CHAPTER 14

ARE US BOND INTEREST RATES AN INDICATOR FOR THE GREEN BOND MARKET?

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ABSTRACT

Climate changes are increasing daily and appear as a global problem threatening the environment and humanity. Many non-governmental organizations and associations work to protect the environment. In financial markets, the importance of green bonds, which are used in financing green projects that each country agrees on, is increasing to benefit the environment and ensure sustainable development. This study it is aimed to determine the relationship between the US 10-year bond rates and the green bond index with monthly data for June 2011-August 2021. The analysis examined the long-term and causal relationship between the series using unit root, cointegration, and causality tests. The analysis findings showed no cointegration relationship between the series that became stationary at the first difference but a one-way causality relationship from the US 10-year bond interest rates to the green bond index.

Keywords: Bond Market, Green Bonds, Cointegration, Causality

1. Introduction

The increasing relationship between ecosystems and the financial system causes developments that directly affect many areas. One of the most apparent effects of this relationship is manifested by the emergence of new green financial instruments such as green bonds, which are becoming more and more widespread globally. Green bonds attract the attention of investors more and more every day, as they offer the opportunity to finance projects that generate financial profits and direct environmental benefits (Galaz et al., 2015, p. 572). Green bonds are debt instruments issued by the public, private, or multilateral institutions used to finance climate-friendly or other environmental tasks. These projects include renewable energy and energy efficiency projects, clean transportation projects such as light rail systems, construction of energy-efficient buildings, afforestation, and other investments. Green bonds can be issued to finance a variety of projects that are covered by the principle of environmental sustainability and address climate issues such as water management, pollution control, toxic waste cleanup, or seawall construction, including projects that do not directly reduce greenhouse gas emissions (Chiang, 2017, p. .7)).

Green bonds, in which the issuer commits to use the bond revenues only in environmentally friendly products, emerge as a potential financing tool for renewable energy. The main distinguishing feature of green bonds is that they are marketed as green to investors, and their income is converted into green projects. This shows that, unlike traditional bonds, the bondholder has a say in how the bond proceeds will be used. It is essential to distinguish between green bonds, which are divided into labeled and unlabeled green bonds. Labeled green bonds refer to bonds marketed as green bonds, while unlabeled green bonds refer to adhesives used for environmentally friendly projects but not marketed as green bonds. In addition, since green bond issuance is less than traditional bond issuance and potential investors are the same for both asset classes, it is thought that conventional bond investors will continue more demand with the increase in green bond issuance (Ng and Tao, 2016, p. 514).

Aiming to finance initiatives that benefit the environment with its revenues, green bonds were first issued by the European Investment Bank in 2007 and then by the World Bank in 2008. Pioneering bond issuance, these banks create high-quality, fixed-income bonds to finance projects aimed at mitigating climate change. After the first green bond issuances, the European Investment Bank and the World Bank continued to support green bonds and made new issuances (CAIA, 2016, p. 7). Until 2013, green bonds were issued mainly by actors such as the European Investment Bank, the World Bank, and the International Finance

Corporation (IFC), as well as local government institutions, municipalities, and national development banks. With the increased risk appetite for such bonds, issuers and investors participating in the green bond market have also begun to diversify. 2013 and 2014 saw a more active participation of private sector issuers, including supported companies and banks, with the introduction of green bond principles (OECD, 2015, p. 8). Multiple green bond indices, which provide a reference point for investors, were created in 2015. IFC issued the first offshore green bond. In 2016, the volume of green bonds increased by 92% compared to the previous year. With Poland's issuance of green bonds, the first independent issuer was launched. Annual green bond issuances reached $167.3 billion in 2018, with the World Bank Group announcing a new set of climate targets for 2021-2025 in 2018. IFC and Amundi, a French asset management company, launched the Amundi Planet Emerging Green One Bond Fund, the World's largest green bond fund in emerging markets. Annual green bond issuances in 2019 increased by 51% compared to 2018 and reached $257.7 billion. In 2020, IFC was elected as the Chairman of the Green, Social, and Sustainability-Related Bond Principles Steering Committee (IFC, 2020, p. 7).

The use of green bonds in financing renewable energy investments in the World is increasing daily, and their issuances are carried out by central banks, governments, and financial institutions. Due to the increasing interest in green bonds, it is aimed to determine the relationship between the US 10-year bond interest rates and the green bond index and to contribute to the literature. Monthly data from June 2011 to August 2021 were used in the study. The relationship between the indicator indices of the relevant countries was investigated with the VAR method. In the analysis, firstly, the stationarity of the series at the same level and the first differences were verified by the ADF (Augmented Dickey-Fuller) unit root test. Then the appropriate lag length was determined, the VAR model was created, and the long-term relationship between the variables was examined with the Johansen cointegration analysis. The causality relationships of the variables were investigated with the Granger causality test. Since the study reveals the relationship between the American bond market and the green bond index, it is thought that it will significantly contribute to the literature in the field where very few studies exist. Before moving on to the application part of the study, a literature review including Turkey was included, and information about similar studies was mentioned. After the literature review, the data set of the research and the econometric method were explained. The findings obtained as a result of the analyzes were given before the conclusions and recommendations. The study was completed with the evaluation of the findings in the decision, comments, and suggestions for future studies.

2. Literature Review

Within the literature review's scope, the study's basic structure was created by considering the relevant studies. According to the results, the analysis section of this study, which examines the relationship between the American bond market and the green bond index with the help of econometric models, is given below.

First, theoretical studies on the green bond market in Turkey are included. In both studies, Kandır and Yakar (2017) suggested what needs to be done to benefit from green bonds in financing renewable energy in Turkey. Özkan (2019) gave information about the green bond market and its situation in Turkey. In his theoretical study, Dural (2020) discussed the latest developments in the green bond market, market potential, and future expectations. Sürmeli Sarıgül and Altay Topçu (2020) made suggestions in their study to benefit more from green bond issuance in the financing of Turkey's renewable energy resources.

In his case study, Menteşe (2021) focused on meeting the financing needs of environmentally friendly projects by issuing bonds. After talking about the World and Turkey's practices on green bonds, he concluded that the publication of green bond regulations and the issuance of green bonds could be achieved by increasing incentives.

Reboredo (2018) examined the co-movement between green bonds and financial markets in his study and found that the green bond market matched with the corporate and treasury bond markets and weakly acted with the stock and energy commodity markets. Reboredo also showed that green bonds are affected by significant price spillovers from corporate and treasury fixed income markets. Significant price fluctuations in equity and energy markets have a negligible effect on green bond prices.

Broadstock and Cheng (2019) examined the determinants of correlation models between green and black bond markets in their study. They found evidence that the link between green and black bonds is sensitive to changes in financial market volatility, economic policy uncertainty, daily economic activity, and positive and negative news about oil prices and green bonds.

Anh Tu et al. (2020) aimed to conduct a multi-dimensional analysis to find and prioritize the factors affecting the development of green bond markets. The findings revealed that the most critical factors directly affecting the expansion of the green bond market are the legal infrastructure, the official interest rate of green bonds, and economic stability.

Hammoudeh et al. (2020) examined the time-varying causal relationship between green bonds and other assets, including US conventional bonds, WilderHill clean energy (stock) index, and CO2 emission allowance prices, between 30 July 2014 and 10 February 2020. From the end of 2016 to the sampling period, they revealed a critical causality ranging from the US 10-year Treasury bond index to green bonds.

Lee et al. (2020) examined the causal relationship between oil price, geopolitical risks, and the green bond index in the United States between December 2013 and January 2019. As a result, they revealed one-way Granger causality from geopolitical threat to the oil price. They also observed a significant bidirectional causality from the oil price to the green bond index. They revealed a causal relationship between geopolitical risk to the green bond index.

Gilchrist et al. (2021) evaluated a systematic literature review focusing on the determinants and potential benefits of corporate involvement in environment-friendly practices in the context of green bonds and green loans.

In their study, Liu et al. (2021) first examined the dynamic dependency structure between green bonds and various global and sectoral clean energy markets by using copula approaches that do not change over time and over time in July 2011- February 2020. A result of the empirical analysis showed that there is a positive mean and tail dependence that changes over time between green bonds and clean energy stock markets.

Nguyen et al. (2021) examined the interrelationship between green bonds and other asset markets, including equities, commodities, clean energy, and conventional bonds, from 2008 to 2019. As a result, while the association between stocks, commodities, and clean energy was high, it was found that the diversification benefit of green bonds emerged due to a low or negative correlation between stocks and commodities.

3. Data Set and Econometric Method

The monthly data set for 2011 June-2021 August was used in the study. The dependent variable in the study is the S&P Green Bond Select Index (S&P Green Bond Index), and the independent variable is the US 10 Year Bond Rates. The data sets were included in the analysis by applying the logarithmic transformation. Table 1 presents the variables, abbreviations, and data sources used in the study.

Table 1. Variables used in the study

Variable Abbreviation	Explanation Data Source
LSPGRBOND	S&P Green Bond Index Investing
LABD10Y	US 10-Year Bond Rates Investing

Figures 1 and 2 represent the graphs of the time series used in the study. The graphics were created with the help of the EViews 10.0 package program, in which the analyzes were made.

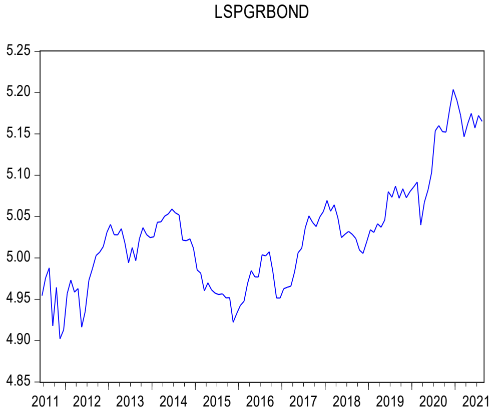

Figure 1:S&P Green Bond Index Series

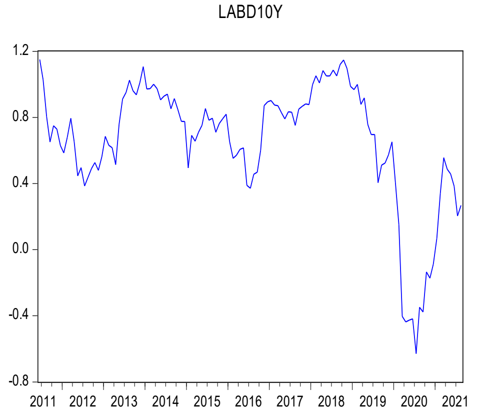

Figure 2: US 10-Year Bond Rates Series

To determine the relationship between the two-time series created by taking the logarithms of the S&P Green Bond Index and the US 10-year bond interest rates, the unit root test, cointegration test, and Granger causality test were applied using the E-Views 10.0 package program.

The model established for the study is as follows:

LSPGRBOND= $\beta_0 + \beta_1$ LABD10Y + ε_t

4. Findings

The prerequisite for time series analysis is that the series is stationary. Stationary series can be obtained by taking the first difference of the non-stationary series at level values. In the study, the stationarity test of the series was carried out using the ADF unit root test. As indicated in the ADF unit root test results in Table 2, it was determined that both time series became stationary when the first difference was taken.

Table 2. ADF Unit Root Test Results

Variable	**ADF-t statistics (Level) Constant&Trend**	**ADF-t statistics (First Difference) Constant&Trend**
LSPGRBOND	-2.156087	-12.14987*
LABD10Y	-1.993029	-9.570943*
Critical Values		
%1	-4.034997	-4.035648
%5	-3.447072	-3.447383
%10	-3.148578	-3.148761

To examine the cointegration relationship between the series determined to be stationary at the same level (1st difference), first of all, the leg lengths were determined, and the appropriate VAR model was established. Table 3 presents the optimal lag length and lag length criteria for selecting the VAR model. The optimal lag length for the model was determined to be one, and the VAR (1) model was created.

Table 3. Lag Length Criteria for the VAR Model

Lag	LogL	LR	FPE	AIC	SC	HQ
0	114.8742	NA	0.000481	-1.963029	-1.915291	-1.943653
1	394.3171	544.3062	4.00e-06*	-6.753341*	-6.610127*	-6.695211*
2	395.9291	3.083827	4.17e-06	-6.711811	-6.473121	-6.614928
3	398.7398	5.279102	4.26e-06	-6.691126	-6.356961	-6.555490
4	400.4594	3.170126	4.43e-06	-6.651468	-6.221826	-6.477078
5	402.0985	2.964568	4.62e-06	-6.610408	-6.085291	-6.397265
6	403.3484	2.217320	4.85e-06	-6.562581	-5.941988	-6.310686
7	409.3717	10.47523*	4.69e-06	-6.597768	-5.881699	-6.307119
8	412.0483	4.561853	4.80e-06	-6.574753	-5.763207	-6.245351

To determine whether the predicted VAR (1) model according to the appropriate lag length is stable, it is investigated whether the inverse roots of the AR-characteristic polynomial are within the unit circle. According to Figure 3, it has been determined that the inverse roots of the AR-characteristic polynomial are located within the unit circle, and the VAR (1) model is stable. To test possible autocorrelation and varying variance problems in the model, LM and White tests were performed, and the results are presented in Table 4. Since the p probability values of the tests in Table 4 are more significant than 0.05, it can be stated that there is no autocorrelation and varying variance problems in the estimated VAR (1) model. The Inverse Roots Graph of the AR-Characteristic Polynomial of the Models.

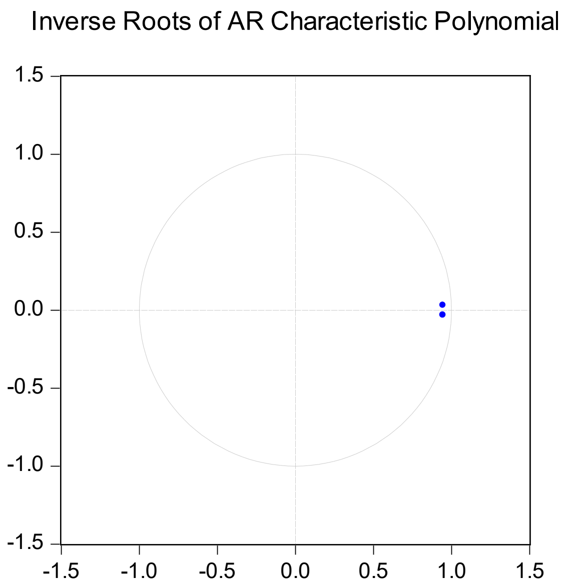

Figure 3: The Inverse Roots Graph of the AR-Characteristic Polynomial of the Models

Table 4. VAR(1) Autocorrelation (LM) ve Varying Variance (White) Test Results

	Lag Length	LM Test of p Probability Value	White Test of p Probability Value
VAR(1) Model	1	0.3420	0.0529

Johansen cointegration test based on the VAR model was applied, and test results are presented in Table 5.

Table 5. Johansen Cointegration Test Results for VAR(1) Model

Variable	H_0	Trace Statistics	5% Critical Value	p
LSPGRBOND-LABD10Y	r=0	9.990169	15.49471	0.2815 0.2219
	r≤1	1.492124	3.841466	
	H_0	**Max Eigen Statistics**	**5% Critical Value**	**p**
LSPGRBOND-LABD10Y	r=0	8.498045	14.26460	0.3303 0.2219
	r≤1	1.49124	3.841466	

The results of the cointegration analysis presented in Table 5 showed that the null hypothesis could not be rejected at the 5% significance level, and there was no long-term relationship between the variables. Since there was no cointegration relationship between the variables, the VAR-based Granger causality test was applied. Granger causality test results are presented in Table 5. According to Table 6, At the 5% significance level, the null hypothesis that US 10-year bond rates are not the Granger cause of the S&P Green Bond Index is rejected. Based on this finding, it can be stated that the US 10-year bond interest rates are the Granger cause of the S&P Green Bond Index, and there is a one-way causality relationship between the variables.

Table 6. Granger Causality Test Results

H_0	F Statistics	p
LABD10Y-LSPGRBOND	5.32714	0.0227
LSPGRBOND-LABD10Y	0.22117	0.6390

5. Result and Suggestions

The green bond market has made significant progress recently, providing funds for projects that consider climates and have environmental benefits in harmony with the economy. Green bonds contribute to stakeholders and countries by financing environmentally beneficial projects to prevent climate change's adverse effects. The increasing importance of sustainability increases the importance of supporting projects developed in this direction. The increase in project opportunities underpin green bonds is also essential for developing the said market. With the rise of environmental awareness, green bonds appear in financial markets as an alternative instrument where investors can protect their ecological sensitivity and purchase fixed income security.

Revealing the relationship between green bond markets and other markets or assets is essential in determining the risk-return characteristics of green bonds and understanding their role in a sustainable economy. It is thought that reducing the uncertainties regarding green bonds, which are not yet known by the markets and which investors are less interested in than traditional bonds, may also contribute to the development of the market. For this reason, it is necessary to increase the number of studies, which are pretty limited in the literature. It is anticipated that the study can contribute to the literature at this point. This study it is aimed to determine the relationship between the US 10-year bond interest rates and the green bond index. According to the findings of the study in which the monthly data sets for the period June 2011-August 2021 were examined, it was found that there was no long-term relationship between the S&P Green Bond Index and the US 10-year bond interest rates. It was determined that the US 10-year bond interest rates were the cause of the S&P Green Bond Index.

It has been observed that there is a one-way causality relationship between the US 10-year bond interest rates to the green bond index. For this reason, it can be stated that the US 10-year bond interest rates have an economic effect on the green bond index, and the variables in question act interdependently in this direction. On the other hand, the lack of causality from the green bond index to the US 10-year bond interest rates reveals the expectation that green bonds can be added to diversified portfolios, including public and private sector bonds.

It is thought that developing the green bond market, which attracts the attention of renewable energy investors, academics, and other relevant stakeholders, will contribute to sustainable finance. Although it has been observed that the green bond market has shown impressive growth in recent years, it can be stated that this growth should be accelerated. The contribution of green bonds to portfolio diversification makes it essential for policymakers to encourage policies that support the development of the green bond market in parallel with economic growth and financial development. The results obtained in this study will guide future studies. It is thought that focusing on the relationship of green bonds with more than one variable and analyzing different variables in different markets is essential in reducing the uncertainties regarding the said instrument.

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