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ANALYSIS OF THE RELATIONSHIP BETWEEN GREEN BONDS AND EQUITY MARKETS BY CROSS-QUANTILOGRAM METHOD

Yeşil Tahvil ile Pay Piyasaları Arasındaki İlişkinin Çapraz Kantilogram Yöntemi ile Analizi

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Keyword:
Green Bond,
S&P 500 Index,
Cross-Quantilogram.

JEL Codes:
G15, Q2, Q4.

Abstract

In our rapidly growing and developing world, various environmental and climate problems are experienced due to this development. Many countries are turning to renewable energy investments to meet their energy needs with the increasing population and industrialization. This raises the question of how to finance renewable energy investments. To overcome these problems, many environmentally friendly projects and investments have come to the fore and have been financed in recent years. Undoubtedly, one of the most important factors in providing this financing is green bonds. Green bonds have become an important financial instrument for financing environmentally and climate-beneficial projects and renewable energy investments. In the study, it is aimed to analyze the relationship among the daily data between 31.07.2012 and 29.07.2022 and the S&P 500 and S&P Green Bond Index by using the Cross-Quantilogram method. The cross-quantilogram method is an innovative method that can be easily used to determine the cross-correlation relations between different quantile and delay values and variables. According to the empirical results obtained in the study, there is a negative correlation between 2014 and 2018 according to the bidirectional cross-correlation data between the S&P 500 index and the S&P Green Bond index.

Anahtar Kelimeler:
Yeşil Tahvil,
S&P 500 Endeksi,
Çapraz Kantilogram.

JEL Kodları:
G15, Q2, Q4.

Öz

Hızla büyüyen ve gelişen dünyamızda bu gelişmeye bağlı olarak çeşitli çevre ve iklim sorunları yaşanmaktadır. Artan nüfus ve sanayileşme ile birlikte birçok ülke enerji ihtiyacını karşılamak için yenilenebilir enerji yatırımlarına yönelmektedir. Bu da yenilenebilir enerji yatırımlarının nasıl finanse edileceği sorusunu gündeme getiriyor. Bu sorunları aşmak için son yıllarda birçok çevre dostu proje ve yatırım gündeme gelmekte ve finanse edilmektedir. Bu finansmanın sağlanmasındaki en önemli etkenlerden biri de hiç kuşkusuz yeşil tahvillerdir. Yeşil tahviller, çevreye ve iklime faydalı projelerin ve yenilenebilir enerji yatırımlarının finansmanı için önemli bir finansal araç haline geldi. Çalışmada, 31.07.2012-29.07.2022 tarihleri arasındaki günlük veriler ile S&P 500 ve S&P Yeşil Tahvil Endeksi arasındaki ilişkinin Çapraz Kantilogram yöntemi kullanılarak analiz edilmesi amaçlanmaktadır. Çapraz kantilogram yöntemi, farklı kantil ve gecikme değerleri ve değişkenleri arasındaki çapraz korelasyon ilişkilerini belirlemek için kolaylıkla kullanılabilen yenilikçi bir yöntemdir. Çalışmada elde edilen ampirik sonuçlara göre S&P 500 endeksi ile S&P Yeşil Tahvil endeksi arasında çift yönlü çapraz korelasyon verilerine göre 2014 ve 2018 yılları arasında negatif bir korelasyon bulunmaktadır.

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1. Introduction

In our rapidly developing world, the population is increasing at the same rate. Both large states and state associations and large companies are trying to offer solutions for the environmental and climatic problems caused by this development. Although the number of countries is insufficient, they try to implement legal sanctions to prevent climate and environmental problems and try to prevent the damage caused by low-quality production materials to the environment. In the financial system, companies are constantly turning to low-cost and low-production materials to increase their profitability even more. This situation leaves companies in the dilemma of harming the environment or making more profit. Looking at the environmental analyzes in recent years, it is not difficult to understand which option companies have chosen. For this reason, the need to further increase the deterrent legal sanctions taken by governments arose. In addition to sanctions, states have started to provide support and incentives to companies that make ecological, nature-friendly, and environmental investments, and companies have started to shift their investments to this area. At this point, the question of how to finance these investments arose. In green bonds, which are one of the innovative investment tools, renewable energy has emerged as a financial tool to finance investments that are beneficial to the environment and nature. The point where green bonds differ from conventional bonds is the use of revenues from bonds to finance nature-friendly projects. Park et al. (2020) in their work in 2020, define green bonds as a long-term financing investment for projects that will benefit the environment to be stable and sustainable.

Although green bonds are an innovative and new financial instrument, they have become a tool that investors have no difficulty in accepting, since they do not differ from conventional bonds in terms of usage. Bond investors have recently started to demand more and more green bonds as they know that the money they pay in the purchase of bonds will be used in environmentally friendly and environmentally beneficial projects. This has led to the formation of a separate green bond markets in countries. In 2007, the European Investment Bank issued the "climate awareness bond" for the first time in the world, with 600 million Euros (Chartered Alternative Investment Analyst Association [CAIA], 2016). With the funds obtained from this issue, renewable energy investments were financed. The European Investment Bank was followed by the Scandinavian Bank together with the World Bank in 2008 and they used the name "green bond" for the first time.

It is vital to evaluate the relationship between green bonds and other financial asset markets in order to determine the financial behavior or expectations of bond investors and to determine whether bond investors can use green bonds as an effective hedger in their portfolios (Nguyen et al., 2021). These bonds, which have been used as green bonds since 2008, have started to increase in demand by investors, and green bond indices have been formed in the stock markets of large countries and have started to gain value. In this context, one of the leading countries and stock markets is the S&P (Standard and Poors) stock market. The S&P 500 index, which is included in the US-based stock market, is an index that constitutes the largest 500 companies in the USA. The green bond index is also traded on this stock market as the S&P Green Bond Index. The S&P 500 and S&P Green Bond indices were taken as a sample, both because it is one of the stock markets where green bonds are first traded as an index, and because it includes the 500 largest companies in the USA, which has a very large place in the world economy. Although there are different stock exchanges where green bonds are traded apart from S&P, another reason for choosing S&P as a sample is that it hosts both the leading companies in terms of energy investors among the top 500 companies in the USA and it is the largest stock market where green bonds are traded.

In the study, the cross-quantilogram method developed by Han et al. (2016) was used and the work of Pham (2021b) was followed. The main purpose of the study is to analyze the relationship between the S&P 500 and the S&P Green Bond index, to reveal the correlation between them, and to provide a different perspective by offering solutions to both the law-making authorities and investors with this new method. In addition, the study has various contributions to the previous literature. Firstly, focusing on the relationship between green bonds and financial markets, this study provides evidence for the use of green bonds as a diversifying investment tool in stock portfolios. Another contribution is the use of cross-quantilogram methodology allows us to explore correlation dynamics even in non-stationary time series at different period intervals. In the traditional methodology, there are usually correlation relations between the variables made by taking the time series as a whole. Although the green bond is a new investment tool in the finance literature, its name has started to be mentioned in the literature recently due to the studies of researchers and its involvement in government-supported projects. For this reason, it is planned that the study will both contribute to the literature with the applied cross-quantilogram method and be a new guide for researchers who will work on this subject.

The next part of the study will be organized as follows; After the necessary information about green bonds is discussed in the introduction part, in the second part, the theoretical and empirical studies and results of the green bonds in the literature will be given. Then, in the third section, the methodology section, the data and detailed explanations of the method to be applied will be presented. In the fourth section, the application section, the tests related to the cross-quantilogram method and the findings obtained as a result of these tests will be included.

2. Literature

Studies examining green bonds with the cross-quantilogram method are very limited, both because the green bond does not have much history in the literature and because the applied method is a new method. As similar studies in the international literature, Linh Pham's 2 studies investigating the relationship between green bonds and green bond markets in 2021 with the cross-quantilogram method, and Arif et al. (2022) study is available. In the literature section on green bonds, studies related to different methods and fields will be summarized and detailed reviews will be given in similar studies. Green bond issuances have increased in recent years, as there are incentives for both investors and firms to use sustainable instruments for green bonds, resulting in a recent surge in international research papers on green bonds. Studies in the literature have generally been in the direction of comparing the pricing of green bonds and traditional bonds and the price dependence of green bonds and other financial instruments (Cortellini and Panetta, 2021).

Although studies on green bonds have increased in the literature in recent years, the number of empirical studies on green bonds is very few compared to theoretical studies, since there is not much history. One of the earliest studies to conduct case studies on investor behavior after bond issuance announcements on green bonds is Roslen et al. (2017) in their study. Roslen et al. (2017) in their study where they examined 156 green bond announcements from 6 countries between 2010 and 2015, found that the shareholders generally responded positively, especially one day after the green bond announcements by the issuers. After the work of Roslen et al. (2017) other researchers intensified their studies on green bond announcements in different countries in different periods and with different methods. In his study, Baulkaran (2019) examined the reaction of the stock markets to the green bond announcement and concluded that the cumulative abnormal returns are positive and significant, according to the findings he obtained. This shows that shareholders see the issuance of green bonds as a value-enhancing factor and use the funds obtained in profitable green projects or as a risk reduction tool.

The first studies on green bonds generally included theoretical information (Ehlers and Packer, 2017; Kandir and Yakar, 2017; Zerbib, 2017; Banga, 2019). Among empirical studies, the first study examining the volatility structure and the relationship with a limited number of other markets was conducted by Pham (2016). In her study, Pham tried to reveal the daily closing prices of the S&P green bond index and the volatility structure of the GARCH model indices between 2010 and 2015. In her study, she concluded that volatility clusters are more intense in the labeled green bond market. Park et al. (2020) analyzed the spread of volatility dynamics between green bond markets and stock markets. In their study, they found that although green bonds exhibit asymmetric volatility phenomenon, unlike stock markets, volatility is sensitive to positive return shocks. A similar study was done by Nur and Ege (2022). In their study, Nur and Ege (2022) made volatility estimations to investigate the short-long-term relationship between the S&P 500 index and the S&P Green Bond Index between 2010 and 2020. According to their findings, they determined a long-term cointegration relationship between the S&P 500 index and the S&P Green Bond Index. They also concluded that there is a one-way Granger Causality relationship from the S&P 500 index to the S&P Green Bond Index.

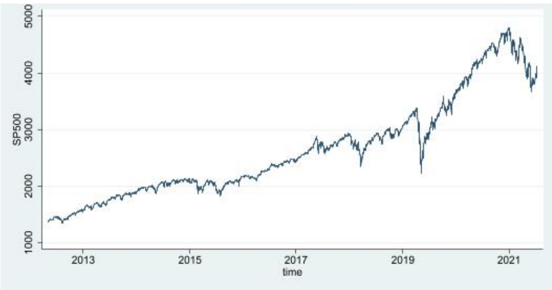
One of the distinguishing points in investment in green bonds is the type of company that issues the green bond. Studies examining the relationship between stock market indices and green bonds in the literature are divided into financial issuers and non-financial issuers (Zhou and Cui, 2019; Tang and Zhang, 2020). In this distinction, non-financial, namely corporate green bond issuers generally use green bonds to finance their own green projects, while financial issuers use green bonds for green loans (Zhou and Cui, 2019; Lebelle et al., 2020; Wang et al., 2020).

There are studies comparing green bonds with classical (black) bonds. Barclays (2015) stated in his study that there is a 20bps negative premium between the green and black bond spreads offered by the same issuer. Then, in the report of a similar research conducted by Bloomberg (2017), it was stated that this premium was negative 25bps. Reboredo (2018) found a positive correlation between green bonds and classical bonds in his study. He also stated that due to the weak joint movements of green bonds, it would be beneficial in diversification against stock and energy markets. Fernandes et al. (2022) tried to estimate the versatility for green bonds, stock markets and US economic sector bonds. In their study, they stated that there is a non-linear cross-correlation relationship between green bonds and US bonds. In the study conducted by Broadstock and Cheng (2019) examined the changing relationships of green and black bonds over time between the 2008 and 2018 periods and investigated the determinants of the correlation relationship between them. In the study, which tried to determine the determinants of the correlation models between the green and black bond markets, they tried to predict whether both the correlations and the determinants changed over time using a two-stage sequential methodology. It has been determined that the link between green and black bonds is sensitivity to changes in financial market volatility, economic policy uncertainty, daily economic activity, oil prices, and positive and negative news about green bonds. Nguyen et al. (2021), they examined the relationship between green bonds and other financial asset markets at different frequencies and the dynamic properties of the correlation between asset pairs in the period between 2008 and 2019. According to their findings from the study, they found that most correlations emerged and reached their peak in the post-global economic crisis period. In addition, they argued that the diversification benefit of green bonds emerged significantly due to the negative and low correlation between stocks and green bonds. The cross-quantilogram method to be applied in the study is essentially a method in which cross correlations in time series are calculated. For this reason, the research of Broadstock and Cheng (2019) and Nguyen et al. (2021) is one of the studies that is similar to our study as it examines the correlation relationship between green bonds and black bonds and other asset markets.

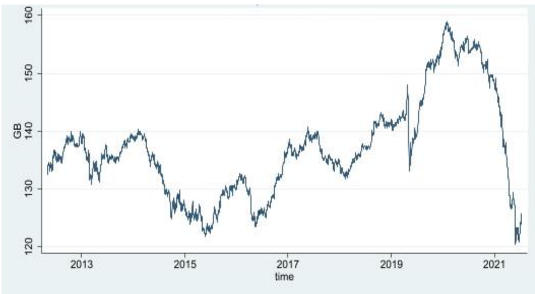
Considering green bonds as a part of green capital, Pham (2021a) analyzed regional green capital markets using the cross-quantilogram method. She states that previous studies have overlooked the heterogeneity between sub-sectors such as the green capital market and green bonds, as they have analyzed both green bonds and the green capital market collectively. In her study, he used the cross-quantilogram method, which does not require any moment condition, to measure the cross quantile dependence between the time series. According to her findings, he determined that the movements in the US market in the green stock market can predict the movements in the Asian and European markets under all market conditions. In another article where the author examines green bonds and the green bond markets, she also performed an analysis with the cross-quantilogram method (Pham, 2021b). In her study, by separating the time series data of the green bond and green stock market into different frequency bands, she first determined that the connection between green bonds and green stocks varies between short-term, medium, and long-term investment horizons. She then used the cross-quantilogram method to detect cross-quantile dependence between green capital and green bonds and to capture the spreads between markets under various market conditions. In the study, stock indices from the NASDAQ OMX Green Economy family were used. These indexes are the clean energy-focused index, green building index, green transportation index, and global water index. Pham (2021b) concludes in her study that green bonds are more likely to be affected by other fixed-income assets such as public or private sector bonds and that the link between green bonds and green capital is not great under normal market conditions. She found that green bonds and green capital tend to act together in extreme market conditions and that the dependence between green bonds and green capital is short-lived in both normal and extreme market conditions. Pham's study in 2021 is one of the studies we followed while designing our study, as it was a study in which different indices were analyzed by the cross-quantilogram method. Alongside Pham's work, cross Arif et al. (2022) used the cross-quantilogram methodology for green bonds. In their study, they investigated the hedging potential of green bonds for different asset markets during the Covid-19 process. In their study, where they applied the cross-quantilogram method in order to better reveal the dynamic relationship between two assets in different market conditions, they concluded that the green bond index can serve as a diversifying asset for medium and long-term stock investors.

3. Data and Methodology

Our main data set used in the study, S&P 500 index and the S&P Green Bond index, were obtained from the Yahoo (2022) Finance database. The time series data set was created by using the daily data between 31.07.2012 and 29.07.2022. In the study, the S&P Green Bond Index was used to take into account the performance of the global green bond market. The S&P Green Bond Index, which is not very old, has started to be traded since 2014. Before 2014, green bonds were also traded, but since 2014 they have started to be traded as an index. In the study, the data of the green bonds for 2 years before the index was also included in the analysis. The reason for this is to analyze the effects of green bonds before and after they become indexes. The Green Bond Index includes green bonds issued by the multilateral government and corporate entities globally and with no minimum credit requirement. In addition, the S&P 500 index is among the variables. The S&P 500 index covers the 500 most valuable companies in the United States. In the light of this information, it is thought that the inclusion of both variables in the S&P will provide a consistent methodology in the calculation of the variables.



Graph 1. S&P 500 Index



Graph 2. Green Bond Index

The time series of the S&P 500 index, which is the variable we consider in the study, is shown in Graph 1, and the time series of the S&P Green Bond index is shown in Graph 2. An upward trend is observed in both graph. The reason for the sudden decrease in 2020 is the declaration of the coronavirus as a pandemic, which can be seen in both time series graphs. In both indices, which showed an upward trend until 2021, a sudden decrease is observed at the beginning of 2022, which can be said to be the reason for the start of the Russia-Ukraine war. Although an upward trend has been observed in both indices since 2012, it is seen that both the coronavirus and the Russia-Ukraine war caused a decrease in index values. While both indices were affected by the coronavirus pandemic at almost the same rate, the S&P Green Bond Index was more affected by the Russia-Ukraine war and its value declined to the lowest levels. The reason for this is that the war has affected the companies operating in the energy sector a lot. Since renewable energy investments are one of the most important sectors in which green bonds provide financing, the problems occurring in the energy sector are also reflected in the green bond index.

For the application part of the study, the cross-quantile dependence between the S&P 500 and S&P Green Bond Index returns will be examined to determine how the strength and duration of the spreads between the indices will change under the up and down market movements.

Cross-quantilogram is a method developed by Han et al. (2016). This method does not include moment conditions and is based on quantitative points. For this reason, it gives good results in the analysis of variables in financial time series. In addition, since the cross-quantilogram approach can accommodate long delays at relatively small computational costs, it allows the direction, magnitude, and duration of dependency to be determined simultaneously in all parts of the spin distributions (Pham, 2021b).

The cross-quantilogram method has some advantages over other techniques. First, the method measures the predictability of the distribution of each variable from one time series to another. Thus, as in Graph-1 and Graph-2, it also provides the opportunity to measure the directional spreads of decline, normality, and rise among financial assets in a wide variety of market conditions. Another advantage is that this method has very long delays when compared to traditional regression-type models. Therefore, it can measure the strength of directional spillovers, in short, medium, and long-term investments. The prerequisite of the cross-quantilogram method is that the series are stationary.

The cross-quantilogram is a method that examines the relationships of the two series according to the distribution characteristics in the right and left tails. Cross-correlation is one of the most frequently used methods to estimate the correlation between variables in time series. In cross-correlation, it reveals the correlations of one variable at time t and the other variable at t-1, t-2, t-3. This is used to predict the future value of one variable for another variable.

The methodology of the cross-quantilogram method is expressed as follows:

Let y_{it} has to be a strictly stationary time series. Here i is the index and t is the time series (i = 1, 2, t = 1, … , T). Let f_i(.) and f_i(.) be the corresponding quantile functions for y_{it}, assuming that i = 1, 2. Let q_{it} (τ_i) = inf$\{v$: F_i $(v) \geq \tau_i\}$ τ_i ∈ (0, 1) are distribution and density functions.

The cross-quantilogram $\{y_{1t} \leq q_{1t}(\tau_1)\}$ and $\{y_{2t-k} \leq q_{2t-k}(\tau_2)\}$, between the two events show the lag length “k” in this equation. (k = $\pm 1, \pm 2, \dots$) and for the pair τ_1 and τ_2 are formulated as follows:

$$\rho_\tau(k) = \frac{E[\psi_{\tau_1}(y_{1t} - q_{1t}(\tau_1))\,\psi_{\tau_2}(y_{2t-k} - q_{2t-k}(\tau_2))]}{\sqrt{E[\psi_{\tau_1}{}^2(y_{1t} - q_{1t}(\tau_1))]}\sqrt{E[\psi_{\tau_2}{}^2(y_{2t-k} - q_{2t-k}(\tau_2))]}} \quad (1)$$

In this equation, $\psi_a(u)$ = 1[u < 0] – a is the quantile process. The cross-quantilogram captures the serial dependencies at different quantile levels between the two series and is invariant due to the strict monotic transformation that can be applied to both series, such as the logarithmic transformation. In the case of two events, $\{y_{1t} \leq q_{1t}(\tau_1)\}$ and $\{y_{2t-k} \leq q_{2t-k}(\tau_2)\}$ indicate no cross-dependency or directional predictability from the)}, $\rho_\tau(k) = 0$, $\{y_{2t-k} \leq q_{2t-k}(\tau_2)\}$ event to the $\{y_{1t} \leq q_{1t}(\tau_1)\}$ event.

To test the null hypothesis of H_0 : $\rho_\tau(1)$ = ….. = $\rho_\tau(p)$ = 0, Han et al. (2016) suggest the Ljung-Box type test statistic;

$$Q_\tau{}^*(\text{p}) = \text{T (T + 2)} \sum_{k=1}^{p} \hat{p}^2{}_\tau(k)/(T-k) \quad (2)$$

The $\hat{p}_\tau$ (k) given in this equation is the cross-quantilogram formulated below.

$$\hat{p}_\tau(k) = \frac{\sum_{t=k+1}^{T}\psi_{\tau_1}(y_{1t} - \hat{q}_{1t}(\tau_1))\,\psi_{\tau_2}(y_{2t-k} - \hat{q}_{2t-k}(\tau_2))}{\sqrt{\sum_{t=k+1}^{T}\psi_{\tau_1}{}^2\ (y_{1t} - \hat{q}_{1t}(\tau_1))}\sqrt{\sum_{t=k+1}^{T}\psi_{\tau_2}{}^2\ (y_{2t-k} - \hat{q}_{2t}(\tau_2))}} \quad (3)$$

$\hat{q}_{it}$ (τ_i) (i = 1, 2) shows the predicted quantity function for the time series in the formula. Han et al. (2016) avoided any dependence on the disturbing parameters of the asymptotic distribution and also propose to use the stationary bootstrapping process to approximate the Q statistic of the null distribution of the cross-quantilogram.

4. Findings

In the findings section of the study, the findings obtained by calculating the cross-quantile dependencies between the two indices are expressed. Descriptive statistics about the variables discussed in the study are shown in Table 1:

Table 1. Descriptive Statistics

Variables	Observation	Mean	Stand. Error	Minimum	Maximum
S&P 500 Index	2516	2.6375	0.874297	1.353000	4.797000
S&P Green Bond Index	2516	136.957	8.669966	120.4700	158.9900

As seen in Table 1, in the data set created with a total of 2516 observations, the average of the S&P 500 index was 2.6375, while the average of the S&P Green Bond Index was 136.96. The minimum value of the S&P 500 index is 1.353 and the maximum value is 4.7967, while the minimum value of the S&P Green Bond index is 120.47 and the maximum value is 158.99. Table 2 includes the correlation matrix between the variables.

Table 2. Correlation Matrix between Variables

Variables	S&P 500 Index	S&P Green Bond Index
S&P 500 Index	1.0000	
S&P Green Bond Index	0.6258	1.0000

When the correlation relationship between the variables is examined, it is seen that there is a positive correlation of 63% between the two variables.

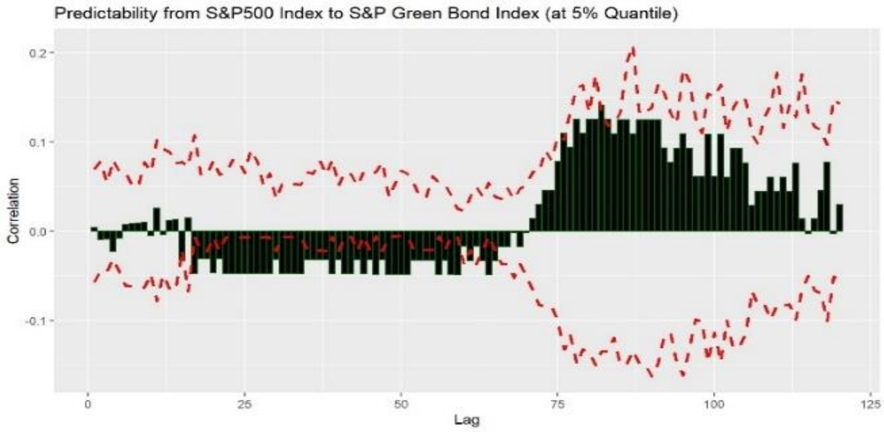
Table 3. Pre-Tests

Variables	JB	Skewness	Kurtosis	ADF	Q	Q^2
S&P 500 Index	265.1***	0.779	2.6843	-15.7801***	2510.777***	5015.3330***
S&P Green Bond Index	164.4388***	0.623	2.8733	-46.3138***	2510.3922***	5011.9849***

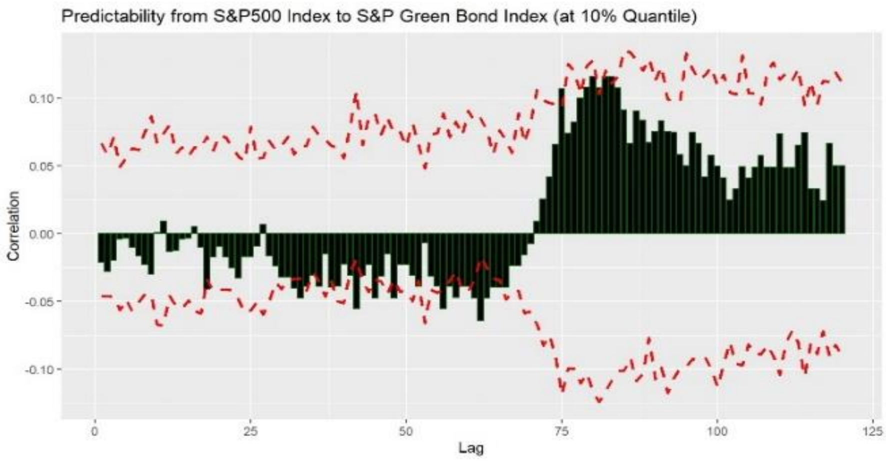
Note: JB and ADF stand for Jarque-Bera normality test and Augmented Dickey-Fuller unit root tests. Q and Q^2 stand for the Ljung-Box test of serial correlation in returns and squared returns. *** Indicates significance at the 1% level.

According to the results shown in Table 3, it is seen that the distribution of the series is not normal in the Jargue-Bera test. In both variables, it is seen that the skewness is close to 0 and the kurtosis is close to 3. It means that the further away the skewness value is from 0 and the kurtosis value is from 3, the less the probability of normal distribution. Ljung-Box statistics show that all series experience series correlation and volatility clustering, and Jarque-Bera tests show that the series do not follow a normal distribution. Finally, since the series are not stationary in the ADF unit root tests, the analysis was continued in this way after taking the 1st difference and making the series stationary.

In the study, the Ljung-Box test described in the methodology section of the cross-quantilogram was used to determine the statistical significance of each cross-quantilogram. Black columns above 0 indicate positive cross-correlation, and black columns below 0 indicate negative cross-correlation. The red dashed lines represent the confidence limit. Bars outside the confidence limit indicate significant correlations at the 5% significance level.



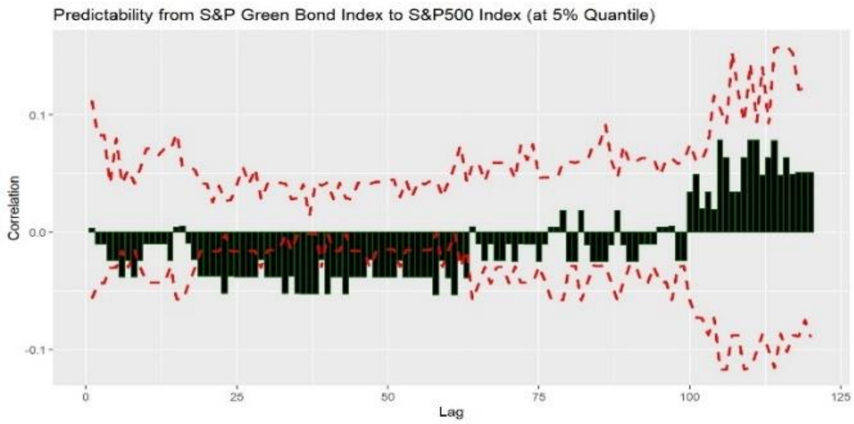
Graph 3. 5% Quantile Graph from S&P 500 Index to S&P Green Bond Index



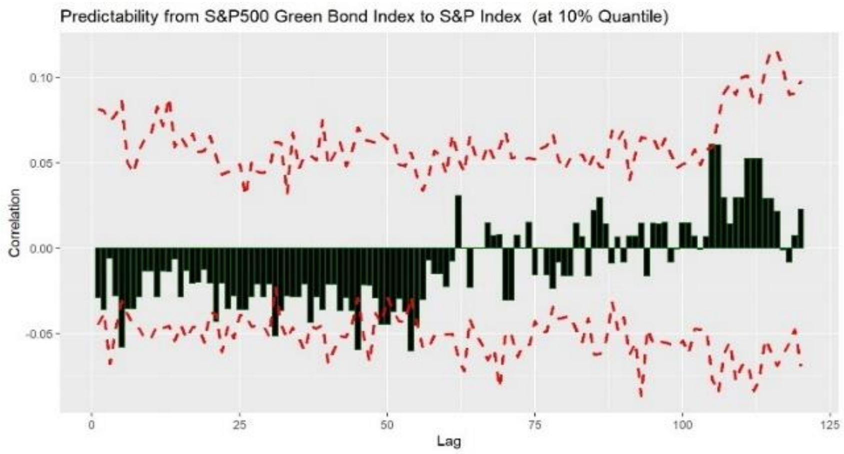
Graph 4. 10% Quantile Graph from S&P 500 Index to S&P Green Bond Index

In Graph-3, it is the cross-quantilogram graph of 5% quantile value from the S&P 500 index to the S&P Green bond index. Especially since 2014, it is seen that there is a negative and significant correlation relationship. This significant relationship continues until the end of 2017. According to Graph 3, the decreases in the S&P 500 index between 2014 and the end of 2017 caused increases in the S&P Green Bond index. While the increases continue in a fluctuating manner, the cross-correlation relationship between the two indices starts to become meaningless as of 2018. There is no significant correlation between the two indices from 2018 until 29.07.2022, the last date of the time series in the study. It is seen that there is only a very short-term significant positive correlation at the beginning and end of 2019. However, in general, it can be said that the significant correlation relationship is negative. This situation can be seen similarly in Graph-1 and Graph-2. While there is a continuous upward trend in the S&P 500 index in Graph-1, there are sharp decreases and fluctuations in the S&P Green Bond index in Graph-2 in 2014.

The reason for this is that the S&P Green Bond index started to be calculated on July 31, 2014. Before this date, green bond investments were made, but after this date, an index covering 150 green bonds was created. Since the index was a new index and investors were shy at first, the index started with a downward trend and entered an increasing trend in the following years. While the graph of 5% quantile values is given in Graph-3, we can see 10% quantile values and cross-quantilogram values of the same indices in Graph-4. Although there are no great differences between them, it is seen that there is a piecemeal negative correlation relationship from 2014 to 2018. It can be said that the S&P 500 index and the S&P Green Bond Index are in a positive but short-term correlation relationship between 2018 and the first months of 2019.



Graph 5. 5% Quantitative Graph from S&P Green Bond Index to S&P 500 Index



Graph 6. 10% Quantitative Graph from S&P Green Bond Index to S&P 500 Index

In both graph 3 and graph 4, the correlation between S&P 500 Index and S&P Green Bond Index is seen. 5% quantile values in Graph-5 and 10% quantile values in Graph-6 show a cross-correlation relationship between S&P Green Bond Index and the S&P 500 index. As can be seen in Graph-5, although it is short-term in 2013, it is seen that there is an almost continuous negative correlation between the two variables at the 5% confidence level, especially from 2014 to the first months of 2018. From 2018 to July 29, 2022, a correlation relationship did not occur within the confidence limit. In graph 6, which is shown with 10% quantile values, negative correlations are seen at the 5% confidence level, piece by piece, until 2018.

The findings are also consistent with those obtained in the study of Pham (2021b). Pham, in her study, determined that green bonds and the capital market tend to move together. In addition, the findings are consistent with the study of Nguyen et al. (2021). Nguyen et al. (2021) stated that the significant correlation relationship between green bonds and stock markets emerged after the global economic crisis and then disappeared, and stated that this relationship was negative and low. These results are also clearly seen in Graph-4 and Graph-6 where 10% quantile values are shown.

5. Conclusion

In this part of the study, empirical results are presented. The aim of the study is to reveal the interdependence between the S&P 500 index and the S&P Green bond index. We explore how the directional spreads between the S&P 500 index and the S&P Green bond vary between extreme and normal market conditions. For this purpose, the cross-quantile dependence between the two indices was calculated using the cross-quantilogram approach. In the study, the results are visualized using cross-correlation graphs that allow us to summarize all the dependency structures between the variables for a period of 120 months between July 2012 and July 2022. The study was handled and visualized with 5% and 10% quantile values from the S&P 500 index to the S&P Green Bond index and from the S&P Green Bond index to the S&P 500 Index at the same lag at 120 lag lengths.

In general, it is seen that there was a general decrease in the index valuation on 31 July 2014, the period when the green bond index was started to be calculated in S&P. The reason for this can be interpreted as the investors' abstention against the newly calculated index and the fact that the content of the green bonds is not known by the investors at this date. There is a negative correlation between the S&P 500 Index and the S&P Green Bond Index on these dates. As green bonds became widespread in international markets and became more popular with investors, as it be seen in Graph-2, they followed a positive and fluctuating trend as of the last months of 2014 and the first months of 2015. A sharp decline occurred in both indices after 2021, which can be interpreted as the effects of the Covid-19 pandemic. Although there is a positive correlation between the two indices at 10% quantile values in the 5% confidence interval in 2019 and 2020, in general, there is no statistically significant correlation between the two indices except for the 2014 and 2018 intervals. According to these results, it can be said that green bonds can be an alternative financial investment tool for stock investors and can be used to enrich their portfolios. Periods when the green bond market and the stock market are negatively correlated show that green bonds included in portfolios may be the right choice, especially in terms of risk aversion.

The fact that countries support projects for solutions to climate problems and environmental pollution, and start to impose legal sanctions on companies that act otherwise, allows the increase in nature-friendly projects. The financial instrument that stands out in the financing of these projects is green bonds. Considering the increasing awareness of green bonds and investors consciously using their investments to finance nature-friendly projects, it is predicted that the interest in green bonds will increase in the coming years.

The study contributes to the literature in terms of revealing the relationship between the cross-quantilogram methodology, which is a fairly new method, and the green bond market, which is a relatively new financial instrument, and the stock market. In future studies, more comprehensive analysis results can be obtained by including other variables in the energy sector and indices from other countries in the analysis.

Declaration of Research and Publication Ethics

This study which does not require ethics committee approval and/or legal/specific permission complies with the research and publication ethics.

Researcher’s Contribution Rate Statement

I am a single author of this paper. My contribution is 100%.

Declaration of Researcher’s Conflict of Interest

There is no potential conflicts of interest in this study.

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