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THE RELATIONSHIP BETWEEN THE ISSUANCE OF GREEN BONDS AND THE YTM OF FUTURE CONVENTIONAL BONDS

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Abstract

This thesis explores the relationship between green bond issuance and the Yield to Maturity (YTM) of subsequent conventional bonds in the Euro Area. Utilizing multilinear regression, the analysis reveals a nuanced and inconclusive connection. Limitations, including a small dataset and unexplored temporal aspects, highlight the need for refined methodologies. Despite the complexity of findings, this study underscores the intricate dynamics between green and conventional bonds, emphasizing the demand for comprehensive datasets and advanced methods in understanding their evolving relationship within sustainable finance.

Keywords: Sustainable Finance, Green Capital, Green Bonds, Yield to Maturity, Green Bond Principles, Green Bond Market, EU Taxonomy

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Introduction

Environmentally responsible and sustainable practices are causing a radical change in the global financial scene. Green bonds have gained a lot of attention as a crucial tool for funding sustainable initiatives throughout this paradigm shift in terms of their introduction and spread. Unlike traditional bonds, green bonds only allocate capital to environmentally friendly initiatives and adhere to the integrity and transparency standards of the Green Bond Principles (GBP), which were created by the International Capital Markets Association (ICMA) in 2018. Europe is leading the way in this transition as the financial sector adjusts to the demands of climate change and sustainable development. To reduce greenhouse gas emissions by 2050, the European Commission launched the European Green Deal in 2019. It lays out a comprehensive roadmap for a modern, resource-efficient, competitive economy. The European Green Bond Standard (EUGBS), a voluntary standard designed to promote uniformity and comparability within the green bond market, is essential to this approach. The European Union (EU) is prepared to create a strong regulatory framework for green bonds, demonstrating its commitment to sustainable finance, with the legislation scheduled to go into force in December 2024.

With a focus on Europe—the continent with the biggest bond issuance and one that has taken the lead in influencing green finance legislation—this study undertakes a critical investigation of the complex relationships between green bonds and conventional bonds. The primary objective is to examine if the issue of green bonds has an impact on the Yield to Maturity (YTM) of conventional bonds that follow. The YTM, a basic indicator in bond valuation, acts as a prism through which we may understand the larger consequences of green bond issuance on the conventional bond market.

This thesis digs into the intricacies of the green bond market, its development, and the possible ramifications for conventional bonds, within the context of the European Green Deal and the

approaching regulatory framework. Our research is based on a thorough analysis of the literature, which provides information about the financial benefits of green bonds for investors and issuers alike. Still, there are significant gaps that call for a careful analysis of the connection between conventional and green bonds.

Through an extensive data collection and incorporating a multilinear regression analysis this research aims to understand what the relationship between the issuance of green bonds is and the YTM of future conventional bond within the context of the Euro Area. Although the results are different from the initial hypothesis, this research could contribute as a starting point to enhance the understanding of the effect that green bonds have on the issuer.

Green Bonds

What is a green bond?

Green bonds are fixed-income securities that distinguish themselves from conventional bonds by designating the proceeds exclusively for financing or refinancing eligible green projects, such as renewable energy or sustainable water management, with the aim of promoting social welfare and climate-related sustainable activities (Tang and Zhang, 2018; Fatica, Panzica, and Rancan, 2020). What mainly differs green bonds from conventional bonds is that the financed projects should be in conformance with the Green Bond Principles. (ICMA 2018)

Green Bond Principles

The International Capital Markets Association (ICMA) launched the Green Bond Principles (GBP) as voluntary principles to promote integrity and transparency in the green bond market. These guidelines provide guidance to issuers, such as governments, banks, or business organisations, describing the necessary requirements for issuing a green bond. Facilitating the availability of information required to increase capital allocation to environmentally friendly

projects is the main objective of the GBP. Their goal is to make the process of issuing green bonds more transparent.

The GBP is made up of four primary components: use of proceeds, process for project evaluation and selection, management of proceeds, and reporting. When issuing green bonds, issuers are urged to conform to these criteria and show that they are dedicated to shifting their business models towards increased environmental sustainability by means of particular projects.

Following these guidelines enables issuers to demonstrate their commitment to environmental sustainability, and the GBP emphasises how crucial disclosure, transparency, and appropriate proceeds management are to preserving the integrity of the green bond market.

The four components:

1. **Use of proceeds:**

   The first principles states that the utilisation of the proceeds should be dedicated to green projects which must be legally documented. Moreover, the green projects should provide clear environmental benefits which must be assessed by the issuer.

2. **Process for Project Evaluation and Selection:**

   The abovementioned principle emphasises how crucial is establishing a rigorous process for evaluating and selecting green projects. Therefore, issuers are encouraged to make more accurate disclosures on environmental benefits driven by the project, the criteria used for project selection, and the process used for ensuring that the proceeds are invested in proper green activities.

3. **Management of proceeds**

   This principle ensure that the proceeds are used exclusively for the given green project. Hence, issuers are expected to create monitoring and tracking mechanisms to give

investors information regarding how the funds are being managed and used throughout the life of the green bond.

4. **Reporting**

   Issuers must furnish and keep up-to-date information regarding the utilization of proceeds, with annual updates until complete allocation and immediate reporting in the event of significant developments. The yearly report should provide comprehensive insights into the allocation of Green Bond proceeds, encompassing project specifics, allocated amounts, and anticipated impacts. In cases where confidentiality agreements, competitive factors, or a considerable number of projects restrict detailed disclosure, the GBP suggests presenting information in more generalized terms or aggregating it on a portfolio basis (such as indicating the percentage allocated to specific project categories).

Green Bond Market

European Green Deal and European Green Bond Standard

The European Green Deal was established by the European Commission in December 2019, it is a set of policies with the aim of cutting greenhouse gasses emissions by 2050 by transforming the EU into a modern, competitive and resource efficient economy.

Moreover, the European Green Deal underscores the importance of adopting a comprehensive and interconnected strategy, wherein all pertinent policy domains actively contribute to the overarching climate-related objective.

It spans across diverse policy domains such as climate, energy, transport, and taxation, with the objective of enhancing resource efficiency through a shift to a clean, circular economy. Simultaneously, it addresses challenges like climate change, biodiversity loss, and pollution. The initiative places a notable emphasis on sustainable investments as a key driver for

implementing the European Green Deal, allocating a substantial portion of the EU's recovery plan and budget to fund its initiatives.

In greater details, the European Green Deal places a strong emphasis on the necessity of diverting financial flows to investments that are environmentally sustainable. An effective strategy to accomplish this goal is to issue green bonds.

Therefore, the European Commission emphasised the need of having guidelines which would facilitate the enhancement of financial and capital flows into green investments thus establishing the European Green Bond Standards (EUGBS).

The EUGBS is a voluntary standard that seeks to foster consistency and comparability in the green bond market by trying to guarantee that the net proceeds from all bonds are distributed in accordance with e EU taxonomy.

Green Bond Market development

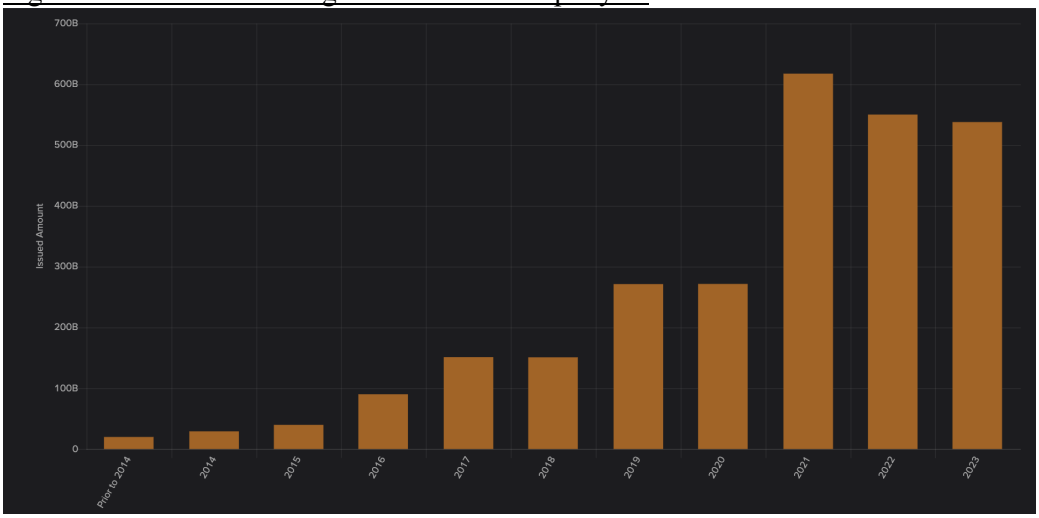
The roots of green bonds are very recent. The first green bond was issued in 2007 by the European Investment Bank with the name of “Climate Awareness Bond”. Since then, thanks to a growing interest and concern regarding climate change and the environment, the Green Bond Market has seen a very rapid increase in the recent years. According to the European Environment Agency, from 2014 to 2021 the issuance of green bonds rose from 0.6% to 8.9% of total bond issued. According to Refinitiv Eikon, the total amount of green bond issued from 2007 until today is 2.79 trillion dollars. As it is possible to see from Diagram 1, the most significant increase in issuance has started in 2019, the same years as the approval of the European Green Deal, driven by an increase in issuance of the private sector green bond market.

Regarding countries, according to Statista, in 2022, China led the global issuance of green bonds, surpassing all other nations by issuing green bonds valued at over $85 billion. The

United States secured the second position, having issued green bonds amounting to $64.4 billion, followed by Germany in third place with $61.2 billion in green bonds.

The big paradox of China is that not only it holds the record for amount issued in green bonds but also for the most polluting country in the world as it the largest contributor to carbon dioxide emissions globally, generating, according to the New York Times, an annual total of 12.7 billion metric tons of emissions. Nonetheless, China committed in the Paris Agreement to achieve its emissions peak by 2030 and increase the proportion of non-fossil fuel energy, such as wind, solar, and nuclear, to 25 percent. Additionally, in 2021, President Xi Jinping announced China's goal to attain carbon neutrality by 2060. China, therefore, is using green bonds as a method for offsetting carbon dioxide emissions to meet the Paris agreement. According to S&P Global, the latter is expected to stay a preeminent actor in the green bond market also for the following years.

Figure 1: Total Amount of green bonds Issued per year



Source: Refinitiv Eikon

Overall, by 2024, according to ING, the global green bond market is projected to generate USD 225 billion in revenue in the US dollar market and € 225 billion in the euro market. This increase is anticipated to continue. Moreover, what will drive the increase in the euro market is the entering into force between November and December 2023 of the European Green Bond

legislation. This last, is expected to increase transparency in the market and increase in supply of green bonds.

Literature review

Green bonds are a rapidly evolving segment of bond market thanks to the overall increase in awareness on climate change and the implementations of governments and central banks of policies promoting transition to net zero.

This literature review seeks to provide a comprehensive overview of how the issuance of green bonds could represent a benefit both for investors and the issuers itself.

Over the past few years there have been several studies regarding financial advantages deriving from the issuance of green bonds for stakeholders.

Gianfrate e Peri (2019) by analysing 121 European Green bonds issued between 2013 and 2017 by adopting a propensity score matching approach, found out that green bonds are more financially convenient than conventional ones. According to the study GB have a lower yield spread than conventional bonds, indicating a lower cost of capital. The study also found that third-party verification of green bonds, such as certification by the Climate Bonds Initiative, can further reduce the cost of capital for issuers.

Fatica, Panzica and Rancan in their study published in 2020, discovered that the reduction in cost of capital is driven by the increasing in demand from the green bonds itself. The authors analyzed 1,500 bonds issued between 2013 and 2019, finding that the reduction in cost of capital is due to a higher demand for green bonds because of an increase in awareness of environmental issues and a growing interest in socially responsible investing. Zerbib (2019) did not focus only on the reduction of cost of capital, but they also found out that green financing policies also reduce the cost of equity. The authors employed green bonds as a tool to examine how non-monetary factors, specifically pro-environmental preferences, influence

bond market prices. Using a matching method and a two-step regression procedure, they estimated the yield differential between green bonds and a hypothetical conventional bond from July 2013 to December 2017. The results revealed a slight negative premium, indicating that, on average, the yield of green bonds is marginally lower than that of conventional bonds. The average premium stood at -2 basis points for the entire sample and for both euro and USD bonds individually. On the other hand, Ran Zhang, Yanru Li, and Yingzhu Liu (2021) focused their research solely on China, one of the most important participants in sustainable development. As previously discussed, the latter leads the global issue of green bonds. The authors by applying the propensity score matching not only confirmed the previous findings affirming that issuing green bond affects the cost of debt and equity, but they also outlined three ways in which issuing green bonds cut corporate cost of capital. Namely, issuing green bonds reduces the perceived risk for bond issuers, it improves the score liquidity and it reduces information asymmetry.

All studies reported before they do not have only have a common conclusion on how issuing green bonds reduces the cost of capital. They also found out that the reduction in cost of capital is more significant when issuers have a high level of environmental disclosure.

When it comes to Environmental disclosure, as of today, there are no proper rules set by European Commission, but only guidelines that issuers are encouraged to follow.

Therefore, to effectively determine the greenness of bonds, second party opinions have risen in importance. The most famous one is “Shades of green”, created by CICERO and then acquired in 2022 from S&P Global, which has been involved in providing independent, research-based evaluations of green bonds since the issue of the first green bond (from Skandinaviska Enskilda Banken). The Shades of Green methodology provides clear insights into the extent to which a green bond is characterized by low-carbon resilience. Second opinions are categorized as Light Green, Medium Green, and Dark Green to indicate varying

degrees of alignment. Dark Green is assigned to initiatives and solutions aligned with the vision of a future characterized by low-carbon and climate resilience. Examples include solar power plants. Medium Green is designated for projects and solutions that signify substantial progress toward the long-term vision but haven't fully achieved it yet. For instance, this category might include energy-efficient buildings. On the other hand, Light Green is allocated to transition activities that avoid committing to emissions. These projects prioritize reducing emissions or providing immediate environmental benefits rather than representing long-term solutions for low-carbon and climate resilience, such as hybrid road vehicles. (S&P Global)

Research Question and Hypothesis

Based on the existing body of literature, the issuance of corporate green bonds can have a multifaceted impact on a company's financial structure. By signalling a commitment to sustainability, companies may experience a lower cost of capital, which, in turn, can positively influence the cost of leverage. Therefore, our hypothesis posits that the issuance of green bonds could have an impact on the yield to maturity of conventional bonds issued after the green bonds. Previous studies have suggested the existence of a relationship between the issuance of green bonds and the decrease in cost of capital for corporations. The objective of this research is therefore to examine whether the introduction of green bonds affects the pricing of subsequent conventional bonds by looking at the behaviour of the Yield to maturity of conventional bonds.

Hence, the research question will be: how does the issuance of green bonds influences future conventional bonds? The focus of the research will be on Bonds issued on the Euronext market, in order to get a European perspective. Moreover, another reason why Europe is the geographic area of interest of this research is mainly due by the commitment of the European Union of developing proper framework and procedures to regulate the green bond market. As of now,

European Union is the pioneer in terms of green bonds frameworks that allow for a proper classification of green bonds.

The initial hypothesis is that green bonds can have an influence on the YTM of conventional bonds issued afterwards.

Data Collection & Methodology

Data Collection

To create a dataset in order to develop the research, I retrieved the list of green bonds issued from 2014 to October 2023 from the Euronext website as the research is intended to capture the behaviour within the EURO area. I then filtered for green bonds quoted in Euro only and issued within the Euro Zone with the intention of having no currency bias.

I collected all the relevant information from Bloomberg, excluding from the original list the products which BBG was not recognizing as green, that were inactive or that already matured and those who did not have issuance amount, yield to maturity, or coupon. This resulted in a total sample of 309 green bonds.

Instead, to gather data for conventional bonds issued after the issuance of green bonds I did manual research on Bloomberg, picking only active products, not yet matured and with available data on amount issued, coupon and yield to maturity.

It is important to consider that the yield to maturity on BBG refers to the specific date it is downloaded. At the beginning the two data sets were downloaded in different days, but to avoid further bias, both datasets were retrieved again on the second of December.

A common pattern encountered while manually selecting the conventional bonds issued after green bonds is that multiple companies once they issued green bonds kept issuing only green bonds. Therefore, from the original list retrieved from Euronext, those bonds were excluded as well.

Once the two-sample data were completed, risk free rates for the Countries of origin of the bonds were retrieved through Statista.

Data Analysis

Table 1 presents the yearly count and the amount issued (in EUR) of corporate bonds from 2014 through the end of 2023. The data is categorized into conventional and green bonds.

The data indicates a noteworthy upward trend in bond issuance for both categories over time, with Green Bonds exhibiting a steady rise in issuances, indicating a growing demand for investments that prioritise environmental concerns. But even with this expansion, Conventional Bonds have continuously raised the largest amount overall, suggesting a sustained dependence on conventional financing methods. A notable change happened in 2023: while the quantity of Green Bonds issued was still less than that of Conventional Bonds, the total amount of capital raised by means of Green Bonds exceeded that of Conventional Bonds. Even if the below data refers only to the same firms, if generalized to the bond market, could suggest a notable increase in sustainable investments or a specific inclination on the part of the market for green projects. While Green Bonds have grown in popularity over the last decade, the total capital raised through Conventional Bonds has far outpaced that of Green Bonds, highlighting the market's continued dominance of traditional financing despite the growing appeal of environmentally focused investments.

Table 1: Comparison Between Green Bonds and Conventional Bonds

	Green Bonds		Conventional Bonds	
Year	**# Bonds**	**Amount issued**	**# Bonds**	**Amount issued**
2014	2	1800M	11	3,935M
2015	1	500M	9	8,052M
2016	6	6,55M	23	17,843M
2017	12	11,750M	29	34,989M
2018	13	11,850M	29	41,299M
2019	45	34,885M	23	16,885M
2020	53	43,485M	35	23,469M
2021	70	50,179.5	50	6,7654M
2022	63	52,048M	40	35,775M
2023	44	41,525M	60	167,749M
Total	309	254,573M	309	417,650M

Table 2 shows in million dollars the amount issued and the number of green bonds issued between 2014 and 2023 divided by sectors. Sectors is shown in accordance with the already predefined Bloomberg's classification database for each issuer. In this case the financial sector includes three subgroups. Namely, Banks, Insurance and Diversified Financials. Industrial instead comprises Capital Goods, Commercial and Professional Services and Transportation. Is not a surprise that the financial sector accounts for nearly 50% of the total amount issued for the sample data of green bonds as Financial institutions dominate the landscape as the most prominent participants in the green bond market Fatica Panzica and Rancan (2021) find that for banks, engaging in the green debt market is a component of a comprehensive environmental strategy, involving a reduction in lending to sectors associated with higher pollution levels. The second sector in order of importance for number and amount issued of green bonds is Utilities. In this case, Utilities make use of green bonds for financing renewable energy projects such as investments on solar plants.

Table 2: Sector Overview of Green Bonds

Sector	#Bonds	Amount issued (€)
Financial	155	125,222M
Utilities	89	66,175M
Government	22	32,300M
industrial	22	16,575M
Consumer, Cyclical	8	6,850M
Basic Materials	4	2,050M
Energy	4	2,150M
Communications	3	2,000M
Consumer, Non Cyclical	2	1,250M
Total	309	254,572.5M

Table 3 instead, shows the number of bonds issued and their respective amount in million dollars from 2014 to 2023 divided per country of issuance. In this case, since the original data retrieved were green bonds issued though the Euronext, is inevitable that more than 60% of

green bonds of the sample data belongs to three of the bourses controlled by Euronext namely France, Italy, and the Netherlands.

If we consider the whole issuance of green bonds within the EU, France still detains the primate in terms of amount issued. According to Eurostat, in 2022 France had the highest amount issued with €94.7 billion, followed by Germany with €63.1 billion, which together represents 59.2% of total outstanding amount within the Eurozone.

Germany in our data sample is forth in ranking as most of their green bonds is listed and traded on German Exchanges and Luxemburg Green Exchange, which are not part of the Euronext.

With respect to Netherlands, the issuance of green bonds has been increasing rapidly over the course of the last few years not only thanks to the issuance of the first certified severing green bond and government strategy to signal different stakeholders but also thanks to their fiscal regime. Indeed, Netherlands has multiple financial holding companies. It is estimated that nearly one third of Dutch green bonds is issued by financial holdings. Companies operating in this sector usually serve as internal lenders, and the money collected is often invested elsewhere. As such, even while the cash is obtained through a Dutch firm, the final investment and, by extension, the improvement of sustainability, usually take place in a separate jurisdiction, according to The Nederlandsche Bank.

Table 3: Overview on Country of issuance of Green Bonds

Countries	#Bonds	Amount issued (€)
France	88	74.886M
Italy	45	31.500M
Netherlands	46	30.399M
Germany	17	24.250M
Spain	18	15.150M
Sweden	15	9,030M
Norway	10	8,250M
Finland	13	7,500M
United states	8	5,997M
Ireland	8	5,400M
Denmark	8	5,250M
Portugal	6	4,450M
Canada	3	2,010M
China	3	1,650M
Switzerland	3	1,500M
Czech Republic	2	1,500M
Poland	3	1,400M
Belgium	2	1,350M
Romania	1	300M
Others	10	22.800M
Total	309	254,572.5M

Table 4 instead, focuses on the summary statistics of both green and conventional bonds. The table shows mean, median, standard deviation, minimum (Min), maximum (Max) and the total number of observations for each bond category. The bond characteristics analysed are Amount measured in million €, Coupon measured in percentage, Yield to maturity, measured as well in percentage and the maturity; measured in years. What comes up from the summary statistics is that the average amount raised by green bonds is €823.86 million, with a median of €750 million. Green bonds exhibit a relatively lower range, varying from €1 million to €6,000 million. In contrast, conventional bonds have a higher mean amount of €1,238.59 million, showcasing a wider range from €8 million to €29,500 million.

Looking instead at the mean coupon rate; for green bonds is 1.84%, with a median of 1.13%. Green bonds tend to have lower coupon rates, with values ranging from 0% to 6%. On the other hand, conventional bonds, on average, have a higher mean coupon rate of 2.47%, with a median of 2%. The coupon range for conventional bonds varies from 0% to 9.13%.

The mean yield to maturity (YTM) for green bonds is of 3.97%, with a median of 3.69%. Instead, conventional bonds have a slightly higher mean YTM of 4.35%, with a median of 4%. The mean maturity period for green bonds is 9.47 years, with a median of 7.78 years. Green bonds have a diverse maturity range, from 2.78 years to 100 years.

Conventional bonds, on average, have a higher mean maturity of 11.62 years, with a median of 10 years. The maturity period for conventional bonds ranges from 1.92 years to 50 years.

In summary, green bonds in our data set generally appear to have lower financing amounts, lower coupon rates, and shorter maturities compared to conventional bonds. These differences reflect the distinctive characteristics of green bonds, aligning with their focus on funding specific environmental projects and potentially exhibiting a relatively lower risk profile than conventional bonds.

Table 4: Bonds Characteristics

	Bond Characteristics					
	Mean	Median	St. Deviation	Min	Max	N
Green Bonds						
Amount (million€)	823.86M	750M	587.49M	1M	6,000M	309
Coupon (Percent)	1,84	1,13	1,64	-	6,00	309
YTM (Percent)	3,97	3,69	1,49	1,57	18,09	309
Maturity (Year)	9,47	7,78	9,94	2,78	100,00	309
Conventional Bonds						
Amount (million€)	1,238.59M	500M	3,433M	8M	29,500M	309
Coupon (Percent)	2,47	2	1,79	-	9,13	309
YTM (Percent)	4,35	4	1,85	0,34	22,27	309
Maturity (Year)	11,62	10	8,40	1,92	50,00	309

Methodology

For developing the analysis, a multilinear regression was used. The choice of implementing a multilinear regression was mainly given by the opportunity to analyse the connection between the dependent variable and several independent variables at once as multilinear regressions helps to better isolate the impact of each independent variable and account for potential

cofounding variables. Moreover, it allowed to easily add or remove independent variables from the model to increase the scope.

In this case, the general equation for the regression is:

$$YTM_i = \beta 0 + \beta 1 X_i + \beta 2 X_i + .. + \beta n X_i + \varepsilon_i$$

As the aim of the research is to investigate any relationship between the issuance of green bonds and the YTM of future conventional bonds, the dependent variable will be the YTM of conventional bond.

The study employed several steps, in which one additional variable was included, in order to see the interaction of each independent variable within the model.

In the initial regression analysis, the independent variables encompassed factors pertaining to the specific attributes of green bonds.

Namely:

$$YTM_i = \beta 0 + \beta 1 Spread\ GB_i + \beta 2 Coupon\ GB_i + \beta 3 Time\ to\ maturity\ GB_i + \beta 4 Amount\ issued\ GB_i + \beta 5 Fixed\ Coupon\ GB_i + \varepsilon_i$$

In this case, YTM refers to the YTM of conventional Bonds. As bonds specifics for the green bonds used as dependent variables, the first one is the yield spread. The latter shows investors' compensation for taking on more risk relative to risk-free assets, is essential for calculating a bond's yield to maturity. The market's perception of green bonds and their "green premium" might influence investor behaviour. The YTM may be impacted if investors seek a comparable premium for traditional bonds issued by the same business entities.

The second dependent variable is the coupon, in this case Coupon is significant when determining the YTM as the latter considers both the interest payments but also any profits or

losses based on changes in the bond's market price. To make informed investing decisions, investors frequently analyse the coupon rates of various bonds. A high coupon rate on green bonds could act as a benchmark for investors determining what a fair rate should be on conventional bonds issued by the same company.

The third dependent variable is the time to maturity of green bonds. It can be positive that through market dynamics and investor perceptions the time to maturity of a green bond influences the YTM of future conventional bonds. The reasoning behind encompasses that companies that issue green bonds with high time to maturity are involved in solid sustainable projects that may attract investors with a long-term sustainability outlook. In this case if investors perceive green bonds as more stable or less risky over time, their choices for conventional bonds issued later may be impacted by this notion, also affecting the return demanded by conventional bonds.

The Amount issued control variable follows a similar reasoning, meaning that a higher amount issued of green bonds may reflect the commitment to sustainability of the issuer entity which could decrease the perceived risk by investors of the subsequent traditional bonds issued, therefore affecting the YTM.

The last control variable used for the first regression is a dummy variable regarding the type of coupon. It was assigned the value of 1 for bonds with fixed coupon and 0 for those who had either zero coupons, floating or variable coupons. As for the previous two variables, the fixed coupon could change the investors point of view regarding the risk assessment. Indeed, bonds with fixed coupon indicates the company’s commitment to fulfil interest payment, giving the perception of being less risky compared to similar products of comparable companies.

The second regression instead considers an additional independent variable; the mid Macaulay Duration of green bonds. Hence:

$$YTM_i = \beta 0 + \beta 1 Spread\ GB_i + \beta 2 Coupon\ GB_i + \beta 3 Time\ to\ maturity\ GB_i + \beta 4 Amount\ issued\ GB_i + \beta 5 Fixed\ Coupon\ GB_i + \beta 6 duration\ GB_i + \varepsilon_i$$

In this research, green bonds' Macaulay duration may be aligned with the issuer's financing strategy and commitment to long-term sustainable initiatives. This coherence can influence investors' expectations about the issuer's financing strategy, which can affect the YTMs of subsequently conventional bonds.

Following on, Moody's rating of green bonds has been included in the third regression as an additional variable. Therefore, the regression will be:

$$YTM_i = \beta 0 + \beta 1 Spread\ GB_i + \beta 2 Coupon\ GB_i + \beta 3 Time\ to\ maturity\ GB_i + \beta 4 Amount\ issued\ GB_i + \beta 5 Fixed\ Coupon\ GB_i + \beta 6 duration\ GB_i + \beta 7\ Rating\ GB_i + \varepsilon_i$$

Moody's ratings are used as an indicator of credit risk. The assumption behind the addition of this variable is that if the green bond has good ratings due to ESG practices, then market participants could perceive a lower credit risk associated with the issuer. In this case, a positive perception would contribute to a lower YTM for the future conventional bonds issued, making the securities more attractive.

For the purpose of including Moody's rating into the regression, numeric values were assigned according to the specific rating, according to the following table:

Table 5: Numerical Conversion of Moody's Rating

Rating	**Aaa**	**Aa1**	**Aa2**	**Aa3**	**A1**	**A2**	**A3**	**Baa1**	**Baa2**	**Baa3**	**Ba1**	**Ba2**	**Ba3**	**B1**	**B2**	**B3**	**Caa**	**Caa1**	**Caa2**	**Caa3**	**CA**
Value	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21

Following on, for the fourth regression we wanted to insert a controlling variable which would account for the current macroeconomic conditions of the market. Hence, the risk-free rate was added as an independent variable. The risk-free rates taken into considerations were the respective of the country of issuance of the bonds.

Regression 4:

$$YTM_i = \beta 0 + \beta 1 Spread\ GB_i + \beta 2 Coupon\ GB_i + \beta 3 Time\ to\ maturity\ GB_i + \beta 4 Amount\ issued\ GB_i + \beta 5 Fixed\ Coupon\ GB_i + \beta 6 duration\ GB_i + \beta 7\ Rating\ GB_i + \beta 8 Risk\ free\ rate + \varepsilon_i$$

Lastly, to account for the "Greenness" of bonds, the rate on Green Bond screening, retrieved from Bloomberg was applied. The screening provides values from 0 to 10, in accordance with the Greenness of the bond taken into consideration, following the Bloomberg parameters based on what is the percentage of use of proceeds that is aligned with sustainable activities, following the Green Bond Principles guidelines.

Regression 5:

$$YTM_i = \beta 0 + \beta 1 Spread\ GB_i + \beta 2 Coupon\ GB_i + \beta 3 Time\ to\ maturity\ GB_i + \beta 4 Amount\ issued\ GB_i + \beta 5 Fixed\ Coupon\ GB_i + \beta 6 duration\ GB_i + \beta 7\ Rating\ GB_i + \beta 8 Risk\ free\ rate + \beta 9\ Screening\ GB_i + \varepsilon_i$$

Results

Table 6: Regression Statistics

Regression Statistics

Regression 1		Regression 2		Regression 3		Regression 4		Regression 5	
Multiple R	0,153830107	Multiple R	0,187325138	Multiple R	0,20726096	Multiple R	0,277681081	Multiple R	0,27794633
R Square	0,023663702	R Square	0,035090707	R Square	0,04295711	R Square	0,077106783	R Square	0,07825416
Adjusted R Square	0,007499193	Adjusted R Square	0,015856635	Adjusted R Square	0,0206261	Adjusted R Square	0,052413988	Adjusted R Square	0,05256531
Standard Error	1,840091995	Standard Error	1,832328288	Standard Error	1,82788287	Standard Error	1,797974063	Standard Error	1,7978305
Observations	308	Observations	308	Observations	308	Observations	308	Observations	308

The Above Table shows the Regression Statistics for all five regressions. In the initial regression, the relationship between the dependent variable and the independent ones appears weak, as indicated by the low R squared value of 0.026. This implies that only about three percent of the variation in the dependent variable is explained by the model. Upon closer examination of individual independent variables, only the "Time to maturity" variable exhibits statistical significance with a P-value of 0.0349. With the inclusion of "Duration," the R squared improves slightly to 0.035, and the P-value for this variable becomes 0.059.

However, statistical significance is not achieved until the introduction of the "Risk-free rate," resulting in a notable increase in R squared to 0.077. The P-value for the "Risk-free rate" is 0.001, indicating its significance. Despite the gradual improvement in R squared with the addition of variables, the F value of 3.12 suggests that the differences between group averages are not statistically significant in comparison to the variability within groups. In the final regression, the inclusion of the green bond screening contributes a marginal increase of 0.001 to R squared. However, only the "Risk-Free rate" remains statistically significant. Although the F test shows significance with a value of 3.79 at a 0.002 significance level, the overall model remains weak. The result suggests that there is not a significant relationship between the issuance of green bonds and the Yield to Maturity (YTM) of conventional bonds, as the R squared is below 0.5, and only one variable is statistically significant.

The below table represents the regression coefficients. Given the fifth regression which, which is the final one, it is possible to notice that the only variable with a significant P value is the

risk-free rate. However, if we look at the coefficients, even if the values are relatively low, we can notice how all variables behaved in such an expected way except for the Green Bond Screening Variable. Namely, the Spread has a positive coefficient, meaning that for one unit increase in Spread, the YTM is expected to grow by 0.1%. The same behavior applies to the following variables: Time to Maturity, Fixed Coupon, Rating, Risk Free rate, and Government Bond Screening. Instead, Coupon, Amount Issued and Duration have a negative coefficient.

One unit increase in Coupon Rate, decreases the YTM by 0.6%. This suggests that bonds with higher coupon rates typically have lower yields to maturity. This behavior is consistent with typical bond market dynamics, in which greater coupon payments provide investors with a higher income stream while lowering the overall return required by investors. As a result, the negative coefficient on the coupon rate in the context of green bonds shows that the market places a higher value on the income-generating side of bonds, presumably indicating a desire for predictable and reliable cash flows in the context of sustainable investments.

In the multilinear regression model, the negative coefficient -0.0811 linked with the duration of green bonds illustrates an intricate economic relationship with the yield to maturity (YTM) of future conventional bonds. This negative coefficient suggests an inverse relationship, meaning that, when all other variables remain constant, the longer duration of green bonds is associated with a decrease in the YTM of following conventional bonds. The interpretation also relates to interest rate sensitivity, implying that longer duration in green bonds is associated with less interest rate-sensitive yields on conventional bonds. This occurrence may be related to investor views of stability and predictability associated with green investments, which may influence risk perceptions.

Regarding Green Bonds screening, our expectations were that since the value goes from 0 to 10, the coefficient would have been negative, meaning that as the green bonds aligned better to the Green Bond Principles having therefore a score closer to 10, the Yield to maturity of

future conventional Bonds would have decreased; thanks to the signaling commitment to sustainable projects. However, in the last regression we can see how the latter has a positive Coefficient. Lastly, the Amount issued instead, even if with a very small negative coefficient value, reflects our initial Hypothesis that a higher amount issued of Green Bonds would reflect a high commitment to sustainability and could decrease the perceived risk in the market of the company, hence lowering the Yield to maturity also for conventional bonds issued afterwards.

Table 7: Regression Coefficients

Regression 1	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	4,801471859	0,370157452	12,97143105	6,92643E-31	4,073057434	5,529886284	4,073057434	5,529886284
Spread	0,000647373	0,000740003	0,874824943	0,382364355	-0,000808842	0,002103589	-0,000808842	0,002103589
Coupon	-0,014745193	0,066664033	-0,22118663	0,825096593	-0,145930025	0,11643964	-0,145930025	0,11643964
Time To Maturity	-0,022580924	0,010656293	-2,119022401	0,034904569	-0,043550913	-0,001610935	-0,043550913	-0,001610935
amount issued	-2,4586E-10	1,8216E-10	-1,34969318	0,178125251	-6,04322E-10	1,12603E-10	-6,04322E-10	1,12603E-10
fixed coupon	-0,083961905	0,296396526	-0,283275605	0,777159659	-0,667225877	0,499302066	-0,667225877	0,499302066
Regression 2	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	4,797792239	0,368600837	13,01622718	4,9704E-31	4,072431301	5,523153176	4,072431301	5,523153176
Spread	0,000631917	0,000736927	0,857503519	0,391848907	-0,000818263	0,002082098	-0,000818263	0,002082098
Coupon	0,004403667	0,067153092	0,065576532	0,947758506	-0,127745327	0,136552661	-0,127745327	0,136552661
Time To Maturity	0,005530608	0,018283756	0,302487518	0,762489368	-0,030449566	0,041510781	-0,030449566	0,041510781
amount issued	-1,87243E-10	1,84029E-10	-1,017463817	0,309749952	-5,49389E-10	1,74903E-10	-5,49389E-10	1,74903E-10
fixed coupon	0,048059139	0,303316255	0,158445642	0,8742119	-0,548829802	0,644948079	-0,548829802	0,644948079
Duration	-0,087375975	0,046279197	-1,888018395	0,059985129	-0,178447721	0,00369577	-0,178447721	0,00369577
Regression 3	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	4,468554985	0,4232819	10,55692433	2,31042E-22	3,63557726	5,30153271	3,63557726	5,30153271
Spread	0,000598062	0,000735455	0,813187174	0,416755645	-0,000849241	0,002045366	-0,000849241	0,002045366
Coupon	-0,020350671	0,068819976	-0,295708776	0,767657067	-0,155781709	0,115080367	-0,155781709	0,115080367
Time To Maturity	0,005724851	0,018239817	0,313865602	0,753841249	-0,030169339	0,041619042	-0,030169339	0,041619042
amount issued	-1,3316E-10	1,86785E-10	-0,712906451	0,476457788	-5,00735E-10	2,34415E-10	-5,00735E-10	2,34415E-10
fixed coupon	0,025042601	0,302935184	0,082666531	0,934171827	-0,57110446	0,621189661	-0,57110446	0,621189661
Duration	-0,080183947	0,046393546	-1,728342711	0,084955736	-0,171481946	0,011114052	-0,171481946	0,011114052
Rating	0,045305761	0,028851643	1,570300926	0,117399198	-0,011471473	0,102082996	-0,011471473	0,102082996
Regression 4	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	3,415332814	0,523080905	6,529263025	2,83167E-10	2,385946381	4,444719247	2,385946381	4,444719247
Spread	0,000643865	0,000723552	0,889866479	0,374252994	-0,000780035	0,002067764	-0,000780035	0,002067764
Coupon	-0,006063498	0,067830041	-0,089392519	0,928829816	-0,139548249	0,127421253	-0,139548249	0,127421253
Time To Maturity	0,008286569	0,017957889	0,4614445	0,644815244	-0,027053294	0,043626433	-0,027053294	0,043626433
amount issued	-1,18244E-10	1,83783E-10	-0,643386558	0,520466439	-4,79917E-10	2,43429E-10	-4,79917E-10	2,43429E-10
fixed coupon	0,062131997	0,298186952	0,208365916	0,835085133	-0,524678952	0,648942947	-0,524678952	0,648942947
Duration	-0,0789423	0,045635956	-1,729826788	0,084693175	-0,168750652	0,010866053	-0,168750652	0,010866053
Rating	0,033458524	0,028602191	1,169788854	0,243017566	-0,022828576	0,089745624	-0,022828576	0,089745624
Risk Free Rate	0,307810939	0,092540295	3,32623686	0,000990109	0,125698148	0,48992373	0,125698148	0,48992373
Regression 5	*Coefficients*	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	3,126797916	0,732505147	4,268636101	2,64371E-05	1,685279304	4,568316528	1,685279304	4,568316528
Spread	0,000765913	0,00075458	1,015018521	0,310917633	-0,000719048	0,002250873	-0,000719048	0,002250873
Coupon	-0,002496741	0,06801466	-0,03670887	0,970741632	-0,136344808	0,131351325	-0,136344808	0,131351325
Time To Maturity	0,008667181	0,017997463	0,481577915	0,630458088	-0,026750561	0,044084923	-0,026750561	0,044084923
amount issued	-1,07462E-10	1,84617E-10	-0,582081594	0,560950351	-4,70776E-10	2,55851E-10	-4,70776E-10	2,55851E-10
fixed coupon	0,075373719	0,300046481	0,25120681	0,801826773	-0,515096653	0,665844092	-0,515096653	0,665844092
Duration	-0,081135001	0,046078322	-1,760806332	0,079293419	-0,171813899	0,009543896	-0,171813899	0,009543896
Rating	0,037843892	0,029413588	1,286612595	0,199224615	-0,020039979	0,095727764	-0,020039979	0,095727764
Risk Free Rate	0,314117283	0,093092052	3,374265337	0,000837772	0,130918673	0,497315893	0,130918673	0,497315893
Green Bond Screening	0,046598586	0,087454814	0,53283043	0,594546743	-0,125506337	0,218703509	-0,125506337	0,218703509

Conclusion

In conclusion, the analysis aimed to explore the relationship between the issuance of green bonds and the yield to maturity (YTM) of future conventional bonds. The findings indicate a weak and inconclusive connection between these variables. The model, incorporating factors such as spread, coupon rate, time to maturity, amount issued, fixed coupon, duration, rating, risk-free rate, and green bond screening, demonstrated limited explanatory power.

Within our context, an R squared of nearly 8% may be considered satisfactory as the YTM of conventional bonds is mainly affected by the complexities of financial markets, investor behaviour, and macroeconomic conditions. Moreover, Regression coefficients, even if not statistically significant; aligned with the initial expectations about in terms of economic behaviour.

The research faced a point of weakness due to the relatively small dataset, which may not fully represent the entire green bond market. The limited availability of data could constrain the generalizability of the findings. Furthermore, the inclusion of additional variables in the model did not significantly enhance its explanatory capability.

An avenue for future research could involve investigating the temporal aspect, exploring the time difference between the issuance of green bonds and conventional bonds. This temporal element could provide insights into how the impact of green bond issuance evolves over time and whether it influences subsequent conventional bond yields differently at various intervals.

In summary, while the current analysis suggests a nuanced and inconclusive relationship, it highlights the need for more comprehensive datasets and refined methodologies to further untangle the dynamics between green bond issuance and the yields of subsequent conventional bonds. To gain a deeper understanding of the changing environment of sustainable finance and its consequences for traditional bond markets, further research is necessary due to the intricacies of investor behaviour and market dynamics.

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Appendix

Appendix A: Regression 1

Regression 1

Regression Statistics	
Multiple R	0,153830107
R Square	0,023663702
Adjusted R Square	0,007499193
Standard Error	1,840091995
Observations	308

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	24,7838779	4,956775581	1,463929574	0,201450397
Residual	302	1022,553443	3,385938551		
Total	307	1047,33732			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	4,801471859	0,370157452	12,97143105	6,92643E-31	4,073057434	5,52988628	4,073057434	5,529886284
24,12422623	0,000647373	0,000740003	0,874824943	0,382364355	-0,000808842	0,00210359	-0,000808842	0,002103589
0,5	-0,014745193	0,066664033	-0,22118663	0,825096593	-0,145930025	0,11643964	-0,145930025	0,11643964
7,000684463	-0,022580924	0,010656293	-2,119022401	0,034904569	-0,043550913	-0,0016109	-0,043550913	-0,001610935
750000000	-2,4586E-10	1,8216E-10	-1,34969318	0,178125251	-6,04322E-10	1,126E-10	-6,04322E-10	1,12603E-10
1	-0,083961905	0,296396526	-0,283275605	0,777159659	-0,667225877	0,49930207	-0,667225877	0,499302066

Appendix B: Regression 2

Regression 2

Regression Statistics	
Multiple R	0,187325138
R Square	0,035090707
Adjusted R Square	0,015856635
Standard Error	1,832328288
Observations	308

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	36,75180722	6,125301203	1,824403416	0,09399849
Residual	301	1010,585513	3,357426954		
Total	307	1047,33732			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	4,797792239	0,368600837	13,01622718	4,9704E-31	4,072431301	5,523153176	4,072431301	5,523153176
24,12422623	0,000631917	0,000736927	0,857503519	0,391848907	-0,000818263	0,002082098	-0,000818263	0,002082098
0,5	0,004403667	0,067153092	0,065576532	0,947758506	-0,127745327	0,136552661	-0,127745327	0,136552661
7,000684463	0,005530608	0,018283756	0,302487518	0,762489368	-0,030449566	0,041510781	-0,030449566	0,041510781
750000000	-1,87243E-10	1,84029E-10	-1,017463817	0,309749952	-5,49389E-10	1,74903E-10	-5,49389E-10	1,74903E-10
1	0,048059139	0,303316255	0,158445642	0,8742119	-0,548829802	0,644948079	-0,548829802	0,644948079
2,34506209	-0,087375975	0,046279197	-1,888018395	0,059985129	-0,178447721	0,00369577	-0,178447721	0,00369577

Appendix C: Regression 3

Regression 3

Regression Statistics	
Multiple R	0,207260959
R Square	0,042957105
Adjusted R Square	0,020626104
Standard Error	1,827882875
Observations	308

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	7	44,99057954	6,427225649	1,923653379	0,06554597
Residual	300	1002,346741	3,341155803		
Total	307	1047,33732			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	4,468554985	0,4232819	10,55692433	2,31042E-22	3,63557726	5,30153271	3,63557726	5,30153271
24,12422623	0,000598062	0,000735455	0,813187174	0,416755645	-0,000849241	0,002045366	-0,000849241	0,002045366
0,5	-0,020350671	0,068819976	-0,295708776	0,767657067	-0,155781709	0,115080367	-0,155781709	0,115080367
7,000684463	0,005724851	0,018239817	0,313865602	0,753841249	-0,030169339	0,041619042	-0,030169339	0,041619042
750000000	-1,3316E-10	1,86785E-10	-0,712906451	0,476457788	-5,00735E-10	2,34415E-10	-5,00735E-10	2,34415E-10
1	0,025042601	0,302935184	0,082666531	0,934171827	-0,57110446	0,621189661	-0,57110446	0,621189661
2,34506209	-0,080183947	0,046393546	-1,728342711	0,084955736	-0,171481946	0,011114052	-0,171481946	0,011114052
4	0,045305761	0,028851643	1,570300926	0,117399198	-0,011471473	0,102082996	-0,011471473	0,102082996

Appendix D: Regression 4

Regression 4

Regression Statistics	
Multiple R	0,277681081
R Square	0,077106783
Adjusted R Square	0,052413988
Standard Error	1,797974063
Observations	308

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	8	80,7568115	10,09460144	3,122642968	0,002096238
Residual	299	966,5805089	3,232710732		
Total	307	1047,33732			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	3,415332814	0,523080905	6,529263025	2,83167E-10	2,385946381	4,444719247	2,385946381	4,444719247
24,12422623	0,000643865	0,000723552	0,889866479	0,374252994	-0,000780035	0,002067764	-0,000780035	0,002067764
0,5	-0,006063498	0,067830041	-0,089392519	0,928829816	-0,139548249	0,127421253	-0,139548249	0,127421253
7,000684463	0,008286569	0,017957889	0,4614445	0,644815244	-0,027053294	0,043626433	-0,027053294	0,043626433
750000000	-1,18244E-10	1,83783E-10	-0,643386558	0,520466439	-4,79917E-10	2,43429E-10	-4,79917E-10	2,43429E-10
1	0,062131997	0,298186952	0,208365916	0,835085133	-0,524678952	0,648942947	-0,524678952	0,648942947
2,34506209	-0,0789423	0,045635956	-1,729826788	0,084693175	-0,168750652	0,010866053	-0,168750652	0,010866053
4	0,033458524	0,028602191	1,169788854	0,243017566	-0,022828576	0,089745624	-0,022828576	0,089745624
3	0,307810939	0,092540295	3,32623686	0,000990109	0,125698148	0,48992373	0,125698148	0,48992373

Appendix E: Regression 5

Regression 5

Regression Statistics	
Multiple R	0,277946329
R Square	0,078254162
Adjusted R Square	0,05256531
Standard Error	1,797830497
Observations	308

Regression 5	*df*	*SS*	*MS*	*F*	*Significance F*
Regression	9	81,7214452	9,080160578	3,798336303	0,00241845
Residual	299	966,7531663	3,233288182		
Total	308	1048,474611			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	3,126797916	0,732505147	4,268636101	2,64371E-05	1,685279304	4,568316528	1,685279304	4,568316528
24,12422623	0,000765913	0,00075458	1,015018521	0,310917633	-0,000719048	0,002250873	-0,000719048	0,002250873
0,5	-0,002496741	0,06801466	-0,03670887	0,970741632	-0,136344808	0,131351325	-0,136344808	0,131351325
7,000684463	0,008667181	0,017997463	0,481577915	0,630458088	-0,026750561	0,044084923	-0,026750561	0,044084923
750000000	-1,07462E-10	1,84617E-10	-0,582081594	0,560950351	-4,70776E-10	2,55851E-10	-4,70776E-10	2,55851E-10
1	0,075373719	0,300046481	0,25120681	0,801826773	-0,515096653	0,665844092	-0,515096653	0,665844092
2,34506209	-0,081135001	0,046078322	-1,760806332	0,079293419	-0,171813899	0,009543896	-0,171813899	0,009543896
4	0,037843892	0,029413588	1,286612595	0,199224615	-0,020039979	0,095727764	-0,020039979	0,095727764
3	0,314117283	0,093092052	3,374265337	0,000837772	0,130918673	0,497315893	0,130918673	0,497315893
3,99	0,046598586	0,087454814	0,53283043	0,594546743	-0,125506337	0,218703509	-0,125506337	0,218703509