Effect of Energy Consumption on Green Bond Issuance

Çağatay Mirgen[1] | *National Defence University, Balıkesir, Turkey*
Yusuf Tepeli[2] | *Muğla Sıtkı Koçman University, Muğla, Turkey*

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Abstract

Green Bonds are fixed-income securities specifically designed to support climate and environmental projects. The demand for the green bond market is growing every day. Green Bonds are gaining importance as they appeal to environmentally conscious investors and are financial instruments that provide economic benefits. The main motivation of this study is to determine whether energy consumption has an effect on green bond issuance. In this context, the relationship between the green bond issuance amounts of 12 countries, including Australia, Canada, China, France, Germany, Japan, the Netherlands, New Zealand, Norway, Sweden, England and the United States, in the years 2014–2021 and the amount of energy consumption in the same period are analysed by panel data analysis. The findings show that there is a significant relationship between coal, peat and oil shale, oil products, natural gas, renewables and waste, electricity and total energy consumption. In the expected direction there is a linear relationship between sustainable energy resources and the green bond issuance.

Keywords	***DOI***	***JEL code***
Green bond issue, energy consumption, panel data analysis	*https://doi.org/10.54694/stat.2023.18*	*C23, G15, 013*

INTRODUCTION

The industrial revolution and consequent development of production processes based on fossil fuels brought population growth and economic prosperity. It has also raised social and environmental challenges by reducing the availability of previously abundant natural resources. Mass production and consumption emerge as a major factor in the deterioration of climate change and ecological balance through the pollution and depletion of natural resources (Schoenmaker, 2017: 7). The negative effects that have emerged with the rapid development of the global economy have caused environmental awareness to come into prominence more than ever before. As a result of the globalization of the economy, the developments in the financial markets have both technological and structural effects on the environment. Many steps have been taken to protect and improve the green environment, especially through green financing instruments. Therefore, the increase of awareness of sustainability in financial terms has led to the green bond implementation.

[1] Department of Business Administration, National Defence University, 10185, Altıeylül, Balıkesir, Turkey. E-mail: cmirgen@msu.edu.tr, phone: (+90)2662214261. ORCID: <https://orcid.org/0000-0002-0970-0121>.

[2] Department of Business Administration, Faculty of Economics and Administrative Sciences, Muğla Sıtkı Koçman University, Kötekli Campus, 48000, Kötekli, Muğla. Turkey. E-mail: yusuftepeli@mu.edu.tr, phone: (+90)2522112097. ORCID: <https://orcid.org/0000-0003-0413-4869>.

Green bonds are financial instruments issued for the use of financing sustainable green projects related to the environment and climate change. Additionally, green bonds have emerged as a promising way to finance the transition to a lower carbon, flexible economy (Banga, 2019: 17). Although there are different definitions of green bonds, there is a growing consensus on for what purpose they are used (OECD, 2017). Many subjects such as renewable energy, green buildings, clean transportation, sustainable waste management, sustainable land use, biodiversity and clean water, financing of environment or climate-friendly projects can be included in the scope of green bonds (MacAskill, Roca, Liu, Stewart and Sahin, 2021: 2). The growing environmental awareness will cause investors to consider social and environmental values as well as financial values. For this reason, investors are more encouraged to adapt their business models to create not only financial values, but also social and environmental values (Schoenmaker, 2017: 32).

Energy is a special issue as it is a key input in almost all other consumption and production processes. Therefore, energy is a very important parameter that controls growth and determines many aspects of human activity in general (Tukker, Charter, Vezzoli, Stø and Andersen, 2017: 113). Energy is fundamental for economic and social development and improving the quality of life in all countries. Energy is described as the ability to do work and can be found in different forms such as chemical, thermal, electrical, mechanical, gravitation, nuclear, radiation, sound, and motion. Energy can be stored, converted or amplified depending on the implementation. Energy sources can be fossil (oil, coal, petroleum, natural gas, etc.), renewable (biomass, hydro, wind, solar, geothermal, marine, hydrogen, etc.) and nuclear (uranium, thorium). The causal effect of emissions generating from burning fossil fuels on climate change is also important for the provision of energy services. In order to reduce or eliminate the effect of this situation, it is necessary to gravitate toward renewable energy sources and increase the production obtained from these sources. For this reason, the financing of green projects becomes crucial. In this context, the purpose of the study is to analyse the effect of energy consumption on green bond issuance. The literature review, research data set, model, method and analysis findings of the study will be explained in order in the following sections.

1 LITERATURE REVIEW

Green finance has attracted the academicians' attention in the last few years, and the literature on green bonds has been enriched with new contributions. By means of these studies, it is understood that green bonds can contribute to the construction of a more sustainable economy and have an awareness-raising effect (World Bank, 2019). When the studies on green bonds are examined, it became clear that many of them enlighten the theoretical framework (Kandır and Yakar, 2017; Ehlers and Packer, 2017; Banga, 2019; Akdağ and Gözen, 2020; Menteşe, 2021; MacAskill, Roca, Liu, Stewart and Sahin, 2021; Özcan and Durmuşoğlu, 2022). In these studies, the development and implementations of green bond and surveys on green bond was carried out. Additionally, there are studies in which econometric models related to the green bond market are built. Reboredo and Ugolini (2020) examined the price link between green bonds and financial markets using the VAR model. As a result, they confirmed that the green bond market was feebly depending on the stock, energy and high-yield corporate bond markets. Reboredo (2018), on the other hand, explained that green bonds have great benefits in diversification for investors in stock and energy markets. Baulkaran (2019) analysed the stock market reaction to the green bond issuance announcement. He stated that the shareholders saw this version of financing as an increment value and the funds obtained from the issuance of green bonds were considered to undertake the profitable green projects or as a risk reduction tool. Wang, Chen, Li, Yu and Zhong (2020) examined the stock market reaction to green bond issuance in China. Pham and Nguyen (2022), on the other hand searched the effects of changes in stock, oil prices and uncertainty of economic policy on green bond yields. Yağcılar and Yilmaz (2022), also examined the reaction of the stock market investor to the announcement of green bond issuance. As a result, they could not come to the conclusion that green bond issues in Turkey make a significant contribution to stockholder value.

Besides these studies, there are also studies examining green bond and energy variables in the literature. Taghizadeh-Hesary, Phoumin and Rasoulinezhad (2023) studied the effects of green bonds issued in Japan and volatility in energy prices on the consumption of three types of green energy (wind, solar and hydro). As a result, they stated that the green bonds issued had positive long-term effects. Ye and Rasoulinezhad (2023) investigated the impact of green bonds issued in 15 Asia Pacific countries on the efficiency of natural resource use. They found that issued green bonds had positive and statistically significant effects on renewable natural resource use efficiency in the short and long term. Huang et al. (2023) examined the impact of investor sentiment and green bond issuance on fossil fuel consumption. They conducted an analysis based on data between 2015 and 2022 for the top ten environmentally sensitive countries. Their findings show that a 1% increase in green bond issuance volume results in a 0.12% decrease in crude oil, a 0.49% decrease in coal and a 0.09% decrease in natural gas consumption.

Dong, Li, Gao and Sun (2023) examined the effects of green bond issuance on renewable energy consumption in Southeast Asian countries. The results showed that the issuance of green bonds was an effective green finance tool in the implementation of development policy related to the distribution of renewable energy in countries in the Southeast Asian region. Zhao, Chau, Tran, Sadiq, Xuyen and Phan (2022) investigated the effect of green bond financing on the investment of energy efficiency for green economic recovery. The findings of the study revealed that green bonds were currently the primary source of financing and increasing the economic growth by 4.9%.

2 RESEARCH DATA SET AND METHOD

As energy consumption increases, the dependency on energy sources that will produce the required energy is also increasing. It is possible to come up with the energy problems over time, especially since fossil fuels are resources that are subject to depletion. Indeed, the energy crisis that started in the 3rd quarter of 2022 in Europe has once again revealed the extent of the need for renewable energy resources: The Paris Climate Agreement also emphasized the importance of supporting environmentally friendly, renewable energy sources in terms of financing due to possible energy crises in the future. Accordingly, it is of great importance to provide the energy production need brought by the increasing energy consumption through sustainable energy investments performed by green financing instruments. In this respect, the main motivation of the study is based on research on the effect of energy consumption on the green bond issuance. Here, data on annual energy consumptions for the data set were obtained from www.iea.org website.

In order to meet the growing need for climate-related data, the IMF and international organizations (OECD, World Bank Group, United Nations, European Commission, European Statistical Office – Eurostat, Food and Agriculture Organization – FAO, International Energy Agency – IEA, and National Oceanic and Atmospheric Administration – NOAA) have been concertedly sharing comprehensive statistical indicators on issues such as climate change, greenhouse gas emissions of economic activities and green finance. In this direction, the data set regarding the annual green bond issuances of the countries was obtained from climatedata.imf.org. The World Bank (2015) defines a green bond as "a debt security that is issued to raise capital specifically to support climate-related environmental projects". In other words, green bonds are fixed-income securities specifically designed to support climate and environmental projects. The green bond market has reached an annual growth rate of 50% since its establishment in 2007. In 2014, the total amount of green bond issuance reached 36.6 billion USD, more than three times the previous year (11 billion USD). This new market is a response to investors' growing demand for financial investments that are both environmentally and economically beneficial. As the green bond market continues to grow, it is important to better understand its risk and return behaviour (Pham, 2016: 263). Therefore, this study investigates the effect of energy consumption on the green bond issuance.

The time range of the data set covers the years 2014–2021. The countries and the years of the relevant data set have been created by considering their continuity. Selected countries comprise 12 countries of Australia, Canada, China, France, Germany, Japan, Netherlands, New Zealand, Norway, Sweden, the United Kingdom and the United States. Green bonds are relatively new financial instruments. The number of countries that regularly issue green bonds every year is limited. For this reason, 12 countries were included in the analysis. The selected countries are those who regularly issue green bonds in the relevant years.

Other explanations of the variables used are shown in Table 1. Detailed explanations on energy variables are presented in the "World Energy Balances Highlights 2023" report prepared by the IEA.

Table 1 Variables

Variables		Scale	Resource
GB	Green Bond	Billion USD (yearly)	climatedata.imf.org
A	Coal, peat and oil shale	Total final consumption (PJ)*	www.iea.org
B	Oil products		
C	Natural gas		
D	Renewables and waste		
E	Electricity		
F	Total		

Note: * Equal to the sum of the consumption in the end-use sectors. Energy used for transformation processes and for own use of the energy producing industries is excluded. Final consumption reflects for the most part deliveries to consumers.
Source: Own elaboration based on Climatedata and IEA

The analysis of panel data is used to test the models that include time- series and cross-section data together. In this context, the research method was carried out with the help of panel regression analysis, as the research dataset includes different countries and different variables belonging to these countries. Panel data analysis was first used in the studies made by Hildreth (1950), and Kuh (1959). However, its real popularity began in the 1990s (Tatoğlu, 2018: 3).

As for the model selection within the scope of the analysis, LR, F and Hausman (1978) tests were performed. According to the results of the relevant tests, it was determined that the fixed effects estimator was appropriate for the model. Finally, the basic assumption tests of the fixed effects model were tested and regression analysis was performed with the Driscoll Kraay resistant estimator.

3 RESEARCH MODEL, ANALYSIS AND FINDINGS

The model fictionalized within the context of research analysis, the performed analysis and findings will be explained respectively below. In this context, first of all, descriptive statistics of the variables are given and the details are shown in Table 2.

Table 2 Descriptive statistics

Variable		Obs.	Mean	Std. dev.	Min	Max
GB	Green Bond	96	11.58	15.992	0.092	74.386
A	Coal, peat and oil shale	96	2 456.862	7 550.586	17.247	32 372.313
B	Oil products	96	6 259.867	9 422.505	254.34	31 739.162
C	Natural gas	96	2 610.074	4 135.022	23.281	16 018.751
D	Renewables and waste	96	940.78	1 570.717	33.07	5 580.397
E	Electricity	96	3 916.359	6 472.156	139.602	27 291.648
F	Total	96	1 6682.2	27 080.182	560.129	96 995.299

Source: Own elaboration based on data from Climatedata and IEA

The model to be used in the analysis is structured as follows:

$$GB_{it} = \alpha_{it} + \beta_1 A_{it} + \beta_2 B_{it} + \beta_3 C_{it} + \beta_4 D_{it} + \beta_5 E_{it} + \beta_6 F_{it} + u_{it}, \quad (1)$$

here: α; represents constant term, "β" the explanatory variable coefficient and "u" the random error term i: units, t: time. Explanations of the variables GB, A, B, C, D, E and F are given in Table 1. After the step of determining the independent variables, the appropriate regression model should be selected. In this context, F test provides an opportunity to make a choice between the classical model and the fixed effects model (Tatoğlu, 2018: 168). The LR test, on the other hand, between the classical model and the random effects model. If the classical model selection is not considered appropriate in terms of the F test and LR rest results, a choice is made between Hausman (1978) test and the fixed effects model or the random effects model.

In this context, the results of the relevant tests are given in Table 3.

Table 3 Determining the appropriate regression model

UNIT EFFECT (Prob>F)	TIME EFFECT (Prob>Chibar2)
Fixed effects (F test)	
Probability value: 0.0000	Probability value: 0.0000
H_0: Unit effects are not significant	H_0: Time effects are not significant
Random effects (LR test)	
Probability value: 0.0000	Probability value: 0.0000
H0: Unit effects are not significant	H0: Time effects are not significant
Hausman test (Prob>Chi2)	
Probability value: 0.0123	

Source: Own elaboration based on data from Climatedata and IEA

When the analysis results in Table 3 are examined, it has been determined that there is a unit and time effect in terms of the results of the F test and LR test, and the classical model is not appropriate. Hausman (1978) test was applied to make a choice between the fixed effects model and the random effects model (Tatoğlu, 2018: 188). According to the results of the two-way Hausman test which considers the unit and time effects together, the probability value was determined as 0.0123. In this case, it has been determined that the use of the fixed effects estimator is appropriate.

The final situation to consider before applying the regression analysis is to perform the basic assumption tests of the model. These assumptions comprise of varying variance, autocorrelation and correlation between units. The test results of the assumptions are shown in Table 4. According to the test results, it was concluded that there was varying variance, autocorrelation and inter-unit correlation for the fixed effects model.

Table 4 Basic assumption tests of Fixed Effects Model

Heteroskedasticity (Wald Test)	Autocorrelation (Durbin-Watson Test)	Inter-Unit Correlation (Pesaran CD Test)
Prob>chi2 = 0. 0000	Durbin-Watson = 1.0550556 Baltagi-Wu LBI = 1.6805674	p-value = 0.0000
H_0: There is no varying variance	If values are less than 2, there is autocorrelation	H_0: There is no correlation between units

Source: Own elaboration based on data from Climatedata and IEA

Wald Test calculates a modified Wald statistic for groupwise heteroskedasticity in the residuals of a fixed effect regression model (Greene, 2000: 598). In respect of the results in Table 4, where the basic assumption tests of the fixed effects model were tested, the Driscoll Kraay resistant estimator should be used for the final regression model. Deviations in basic assumptions are considered with this robust estimator. The results of the regression analysis performed in this context are given in Table 5.

Table 5 The results of regression analysis

Variable		Coefficients	Std. error	t-value	p-value
A	Coal, peat and oil shale	–0.118	0.027	–4.360	0.003*
B	Oil products	–0.096	0.022	–4.390	0.003*
C	Natural gas	–0.115	0.030	–3.800	0.007*
D	Renewables and waste	0.102	0.048	2.140	0.069***
E	Electricity	–0.129	0.031	–4.110	0.005*
F	Total	0.090	0.022	4.100	0.005*
	_cons	113.486	19.032	5.960	0.001*
Number of observations(N)		96			
R^2 value		0.4417			
Prob>F		0.0000			

Note: *** %10, ** %5, and * %1 represent the significance.
Source: Own elaboration based on Climatedata and IEA

When the regression analysis results in Table 5 are examined, the probability value of Prob>F (0.0000) figures the statistical significance at the 1% level of significance. The explanatory power of the model was determined as R^2 value of 0.4417 (44.17%). This value indicates the explanatory power of the independent variables on the dependent variable.

Additionally, it was determined that green bond issuance has a significant relationship (GB) with the coal, peat and oil shale (A) (p = 0.003), oil products (B) (p = 0.003), natural gas (C) (p = 0.007), renewables and waste (D) (p = 0.069), electricity (E) (p = 0.005), total (F) (p = 0.005). In addition, a positive relationship was detected between green bond issuance (GB) and Renewables and waste, and a negative relationship was found with other variables.

CONCLUSION AND RECOMMENDATIONS

The use of renewable energy sources as an alternative to fossil fuels has gained importance day by day in supplying the increasing energy needs. The energy provided from renewable energy sources requires new investments in related production tools. Therefore, green bonds emerging to be used in the financing of renewable energy investments are considered as an opportunity. Green bonds are financial instruments issued to finance projects related to environmental sustainability and climate change. It is generally used to support environmental projects such as energy efficiency, renewable energy and waste reduction. These bonds both provide an opportunity for investors to create environmental impact and contribute to the green economy by supporting sustainability efforts in the energy sector. Environmentally friendly investments are of great importance in reducing the negative effects of climate change and resource use. It also encourages companies to adopt more responsible practices, promote innovation in clean technologies, and create a positive impact on the environment. It is thought that the accompanying increase in environmental awareness will increase the demand for green bonds. In this context, the relationship between energy consumption and green bond was examined in the study.

In the study, energy consumption data of countries that regularly issue green bonds were taken into account. For this reason, 12 countries could be included in the scope of the study. The widest time period covering all these countries was reached between 2014 and 2021. The variables are Green Bond issuances by country and total final consumptions for energy variables. The findings reveal the existence of a significant relationship between green bond issuances (coal, peat and oil shale, oil products, natural gas, renewables and waste, electricity, total consumptions for energy) and the energy consumptions examined. These results are showing similarities with the studies of Ye and Rasoulinezhad (2023), Huang et al. (2023).

The relationship between renewable energy consumption and green bonds often reflects the purpose of these bonds to fund energy projects. By providing financial support to renewable energy projects through green bonds, investors invest in projects that reduce carbon emissions and promote environmental sustainability. In this context, projects financed with green bonds may include efforts to use renewable energy sources and make energy consumption more sustainable, such as wind power plants, solar energy projects, hydroelectric facilities and energy efficiency improvement projects. Research results revealed a positive relationship between renewables and waste energy consumption and green bonds issuance.

Other results obtained within the scope of the research show a negative relationship between coal, peat and oil shale, oil products, natural gas, electricity and total energy consumption and green bonds. Green bonds generally aim to finance projects aligned with environmental sustainability. Coal is one of the oldest and most widely used fossil fuels. However, burning coal causes greenhouse gases to be released into the atmosphere and contributes to climate change. Therefore, reducing coal use can contribute to increasing the use of sustainable energy sources and investing in green energy projects.

The electrical energy sector is one of the largest sources of greenhouse gas emissions worldwide. The largest sectoral increase in emissions in 2022 came from electricity and heat production (IEA, 2022: 3).

The production of electricity through green bonds by environmentally friendly production facilities can have a restrictive effect on greenhouse gas emissions.

Petroleum products and natural gas generally refer to products derived from fossil fuels and used in various industries. The use of these products also causes environmental impacts and climate change problems. Therefore, considering that green bonds are financial instruments that aim to invest into environmentally friendly projects, the projects supported by green bonds may lead to a decrease in the dependence on these energy resources. In this context, energy obtained from coal, peat and oil shale, oil products, natural gas is generally incompatible with green bond criteria. Therefore, it is acceptable to have a negative relationship between them, as obtained in the research results.

The governments agreed to meet the increasing energy needs with renewable energy sources with the growing environmental awareness especially after the Paris Climate Conference, and also many countries even put forward incentive packages for investments in renewable energy sources. Financial institutions and markets are not indifferent to these incentives, and they provide green financing support to companies that operate using environmentally friendly technologies and contribute to sustainable life, with many environmentally friendly green financing instruments they have developed. Green bonds have emerged as one of these financial instruments. The amount of energy obtained from renewable energy sources will also increase with the increase in the issuance of green bonds. In fact, the International Energy Agency has also made statements that approximately 30% of the energy need will be met by renewable energy sources until 2030. Accordingly, the use of renewable energy rather than fossil fuels in energy consumption will be effective in reducing the environmental problems.

In this study, only green bonds from green financing instruments were examined. However, it should not be ignored that investments in renewable energy resources are financed with other green financing instruments. However, since green financing instruments have emerged recently, there may be difficulties in collecting data on them. In the future, it can be predicted that the demand for green financing instruments will increase and their use will become widespread due to reasons such as increasing environmental awareness and focusing on projects that protect nature. This may inspire a new research by providing easier access to large data sets.

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