Variables influencing the issue size of green bonds in the investment portfolios of Rabobank

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Management Summary

The investment office of Rabobank invests part of their portfolio in green bonds. Green bonds are bonds that are used to finance green projects, assets or business activities and are a relatively new fixed income instrument. Rabobank would like to explore the market in green bonds into further detail. This research focuses specifically on the variables influencing the issue size of green bonds. Therefore, the main research question in this research is as follows:

1. Which variables affect the issue size of green bonds in the portfolio of Rabobank?

It is divided into the following four sub-research questions:

1. Which method is suitable to determine the variables which affect the issue size of green bonds in the portfolio of Rabobank?
2. Which variables could potentially influence the issue size of green bonds.
3. How can be determined what influence these variables have on issue size?
4. What effect do the variables found have on the issue size of green bonds in the portfolio of Rabobank?

By doing literature research in the second chapter, the first and second questions are answered. The suitable method to determine the variables influencing the issue size of green bonds is the method of Barua and Chiesa which applies ordinary least squares regression to determine the relationship between issue size and the depending variables. It allows for year-wise estimation. The variables that could potentially influence the issue size of green bonds are based on literature study and are the following as can be seen below in Table X.

Table 1. Potential variables that could influence the issue size of green bonds

Coupon rate	Maturity	Bond rating	Risk premium	Security
Revenue Growth	Capital Structure	Return on Assets	Issuer rating	Sector
Market of distribution	Market interest rate	Market type	Fiscal government balance	Population
Ratio of exports to GDP	Total Asset	Inflation	Unemployment rate	Currency
GDP per capita				

In chapter 3, Methodology, the third research question is answered as the method of Barua and Chiesa is explained. By applying ordinary least squares regression and making an econometric linear model that shows the relationship between issue size and the depending regression variables, the effect of these variables on green bonds issue size can be determined.

This method is applied on the available portfolio data of Rabobank for green bonds issued in the period between 2019 and 2023. All bonds issued in this period are considered, as well as year-wise estimations which show the effects of the variables on issue size per year. Due to limited data availability, a partial regression is executed to prevent overfitting due to a small ratio between observations and independent regression variables.

As a result, maturity, issuer rating, firm size and capital structure show a positive effect, whereas bond rating, revenue growth, return on assets and the real-estate sector show a negative effect. It should be noted that the explanatory power of the model is very low due to low R-squared values, meaning that the variables considered are of little influence on green bonds issue size

Preface

The report before you is my master thesis. It is written as graduation assignment in cooperation with Rabobank U.A. and marks the end of my time as a student in Industrial Engineering & Management, specialising in Financial Engineering & Management at the University of Twente.

The completion of this thesis could not have been achieved without the support of some people closely involved. First, I would like to thank Laura Spierdijk for her clear and extensive feedback on all chapters of my thesis. Her guidance was invaluable in delivering a complete master thesis. Second, I would like to thank my second supervisor Berend Roorda for his valuable feedback in the final phase of the project. Another big thank you goes out to Rishma Moennasing, my external supervisor at Rabobank, who has given me the opportunity to write a graduation thesis within the investment office of Rabobank and was always a kind support in completing this research. I would like to thank all colleagues in the investment office for their valuable talks about my research and their help into getting me the right data for conducting it. Furthermore, all people mentioned above have been very supportive when my research had to be interrupted due to medical reasons and I cannot thank them enough for this.

A special word of thanks goes to Cornelis and Ipek. Throughout my entire study phase, Cornelis has been a very valuable academic counsellor who always provided me with useful advice to continue my studies successfully. Ipek has been a great source of advice as well and was always available to discuss about my latest updates regarding graduation. Finally, all my friends and family cannot be thanked enough for their support during the process.

Pim Eerden, April 2024

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1. Introduction

In the recent past, green bonds were added to the fixed income area of investments. Compared to conventional bonds, funds raised by green bonds are exclusively used to finance or re-finance 'green' projects, assets, or business activities. They came into existence when global warming was first linked to human activity and the need arose for investing in projects helping the climate. (Organisation for Economic Co-operation and Development, 2016) The first green bond was issued in 2007 and the market in green bonds is still relatively new and upcoming. Total issue size went over 500 billion US dollars in 2021 and banks have started investing in them. For the investment departments of banks, financial returns are their priority, but regulations and the societal urgency to fight climate change has directed them towards investing more sustainably. This also holds for the investment office of Rabobank, who are investing 20% of their portfolio in green bonds currently and would like to explore the market in green bonds in further detail. In cooperation with the investment office of Rabobank, we research green bonds while specifically focusing on the variables influencing its issue size.

1.1 Problem Context

As already mentioned, green bonds are used to finance green projects, assets or business activities, and Rabobank invests in them as well. The investment office of Rabobank sets up investment portfolios and manages them. They put together the product range of investment funds and determine the policy for sustainable investing. Investments should comply to minimum requirements in the field of environment, social and governance (ESG) and only products that comply to these requirements are included in asset management. This means that ESG-policy does not only lead to good financial returns that fit within their intended risk return ratio, but also considers the societal impact of investments.

The policy for sustainable investment consists of the following 5 ESG-pillars.

1. Exclusions and restrictive measures
2. Sustainable investments (EU SFDR)
3. Reducing carbon intensity
4. Sustainable theme's
5. Active shareholding

As part of the second pillar 'Sustainable investments (EU SFDR)', Rabobank will invest more in companies that earn part of their revenue from activities that have a positive impact on the environment and society or give a solution to climate challenges or the transition to renewable energy. Additionally, companies can be included that have a plan to reduce CO_2-emissions, as these companies are often leaders in sustainability and eventually will reduce climate risks. For all so-called 1895-equity funds, the goal is to invest 20% of the fund in companies that partially (minimal 20%) generate their revenues with sustainable goals and/or a carbon reduction plan.

Hence, Rabobank also takes into account more green bonds in their portfolio. In the portfolio of Rabobank, these are bonds issued by governments or companies to become more sustainable, for example by building wind farms or other initiatives on sustainable energy or by making new sustainable products or services. The yield of these bonds is typically comparable to those of ‘normal’ bonds of the issuer, but the generated money will be used for sustainable targets. Currently, 20% of investments is allocated to green bonds. (Rabobank Nederland, 2023)

1.2 Core problem

As the market in green bonds is still relatively new and upcoming, it is unclear for Rabobank, how interesting green bonds will be for them in the future. They would like to know the market, developments, characteristics, and growth potential in green bonds. Will this be interesting enough to invest more in than the current 20% allocation to green bonds?

As determined in interviews with employees of the investment office, it becomes clear that in the company, a minimum allocation of 20% of investments should be reserved for green bonds. This allocation is determined in line with the company’s sustainable investing policy, which outlines the inclusion of green bonds issued by governments or corporations aimed at sustainability initiatives such as wind farms or other green projects, as well as the development of sustainable products and services. With an allocation of 20% of investments towards green bonds, it is no mere coincidence that Rabobank has achieved credibility in sustainable investing. Considering the supply of green bonds, it is uncertain which variables drive the supply of green bonds. Also, Rabobank has mentioned that from 2024, new legislation will turn into practice, which might have an effect on the future supply of green bonds.

Furthermore, it is currently known that the return on green bonds is similar to the return of conventional bonds. The spread between these returns, called green premium or ‘greenium’ is currently negligible but it is uncertain whether this spread might return in the future. Additionally, it is uncertain whether investing more in green bonds actually has the intended effect. Besides this, it is uncertain whether investing more in green bonds fits within the intended risk return ratio of Rabobank. When assessing the impact of investing more in green bonds for achieving sustainability goals, it is needed to ensure that this does not undermine Rabobank’s intended risk-return ratio.

Also, Rabobank currently does not invest in sustainability linked bonds, but in green bonds only, as sustainability linked bonds have no EU frameworks yet, which green bonds do have. This means that no reporting needs to be done about achieving sustainability goals when issuing a sustainability linked bond, which makes these types of bonds prone to greenwashing.

These problems can be depicted in a Fishbone model, combined with a problem cluster, as suggested by Heerkens and van Winden. (Heerkens & van Winden, 2017) This is shown below in Figure 1.

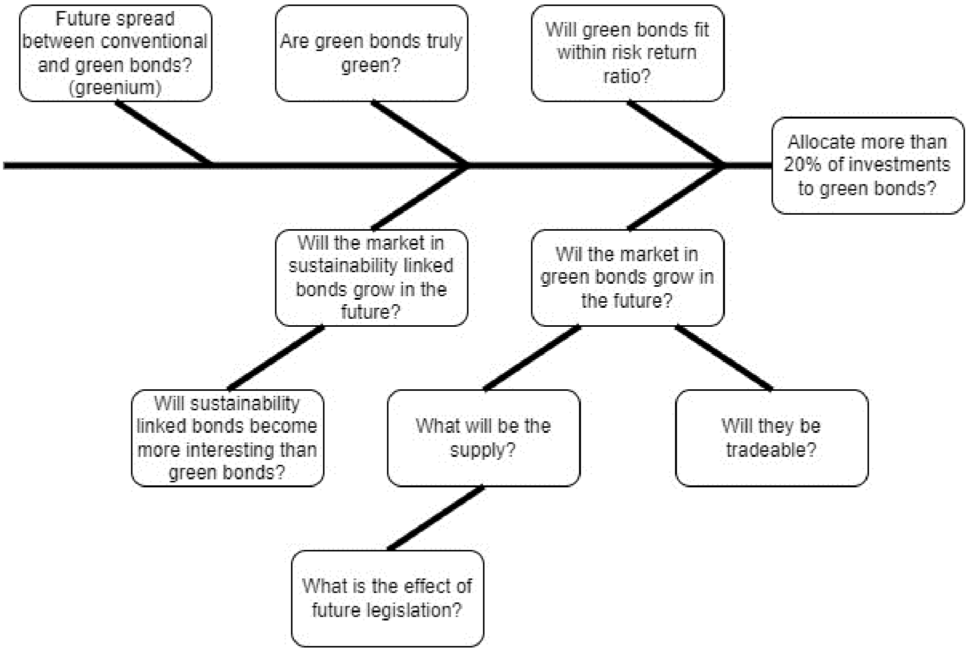

Figure 1. Fishbone model of problem context.

As can be seen in Figure 1, all these problems contribute to one single core problem for Rabobank regarding green bonds, which can be formulated as an action problem:

There is no clear understanding to Rabobank whether they should remain at or increase their 20% allocation to green bonds in the future.

By providing answers to the problems leading to the core problem, the lack of knowledge on how much to invest in green bonds can be solved.

1.3 Research goal

As mentioned in the previous section, several smaller problems are leading to the core problem of Rabobank. One of these problems is the uncertainty in the variables that drive the supply of green bonds. According to Barua and Chiesa, "understanding the supply-side dynamics is equally, if not more, important than demand-side in shaping green bonds market for a greener economy". They mention that the green bond market is "supply-pushed", which means that despite an increase in demand for green bonds, the green bonds issued originate from issuers who need to meet certain sustainability goals. So, the size of sustainable investments in the real sector depends on the size of investments raised by green bonds issuances, which is the supply of green bonds. So, the larger the issue size of a green bond, the more bonds are supplied, and the more money is directed towards actual investments. In their research, they research what influences the issue size decisions of firms by determining the impact of certain variables on this issue size for the period of 2010 to 2017. (Barua & Chiesa, 2019)

In this research we are interested in the variables influencing the issue sizes of the green bonds in the fixed income portfolios of Rabobank. For Rabobank this means an answer to one of their problems, namely the drivers behind the size of green bond issuances. With the scope of the master thesis assignment, this means the core problem will be solved partially by answering a part of the problems of Rabobank considering green bonds, by applying a method on portfolio data to see which variables influence the issue size of green bonds.

To come to an answer to this problem, we formulate one main research question:

1. Which variables affect the issue size of green bonds in the portfolio of Rabobank?

We try to answer this research question by collecting data on green bonds issuances and analysing this data and see which variables in this data are of effect on the issue size of green bonds. This main research question can be divided into several sub-research questions which decompose the main research questions into more detail. In the next section they are described.

1.3.1 Sub-research questions

Below, each of the following sub-research questions is explained together with a method on how to answer them.

1. <u>Which method is suitable to determine the variables which affect the issue size of green bonds in the portfolio of Rabobank?</u>
   First, it is needed to know which method is suitable for answering which variables influence the issue sizes of green bonds in the portfolios of Rabobank. By doing literature research, existing methods in academic literature can be compared to come up with a suitable method that fits the data of Rabobank.
2. <u>Which variables could potentially influence the issue size of green bonds.</u>
   Second, it is needed to know which variables could be considered influential to the size of green bonds, before it could be estimated by how much they will influence issue size. By doing literature study, these variables can be determined and used in the remainder of this research.
3. <u>How can be determined what influence these variables have on issue size?</u>
   By means of the method found in research sub-question 1, it can be derived how could be calculated how much influence each of the variables found in sub-research question 2 has on the issue size of green bonds in the portfolio of Rabobank.
4. <u>What effect do the variables found have on the issue size of green bonds in the portfolio of Rabobank?</u>
   By applying the method found in sub-research question 1 on portfolio data from Rabobank, it can be calculated and quantified what will be the effect of the found variables from sub-research question 2 on the issue size of green bonds in the portfolio of Rabobank, by using the knowledge obtained in sub-research question 3.

In the end by answering these sub-research questions sequentially, the main research question can be answered to see which variables affect the issue size of green bonds in the portfolio of Rabobank and therefore answer the main research question and part of the core problem.

1.4 Research Design

This research design explains which specific methods are used to answer the sub-research questions in the previous section. With this approach being clear, we are ready to gather the required data that is needed for answering the sub-research questions. Depending on the sub-research question it might vary what data is needed. By analysing this data and applying scientific methods on it, conclusions can be drawn, and an answer can be given on the main research question.

1.4.1. Data and methodology

First, to find a methodology suitable for answering which variables are of influence on the issue size of green bonds in the portfolio of Rabobank, literature research must show which methods in the past were used in academic literature to answer this question. Next, in order to determine which variables could be of any influence on the issue sizes of green bonds in the portfolio of Rabobank, it is needed to conduct literature study and consult these researches from the past which could have researched which variables are of influence. These variables will form the basis for the research and will be used to determine which variables actually have an effect on the issue size of green bonds. Then, the method found is consulted to determine how it can be calculated which specific influence these variables have. Next, portfolio data on green bond issuances from Rabobank is collected and it is observed which of the variables found in sub-research question 2 can be observed in this data. Within Rabobank, this data can be derived from their data source Aladdin, in which their portfolio data is available. The method found from sub-research question 1 is then applied to this data and we end up with results that show which variables influences the issue size of green bonds by how much.

1.5 Scope

This section explains the boundaries set for this research.

One boundary of this research is the fact that it only partially answers the core problem as brought up by Rabobank, as it encompasses a lot of smaller subproblems which fall out of the scope of the master thesis assignment. In further research, these subproblems could be answered to give a more detailed overview on the developments of the relatively new green bond market.

Another boundary can be found in the data that is available for this research. It has to become clear from the portfolio data of Rabobank whether for each variable enough data is available to draw conclusions about how much these variables affect green bond issue size.

1.6 Thesis outline

This section encompasses the content covered in each chapter of this research.

Chapter 1: Introduction

In chapter 1 the topic of this research is introduced. Its context on why green bonds are issued and why they are used in the portfolios of Rabobank is explained. Various issues around green bonds as mentioned by Rabobank are denoted in a problem cluster and are used to come up with the core problem. Then, the next sections describe the goal of this research and how the core problem will be partially solved by addressing (sub-)research questions. It is described which methods are used to answer these questions and the scope of the research is defined.

Chapter 2: Theoretical Framework

Chapter 2 includes the theoretical framework of this research. By means of literature research, it answers the first sub-research question by showing which academic method is suitable for eventually determining which variables affect the issue size of green bonds in the portfolios of

Rabobank. Then, this chapter answers the second sub-research question by answering which variables could potentially influence the issue size of green bonds.

Chapter 3: Methodology
This chapter explains the methodology that will be used and applied on data of Rabobank to be able to come to an answer to the research question and sub-research questions. It provides an answer to sub-research question 3, by showing how the method from sub-research question 1 could be applied.

Chapter 4: Data
This Chapter describes what the portfolio data of Rabobank looks like and how the methodology found in sub-research question 1 can be applied to it.

Chapter 5: Results
By applying the explained method from chapter 3 on the data, it becomes visible by how much the found variables from sub-research question 2 influence the issue size of green bonds in the portfolios of Rabobank, meaning it answers sub-research question 4.

Chapter 6: Conclusion, Discussion and Recommendations
This chapter concludes the research and answers the main research question, namely which variables actually influence the issue size of green bonds, both positively and negatively in the portfolio of Rabobank. This chapter also discusses limitations of the research and gives recommendations for further research.

2. Theoretical Framework

This chapter provides answers to the first and second sub-research questions that will be of relevance later in answering sub-research questions three and four. First, some context is given about the history and need for green bonds, and it is mentioned which sources in literature address the context of problems arising due to the upcoming green bonds market. Then, it is researched which methods already exist in literature for specifically determining which variables affect the issue size of green bonds and it is determined which of these methods is suitable for answering the main research questions. Finally, it is researched which variables could be influential to the issue size of green bonds in the portfolio of Rabobank.

To arrive at the outcomes of the literature study, several databases were used to come up with relevant sources. In Table 2, it can be seen which keywords were used in which database to arrive at which source. The library of the University of Twente was mainly used (FindUT), as it allows access to all UT-subscribed content. For a broader search, Google Scholar was used sometimes. Sometimes, non-scientific reports were consulted which were found via a search engine such as Google. Not all search terms directly led to the sources mentioned in the literature study, because sometimes cited references within another study were consulted, which is denoted in the rightmost column of Table 2.

Table 2. Keywords and databases used to arrive at (scientific) sources used in literature review.

Keywords	Database / search engine	Source Found	Cited source
Green bonds definition	Google	(International Renewable Energy Agency, 2020)	
History of green bonds	Google	(The World Bank, 2019)	
Green bonds portfolio allocation	Google Scholar	(Swinkels, 2022)	
Green bonds issuance data	Google	(Climate Bonds Initiative, 2022)	
Green bond issuance size	Google Scholar	(Dan & Tiron-Tudor, 2021)	(Löffler, et al., 2021) , (MacAskill, et al., 2020) , (Tu, et al., 2021) , (Tolliver, et al., 2020)
Variables influencing green bonds issue size	FindUT	(Cicchiello, et al., 2022)	
Issue size green bonds	FindUT	(Barua & Chiesa, 2019)	(Barua & Chiesa, 2018)

2.1 Existing literature concerning green bonds

According to the International Renewable Energy Agency IRENA: “green bonds are a type of fixed income securities whose proceeds are meant to be allocated to sustainable assets.” They mention that the green bond market can function as a bridge between sustainable assets and the providers of capital. (International Renewable Energy Agency, 2020) The need for such green bonds arose in 2007, when the United Nations published a report in which they linked global warming to human activity and a Swedish pension fund wanted to invest in projects helping the climate. However, they did not know how to find such a project. The World Bank offered such investments, but the missing element was that investors did not know whether such an investment was truly sustainable and addressed their climate concerns. This led to the invention of the green bond and its first issuance in 2008 by the World Bank. The bond defined criteria for projects that could make use of the support of green bonds, and it added impact reporting such that investors would be sure that their investments would be truly sustainable. (The World Bank, 2019)

According to Swinkels, green bonds are a relatively new instrument that could help the energy transition. They can be issued by governments, supranational organizations, government-related institutions or by corporates and typically are used to raise money for ‘green’ projects that are formed to reduce or avoid climate change, meaning that they are particularly interesting for investors who are concerned about climate change. (Swinkels, 2022)

The Climate Bonds Initiative, which is an international non-profit organization that aims at mobilizing capital for climate action, mentions that since the first green bond was issued in 2008, the green bond market has grown a lot and total issuance volume was at a peak of 582.4 billion dollar in 2021 as can be seen below in Figure 2. In 2022, issuance was at a lower volume due to the war in Ukraine which had a significant effect on capital markets. (Climate Bonds Initiative, 2022)

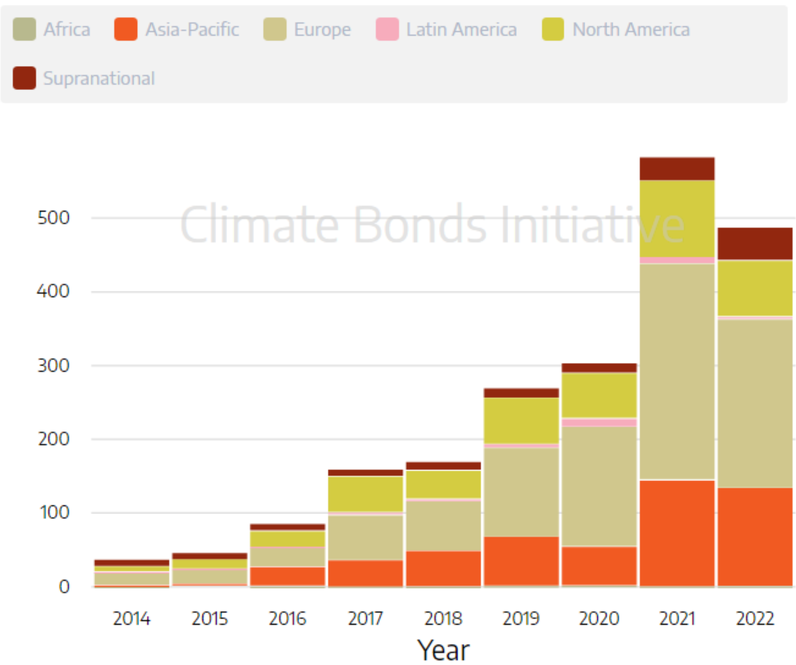

Figure 2. Green bond Issuance by Volume in billion dollars. (Climate Bonds Initiative, 2022)

2.1.1 Problems arising due to the existence of green bonds

Since green bonds entered the fixed income market of investments, many studies have researched the problems that came with this new instrument.

For example, many studies address the problem of pricing green bonds and the existence of a green premium ("greenium"), which is the difference in the yield between a green and a conventional bond. (Dan & Tiron-Tudor, 2021) For example, a study from 2021 by Löffler, Petreski and Stephan called "Drivers of green bond issuance and new evidence on the "greenium"", studied the difference between the yields of conventional and green bonds and it concluded that this yield is lower for green bonds. (Löffler, et al., 2021) Then, other studies determined which variables contribute to this difference, and for example MacAskill et. al discovered that this "greenium" is influenced by several variables such as bond credit rating and bond type. (MacAskill, et al., 2020)

Another example of a study concerning green bonds is a research from Cicchiello, Cotugno, Monferrà and Perdichizzi from 2022 called "Which are the variables influencing green bonds issuance? Evidence from the European bonds market." This research merely focuses on which variables determine whether an issuer issues a conventional or a green bond. It concludes that multiple variables like current ratio, long debt and an independent director could significantly affect whether an issuer issues a conventional or a green bond. (Cicchiello, et al., 2022)

A study from Tu, Rasoulinezhad and Sarker called "Investigating solutions for the development of a green bond market: Evidence from analytic hierarchy process" investigated the solutions for developing a green bond market in Vietnam and determined which variables drive such a market. They found that determinants of this market in Vietnam are legal infrastructure, interest rate, and economic stability by performing a decision-making method called the analytic hierarchy process. (Tu, et al., 2021)

2.2 Existing methods to determine variables influencing the issue size of green bonds

In academic literature, the amount of research specifically focusing on the variables influencing green bonds issue size is minimal. However, there are some sources which address this specific problem and could therefore be of use to answer sub-research question 1 and 2. These research are discussed below.

2.2.1 Barua and Chiesa

Suborna Barua and Micol Chiesa have done multiple research considering green bonds. In one of their studies from 2018 titled "The surge of impact borrowing: the magnitude and determinants of green bond supply and its heterogeneity across markets", they found that green bonds issue size is affected by several variables, which are coupon rate, bond rating, issuer rating, collateral availability, issuer sector and the financial health of the issuer. They discovered this by means of ordinary least squares regression in which the variables considered were the depending variables of the regression, and the green bond issue size was the dependent variable. They checked whether these variables are consistent in green bonds issued in emerging and non-emerging markets. (Barua & Chiesa, 2018)

However, they mention themselves in another newer paper, that this first paper does not take into account the persistence of the effects over time and across several bond ratings. Therefore, in a newer paper, also published by Barua and Chiesa in 2019, titled "Sustainable financing practices through green bonds: What affects the funding size?", they do take this into account. In this research, it is mentioned that until then, "empirical research concerning supply-side dynamics of the green bond market is very limited, particularly on the determining variables of green bond supply to the market." In this research, cross-section ordinary least squares regression is applied on a dataset from Bloomberg from the period of 2010 until 2017 with green bond issuances. By means of the regression, it is determined which variables affect issue size, in which 15 variables are considered which are divided into three categories, which are bond, issuer, and market characteristics. As the data used is cross-sectional, the regression is checked for multicollinearity and heteroscedasticity which could be a problem in estimating the effects that the variables have on green bond issue size.

By applying the regression not only on one large sample of green bonds, but by also looking per year and per rating grade of the green bonds, the effects over time and rating grades are taken into account. The results show that many of the considered variables influence issue size, but the effects do not stay over the years and are heterogeneous across rating grades. Also, the research applies so-called Blinder-Oaxaca decomposition to see if the average issue size of green bonds has changed over time and whether the considered variables cause the difference. (Barua & Chiesa, 2019)

2.2.2. Dan and Tiron-Tudor

Another study that researches the variables influencing the issue size of green bonds is a study from Dan and Tiron-Tudor titled "The Determinants of Green Bond Issuance in the European Union." Just like Barua and Chiesa they also apply ordinary least squares regression, but instead of dividing the variables into three categories, they considered 9 variables and divided them into four categories, namely environmental, social, governance and macroeconomic variables. While the research of Barua and Chiesa focuses on corporate green bonds, this research focuses only on green bonds issued by governments and does this for the period between 2014 and 2019. Just like Barua and Chiesa, this research also checks the data for both multicollinearity and heteroscedasticity.

The results of their research show that bond rating and fiscal balance, population and inflation rate have a significant positive effect on issue size. (Dan & Tiron-Tudor, 2021)

2.2.3 Tolliver et. al

In 2019, Tolliver et. al mentioned that the issuance of green bonds is helpful in reaching the targets of the Paris climate agreement. They mention that since the market in green bonds is still upcoming, there is not much literature available concerning the drivers of the green bond market growth. Therefore, they research whether nationally determined contributions to the Paris agreement and capital market growth drivers influence green bond issue volumes. They researched this for green bonds issued in 49 countries over a period of 10 years between 2007 and 2017. By using exploratory factor analysis, they were able to conclude that nationally determined contributions to the Paris agreement, macroeconomic and institutional factors are all of positive influence on green bond issue size. (Tolliver, et al., 2020)

2.2.4 Best fitting method

To answer research sub-question 1, the available methods for determining the variables which affect the issue size of green bonds in the portfolio of Rabobank should be analyzed and it should be concluded which method is the best fitting. As both the research of Barua and Chiesa and Dan and Tiron-Tudor focus specifically on the variables influencing issue size and both solve the problem by means of regression, we consider this a suitable method to determine the variables. The method of Barua and Chiesa is more elaborated as it considers year-wise estimation and checks the variables across different rating grades. Also, they perform Blinder-Oaxaca decomposition to see whether the average issue size of green bonds has changed over time. As their method is applied on green bonds data from the period 2010-2017, we apply it on more recent portfolio data of Rabobank, depending on what data is available. In the next section, we discuss which potential variables could be considered.

2.3 Potential variables influencing the issue size of green bonds

In the mentioned academic sources in section 2.2, several variables are mentioned that could potentially influence issue size of green bonds in the portfolio of Rabobank. Barua and Chiesa base their potential set of variables on available literature about green bonds, corporate finance literature and data availability and divided them into three categories, namely bond characteristics, issuer characteristics and economy and market characteristics. Dan and Tiron-Tudor divide their variables into the four categories environmental, social, governance and macroeconomic. In Table 3 and Table 4 these potential variables as suggested by Barua and Chiesa and Dan and Tiron-Tudor can be seen.

Table 3. Variables affecting green bonds issue size as considered by Barua and Chiesa

Category	**Variable in Barua and Chiesa**
Bond Characteristics	Coupon rate (CR)
	Maturity (Mat)
	Bond rating (BR)
	Risk premium (RP)
	Security (SEC)
	Currency (CUR_dum)
Issuer characteristics	Total asset (TA)
	Revenue Growth (RG)
	Capital structure (CS)
	Return on assets (ROA)
	Issuer credit rating (IR)
	Sector (SECT_dum)
Economic and Market Characteristics	Market interest rate (MIR)
	Market type (MT_dum)
	Market of distribution (MD_dum)

Table 4. Variables affecting green bonds issue size as considered by Dan and Tiron-Tudor

Variable in Dan and Tiron-Tudor
Issuer rating
Fiscal government balance

Trade openness
Inflation rate
Unemployment rate
GDP per capita
Population

Each variable will be explained in the next section, together with economic reasoning on what would be its expected effect on the issue size of green bonds in the portfolio of Rabobank.

2.3.1 Expected effect of potential variables on green bond issue size

For each variable denoted in Table 3 and Table 4, it is denoted below what they mean and what is their expected effect on green bond issue size. The expected effect is denoted between brackets. Some variables occur in both Table 3 and Table 4 and are therefore only mentioned once.

1. Coupon rate (negative)
   The coupon rate of a bond is the yearly interest rate paid on a bond. It can be considered the cost of financing for issuers of a bond, meaning that a higher coupon rate causes higher interest payments for the issuer. The expected effect on issue size is negative as it could be assumed that a higher cost of financing discourages issuing bonds with larger issue sizes, as it comes with high coupon payments.
2. Maturity (positive)
   The maturity of a bond determines the duration of a bond in years. At the end of the duration, the principal amount of the bond is repaid, and it could be assumed that the maturity of a bond in years, encourages the issue size. It is expected that larger firms can issue bonds of larger size, which comes with longer durations to match the financing needs and repayment schedules of such large issuances.
3. Bond rating (positive)
   The rating of a bond determines the creditworthiness and riskiness of the bond. It is assumed that the better the bonds rating, the more creditworthy and less risky it is and the higher its issue size could be, as potential investors will have more confidence in such a bond and would more easily invest money in it.
4. Risk Premium (negative)
   The risk premium of a bond is the extra return above the risk-free rate that an investor expects to get for taking the risk of holding a bond with a higher risk of default. Therefore, the higher the risk premium, the riskier the bond, and therefore we expect risk premium to have a negative effect on issue size as investor will be less likely to invest in such a bond.
5. Security (positive)
   The security of a bond is a variable that simply shows whether a security is available for repayment ability and the assumption here is that an available security allows for a higher issue size as it makes the investment more secure for investors and therefore more attractive to invest in it.
6. Currency (positive)
   The variable currency is a dummy variable that simply shows whether a green bond is issued in a certain currency or not. The expected effect would be that more internationally

accepted currencies have larger issue sizes, as these bonds have a larger potential pool of investors which could allow for higher issue sizes.

7. Total Asset (positive)
   The variable total asset shows the value of the total assets of the company issuing the bond and can be seen as an indication of the size of a firm. It is expected that larger firms with a higher value of total assets have more financing needs and therefore this variable is expected to have a positive effect on issue size.
8. Revenue growth (Negative)
   The variable revenue growth shows the year-on-year percentage growth in revenue of the company issuing the bond and shows the business performance and potential of the issuing company. It is expected that better performing companies have less external financing needs and therefore this variable is expected to have a negative effect on issue size.
9. Capital structure (Negative)
   This variable shows the debt to capital ratio of the issuer of the bond. The higher this ratio, the more relying the issuer is on debt instead of capital to finance its businesses and this is expected to have a negative effect on the bonds issue size as investor might perceive bonds issued by this issuer to be riskier in terms of creditworthiness.
10. Return on Assets (negative)
    The variable return on assets shows the profitability of the issuer of the bond and it is expected that companies with higher profits require less external funding and therefore this variable is expected to have a negative effect on issue size.
11. Issuer credit rating (positive)
    This variable shows the creditworthiness of the bond's issuer. Just like with bond rating, this variable is expected to have a positive effect on issue size, as investors will have more confidence in a bond issued by an issuer with a good issuer rating.
12. Sector (positive)
    This variable simply checks to which sector the raised money of an issued bond is flowing. The effect of this variable is positive, simply because we expect some sectors to raise more money than others.
13. Market interest rate (positive)
    This variable is simply the lending rate as charged by financial institutions at the moment of issuing a bond and is therefore an indicator of the alternative cost of financing for companies. We expect this variable to have a positive effect on issue size, as the higher this market interest rate, the higher the alternative cost of financing and the more likely an issuer will raise funds via a green bond.
14. Market type (positive)
    This variable simply shows whether the market of sales of a bond is an emerging market or not. It is expected that green bonds issued in emerging markets have higher issue sizes, as these countries "are fast-growing economies with a simultaneous concern for environmental impact." (Barua & Chiesa, 2019)
15. Market of distribution (positive)
    This variable controls whether the target of the issued bond is domestic, foreign, international or global and it is expected that a more international target is associated with larger issue sizes as it could attract a broader range of investors from different countries

which could allow for a higher demand and therefore the issuer could issue bonds of a larger size.

16. Fiscal government balance (positive)
This variable shows the net borrowing of a government, and we expect this variable to have a positive effect on green bonds issuance, cause green bonds could fund the deficit on a governments balance.
17. Trade openness (positive)
This variable shows the connection of an issuer with the rest of the world and is expressed as the ration of exports to the GDP of the issuing country. It is expected that the higher this ratio, the more open an issuer is to the rest of the world and the higher bond issuance can be, since Tolliver et al. found that trade openness impacts financing costs and leads to growth of the green bond market. (Tolliver, et al., 2020)
18. Inflation rate (negative)
This variable is an indicator of the quality of economic management of the issuing country and therefore of its creditworthiness. Therefore, we expect this variable to have a negative effect on issue size, as investors are less likely to invest in bonds issued by less creditworthy issuers.
19. Unemployment rate (positive)
This variable is expected to have a positive effect on the issue size as literature has shown that higher unemployment rates lead to an increase in debt level. (Dan & Tiron-Tudor, 2021)
20. Population (positive)
This variable is expected to have a positive effect on issue size, as a larger population of a country allows for an increasing demand in investment projects, for which more financial resources are needed, like fore example green bonds.
21. GDP per capita (positive)
This variable is an indicator of the size of a country's economy. We expect this variable to have a positive effect on issue size, as research has shown that the larger a country's economy, the more bonds they issue as they have more capacity to issue them. (Dan & Tiron-Tudor, 2021)

In the end, this results in the following list of potential variables that could influence green bond issue size in the portfolio data of Rabobank, and their expected effects, as can be seen in Table 5. With these possible variables, it could be checked in the data of Rabobank whether these variables are available and subsequently the method found in section 2.2 can be applied.

Table 5. List of variables that could potentially affect green bond issue size together with its expected effect

Variable	**Expected effect**
Coupon rate (CR)	Positive
Maturity (MAT)	Negative
Bond rating (BR)	Positive
Risk premium (RP)	Negative
Security (SEC)	Positive
Currency (CUR)	Positive
Total asset (TA)	Positive

Revenue Growth (RG)	Negative
Capital structure (CS)	Negative
Return on assets (ROA)	Negative
Issuer credit rating (IR)	Positive
Sector (SECT)	Positive
Market interest rate (MIR)	Positive
Market type (MT)	Positive
Market of distribution (MD)	Positive
Fiscal government balance (FGB)	Positive
Ration of exports to GDP (EG)	Positive
Inflation (Inf)	Negative
Unemployment rate (UR)	Positive
GDP_per_capita (GDP)	Positive
Population (Pop)	Positive

2.4 Conclusion

In this chapter, the literature review has provided the answers to the first and second sub-research question as mentioned in section 1.3.1. We answer the first sub-research questions by concluding that the suitable method to determine the variables influencing green bonds issue in the portfolio of Rabobank is the method of Barua and Chiesa which applies ordinary least squares regression to determine the relationship between issue size and the depending variables. Also, this method allows for considering year-wise estimation and checking the persistence of the variables across rating grades. Furthermore, Blinder-Oaxaca decomposition could show whether the average issue size of green bonds has changed over time.

The second sub-research question is answered based on the existing literature, by determining which variables could potentially influence the issue size of green bonds. The potential list of variables that could be influential can be seen in Table 5 and the data of Rabobank must reveal whether all these variables are available.

3. Methodology

This chapter explains how the ordinary least squares regression of Barua and Chiesa works and how it can be applied to the data from Rabobank.

3.1 How is determined what influence a variable has on issue size?

Barua and Chiesa came up with a method on how to determine the influence of each variable on the issue size of green bonds. They applied ordinary least squares estimation (OLS) to come up with a quantification of how much each variable influences the size of green bond issuance. The formula they used for issue size included the following variables and variable abbreviations, according to their nomenclature, as can be seen below in Table 6. The variables included are sometimes categorical variables and dummies are made for these variables, which means they are made binary and therefore useful in the regression. Whether a dummy variable is used or not by Barua and Chiesa is shown in the rightmost column of Table 6.

Table 6. Variables used in OLS regression of Barua and Chiesa

Variable name	Variable abbreviation	Dummy used?
Coupon rate	CR	No
Maturity	MAT	No
Bond rating	BR	No
Security	SEC	Yes
Risk premium	RP	No
Denomination currency	CUR	Yes
Firm size	TA	No
Business growth	RG	No
Capital structure	CS	No
Issuer credit rating	IR	No
Profitability	ROA	No
Sector of issuer	SECT	Yes
Market interest rate	MIR	No
Market type	MT	Yes
Market of distribution	MD	Yes

By applying a linear econometric model, they could estimate the effects of these variables on the total issue size of green bonds with ordinary least squares regression. This model was of the following form:

$$Ln(\text{issue\_size}_i) = \alpha + \beta_1\text{CR}_i + \beta_2\text{MAT}_i + \beta_3\text{BR}_i + \beta_4\text{SEC}_i + \beta_5\text{RP}_i + \beta_6\text{CUR}_i + \beta_7\text{Ln}(\text{TA}_i) + \beta_8\text{RG}_i + \beta_9\text{CS}_i + \beta_{10}\text{IR}_i + \beta_{11}\text{ROA}_i + \beta_{12}\text{MIR}_i + \beta_{13}\text{MT}_i + \beta_{14}\text{MD}_i + \varepsilon_i$$

With this linear model equation, a linear relationship between issue size and the independent variables is assumed. Here, a is the constant, ε_i the error term and β_k the coefficients that determine the impact of each variable on the i-th issue size. Each of these coefficients comes with a significance level, which denotes how strong the relationship between the variable and the issue size is. The natural logarithm will be applied over the issue sizes and the variable firm size (TA), to compensate for a possible bias of very large values and to take into account heteroscedasticity. (Barua & Chiesa, 2019).

By checking Rabobank's data on green bond issuances, the formula can be completed by checking whether the variables found in section 2.3 are available in Rabobank's data. When the regression is applied on this data in Excel and the coefficients and their significances are known, it becomes visible how strong the chosen variables relate to the issue size of green bonds in the portfolio of Rabobank. This means that conclusions can be drawn, and the main research question can be answered to know which variables actually affect the issue size of green bonds in the portfolio of Rabobank. Rabobank could then use this information and monitor these variables and use them for risk management purposes to see how changes in these variables might affect portfolio performance.

In the paper of Barua and Chiesa, the coefficient and the significance of the considered variables are determined for all bonds from the period 2010-2017 but are also calculated per year and across all rating grades of bonds. These rating grades are determined into high-grade, medium-grade and other bonds, according to the rating methodologies of Moody's and Standard & Poor's. High-grade bonds are bonds with rating AA- or higher. Medium-grade bonds are bonds with a rating between A+ and BBB- and the so-called 'other bonds' are bonds with no rating, or a rating lower than BBB-.

Rabobank's data needs to be checked to see for which time period and rating grades data is available and it needs to be tested on multicollinearity. To test for multicollinearity in the data, the variance-inflation factor is used (VIF) which, according to Gujarati, "measures the degree to which the variance of the coefficient estimates is inflated because of collinearity." The variance inflation factor is calculated with the equation $VIF = 1/(1 - R^2)$, in which the R^2 are the R^2 for the regressions of each of the depending variables, used as dependent variables. (Gujarati, 2012)

Another problem in the portfolio data of Rabobank is heteroscedasticity. According to Gujarati, heteroscedasticity means that the error term in the regression model has unequal variance across observations. This leads to OLS estimators no longer being of minimum variance, which means they are not the best estimators possible anymore, and as a result, conclusions about the statistical significance of the estimated regression coefficients could be wrong. (Gujarati, 2012) The data consists of multiple issuances of the same issuer in different years, which means the data is cross-sectional, which could cause biased estimates of the coefficients in the regression. The Breusch-Pagan test could be done to show whether heteroscedasticity is present, as suggested by Barua and Chiesa but it is unnecessary as we will find heteroscedasticity anyway. The biggest problem is the inconsistency of standard errors. To compensate for this, Barua and Chiesa suggest to perform ordinary least squares regression with robust-standard errors, which is called White-Huber standard errors and produces standard errors in the regression which are corrected for heteroscedasticity. (Barua & Chiesa, 2019). This type of regression will be performed on Rabobanks' green bond portfolio data.

3.2 Conclusion of methodology

In this methodology chapter, the third sub-research question from section 1.3 is answered as we have discovered how it can be determined what influences the found variables in chapter 2 have on issue size. It can be determined by applying ordinary least squares regression and making an econometric linear model that shows the relationship between issue size and the depending regression variables. These variables are determined from Rabobank's available data, and by applying the regression analysis in Excel on this data, and correcting the data for multicollinearity and heteroscedasticity, it can become visible what effect each variable will have on green bonds issue size.

4. Data and method

This chapter explains what the portfolio data of Rabobank looks like and how the methodology found in sub-research question 1 can be applied to it.

4.1 Data Collection

The method of Barua and Chiesa applies ordinary least squares regression to a set of variables that could potentially influence green bonds issue size. Their issuance data comes from data source Bloomberg, and they mention: "We use Bloomberg data on 771 green-labelled bond issuances issued from 2010 to 2017 for all variables as of the issue date of each bond." (Barua & Chiesa, 2019) In this research we are interested in these variables in a more recent past to determine which variables are of influence nowadays on the issue size of green bonds in the portfolio of Rabobank. Within Rabobank, similar data is available via their data source called 'Aladdin' in which their portfolio data is available. This data source is provided by their partner BlackRock. When looking into the fixed income environment of this data platform, all of Rabobank's positions in bonds are visible. This bond data consists of bonds separated in 19 data collections of bond portfolios.

For all the bonds in these portfolios, several variables can be selected. First, a variable called 'Refinitiv Green Bond Flag' is available which indicates if a bond is considered a green bond. By using this variable, the bond data can be filtered to view green bonds only. Next, the variable 'Amount Issued' is selected, which is the issue size of the bond and the dependent variable in the regression in this research. Next, it is checked whether the depending variables as determined in chapter 2 in Table 5 are available in Aladdin as well. For most variables this was the case, although the names of the variables in Aladdin were sometimes slightly different, but by looking at their definitions it could be checked whether they correspond to the variables that were found in chapter 2. In table 7 below it can be seen which variables found in chapter 2 were available in Aladdin and under which name. An additional column is added to show whether this variable is numerical or categorical. In the case of a categorical variable, it is included between brackets how many categories are present in the data.

Table 7. Available variables as compared to variables from Table 5

Variable in Table 5	**Variable name in Aladdin**	**Variable type**
Coupon rate (CR)	Coupon	Numerical
Maturity (MAT)	Maturity	Numerical
Bond rating (BR)	Barclays Rating	Categorical (27)
Risk premium (RP)	Not available	Not applicable
Security (SEC)	Not available	Not applicable
Currency (CUR)	Currency	Categorical (7)
Total asset (TA)	Total Assets	Numerical
Revenue Growth (RG)	Net Income – 1 Yr Growth (%)	Numerical
Capital structure (CS)	Long Term Debt to Capital (%)	Numerical
Return on assets (ROA)	ROA (%)	Numerical
Issuer credit rating (IR)	Issuer Rating	Categorical (12)
Sector (SECT)	FTSE Sector	Categorical (29)

Market interest rate (MIR)	Not available	Not applicable
Market type (MT)	Market Name	Categorical (9)
Market of distribution (MD)	Not available	Not applicable
Fiscal government balance (FGB)	Not available	Not applicable
Ration of exports to GDP (EG)	Not available	Not applicable
Inflation (Inf)	Not available	Not applicable
Unemployment rate (UR)	Unemployment Flag	Numerical
GDP per capita (GDP)	GDP nominal (USD)	Numerical
Population (Pop)	Not available	Not applicable

'Barclays Rating' is a variable that calculates a bonds credit rating using the Barclay's methodology. It makes use of the three rating agencies S&P, Moody's and Fitch and uses the middle rating when all three are available. If the bond is rated by only two of these three, the lower rating is used and when only one rating is available, that one is used.

After selecting all these variables as 'column measures' in the data platform Aladdin, they could be exported to Excel. For each of the portfolios this was done and by adding all data of these portfolios together, one big dataset was generated with all green bond data of Rabobank's bond portfolios.

4.2 Data analysis

After putting all green bonds data in one excel sheet, it could be analysed. This resulted in data for 11880 green bonds. First, when looking at the variables, it was clear that the second variable 'Maturity', was just the end date of the duration of each green bond. By adding an extra variable 'Issue date', the difference between the end date of the bond and the issue date could be calculated in a new column called 'Maturity in years', to calculate the duration of the bond in years. Second, it was observed from Aladdin that the variable 'Amount issued' denotes the issue sizes of the bonds in their denominated currency. By using historical exchange rates between the currency of denomination and Euro, the issue size in Euros at the moment of issuing was generated, such that all issue sizes are in the same currency.

By sorting the data, it could be checked how much bonds of which type were available. Barua and Chiesa divided their green bond data into rating grades to see how much bonds of each rating grade are available. They divided the bonds into investment grade and noninvestment grade bonds of which the investment grade bonds were again divided into high grade and medium grade bonds. Also, a category called 'other bonds' was considered, which is the sum of noninvestment grade bonds and unrated bonds and is used for comparison purposes. A similar analysis is done for the green bond data of Rabobank, and this can be seen in Table 8 below. This is done to see how much bonds of each year and each rating grade are available, to determine if looking at the effect of each variable on issue size per year and across rating grades makes sense or whether for some years or rating grades no bonds are found in the portfolio. Here, investment grade bonds are bonds rated BBB- or higher. High grade bonds are of rating AA or higher. Noninvestment grade bonds are bonds with a rating of BB+ or lower and other bonds are considered bonds with either no rating or a noninvestment grade rating.

Table 8. Number of bonds issued per year per rating grade.

	Investment grade		Noninvestment grade	Other bonds	Total bond
Year	**High grade**	**Medium grade**			
2012	0	3	0	0	3
2013	0	0	0	0	0
2014	24	31	0	0	55
2015	37	59	0	0	96
2016	50	150	0	0	200
2017	121	300	0	0	421
2018	164	329	1	8	501
2019	306	735	7	25	1066
2020	305	1101	14	21	1427
2021	462	2029	66	126	2617
2022	595	1995	29	112	2702
2023	577	2022	27	153	2752
2024	2	36	1	2	40
Total	2643	8790	145	447	11880

Not for each green bond issuance, data is available in Aladdin for every variable. However, in regression analysis this is needed as Excel cannot include variables without observations for some of the green bonds issued. This means it cannot perform a regression analysis. Therefore, the green bonds issued that have no observations for any of the variables, are omitted from the data. However, some variable columns don't contain much data at all, and omitting the green bonds corresponding to these variables would result in few remaining data. Therefore, first it is checked for each variable how many observations are available for each green bond issued as can be seen below in Table 9. Then, it is determined how much data is left after removing all green bonds without observations for any variable, and whether enough data is still available. As the regression will focus on newer data as compared to the paper of Barua and Chiesa, it is denoted only for green bonds issuances as of 2018.

Table 9. Number of blank observations per variable

Variable in Table 5	Variable in Aladdin	Green bonds without observation (blanks)
Coupon rate (CR)	Coupon	8545
Maturity (MAT)	Maturity	0
Bond rating (BR)	Barclays Rating	302
Currency (CUR)	Currency	0
Total asset (TA)	Total Assets	6061
Revenue Growth (RG)	Net Income – 1 Yr Growth (%)	6662
Capital structure (CS)	Long Term Debt to Capital (%)	6054

Return on assets (ROA)	ROA (%)	6114
Issuer credit rating (IR)	Issuer Rating	124
Sector (SECT)	FTSE Sector	2482
Market type (MT)	Market Name	0
Unemployment rate (UR)	Unemployment Flag	10226
GDP per capita (GDP)	GDP nominal (USD)	10381

It can be seen that for the last two variables Unemployment rate and GDP per capita, a very high number of green bonds are without data. As this is simply country-specific data, it should be available, but in the data system Aladdin it is mostly only available for bonds issued by governments and not for bonds issued by corporates. This country-specific data however could be retrieved from databases such as the Worldbank, but since it appears to be hard to manually match the two datasets together, we therefore decide not to take these variables into account anymore. By removing these two variables and removing the green bonds with empty observations for all other variables, we would be left with the following number of green bonds for each year and each rating type as denoted below in Table 10.

Table 10. Remaining number of green bonds after deleting green bonds without observations for every variable

	Investment grade		**Noninvestment grade**	**Other bonds**	**Total bond**
Year	**High grade**	**Medium grade**			
2018	4	36	1	1	41
2019	12	87	2	2	101
2020	8	129	8	8	145
2021	17	263	21	21	301
2022	17	257	13	13	287
2023	16	240	14	14	270
2024	0	16	1	1	17
Total	74	1028	60	60	1162

It becomes clear that in total, only 1162 green bonds are remaining in the final dataset. For the years 2018 and 2024 and for high grade and noninvestment grade bonds, only a low number of bonds issuances is still available. We could therefore continue with data for the years 2019 till 2023 only. When enough data would be available for all rating types, a comparison could be done between rating grades, to see whether the effects of the variables on green bond issue size persists across rating grades. But regression will be hard to do with little data available for high grade and noninvestment grade bonds and therefore, the comparison across rating grades is left out.

4.2.1 Partial Regressions

If we would perform a year-wise regression on this final dataset, we would consider regression with relatively few data and many independent variables. We still perform this 'full' regression to observe the effects of all independent variables on the issue size of green bonds, but we also include partial regressions, in which a part of the independent variables is included. This would mean that larger datasets are considered, as we could leave out independent variables which have a lot of missing data, as was observed in Table 9. Besides, it will create more output than just one regression applied to different time periods, and it could prevent the ratio between observations and independent variables being too small, as this could mean overfitting.

When we take another look at Table 9, we could consider doing partial regressions with the independent variables that have no large amounts of missing data. This would mean that it could be done with the variables Maturity, Barclays Rating, Currency, Issuer Rating, FTSE Sector, and Market Name as all other variables have large percentages of over 50 percent of missing data. The remaining number of green bonds after continuing with these variables only and removing the green bonds without observations for these variables can be seen below in Table 11.

Table 11. Remaining number of green bonds after deleting green bonds without observations for partial regression

	Investment grade		**Noninvestment grade**	**Other bonds**	**Total bond**
Year	**High grade**	**Medium grade**			
2018	35	259	1	295	295
2019	115	664	7	7	786
2020	86	988	14	14	1088
2021	148	1859	64	64	2071
2022	267	1829	29	29	2125
2023	254	1784	27	27	2065
2024	1	34	1	1	36
Total	906	7417	143	143	8466

It becomes clear that in total, 8466 green bonds are remaining in the partial dataset with only six independent variables considered. Again, just like in Table 10, it can be seen that for the years 2018 and 2024, only a low number of bonds issuances is still available. Therefore, just like with the regression that considers all independent variables, we continue with data for the years 2019 till 2023. Again, most bonds are medium rated, meaning a comparison between rating grades is left out.

4.3 Dummy variables

For each available variable in the data, statistics could be calculated. The number of observations shows how often a variable is observed in the remaining data and furthermore, the minimum and maximum value and mean and standard deviation of these variables can be calculated. However, some of the data is categorical, meaning that dummy variables are needed to make them measurable. As already mentioned in Table 7, this is the case for the variables 'Barclays Rating, 'Currency', 'Issuer Rating', 'FTSE Sector' and 'Market Name'. In this section it is explained how dummy variables are made from these categorical variables.

A dummy variable is a binary variable that simply denotes whether a certain category in a categorical variable is present or not. The number 1 denotes its presence and the number 0 its absence. A categorical variable cannot be used in regression without making a dummy of it first.

For the variable ‘Barclays Rating’ we observe many bond ratings. But we already know from Table 10 and Table 11, that most of the bonds have a medium rating. It would be possible to make three new dummy variables called ‘high-grade’, ‘medium-grade’ and ‘other’ but the number 1 will be rarely observed for the variables ‘high-grade’ and ‘other’, which will be problematic in the regression analysis. Besides, to avoid a so-called ‘dummy trap’, one of the Barclays Rating dummies could not be taken into account anyway, as this would lead to multicollinearity issues. Therefore, we only make a dummy for medium grade bonds, meaning that we only take into account the effect of the variables on issue size of medium rated bonds.

When we follow the same rating division for issuer rating as for bond rating, a simple calculation shows that in the data, just like for bond rating, 79% of issuers are medium rated, while the other 21% has no rating. So, for the variable issuer rating it would also be problematic to do a regression analysis as a dummy trap would occur since an issuer is either medium, or other rated. To avoid a dummy trap again, we only make dummy variables for medium rated issuers.

When making dummies of the variable ‘FTSE Sector’ it is observed that for the full regression with all independent variables, 29 sectors are available, of which most sectors have only very small occurrences percentages. This allows for grouping the sectors into a smaller number of sectors. In Table 12 below, the mean of each sector can be seen, and it is shown in which group they are placed. Grouping is done by a self-made division into five groups. The groups considered are Financial, Industrial, Real-Estate, Utility and Others.

Table 12. Grouping of sector variables for full regression data

Sector Group	Mean	Subsector	Mean
Financial	0.495	Banks	0.448
		Finance and Credit Services	0.005
		Investment Banking and Brokerage Services	0.014
		Life Insurance	0.013
		Non-life Insurance	0.016
Industrial	0.124	Automobiles and Parts	0.044
		Chemicals	0.007
		Construction and Materials	0.003
		Electronic and Electrical Equipment	0.014
		General Industrials	0.009
		Industrial Materials	0.011
		Industrial Metals and Mining	0.002
		Industrial Support Services	0.001
		Industrial Transportation	0.011
		Oil, Gas and Coal	0.006
		Technology Hardware and Equipment	0.016
Real-Estate	0.129	Household Goods and Home Construction	0.001
		Real Estate Investment and Services	0.043
		Real Estate Investment Trusts	0.085
Utility	0.219	Electricity	0.151
		Gas, Water and Multi-utilities	0.068

Others	0.033	Consumer Services	0.003
		Food Producers	0.004
		Personal Care, Drug and Grocery Stores	0.002
		Personal Goods	0.002
		Software and Computer Services	0.002
		Telecommunications Service Providers	0.016
		Travel and Leisure	0.004
		Waste and Disposal Services	0.001

From this table it is observed that there are almost zero observations in the 'others'-sector, meaning it has little use in a regression analysis and is therefore omitted.

When looking at the Sector data for the partial regression, we observe that 36 sectors are available. When grouping these sectors again in a smaller number of six sectors, it can be seen below in Table 13 what is the mean of each sector.

Table 13. Grouping of sector variables for partial regression data

Sector Group	**Mean**	**Subsector**	**Mean**
Financial	0.420	Banks	0.338
		Finance and Credit Services	0.017
		Investment Banking and Brokerage Services	0.043
		Life Insurance	0.008
		Non-life Insurance	0.013
Industrial	0.140	Automobiles and Parts	0.035
		Chemicals	0.011
		Construction and Materials	0.005
		Electronic and Electrical Equipment	0.009
		General Industrials	0.010
		Industrial Engineering	0.001
		Industrial Materials	0.008
		Industrial Metals and Mining	0.002
		Industrial Support Services	0.002
		Industrial Transportation	0.035
		Oil, Gas and Coal	0.010
		Technology Hardware and Equipment	0.013
Medical	0.002	Healthcare Providers	0.000
		Medical Equipment and Services	0.002
		Pharmaceuticals and Biotechnology	0.001
Real-Estate	0.110	Household Goods and Home Construction	0.001
		Real Estate Investment and Services	0.031
		Real Estate Investment Trusts	0.078
Utility	0.294	Electricity	0.231
		Gas, Water and Multi-utilities	0.063

Others	0.028	Beverages	0.002
		Consumer Services	0.001
		Personal Care, Drug and Grocery Stores	0.002
		Personal Goods	0.002
		Retailers	0.003
		Software and Computer Services	0.001
		Telecommunications Equipment	0.001
		Telecommunications Service Providers	0.015
		Travel and Leisure	0.001
		Waste and Disposal Services	0.000

It is observed from this table that there are almost zero observations in the medical sector and others sector, meaning it has little use in a regression analysis and is therefore omitted.

As already mentioned before in Chapter 2, the variable 'Market Name' should simply show whether a green bond is issued in an emerging market or not. Therefore, a dummy variable could be made and is assigned the value one when the bond is issued in an emerging market. However, when checking the data, we notice that no bond is issued in an emerging market and all bonds are issued in so-called 'developed' markets.

The last variable that requires a dummy variable is the variable Currency. As already mentioned in section 2.3.1, the expected effect of this variable is that more internationally accepted currencies have larger issue sizes. When making an analysis of all green bonds issued in the data, it appears that 72% of the green bonds is issued in Euros and 22% in USD and all other currencies barely occur and are therefore not useful in regression. Therefore, we make currency dummies of the currencies in Euro only. We do not make a dummy for bonds listed in USD, as we want to avoid a dummy trap.

4.4 Multicollinearity and correlation

The data needs to be checked for multicollinearity, to see if certain variables might be needed to leave out of the research. According to Gujarati, multicollinearity exists when there is an exact linear relationship among the depending variables in a regression model. In regression, the assumption is that such exact relationships do not exist. In the case of perfect collinearity, a perfect linear relationship exists between two depending variables. Imperfect collinearity exists when besides the perfect relationship, there is some random error term in the relationship. Perfect collinearity is rare, but often, depending variables are seen to be highly collinear, which is called imperfect collinearity and it makes the regression estimators have large variances and covariances which makes estimations difficult. (Gujarati, 2012)

To test for multicollinearity in the data, the variance-inflating factor is used (VIF) as mentioned in Chapter 3. It is calculated with the equation $VIF = 1/(1 - R^2)$. The R^2 are found by applying regression but instead of using issue size as dependent variable, run the regressions 13 times with each of the depending variables as a dependent variable. Doing this for each of the datasets and variables, this resulted in the following VIF scores as observed in Table 14 and 15.

Table 14. Variance inflation factor scores for each variable in each year in the full regression dataset

Variable	2019-2023	2019	2020	2021	2022	2023
Coupon	1.11	6.08	1.68	3.00	1.31	1.68
Maturity	1.31	2.80	1.68	2.05	1.76	1.55
Total Assets	1.07	1.12	1.08	1.12	1.15	1.29
Revenue Growth	1.11	1.37	1.74	1.30	1.14	1.11
Capital Structure	1.50	1.53	1.79	1.60	1.40	1.84
Return on Assets	1.70	2.61	3.18	1.56	2.47	1.88
Barclays Rating	1.25	2.95	1.63	1.34	1.3	1.25
EUR Currency	1.25	4.45	1.56	2.53	1.58	1.46
Issuer Rating	1.20	2.23	1.28	1.41	1.27	1.29
Financial Sector	9.17	9.75	11.41	8.46	11.00	15.8
Industrial Sector	4.73	2.57	4.59	3.58	5.56	11.2
Real-Estate Sector	4.52	4.18	7.72	5.42	3.72	2.53
Utility Sector	6.27	7.07	7.73	5.48	6.29	10.8

Table 15. Variance inflation factor scores for each variable in each year in the partial regression dataset

Variable	2019-2023	2019	2020	2021	2022	2023
Maturity	1.13	1.22	1.20	1.21	1.14	1.11
Barclays Rating	1.20	1.80	1.34	1.17	1.19	1.15
Issuer Rating	1.15	1.60	1.25	1.23	1.16	1.09
EUR Currency	1.04	1.16	1.06	1.10	1.09	1.02
Financial Sector	7.57	6.98	6.22	6.83	10.20	7.83
Industrial Sector	4.21	3.45	4.03	3.25	6.01	4.95
Real-Estate Sector	3.62	3.57	4.81	4.20	4.10	1.72
Utility Sector	6.40	7.08	6.06	5.33	8.22	6.69

For the full regression, it can be seen that for every column, one of the highest VIF-values is found for the financial sector dummy. Other high values are found for the other sector dummies. For the partial regression, high VIF-values are also observed for the sector dummies, and especially for the financial sector dummy in most time periods. To support these calculations, correlation matrices for the depending variables in all datasets are made and can be found in appendix 1 in Figures 7 to 18. In these matrices, we observe high correlation values between the financial sector dummy and the other sectors in each dataset for both the full and partial regression. A possible explanation for this high correlation could be that changes in the financial sector could impact investment decisions in the other sectors, as the financial sector has a major role in providing investment opportunities for companies in the other sectors. It could be an indication of the connection between the financial market and other industries.

To compensate for these high VIF-values and high correlation scores, we perform regression analysis again, but now without the financial sector variable for both datasets, because apparently it might look too much like another variable, as suggested by the high VIF-score. The VIF-values resulting from the regression analysis without the financial variable can be seen below in Table 16 and Table 17. From these tables we see no significant troublesome VIF-scores.

Table 16. Variance Inflation Factor scores for the full regression for each variable after removing the financial sector dummy variable

Variable	2019-2023	2019	2020	2021	2022	2023
Coupon	1.11	5.60	2.07	2.88	1.31	1.67
Maturity	1.26	2.76	1.61	2.05	1.55	1.46
Total Assets	1.07	1.11	1.08	1.12	1.55	1.29
Revenue Growth	1.11	1.33	1.50	1.29	1.12	1.09
Capital Structure	1.50	1.52	1.75	1.59	1.40	1.84
Return on Assets	1.62	1.93	2.19	1.53	2.30	1.84
Barclays Rating	1.25	2.89	1.63	1.32	1.28	1.23
EUR Currency	1.22	4.45	1.49	2.53	1.57	1.46
Issuer Rating	1.20	2.22	1.27	1.35	1.27	1.28
Industrial Sector	1.97	2.22	2.46	1.64	2.73	2.42
Real-Estate Sector	1.36	1.72	2.72	1.54	1.42	1.09
Utility Sector	1.57	2.33	2.17	1.74	1.62	1.59

Table 17. Variance Inflation Factor scores for the partial regression for each variable after removing the financial sector dummy variable

Variable	2019-2023	2019	2020	2021	2022	2023
Maturity	1.10	1.22	1.11	1.17	1.08	1.10
Barclays Rating	1.19	1.78	1.29	1.16	1.18	1.14
Issuer Rating	1.14	1.60	1.23	1.17	1.16	1.09
EUR Currency	1.04	1.13	1.06	1.06	1.09	1.02
Industrial Sector	1.16	1.16	1.29	1.11	1.22	1.23
Real-Estate Sector	1.18	1.30	1.44	1.18	1.16	1.05
Utility Sector	1.34	1.72	1.56	1.39	1.24	1.29

4.5 Final statistics

Finally, after all dummy variables are made, a table with the statistics per variable used in both the full and partial regression could be made. In the two subsections of this chapter, these final statistics are discussed.

4.5.1 Final statistics for the full regression

Table 18 below contains the number of observations (Obs) per variable, the mean value (Mean), standard deviation (Std. Dev.), minimum and maximum value observed per variable (Min/Max) in the full regression.

Table 18. Statistics of regression variables for the full regression

Variable	Obs	Mean	Std. Dev.	Min	Max
Amount Issued (in million €)	1104	659.22	341.56	134.23	6283.71
Coupon (CP) (in %)	1104	2.73	1.91	0.01	9.13
Maturity (MAT) (in years)	1104	10.83	12.57	2.00	60.92
Total Assets (TA) (in million €)	1104	11200400	53411600	1718.28	688476000
Revenue Growth (RG) (in %)	1104	21.40	95.48	-98.32	569.27
Capital Structure (CS) (in %)	1104	52.24	19.36	2.05	94.59
Return on Assets (ROA) (in %)	1104	3.11	4.10	0.20	37.83
Dummy Variables	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Medium Barclays Rating Dummy (BR)	976	0.88	0.32	0.00	1.00
EURO Currency Dummy (EUR)	795	0.72	0.45	0.00	1.00
Medium Issuer Rating Dummy (IR)	779	0.71	0.46	0.00	1.00
FTSE Sector Dummies	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Industrial (IND)	137	0.12	0.33	0.00	1.00
Real-Estate (RE)	142	0.13	0.33	0.00	1.00
Utility (UT)	242	0.22	0.41	0.00	1.00

We observe from these sample statistics, that 1004 observations are available for all numerical variables. For the Amount Issued, we observe a standard deviation of 341.56 million Euro, indicating a wide dispersion of values around the mean of 659.22 million Euro. The range from minimum to maximum issue size demonstrates significant variability in the issuance amounts. The same holds for the variable Coupon which shows a standard deviation of 1.91 compared to a mean of 2.73. Also, for maturity, the standard deviation of 12.57 years indicates considerable variability in maturity lengths. The average maturity is approximately 11 years, whereas the largest maturity found in the data is approximately 61 years. For the variable Total Assets, the dispersion of asset values is even larger as its standard deviation is 53411600 million Euro compared to a mean of 11200400 million Euro. Revenue Growth ranges from -98.32% to 569.27% and indicates variability in the composition of capital as the standard deviation is 19.36% compared to a mean of 52.24%. Return on Assets shows an average return of 3.11% with a standard deviation of 4.10%. It ranges from 0.20% to 37.83%.

For each variable for which a dummy variable is made, the number of 1's in the binary variable varies but is at least 12% as can be seen in the column 'Mean'. Obviously for each of these dummy variables, its minimum and maximum value are respectively 0 and 1, as it is a binary variable. 88% of the observations are categorized under Medium Barclays Rating Dummy (BR), 72% under EURO Currency Dummy (EUR) and 71% under Medium Issuer Rating Dummy (IR). The standard deviations for these dummies are respectively 0.32, 0.45 and 0.46. For the FTSE Sector Dummies, the observed mean values are lower and are 12%, 13% and 22% for respectively the Industrial, Real-Estate and

Utility dummy. The corresponding standard deviations to these variables are respectively 0.33, 0.33, and 0.41.

4.5.2 Final Statistics for the partial regression

Table 19 below contains the number of observations (Obs) per variable, the mean value (Mean), standard deviation (Std. Dev.), and minimum and maximum value observed per variable (Min/Max) in the full regression.

Table 19. Statistics for the regression variables for the partial regression

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Amount Issued (in million €)	8135	826.56	3955.26	150.00	100000.00
Maturity (MAT) (in years)	8135	10.11	9.99	2.00	100.00
Dummy Variables	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Medium Barclays Rating Dummy (BR)	7124	0.88	0.33	0.00	1.00
Medium Issuer Rating Dummy (IR)	5514	0.68	0.47	0.00	1.00
EURO Currency Dummy (EUR)	5280	0.65	0.48	0.00	1.00
FTSE Sector Dummies	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Industrial (IND)	1138	0.14	0.35	0.00	1.00
Real-Estate (RE)	893	0.11	0.31	0.00	1.00
Utility (UT)	2392	0.29	0.46	0.00	1.00

From these sample statistics we observe that 8135 observations are available for the numerical variable Maturity and the Amount Issued. For Amount Issued, we observe a mean of 826.56 million Euro and a standard deviation of 3955.26 million Euro, indicating a wide dispersion of values around the mean, just like in Table 18. Again, the range from minimum to maximum issue size demonstrates significant variability in the issuance amounts, as the lowest amount issued is 150 million Euro and the maximum is 100000 million Euro. The same holds for the variable Maturity, which shows a standard deviation of 9.99 years compared to a mean of 10.11 years and a minimum and maximum maturity of respectively 2, and 100 years.

For each variable for which a dummy variable is made, the number of 1's in the binary variable varies but is at least 11%. 88% of the observations are categorized under Medium Barclays Rating Dummy, 68% under Medium Issuer Rating Dummy (IR) and 65% under EURO Currency Dummy (EUR). The standard deviations for these three dummies are respectively 0.33, 0.47 and 0.48. For the FTSE Sector Dummies, the observed mean values are lower and are 14%, 11% and 29% for respectively the Industrial, Real-Estate and Utility dummy. The corresponding standard deviations to these variables are respectively 0.35, 0.31, and 0.46.

4.6 Outliers

With the data that is left, it is observed whether any large outliers are present which could influence the regression analysis. From Figure 3, it can be seen that for all issuances from 2019 until 2023, there are clear outliers in issue sizes. As these outliers are likely to cause errors in the regression analysis, the issue sizes are converted with the natural logarithm to remove large value bias, as mentioned before in chapter 3, and suggested by Barua and Chiesa. In the full regression, the same is done to remove large value bias and heteroscedasticity for the variable Total Assets as can be seen in Figures 5 and 6.

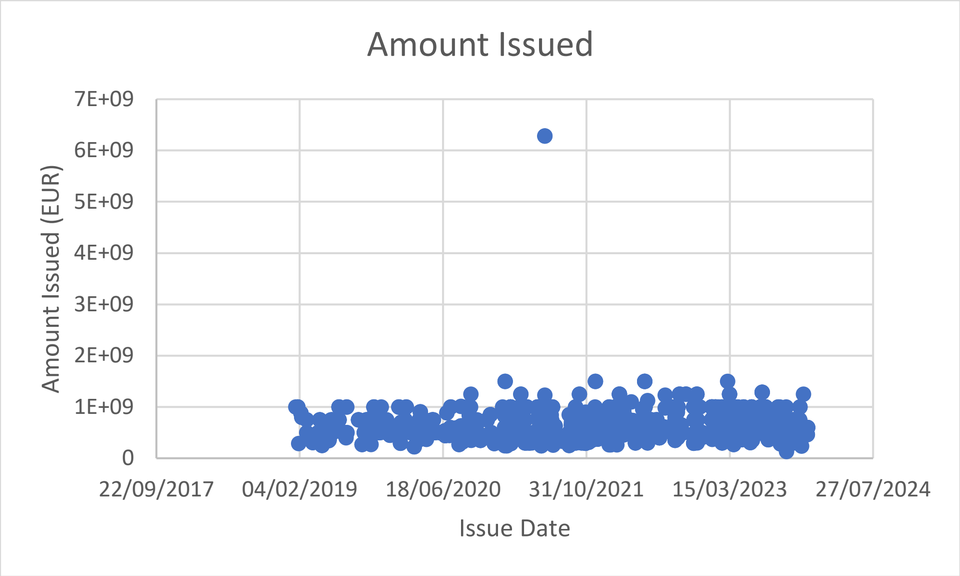

Figure 3. Outliers observed in issue size for all green bonds data

When applying the natural logarithm over the issue size, the resulting plot shows no very large outliers anymore, as can be seen below in Figure 4.

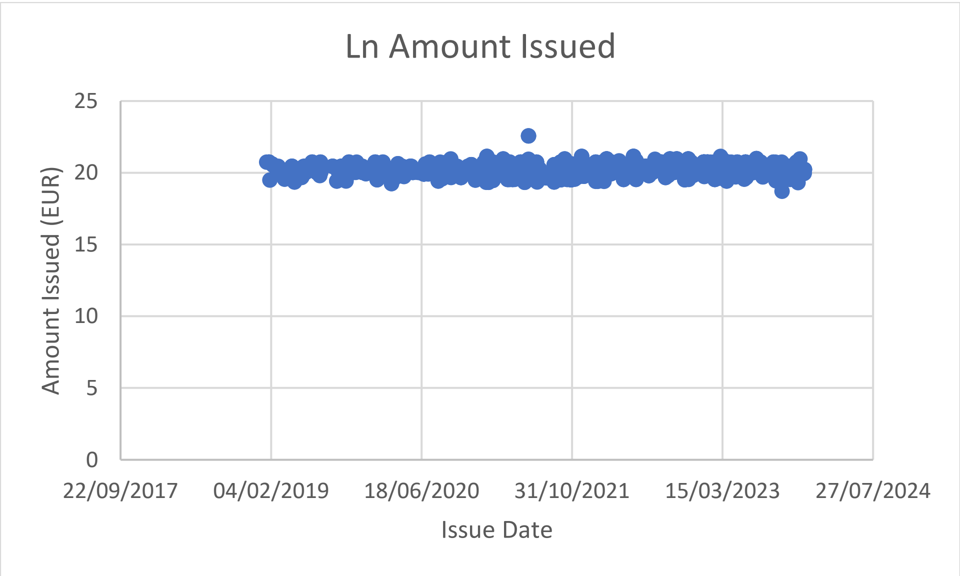

Figure 4. Natural logarithms of issue sizes of all green bonds issued

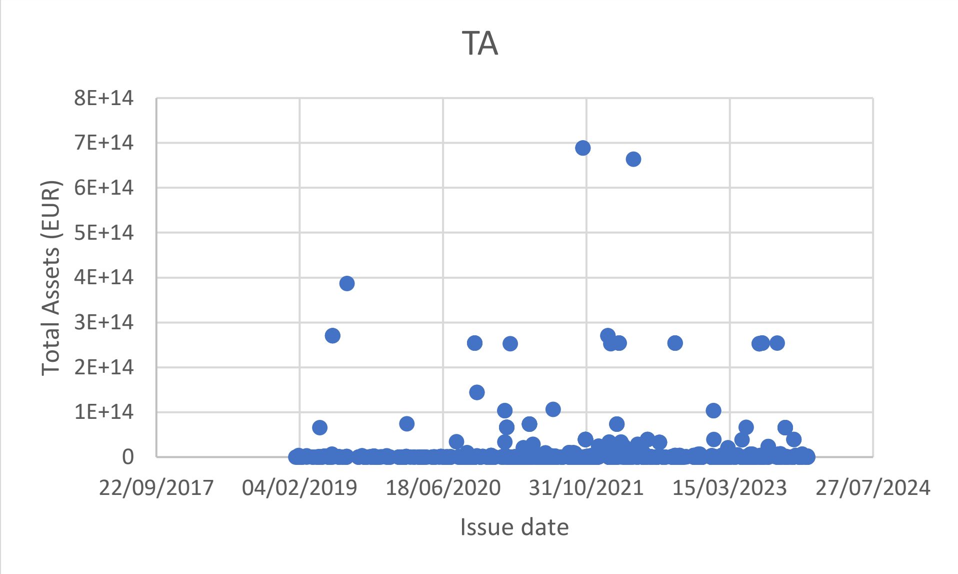

Figure 5. Outliers observed in Total Assets for all green bonds data

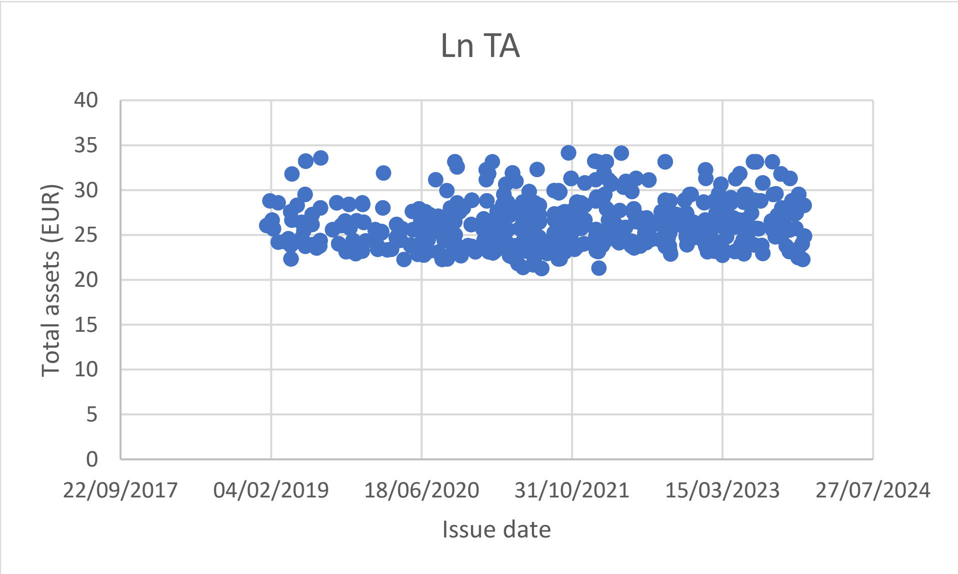

Figure 6. Natural logarithms of Total Assets for all green bonds issued

4.7 Modelling

On the data, ordinary least squares regression is applied to see which variables influence the size of green bond issuance.

The available variables in Aladdin could be collected into a similar linear relationship as defined by Barua and Chiesa, as mentioned before in Chapter 3. By filing in the available variables and abbreviations as defined in Table 18, and by applying the econometric model from Barua and Chiesa, the function for the full regression with all variables will become of the form:

$$Ln(\mathrm{Issue}_{\mathrm{size}_\mathrm{i}}) = \alpha + \beta_1 \mathrm{C}P_i + \beta_2 \mathrm{MAT_i} + \beta_3 \mathrm{Ln(TA_i)} + \beta_4 RG_\mathrm{i} + \beta_5 \mathrm{CS_i} + \beta_6 ROA_\mathrm{i} + \beta_7 BR_i + \beta_8 \mathrm{EUR_i} + \beta_9 \mathrm{IR_i} + \beta_{10} \mathrm{IND_i} + \beta_{11} \mathrm{RE_i} + \beta_{12} \mathrm{UT_i} + \varepsilon_i$$

For the partial regression with only a few independent variables considered, the function will be of the smaller form:

$$Ln(\text{Issue}_{\text{size}_i}) = \alpha + \beta_1\text{MAT}_i + \beta_2\text{MAT}_i + \beta_3 BR_i + \beta_4 IR_i + \beta_5\text{EUR}_i + \beta_6 IND_i + \beta_7\text{RE}_i + \beta_8 UT_i + \varepsilon_i$$

As mentioned before, here α is the intercept, β_k the coefficients that will be estimated and ε_i is the error term. As mentioned before, for the variables Barclays Rating, Currency, Issuer Rating, and FTSE Sector, dummy variables are made, as these variables are categorical and don't take numerical values. First, the parameters of the equation are estimated in Excel by using ordinary least squares regression for all bonds together. Then, the same OLS regression is done for all other years from 2019 until 2023.

4.7.1 Correcting for heteroscedasticity

As we know now which variables are left out due to multicollinearity, ordinary least squares regression can be performed with robust-standard errors to produce standard errors corrected for heteroscedasticity, as already mentioned in section 3.1. The Real Statistics Data Analysis Tool in Excel allows for producing heteroscedasticity-corrected standard errors by means of the White-Huber standard errors method, which should, according to Barua and Chiesa "obtain the efficient least square estimators and appropriate statistics." (Barua & Chiesa, 2019). In the next chapter, the results will be discussed.

4.8 Conclusion

This chapter provides no answer to one of the four sub-research questions form section 1.3, but it shows how the necessary data is gathered and processed to be able to perform a regression analysis with it to answer what effect the found variables have on issue size of green bonds in the portfolio of Rabobank. It is shown how to deal with missing variable data, categorical variables, multicollinearity, outliers, and heteroscedasticity. Finally, the econometric models for the full and partial regression are given that will be used to arrive at the results in the next chapter.

5. Results

After correcting the data for multicollinearity and heteroscedasticity, the ordinary least squares regression results can be seen for the full and partial regression per variable in the next sections in Table 20 and Table 21. The results per time period are shown in the numbered columns 1 to 6. The significance levels per variable (P-values) of the regression are denoted by one, two, or three asterisks. Three significance levels are considered, which are the 1%, 5% and 10% significance levels which correspond respectively to three, two and one asterisk. In parentheses, the robust standard errors, as obtained by the White-Huber method can be seen. Also, below the variables, the R-squared value, the adjusted R-squared value, and the constant are denoted. Above the variables, the number of observations and independent variables per regression are denoted, as well as the ratio between these two, which works as an indication of overfitting, as already mentioned in section 4.2.1. When this ratio is below 30, it could be an indication of overfitting, as mentioned by Babyak. (Babyak, 2004)

5.1 Full regression results

In Table 20 below, the full regression results can be seen.

Table 20. OLS regression results of the full regression for all bonds and per year

Dependent variable: Amount Issued in EUR						
Regression	1 (2019-2023)	2 (2019)	3 (2020)	4 (2021)	5 (2022)	6 (2023)
# Observations	1104	101	145	301	287	270
# Indep. variable	12	12	12	12	12	12
Ratio obs./indep. Var.	92	8.42	12.08	25.08	23.92	22.5
CP	4.93 (4.51)	-49.74 (151.66)	1.89 (16.39)	75.69 (109.00)	-23.70 (14.59)	-44.03*** (15.20)
MAT	3.90** (1.57)	4.97 (5.77)	2.49 (1.81)	4.91** (2.21)	-1.30 (3.00)	7.18*** (1.40)
TA	14.55** (6.43)	18.50 (21.90)	22.27*** (8.25)	5.61 (21.92)	10.07 (10.64)	37.62*** (9.73)
RG	-0.28*** (0.09)	-0.51 (0.70)	-0.69** (0.27)	-0.45** (0.18)	-0.34 (0.23)	-0.14 (0.15)
CS	1.63** (0.67)	1.50 (3.26)	-3.16** (1.36)	3.06 (2.03)	3.75** (1.53)	0.58 (0.86)
ROA	-3.88** (1.72)	-1.82 (36.10)	26.08** (11.15)	-6.75 (4.40)	-11.56** (5.26)	3.07 (3.41)
BR	-69.55 (46.72)	48.50 (134.31)	-42.34 (64.46)	-89.66 (87.47)	-155.42 (176.31)	-79.19* (46.35)
EUR	-41.90 (52.72)	-184.11 (562.35)	27.26 (42.32)	-118.87* (60.72)	-154.64 (162.91)	125.99*** (36.83)
IR	80.43*** (25.46)	-150.92 (228.30)	69.83 (31.88)	145.77** (70.93)	12.95 (81.64)	128.47*** (31.72)
IND	64.39** (30.89)	-91.77 (225.19)	-131.83 (96.44)	36.86 (73.22)	77.68 (98.42)	56.86 (50.96)
RE	-130.06***	-179.72	-221.67	-158.93*	-90.79	-11.12

	(26.58)	(109.34)	(68.79)	(82.58)	(72.93)	(86.19)
UT	21.60	-130.65	-4.37	176.82	-17.80	-51.77
	(32.20)	(96.37)	(59.98)	(153.87)	(40.12)	(40.47)
Constant	606.13***	898.70	721.94***	453.97	908.30**	692.23***
	(78.61)	(637.18)	(147.56)	(298.25)	(360.27)	(120.03)
R Square	0.05	0.12	0.34	0.10	0.09	0.26
Adjusted R Square	0.04	-0.01	0.28	0.06	0.05	0.22

The first thing that stands out from these full regression results, is that the ratio between observations and independent variables is only above 30 for the dataset with all bonds between 2019-2023. For all other datasets it is below 30 which could be an indication of overfitting. From the R squared values in Table 20, we notice that for all bonds between 2019 and 2023, only about 5% of the variations in issue size can be explained by the variations in the regression variables. The explanatory strength of the model is higher for all individual years in columns 2 to 6, but still remains low as the highest R square value is find for bonds issued in 2020 and is only 0.34.

For the variable Coupon, we notice that the coefficient fluctuates across different years. Sometimes it is positive, sometimes negative. Only for the year 2023 it is significant and shows a negative effect. Maturity also shows a mixed effect on green bonds issue size across different years. Significance of the coefficients is only found in 2021, 2023 and for the whole period 2019-2023, in which the coefficients all show a positive effect. Total Assets seems to have a positive effect on green bond issue size for all time periods considered. In 2020, 2023 and the period between 2019 and 2023, the coefficients are significant. Revenue Growth shows a consistent negative effect on issue size, but only shows significance for the period with all bonds, and in 2020 and 2021. Capital Structure mostly shows a positive effect on issue size but shows a negative effect for bonds issued in 2020. A 5% significance is only observed for all bonds and in 2020 and 2022. Return on Assets shows a wide mix of results, as it shows a positive effect on issue size in 2020 and 2023 but shows a negative effect in all other years. Significance is only observed in 2020, 2022 and the period with all bonds considered.

Then for the dummy variables considered, only the Real-Estate Sector shows a consistent negative effect on issue size, but only shows significance in 2021 and over the period with all bonds. All other dummy variables show no consistent negative or positive effect over all years considered. Barclays Rating mostly shows a negative effect except for 2019, but only shows significance in 2023. The Euro currency variable also mostly shows a negative effect except for 2020. It shows significance only in 2021 and 2023. Issuer Rating, on the other hand, mostly shows a positive effect but only shows a negative effect on issue size in 2019. It only shows significance in 2021, 2023 and over the period with all bonds considered. The industrial sector and utility sector dummies show no consistent positive or negative effect, neither do they show a consistent significant effect among its coefficients.

5.2 Partial regression results

In Table 21 below, the partial regression results can be seen.

Table 21. OLS regression results of the partial regression for all bonds and per year

Dependent Variable: Amount Issued in EUR						
Regression	1 (2019-2023)	2 (2019)	3 (2020)	4 (2021)	5 (2022)	6 (2023)
# Observations	8135	786	1088	2071	2125	2065
# Indep. variable	7	7	7	7	7	7
Ratio obs./indep. Var.	1162.14	112.29	155.43	295.86	303.57	295
MAT	0.00*** (0.00)	0.00** (0.00)	0.00 (0.00)	0.01*** (0.00)	0.00 (0.00)	0.01*** (0.00)
BR	-0.12*** (0.02)	-0.28*** (0.08)	-0.02 (0.04)	-0.09** (0.04)	-0.08*** (0.03)	-0.16*** (0.05)
IR	0.13*** (0.01)	0.16*** (0.05)	0.07*** (0.03)	0.20*** (0.02)	0.19*** (0.02)	0.02 (0.02)
EUR	0.08*** (0.01)	0.03 (0.05)	0.17*** (0.02)	-0.04 (0.03)	0.22*** (0.02)	0.01 (0.03)
IND	-0.01 (0.02)	-0.19*** (0.06)	0.06 (0.04)	-0.07** (0.03)	0.01 (0.03)	0.01 (0.02)
RE	-0.19*** (0.01)	-0.24*** (0.06)	-0.16*** (0.03)	-0.22*** (0.03)	-0.08*** (0.03)	-0.19*** (0.04)
UT	-0.10*** (0.01)	-0.27*** (0.05)	-0.05** (0.03)	-0.17*** (0.04)	0.00 (0.02)	-0.15*** (0.02)
Constant	20.21 (0.03)	20.42 (0.09)	20.06 (0.05)	20.17 (0.05)	20.03 (0.04)	20.39 (0.06)
R Square	0.05	0.11	0.11	0.05	0.10	0.05
Adjusted R Square	0.05	0.11	0.11	0.05	0.05	0.04

As compared to the full regression results, the partial regression results show better values for the ratios between observations and independent variables, as for all regression, it is far above 30, since the partial regression considers more data, with less independent variables. From the R squared values in Table 21, we notice that for all bonds between 2019 and 2023, just like in the full regression, only about 5% of the variations in issue size can be explained by the variations in the regression variables. This low explanatory power of the model is at a similar level in 2021 and 2023. In the years 2019, 2020 and 2022 it is slightly higher, but still low, at a level of approximately 10%.

For the variable Maturity, we notice that the coefficient is positive over all years, but only significant in the periods 2019-2023, 2019, 2021 and 2023. Barclays Rating shows a consistent negative effect on issue size. The effect is significant over all time periods considered except for 2020. Issuer Rating shows a consistent positive effect, which is significant in all time periods except 2023. The Euro currency dummy shows mixed results, as it shows a negative effect in 2021, but a positive effect in all other time periods. Significance is only seen in the periods 2019-2023, 2020 and 2022. The industrial sector dummy also shows mixed results, as in 2020, 2022, and 2023 it shows a positive effect and in the other time periods it shows a negative effect. For this variable, significance is only observed in 2019 and 2021. For the real-estate sector dummy, we observe a consistent negative effect on issue size that is significant in all time periods except for 2022. The utility sector dummy shows a significant negative effect on issue size in all periods except for 2022, where it shows a positive and insignificant effect.

5.3. Conclusion of Results

In this chapter, the fourth sub-research question from section 1.3 can be answered. From Table 20 and 21 we can draw conclusions about what effect the found variables have on the issue size of green bonds in the portfolio of Rabobank and we can compare these results to the findings of Barua and Chiesa from 2019. The first thing that stands out is whether the results of the regression analyses can be trusted or not, based on the ratio between observations and independent variables. It seems that the most reliable results come from the partial regression results and in the full regression only from the regression that considers all bonds between 2019 and 2023. Drawing conclusion from the other 5 columns in the full regression could be unreliable due to overfitting.

When we compare the results of the regression over all bonds in the full regression with the partial regression results over the same time period, we observe that maturity has a positive significant effect in both. Bond rating has a negative effect in both, but is only significant for the partial regression. Issuer rating is both positive and significant in both the full and partial regression. The Euro currency dummy shows a significant positive effect in the partial regression and an insignificant negative effect in the full regression. For the industrial sector dummy, it is the other way around. The real-estate currency dummy shows a negative significant effect in both the full and partial regressions, whereas the utility sector dummy shows a negative significant effect in the partial regression, but a positive insignificant effect in the full regression.

When comparing our results with the findings from Barua and Chiesa, the first thing that stands out is the difference of explanatory power. Barua and Chiesa find R-squared values of at least 0.58, whereas in our regressions, the highest found value is 0.11 in the partial regression results and 0.34 for one of the results in the full regression. An explanation for this could be that Barua and Chiesa have more variables available in their research. It could be the case that some important predictor variables are missing in our model, which capture the true relationship between issue size and the depending variables. For example, as shown in Table 7, some variables like risk premium or security were used in the research of Barua and Chiesa but are not available in Aladdin. Another reasoning could be that the assumption of a linear relationship between the independent and dependent variables does not hold anymore with the newer portfolio data considered, which could explain low R-squared values. It could also be the case that the time difference between our regression and the regression of Barua and Chiesa plays a role. Market circumstances such as for example interest rates or availability of funding could have changed the willingness of issuers to issues green bonds, and therefore affecting the explanatory power of our regression analysis.

6. Conclusions, limitations, and recommendations

This chapter concludes the research by answering the main research question as stated in chapter 1, section 1.3 and discusses limitations of the research and provides recommendations for further research.

6.1 Conclusion

In section 1.3, the main research question was stated as follows:

> Which variables affect the issue size of green bonds in the portfolio of Rabobank?

Based on the results in chapter 5, the variables that have a positive and significant effect on green bonds issue size are maturity, issuer rating, firm size and capital structure. The variables with a negative significant effect on green bonds issue size are bond rating, revenue growth, return on assets and the real-estate sector. The variables with an unclear effect due to different results in the full and partial regression are the euro currency, industrial sector and utility sector.

When comparing these effects to the expected effects of these variables as mentioned in section 2.3.1, only for maturity, issuer rating, firm size, revenue growth, total assets and return on assets the expected effects have come true. For maturity, a positive effect on issue size was expected due to larger issue sizes corresponding to larger firm sizes which influence the duration of a bond. We indeed observe a positive effect on issue size for the variable firm size as well. So, our hypothesis about larger firms being able to issue larger bonds and bonds of longer durations is true. For the variable issuer rating, a positive effect was expected as well as we expected that investors would have more confidence in a bond issued by an issuer with a good issuer rating. Our hypotheses also hold for the variables revenue growth and return on assets, as apparently better performing, and more profitable companies indeed need less external financing.

Apparently, our hypotheses were not true for the variables capital structure, bond rating and the real estate-sector. For the first variable, capital structure, we expected a negative effect, but the regression results showed a positive effect. We reasoned that investors might perceive bonds issued by issuers with a larger debt to capital ratio as riskier. The observed positive effect could have multiple explanations but one of them could be that companies with higher debt levels might also have stronger growth prospects, which could attract investors to their issued green bonds which would lead to a positive effect of capital structure on issue size. For bond rating, we expected a positive effect but observed a negative one. We reasoned that the better the bonds rating, the more creditworthy and less risky it would be, leading to more confidence from investors and therefore higher issue sizes. However, our regression analysis considers medium rated bonds only and a dummy variable determines whether this rating is available or not. This medium rating could be perceived as low enough to show a negative effect on bond rating. For the variable sector, we expected a positive effect. This hypothesis only mentioned that we expect some sectors to raise more money than others. Therefore, the explanation for the negative effect of the real-estate sector could be that this is one of the sectors that does not attract many issuances in green bonds.

However, it should be noted that due to the very low R squared values in the regression, the explanatory strength of the model is low. This means that the explanatory variables included in our model do not capture a significant portion of the variation in green bonds issue size. Therefore, it could be concluded that the variables considered are of little influence on green bonds issue size, despite showing significance.

For Rabobanks' policy regarding green bonds, the effects found could say something about market circumstances. For example, if the value of certain risk drivers decreases, this could mean market tightness on the supply side of the market. All variables that show a significant effect could be monitored for risk management purposes and Rabobank could alter its investment strategies according to observed changes in variables that have a certain effect on the supply side of the market in green bonds. This could mean reallocating the portfolio composition or exploring other markets.

6.2 Limitations of the research

As mentioned in chapter 4, the remaining sample size of green bonds after omitting green bonds with no data for some of the depending variables, is limited, due to many variable data not being available for every green bond issued. Therefore, a limitation of this research is the data availability. With more data available for each variable for each green bond, more depending variables could be taken into account in the regression analysis without getting overfitting problems as the ratio between observations and independent variables would remain acceptable. Now, for the full regression, these ratios were not always acceptable, as some green bonds could not be taken into account due to the limited availability of some variable data.

6.3 Recommendations for further research

As was mentioned in chapter 1 and could be seen in Figure 1, Rabobank has raised many questions concerning the topic of green bonds, which all lead up to one core problem. The main research question in section 1.3 only answers a part of these broader problems raised by Rabobank. The research still provides valuable insights into one aspect of the overlapping core problem, but to form a complete understanding of the portfolio allocation problem in green bonds, further research is required. A recommendation for further research therefore is to consider the entirety of problems raised by Rabobank concerning green bonds to offer a better solution to the core problem.

Another recommendation could be to include variables based on their data availability. To screen the chosen variables based on this, overfitting could be prevented as the ratios between observations and independent variables would remain acceptable as not much green bond data would need to be discarded cause of limited data availability from the variables.

Additionally, a recommendation in further research would be to consider other methods than ordinary least squares regression, such as machine learning algorithms which could capture a non-linear relationship between variables and issue size and could perhaps provide more accurate estimations of the effects.

It could also be recommended to add a control group in future research. This control group could check whether the effects of the variables on the issue size of green bonds is different or similar to the effects of the same variables on the issue sizes of conventional bonds in Rabobanks' portfolio.

This could determine whether the observed effects are unique for green bonds or if they are general for all bond types.

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Appendix 1

2019-2023	CP	MAT	TA	RG	CS	ROA	BR	EUR	IR	FIN	IND	RE	UT
Coupon	1.00												
Maturity	0.07	1.00											
Total Assets	0.00	-0.08	1.00										
Revenue Growth	0.04	-0.13	0.00	1.00									
Capital Structure	-0.11	-0.11	0.01	0.06	1.00								
Return on Assets	0.07	0.09	-0.08	0.15	-0.33	1.00							
Barclays Rating	-0.01	-0.05	0.00	-0.09	-0.22	0.01	1.00						
EUR Currency	-0.25	0.06	-0.14	-0.08	0.18	-0.10	-0.08	1.00					
Issuer Rating	0.00	-0.04	0.10	-0.06	0.14	-0.10	0.29	-0.12	1.00				
Financial Sector	-0.04	-0.32	0.09	0.10	0.42	-0.51	-0.12	0.18	0.14	1.00			
Industrial Sector	0.14	-0.01	0.08	0.03	-0.42	0.50	-0.01	-0.14	-0.08	-0.37	1.00		
Real-Estate Sector	-0.08	-0.06	-0.08	-0.08	-0.13	0.11	0.02	-0.18	-0.04	-0.38	-0.14	1.00	
Utility Sector	-0.03	0.40	-0.09	-0.10	-0.09	0.10	0.15	0.08	-0.06	-0.53	-0.20	-0.20	1

Figure 7. Full regression correlation matrix of depending regression variables for period 2019-2023

2019	CP	MAT	TA	RG	CS	ROA	BR	EUR	IR	FIN	IND	RE	UT
Coupon	1.00												
Maturity	0.37	1.00											
Total Assets	-0.14	-0.11	1.00										
Revenue Growth	-0.08	-0.13	-0.02	1.00									
Capital Structure	-0.41	-0.19	0.07	0.15	1.00								
Return on Assets	0.31	0.16	-0.15	0.28	-0.02	1.00							
Barclays Rating	0.23	0.13	0.08	-0.15	-0.37	-0.15	1.00						
EUR Currency	-0.68	0.18	0.09	0.04	0.30	-0.17	-0.08	1.00					
Issuer Rating	0.03	-0.08	0.11	-0.16	-0.04	-0.25	0.60	-0.18	1.00				
Financial Sector	-0.64	-0.40	0.24	0.19	0.37	-0.48	-0.31	0.30	0.02	1.00			
Industrial Sector	0.25	-0.04	0.00	0.10	0.02	0.53	-0.30	-0.09	-0.20	-0.19	1.00		
Real-Estate Sector	0.22	-0.13	-0.09	-0.22	-0.23	-0.02	0.17	-0.24	0.03	-0.35	-0.10	1.00	
Utility Sector	0.28	0.57	-0.16	-0.13	-0.24	0.14	0.29	0.05	0.00	-0.60	-0.17	-0.30	1.00

Figure 8. Full regression correlation matrix of depending regression variables for 2019

2020	CP	MAT	TA	RG	CS	ROA	BR	EUR	IR	FIN	IND	RE	UT
Coupon	1.00												
Maturity	0.33	1.00											
Total Assets	-0.02	-0.04	1.00										
Revenue Growth	0.01	-0.20	-0.05	1.00									
Capital Structure	-0.15	-0.01	0.04	0.09	1.00								
Return on Assets	0.11	-0.13	-0.19	0.24	-0.42	1.00							
Barclays Rating	-0.15	-0.20	0.07	-0.07	-0.31	0.14	1.00						
EUR Currency	-0.47	0.05	0.00	0.04	0.18	-0.06	-0.12	1.00					
Issuer Rating	-0.09	0.13	0.02	-0.03	0.07	-0.18	0.20	-0.05	1.00				
Financial Sector	-0.34	-0.13	0.16	0.27	0.43	-0.60	-0.25	0.23	0.16	1.00			
Industrial Sector	-0.02	-0.06	-0.03	0.09	-0.45	0.47	-0.02	-0.06	0.04	-0.26	1.00		
Real-Estate Sector	0.25	-0.16	-0.12	-0.23	-0.16	0.21	0.10	-0.11	-0.18	-0.42	-0.20	1.00	
Utility Sector	0.15	0.28	-0.01	-0.09	-0.03	0.04	0.21	-0.05	-0.08	-0.43	-0.21	-0.34	1.00

Figure 9. Full regression correlation matrix of depending regression variables for 2020

2021	CP	MAT	TA	RG	CS	ROA	BR	EUR	IR	FIN	IND	RE	UT
Coupon	1.00												
Maturity	0.27	1.00											
Total Assets	-0.08	-0.09	1.00										
Revenue Growth	0.21	-0.15	0.01	1.00									
Capital Structure	-0.30	-0.15	0.01	0.06	1.00								
Return on Assets	0.14	0.02	-0.04	0.22	-0.28	1.00							
Barclays Rating	-0.05	0.07	-0.17	-0.12	-0.19	-0.05	1.00						
EUR Currency	-0.61	0.17	-0.06	-0.23	0.21	-0.01	-0.12	1.00					
Issuer Rating	-0.08	-0.08	0.09	-0.18	0.13	-0.02	0.29	-0.19	1.00				
Financial Sector	-0.41	-0.31	0.07	-0.08	0.42	-0.48	-0.06	0.14	0.14	1.00			
Industrial Sector	-0.01	-0.04	0.15	0.08	-0.39	0.34	0.02	-0.07	-0.06	-0.30	1.00		
Real-Estate Sector	0.32	-0.14	-0.09	0.02	-0.12	0.23	-0.08	-0.18	0.04	-0.48	-0.16	1.00	
Utility Sector	0.06	0.55	-0.08	-0.07	-0.09	0.10	0.13	0.12	-0.07	-0.46	-0.15	-0.25	1.00

Figure 10. Full regression correlation matrix of depending regression variables for 2021

2022	CP	MAT	TA	RG	CS	ROA	BR	EUR	IR	FIN	IND	RE	UT
Coupon	1.00												
Maturity	0.21	1.00											
Total Assets	-0.01	-0.05	1.00										
Revenue Growth	-0.01	-0.09	-0.02	1.00									
Capital Structure	-0.09	0.03	0.02	0.05	1.00								
Return on Assets	0.04	0.31	-0.10	-0.04	-0.31	1.00							
Barclays Rating	-0.04	-0.17	0.07	-0.07	-0.20	0.05	1.00						
EUR Currency	-0.34	-0.11	-0.26	0.02	0.19	-0.18	-0.11	1.00					
Issuer Rating	0.03	0.14	0.11	0.13	0.05	-0.10	0.25	-0.14	1.00				
Financial Sector	0.03	-0.39	0.12	0.24	0.38	-0.65	-0.15	0.22	0.08	1.00			
Industrial Sector	0.05	0.00	0.03	-0.09	-0.40	0.60	0.05	-0.35	0.03	-0.43	1.00		
Real-Estate Sector	-0.10	0.02	-0.07	-0.14	-0.18	0.06	0.10	-0.14	-0.05	-0.34	-0.11	1.00	
Utility Sector	-0.07	0.31	-0.11	-0.11	-0.07	0.21	0.11	0.13	-0.10	-0.57	-0.18	-0.14	1.00

Figure 11. Full regression correlation matrix of depending regression variables for 2022

2023	CP	MAT	TA	RG	CS	ROA	BR	EUR	IR	FIN	IND	RE	UT
Coupon	1.00												
Maturity	0.32	1.00											
Total Assets	0.17	-0.09	1.00										
Revenue Growth	0.08	-0.13	0.01	1.00									
Capital Structure	-0.18	-0.17	-0.05	0.05	1.00								
Return on Assets	0.07	0.10	-0.07	0.15	-0.46	1.00							
Barclays Rating	-0.11	-0.15	0.07	-0.06	-0.17	0.07	1.00						
EUR Currency	-0.41	0.01	-0.34	-0.05	0.08	-0.13	0.02	1.00					
Issuer Rating	-0.11	-0.13	0.13	0.01	0.27	-0.10	0.26	-0.10	1.00				
Financial Sector	0.00	-0.35	-0.02	0.09	0.51	-0.50	-0.04	0.09	0.20	1.00			
Industrial Sector	0.16	0.10	0.16	0.06	-0.53	0.58	-0.03	-0.10	-0.21	-0.55	1.00		
Real-Estate Sector	0.13	0.00	-0.04	-0.04	-0.03	-0.01	-0.02	-0.18	-0.04	-0.18	-0.08	1.00	
Utility Sector	-0.24	0.26	-0.11	-0.11	-0.12	0.04	0.13	0.08	-0.05	-0.57	-0.26	-0.08	1.00

Figure 12. Full regression correlation matrix of depending regression variables for 2023

2019-2023	MAT	BR	IR	EUR	FIN	IND	RE	UT
Maturity	1.00							
Barclays rating	0.06	1.00						
Issuer Rating	0.04	0.32	1.00					
EUR Currency	-0.07	-0.06	-0.07	1.00				
Financial Sector	-0.27	-0.24	0.03	0.18	1.00			
Industrial Sector	-0.03	0.05	-0.01	-0.02	-0.34	1.00		
Real-Estate Sector	-0.03	0.10	-0.08	-0.09	-0.30	-0.14	1.00	
Utility Sector	0.29	0.14	0.03	-0.10	-0.55	-0.26	-0.23	1.00

Figure 13. Partial regression correlation matrix of depending regression variables for period 2019-2023

2019	MAT	BR	IR	EUR	IND	FIN	RE	UT
Maturity	1.00							
Barclays rating	0.14	1.00						
Issuer Rating	0.09	0.57	1.00					
EUR Currency	-0.06	-0.15	-0.20	1.00				
Financial Sector	-0.10	-0.23	-0.17	0.06	1.00			
Industrial Sector	-0.29	-0.30	-0.09	0.29	-0.24	1.00		
Real-Estate Sector	-0.09	0.15	-0.06	-0.05	-0.12	-0.26	1.00	
Utility Sector	0.42	0.31	0.18	-0.25	-0.28	-0.60	-0.29	1.00

Figure 14. Partial regression correlation matrix of depending regression variables for 2019

2020	MAT	BR	IR	EUR	FIN	IND	RE	UT
Maturity	1.00							
Barclays rating	0.04	1.00						
Issuer Rating	0.13	0.36	1.00					
EUR Currency	-0.03	-0.13	-0.03	1.00				
Financial Sector	-0.21	-0.32	0.01	0.15	1.00			
Industrial Sector	-0.09	0.09	0.15	0.08	-0.26	1.00		
Real-Estate Sector	-0.11	0.13	-0.11	-0.12	-0.31	-0.20	1.00	
Utility Sector	0.28	0.11	-0.02	-0.13	-0.45	-0.29	-0.35	1.00

Figure 15. Partial regression correlation matrix of depending regression variables for 2020

2021	MAT	BR	IR	EUR	FIN	IND	RE	UT
Maturity	1.00							
Barclays rating	0.01	1.00						
Issuer Rating	0.00	0.35	1.00					
EUR Currency	-0.02	-0.07	-0.13	1.00				
Financial Sector	-0.29	-0.13	0.01	0.24	1.00			
Industrial Sector	-0.04	0.02	0.04	0.00	-0.30	1.00		
Real-Estate Sector	-0.07	0.08	-0.05	-0.12	-0.39	-0.15	1.00	
Utility Sector	0.37	0.09	0.09	-0.12	-0.51	-0.20	-0.26	1.00

Figure 16. Partial regression correlation matrix of depending regression variables for 2021

2022	MAT	BR	IR	EUR	FIN	IND	RE	UT
Maturity	1.00							
Barclays rating	0.07	1.00						
Issuer Rating	0.06	0.31	1.00					
EUR Currency	-0.17	-0.04	-0.04	1.00				
Financial Sector	-0.20	-0.22	0.07	0.18	1.00			
Industrial Sector	-0.06	0.11	0.04	-0.20	-0.39	1.00		
Real-Estate Sector	-0.01	0.09	-0.14	-0.03	-0.28	-0.14	1.00	
Utility Sector	0.21	0.08	-0.03	-0.01	-0.56	-0.27	-0.20	1.00

Figure 17. Partial regression correlation matrix of depending regression variables for 2022

2023	MAT	BR	IR	EUR	FIN	IND	RE	UT
Maturity	1.00							
Barclays rating	0.07	1.00						
Issuer Rating	-0.05	0.20	1.00					
EUR Currency	-0.04	-0.01	-0.01	1.00				
Financial Sector	-0.30	-0.28	0.09	0.08	1.00			
Industrial Sector	0.11	0.11	-0.14	0.05	-0.43	1.00		
Real-Estate Sector	0.00	0.06	-0.04	-0.08	-0.16	-0.07	1.00	
Utility Sector	0.23	0.17	-0.01	-0.12	-0.61	-0.29	-0.10	1.00

Figure 18. Partial regression correlation matrix of depending regression variables for 2023