimed at tackling climate change. Similar findings are observed by Saha and Maji (2023), Alamgir and Cheng (2023) in a global context, and Meo and Abd Karim (2022) in a developed countries context.
7. Several limitations of the research must be considered when evaluating the results. The timeframe of the research is between 2017 and 2023. This timeframe may not capture long-term trends of the green bond market and its impact on achieving SDGs in Nordic countries. Additionally, only data on active green bonds was extracted from the Bloomberg terminal, which excludes matured bonds from the scope of this research. Furthermore, the research focuses on the Nordic region, which might not capture global trends or differences in practices across regions.

8. Given the limitations of this research, there are several key areas where future exploration is recommended. Future studies should aim to investigate the long-term impact of green bonds on greenhouse gas emissions, including their role in achieving SDGs over multiple decades. Furthermore, future research could explore the impact of green bonds on achieving other SDGs or focusing on other regions.

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ASSESSMENT OF THE IMPACT OF GREEN FINANCE ON ACHIEVING THE SUSTAINABLE DEVELOPMENT GOALS

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Master Thesis

Finance and Banking Master Programme

Faculty of Economics and Business Administration, Vilnius University

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SUMMARY

62 pages, 12 tables, 25 figures, 88 references.

The main purpose of this thesis is to determine the impact of green bonds on achieving Sustainable Development Goal 13 in Nordic countries.

The Master thesis is divided into three main sections: a literature review, the research methodology and its findings, and a conclusion with recommendations.

Literature analysis reviews the concept of Sustainable Development Goals, sustainable financial systems, green finance, green financial products, and green bonds. Furthermore, the thesis includes bibliometric analysis, which explores published literature on green finance, green bonds, greenhouse gas emissions, and Sustainable Development Goals.

This research is based on a sample of 4 countries such as Denmark, Sweden, Norway, and Finland. This study covers a period starting from 2017 to 2023 and focuses on Sustainable Development Goal 13 - take urgent action to combat climate change and its impacts. Data analysis methods, tools, and techniques, such as descriptive statistics, Pearson's correlation analysis, redundant fixed effect test and least squares regression analysis, Breusch-Godfrey, Breusch-Pagan, and White tests, are used to achieve the aim, objectives, and answer research questions of this thesis.

Results of descriptive statistics analysis indicate a steady and significant increase in the amount of green bonds issued and a decline in greenhouse gas emissions. The findings demonstrate a strong negative correlation between the amount of green bonds issued and greenhouse gas emissions. Least squares regression results demonstrate that green bonds have a strong negative impact on greenhouse gas emissions in Nordic countries and contribute to the achievement of Sustainable Development Goal 13.

The conclusions and recommendations summarise key findings from the analysis of scientific literature, developed methodology, and the results of the study. The author believes that the findings of this thesis could offer valuable guidelines to investors who strive to enhance their investments in financial products that are in line with environmental sustainability.

ŽALIŲJŲ FINANSŲ POVEIKIO VERTINIMAS DARNAUS VYSTYMOSI TIKSLAMS PASIEKTI

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Darbo vadovė - Prof. Dr Jelena Stankevičienė, Vilnius, 2025

SANTRAUKA

62 puslapiai, 12 lentelių, 25 paveikslėliai, 88 nuorodos.

Pagrindinis šio magistro darbo tikslas yra išanalizuoti žaliųjų obligacijų poveikio vertinimą darniam vystymosi tikslui (numeris 13) pasiekti.

Magistro baigiamasis darbas apima tris pagrindines dalis: literatūros apžvalgą, tyrimo metodiką ir rezultatus, bei išvadas su rekomendacijomis.

Mokslinėje literatūrinėje analizėje nagrinėjami darnaus vystymosi tikslai, tvarių finansų sistema, žalieji finansai, žaliųjų finansų produktai ir žaliosios obligacijos. Mokslinė literatūra susijusi su žaliaisiais finansais, žaliosiomis obligacijomis, šiltnamio efektą sukeliančių dujų emisija ir darniais vystymosi tikslais analizuojama bibliometrinės analizės metodu.

Tyrimo laikotarpiu nuo 2017 iki 2023 nagrinėjamos keturios šalys: Danija, Švedija, Norvegija ir Suomija. Tyrimą sudaro darnaus vystymosi tikslas (numeris 13) - imtis skubių veiksmų kovoti su klimato kaita ir jos poveikiu. Tyrimo tikslams ir uždaviniams pasiekti, bei atsakyti į tyrimo klausymus naudojamos aprašomoji statistinė, mažiausių kvadratų regresinė ir Pirsono koreliacinė analizės bei atliekami Breusch-Godfrey, Breusch-Pagano, White ir nepakankamo kintamojo fiksuoto poveikio testai.

Aprašomoji statistinė analizė buvo taikoma parodyti nuolat kylančią išleistų žaliųjų obligacijų sumą, mažėjančią šiltnamio efektą sukeliančių dujų emisiją. Rezultatai atskleidė stiprią neigiamą koreliaciją tarp žaliųjų obligacijų sumos ir šiltnamio efektą sukeliančių dujų emisijos. Mažiausių kvadratų regresinė analizė buvo taikoma parodyti, kad žaliosios obligacijos turi stiprų neigiamą poveikį šiltnamio efektą sukeliančių dujų emisijai Skandinavijos šalyse ir prisideda prie darnaus vystymosi tikslo (numeris 13) pasiekimo.

Išvados ir rekomendacijos apibendrina mokslinės literatūros analizę, metodologiją ir tyrimo rezultatus. Autorė mano, kad šio darbo išvados galėtų suteikti vertingų gairių investuotojams, siekiantiems nukreipti savo investicijas į finansinius produktus, atitinkančius aplinkos tvarumą.

ANNEXES

Annex 1

The overview of Sustainable Development Goals

The Sustainable Development Goals	
1	End poverty in all its forms everywhere.
2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3	Ensure healthy lives and promote well-being for all at all ages.
4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
5	Achieve gender equality and empower all women and girls.
6	Ensure availability and sustainable management of water and sanitation for all.
7	Ensure access to affordable, reliable, sustainable and modern energy for all.
8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.
10	Reduce inequality within and among countries.
11	Make cities and human settlements inclusive, safe, resilient, and sustainable.
12	Ensure sustainable consumption and production patterns.
13	Take urgent action to combat climate change and its impact.
14	Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
15	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels.
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Source: United Nations, 2023.