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Do Green Bonds Deliver Sustainable Outcomes in Emerging Economies? Evidence from Türkiye[*]

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ABSTRACT

This study examines the impact of green bond issuances on renewable energy, a widely accepted indicator of sustainability performance, in the context of Türkiye. The analysis uses monthly data covering the period from October 2022 to October 2025 and applies the Autoregressive Distributed Lag (ARDL) approach to examine both short- and long-run dynamics. Empirical findings indicate that green bond issuances do not have a statistically significant effect on renewable energy development over the sample period. This result suggests that, in a developing economy such as Türkiye, green bonds have not yet functioned as an effective financial instrument for stimulating renewable energy investments. However, this finding does not necessarily imply an inherent inefficiency in green bonds. Instead, it reflects structural constraints within the sustainable finance ecosystem, including limited institutional capacity, regulatory challenges, and insufficient financial market depth, which may limit the contribution of green bonds to renewable energy expansion.

***Keywords**: Green Bonds, Renewable Energy, Sustainable Finance, ARDL Methodology*

***JEL Classification**: G12, Q42, Q56*

Yeşil Tahviller Gelişmekte Olan Ekonomilerde Sürdürülebilir Sonuçlar Sağlıyor mu? Türkiye'den Kanıtlar

ÖZET

Bu çalışma, sürdürülebilirlik performansının yaygın olarak kabul edilen bir göstergesi olan yenilenebilir enerji üzerindeki yeşil tahvil ihraçlarının etkisini Türkiye bağlamında incelemektedir. Analiz, Ekim 2022 ile Ekim 2025 arasını kapsayan aylık verileri kullanmakta ve hem kısa hem de uzun vadeli dinamikleri incelemek için Otoregresif Dağıtılmış Gecikme (ARDL) yaklaşımını uygulamaktadır. Ampirik bulgular, yeşil tahvil ihraçlarının örneklem dönemi boyunca yenilenebilir enerji gelişimi üzerinde istatistiksel olarak anlamlı bir etkisinin olmadığını göstermektedir. Bu sonuç, Türkiye gibi gelişmekte olan bir ekonomide yeşil tahvillerin henüz yenilenebilir enerji yatırımlarını teşvik etmek için etkili bir finansal araç olarak işlev görmediğini göstermektedir. Bununla birlikte, bu bulgu yeşil tahvillerin doğasında var olan verimsizliğin kanıtı olarak yorumlanmamalıdır. Bunun yerine, sınırlı kurumsal kapasite, düzenleyici zorluklar ve yetersiz finansal piyasa derinliği de dahil olmak üzere sürdürülebilir finans ekosistemindeki yapısal kısıtlamaları yansıtmaktadır; bu kısıtlamalar yeşil tahvillerin yenilenebilir enerji genişlemesine katkısını sınırlayabilir.

***Anahtar Kelimeler:** Yeşil Tahviller, Yenilenebilir Enerji, Sürdürülebilir Finans, ARDL Metodolojisi*

***JEL Sınıflaması**: G12, Q42, Q56*

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1. INTRODUCTION

The concept of sustainability was first introduced in 1713 by Hans Carl von Carlowitz, in order to draw attention to the excessive use of forests in the Saxony region. In the report published in 1987 by the United Nations Brundtland Commission, sustainability was defined as "meeting the needs of the present without jeopardizing the ability of future generations to meet their own needs" (Bosselmann 2016; Turguttopbaş, 2020: 269). Relatedly, the concept of sustainable development is expressed as a development approach that meets today's needs without reducing the capacity of future generations to meet their own needs (İnneci, 2024: 2435).

The phenomenon of globalization and the uncontrolled production activities it has brought about have, over time, led to negative impacts in many social and economic domains. These adverse effects have not only threatened human health but have also resulted in the pollution of water resources, rising sea levels, a decline in biodiversity, damage to the ozone layer, and numerous other environmental problems (Şahin, 2023: 2; Erdoğan, 2022: 104).

These issues have manifested today as climate change and the climate crisis. The first international initiative aimed at combating the adverse effects of the climate crisis was the Kyoto Protocol adopted in 1997. However, the protocol proved insufficient in curbing the rise in global emissions, as it covered only a limited number of countries and left some nations without binding obligations. The Kyoto Protocol was followed by the Paris Climate Agreement, a binding action plan which secured global consensus in the fight against the climate crisis. The agreement was ratified by 196 countries in 2015. In 2019, the European Commission published the "European Green Deal", outlining green growth targets for a sustainable world (Özbey, 2024).

The most important factor required for sustainable development and for mitigating the effects of climate change is financing. It is estimated that by 2050, approximately 110 trillion USD in financing will be needed for investments in low-carbon projects such as carbon offset facilities, solar panels, wind farms, nuclear power plants, and smart buildings. In Türkiye, which forms the sample for this study, the financing required by 2030 could amount to around 135 billion USD (Dumlu and Keleş, 2023: 262). The scale of financing needed for the

sustainable development transformation is not something that private-sector firms can shoulder alone. Therefore, it is inevitable that countries' capital markets be more actively involved in this process. Indeed, the concept of green bonds was born out of this very need.

Green bonds, which have come to the forefront in financing sustainable development, are debt instruments used to fund environmentally friendly projects and are among the most widely preferred such instruments worldwide (Banga, 2019: 22). The fundamental difference between green bonds and traditional bonds is that the funds obtained from a green bond issuance are used exclusively for sustainable projects with proven environmental benefits, and that green bonds have longer maturities. The primary reason for these longer maturities is cited as the longer time required for investments in green projects to pay off (Li et al., 2020: 2679; Flammer, 2021: 499).

Towards the 2020s, many countries have issued green bonds (Wang & Jiang, 2023). In the case of Türkiye, the market officially initiated in May 2016 with the pioneering 300 million USD green bond issuance by the Industrial Development Bank of Türkiye (TSKB, 2016). The green bond issuances of the United States and China together account for approximately 40% of all green bond issuances worldwide. Other countries among the top ten issuers include developed nations such as France, Germany, the Netherlands, Spain, Sweden, Canada, and Japan (Li et al., 2020: 2680). Prior to 2023, the green bond market has grown by an average of more than 50% annually, approaching a size of nearly US$1 trillion (Alamgir and Cheng, 2023: 3).

The healthy functioning of the green bond market can help channel resources from both the public and private sectors into investments with positive environmental benefits, thereby reducing firms' cost of capital and contributing to economic growth (Hyun et al., 2023: 3042).

Beyond their environmental benefits, green bonds also have distinct implications from the investor's perspective. For investors, green bonds provide financial returns on the one hand, while on the other hand financing investments that are beneficial to the environment. Accordingly, investor interest in green bonds has been steadily increasing (Kandır and Yakar, 2017; Wang & Jiang, 2023). The growing interest in green bonds has, in turn, brought

different derivatives of this instrument to the fore, and an Islamic green sukuk instrument has been developed for investors in the Islamic finance system (Yazıcıoğlu and Baştan Töke, 2022: 340).

2. LITERATURE REVIEW

In the finance literature, companies' issuance of green bonds has been linked to signaling theory. Green bonds send a signal to investors who may lack sufficient information about firms' environmental commitments, that companies investing in green projects are genuine and credible in their sustainability efforts. This reliable signaling effect can positively influence a company's value (Hyun et al., 2023: 3046-3059; Hu et al., 2025: 1582). On the other hand, whether firms issuing green bonds are doing so to genuinely fund green investments or are instead engaging in greenwashing by misrepresenting the scope of their green initiatives is a concern that has been discussed in the literature (Shi et al., 2023; Wang and Shen, 2024; Liu et al., 2025).

The growing investor interest in green bonds and the increase in green bond issuances have led to a rise in studies examining whether green bonds contribute to sustainability goals and what their impact is on firm performance.

Erdoğan (2022, 102) considers green bonds, in the context of the negative environmental impacts of production activities, as an important instrument of sustainable finance and draws attention to the inadequacy of traditional financing methods in addressing environmental problems. Similarly, Şahin (2023, 4) emphasizes that directing green bond revenues into renewable energy investments plays a critical role in combating the climate crisis.

Tang and Zhang (2020), in their analysis of firms operating in 28 countries during the 2007–2017 period, found that green bond issuances led to positive market reactions in stock prices. This finding indicates that green bond issuances are perceived by investors as an environmentally conscious and trustworthy signal. In a similar vein, Flammer (2021) revealed that companies issuing green bonds experienced increases in their market value, and that this rise stemmed from improved perceptions of corporate reputation and credibility rather than from financial returns. Studies conducted specifically on Türkiye have likewise found that

green bond issuances are viewed positively by investors and create short-term positive effects on financial performance (Dumlu and Keleş, 2023).

The effects of green bonds on environmental performance have been addressed in the literature as a separate field of inquiry. Flammer (2020) demonstrated that publicly traded companies experienced significant improvements in their environmental footprints after issuing green bonds. Alamgir and Cheng (2023), in their study covering 67 countries for the period 2007–2021, statistically show that green bond issuances reduce carbon emissions and increase renewable energy production. The study by Wang et al. (2022), focusing on a sample from China, likewise finds that green bond issuances create significant positive effects on green investments and green innovation. Baştürk (2022) revealed that green bond issuances have a positive and statistically significant effect on renewable energy production. Tang and Zhang (2020) observed that with green bond issuances, countries' carbon emissions decreased and renewable energy output increased. These findings indicate that green bonds are not only a financial instrument but also an effective policy tool supporting environmental transformation. Similarly, Hu and Jin (2023) reported a positive effect of green bonds on renewable energy in the case of China.

In studies focusing on Türkiye, which forms the sample of this study, it is stated that the use of green bonds in financing renewable energy investments is still limited, but that this instrument's potential is quite high. Özcan and Durmuşoğlu (2022) emphasize that in order for green bonds to be used more effectively, certification and external evaluation mechanisms need to be strengthened.

This study has been carried out on Türkiye as a case, given that it is a developing country where legal regulations related to sustainability and green bond issuances are in an embryonic stage. Considering that in developing countries green bond markets are still in their nascent phase, and that high transaction costs and a lack of institutional regulatory frameworks constrain the market's development (Banga, 2019), the findings of this study become even more important.

From a sustainability standpoint, renewable energy, which is used as the dependent variable in this study, has emerged as a fundamental strategy for mitigating climate change

and advancing the sustainable management of natural resources. In this context, green bonds have appeared as a promising financial instrument to accelerate renewable energy projects and to encourage the development of sustainable resources (Hu and Jin, 2023).

Overall, the literature shows that green bonds have positive effects on both financial markets and environmental performance. However, especially in developing countries, shortcomings in market depth, regulatory frameworks, and certification mechanisms stand out as key factors limiting the effectiveness of this financing instrument. This situation makes it necessary to examine in more detail the contribution of green bonds to sustainable development goals by jointly considering financial and environmental dimensions on a country- and context-specific basis. Furthermore, the fact that almost all of the existing studies are focused on the US and China highlights a gap in the literature on this topic in developing countries.

With all these considerations in mind, this study analyzes the effect of green bond issuances on renewable energy. The primary reason for choosing Türkiye as the sample for the study is that it is a country with growing investor interest in green bonds and one that can be considered relatively new in terms of its regulatory and institutional environment (Menteşe, 2021).

As a result of the Autoregressive Distributed Lag (ARDL) test conducted with monthly data for the 2022–2025 period, no immediate effect of green bond issuances on renewable energy was found.

The aim of this study is to analyze the short-term and long-term impacts of green bond issuances on renewable energy in Türkiye using the ARDL method. Following the introduction, the study continues with the methodology, analysis, and finally the conclusion.

3. METHODOLOGY AND DATA SET

3.1.Data Set and Variables

In this study, focusing on the case of Türkiye, the effect of green bond issuances on renewable energy usage is analyzed for the period from October 2022 to October 2025 (2022:M10–2025:M10). The data set begins in 2022. This specific timeframe is determined

by data availability, as SPK-approved green bond issuances in Türkiye reached a continuous and measurable volume starting from October 2022, thereby capturing the entire actual history of the domestic market. The population of the study consists of all firms in Türkiye that issued green bonds during this period. The research sample covers all SPK-approved (Capital Markets Board of Türkiye) green bond issuances within these dates, without applying any sector limitations or exclusions. For this purpose, instead of using nominal green bond issuance amounts, the share of green bond issuances in total debt instruments is used as the key indicator. In addition, the variables of energy consumption, Brent crude oil prices, electricity prices, and inflation were also included in the analysis. A detailed description of the variables used in the study is provided in Table 1.

Table 1. Variables Used in the Model

Variables	Abbreviation	Definition	Data Sources
GREEN BOND	GB	The share of green bonds in total issued debt instruments	https://spk.gov.tr/ihrac-verileri
BRENT OIL	Brent	Brent crude oil price (USD)	https://www.eia.gov/
ELECTRIC	ELEC	Average electricity price	https://www.epdk.gov.tr/
INFLATION	INF	Monthly inflation rate (%)	https://www.tcmb.gov.tr/
CONSUMPTION	CONS	Monthly per capita electricity consumption (kWh/person)	https://www.teias.gov.tr/
RENEWABLE ENERGY	REN	Share of renewable energy sources (%)	https://ytbsbilgi.teias.gov.tr/

In the literature, there are various studies that treat the share of renewable energy sources as the dependent variable and analyze its determinants (Przychodzen and Justyna Przychodzen, 2020; Makki et al., 2024; Akarsu and Gümüşoğlu, 2019). Studies that specifically examine the impact of green bond issuance on renewable energy sources include those by Taghizadeh-Hesarya et al. (2023) and Wang and Jiang (2023). Additionally, numerous studies have examined the effects of crude oil (Brent) prices on energy markets and renewable energy investments (Taghizadeh-Hesarya et al., 2023; Broadstock and Cheng, 2019; Van Hoang et al., 2020; Horn et al., 2026; Makki et al., 2024). As a macroeconomic indicator, the relationship of inflation with energy markets has been investigated by Jin et al. (2024) and Makki et al. (2024). Furthermore, the literature includes studies addressing the relationship between energy consumption (demand) and renewable energy (Durante et al., 2022).

The variables included in the study were selected to reflect the key financial and economic factors that can affect the share of renewable energy. The share of renewable energy

in total energy supply (REN) was chosen as the dependent variable because it directly demonstrates the sustainable energy transition. Green bond issuances (GB) were included in the model as a variable related to renewable energy investments, as they are a tool used to finance environmentally friendly projects. Brent crude oil prices (Brent) were used to control for the potential effects of changes in fossil fuel costs on renewable energy. The electricity variable (ELEC) represents the cost of electrical energy in the market, while the inflation rate (INF) was added to the model to reflect macroeconomic conditions in the investment environment. The consumption variable (CONS) aims to control for the impact of changes in the level of economic activity on energy demand and the share of renewable energy.

3.2. Methodology

In this study, taking into account the aim of the research and the structure of the data, the Autoregressive Distributed Lag (ARDL) bounds testing approach was employed, as it is one of the methods widely used in time series analysis. The ARDL method offers significant advantages in that it allows for the simultaneous estimation of short-run and long-run coefficients. Moreover, this approach can be applied even when the explanatory variables have different orders of integration, and it can yield effective results especially in time-series studies with small samples. For these reasons, the ARDL method is widely preferred in the literature, as it provides flexibility in the estimation process and helps mitigate certain endogeneity issues (Hacievliyagil and Eksi, 2019: 79; Doğan and Özarslan Doğan, 2021: 789).

In this context, the general form of the ARDL model estimated in the study is expressed as follows:

$$REN_t = \alpha_0 + \sum_i \alpha_i REN_{t-i} + \sum_j \beta_j GB_{t-j} + \sum_k \gamma_k Brent_{t-k} + \sum_l \delta_l ELEC_{t-l} + \sum_m \varphi_m INF_{t-m} + \sum_n \theta_n CONS_{t-n} + \varepsilon_t \quad (1)$$

Here, REN represents the share of renewable energy in the total energy supply, GB represents green bond issuances, Brent represents crude oil prices, ELEC represents average electricity prices, INF represents the inflation rate, and CONS represents monthly per capita electricity consumption. ε_t represents the error term.

The Autoregressive Distributed Lag (ARDL) analysis process consists of three successive main stages. First, using the Bounds Test, the existence of a cointegration relationship indicating that the variables move together in the long run is investigated. In this study, the existence of a long-run relationship among the variables was examined using the ARDL bounds testing approach. In this context, the F-statistic obtained from the bounds test was compared with the relevant lower and upper critical bound values to evaluate the presence of a cointegration relationship. If the F-statistic exceeded the upper critical bound, it indicated the existence of a long-run relationship among the variables, whereas if it fell below the lower bound, it suggested that no cointegration exists. If the F-statistic lay between the critical bounds, the test results did not permit a definitive conclusion (Dereli, 2019: 251).

Following the confirmation of this relationship, the second stage is undertaken, in which the long-run coefficients reflecting the established equilibrium are estimated.

In the final stage of the analysis, an Error Correction Model (ECM) is constructed in order to identify the short-run dynamics in the process of converging to the long-run equilibrium and to determine the speed at which deviations from equilibrium are corrected (Doğan and Özarslan Doğan, 2021: 790). To verify the reliability and consistency of the estimated model, various diagnostic tests were applied. In this context, the Breusch–Godfrey LM test was used to check whether there was an autocorrelation problem in the model, and the Breusch–Pagan–Godfrey or ARCH tests were used to examine whether there was a heteroskedasticity problem. Additionally, the cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests were applied to check the stability of the model's parameters over time (Brown et al., 1975). The CUSUM and CUSUMSQ tests are important because they provide information about the overall stability of the model without the need to specify a break point.

4. FINDINGS

The descriptive statistics of the variables used in the study are presented in Table 2.

Table 2. Descriptive Statistics

Variable	Mean	Min	Max	Std. Dev.	Obs
REN	0.435	0.309	0.633	0.079	37
BRENT	79.04	64.45	93.72	7.73	37
ELEC	3.12	2.59	3.63	0.47	37
CONS	345	296	418	33.91	37
GB	0.116	0	0.426	0.113	37
INF	3.296	0.04	9.490	1.982	37

The first step of the empirical analysis is to examine the stationarity properties of the time series used. A non-stationary series tends to have a mean and variance that change over time. This non-stationarity can lead to a spurious regression problem when regressions are performed using linear combinations of such series. This situation increases the risk of a Type I error and biases the coefficient estimates (Alimi, 2014: 106). To prevent this critical issue, Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were applied. The results of the unit root tests for the study, along with the stationarity status of each variable, are presented in Table 3.

Table 3. Unit Root Test Results (ADF and PP)

Variables	ADF	PP	Degree of Integration
D(REN) (1. Difference)	-4.968*** (0.0003)	-4.964*** (0.0003)	I(1)
D(BRENT) (1. Difference)	-5.693*** (0.0000)	-6.796*** (0.0000)	I(1)
D(ELEC) (1. Difference)	-5.793*** (0.0000)	-5.793*** (0.0000)	I(1)
CONS (Level)	-5.196*** (0.0000)	-3.116** (0.0342)	I(0)
GB (Level)	-5.743*** (0.0000)	-5.740*** (0.0000)	I(0)
INF (Level)	-3.917** (0.0047)	-3.866** (0.0054)	I(0)

Note: *, **, and *** indicate significance at the 10%, 5%, and 1% levels, respectively. The unit root tests were conducted using a model with an intercept and trend.

The results obtained indicate that the variables are integrated of orders I(0) and I(1), and that no variable is I(2). This finding makes the application of the ARDL bounds testing approach methodologically appropriate.

Table 4. ARDL Bounds Test Results

Test Statistic	**Value**	**k**
F-statistic	3.7949	5
Significance Level	**I(0)**	**I(1)**
10%	2.08	3
5%	2.39	3.38
1%	3.06	4.15

Note: Null Hypothesis: No levels relationship

According to the ARDL bounds test results in Table 4, the calculated F-statistic is 3.7949. This value is above the upper critical bound value of 3.38 given at the 5% significance level. Therefore, at the 5% significance level, the null hypothesis is rejected, and it is concluded that there is a statistically significant long-run cointegration relationship among the variables.

Table 5. ARDL Long-Run Coefficient Estimation Results

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
BRENT	-0.00703	0.004849	-1.44996	0.1643
CONS	-0.00487	0.001857	-2.62207	0.0173
ELEC	-0.03156	0.074456	-0.17669	0.8617
GB	0.322531	0.410974	0.784797	0.4428
INF	0.031356	0.027511	1.139761	0.2693
C	2.593318	0.721573	3.593976	0.0021

Examining the long-run coefficient estimates in Table 5, we observe that Brent oil prices exert a negative effect on renewable energy in the long run, but this effect is not statistically significant. In contrast, the consumption (CONS) variable has a reducing effect on renewable energy in the long run, and this effect is found to be statistically significant at the 5% level. The coefficients for electricity prices (ELEC), green bond(GB), and inflation (INF) do not produce statistically significant results in the long run. Additionally, the fact that the constant term is positive and significant at the 1% level indicates that the long-run structure of the model is statistically consistent.

Table 6. ARDL Error Correction Model (Short Run) Results

Variable	**Coeff.**	**t-Statistic**	**Prob.**
ECM(-1)	**-0.392**	**-3.157**	**0.006**
ΔBRENT	-0.003	-1.434	0.169
ΔCONS	0.002	3.816	0.001
ΔCONS(-1)	0.001	3.540	0.002

ΔELEC	0.005	0.173	0.864
ΔGB(-3)	-0.168	-2.273	0.036
ΔINF(-1)	-0.017	-2.891	0.01
C	1.016	3.719	0.002

Note: Δ denotes the first-difference operator. ECM(-1) is the error correction term.

According to the error correction model results presented in Table 6, the coefficient of ECM(-1) is negative and statistically significant. This finding indicates that short-run disequilibria are corrected toward the long-run equilibrium. The magnitude of the ECM coefficient suggests that approximately 39% of deviations from equilibrium are eliminated within one period. It is observed that some variables and their lagged values are statistically significant in the short run, while other variables do not have a significant effect on short-run dynamics.

Table 7. Diagnostic Test Results

Test	**Statistic**	**Prob.**
Breusch-Godfrey LM	31.326	0.2088
Breusch-Pagan-Godfrey	39.872	0.8055

After identifying the long-run cointegration relationship, diagnostic tests were applied to verify the model's reliability. According to the Breusch-Godfrey LM test results presented in Table 7, the p-value is 0.2088; thus, at the 5% significance level, the null hypothesis of no autocorrelation cannot be rejected. Similarly, the Breusch-Pagan-Godfrey heteroskedasticity test yields a p-value of 0.8055, confirming that there is no heteroskedasticity in the model's residuals (i.e., the residuals are homoskedastic). Additionally, the error terms are observed to be normally distributed, and it is concluded that the ARDL model is overall statistically appropriate, robust, and consistent.

The findings of this study differ from some positive findings in the literature, particularly in that the effect of the green bond (GB) variable on the share of renewable energy is not statistically significant (Taghizadeh-Hesarya et al., 2023; Wang and Jiang, 2023). This difference can be explained by the fact that Türkiye's renewable energy investments are largely shaped within the framework of public policies, incentive mechanisms, and long-term planning. Increases in uncertainty tend to delay the timing of projects rather than completely halting investment decisions, which can lead to the effect appearing weak or insignificant in short- and medium-term analyses. Furthermore, the fact

that most studies finding a positive correlation in the literature cover developed countries and longer time periods can be considered another important factor explaining the difference in Türkiye's findings.

The results of the CUSUM and CUSUMSQ tests, applied to examine the stability of the ARDL model coefficients over time, are shown in Figure 1.

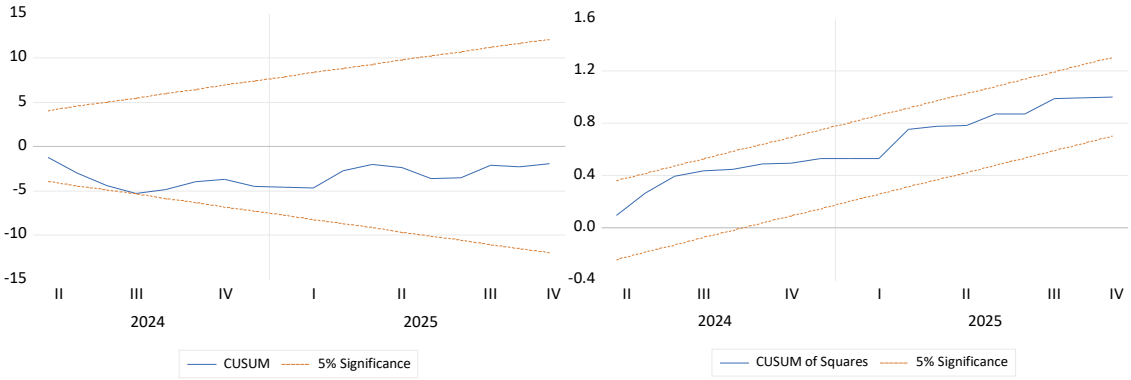

Figure 1. CUSUM and CUSUM of Squares Tests

The results of the Cumulative Sum (CUSUM) test (Figure 1), which was applied to test the stability of the model's estimated parameters over time, strongly support the model's reliability. In the figure, the line representing the cumulative sum path stays within the critical boundaries at the 5% significance level (shown by dashed lines). In the test developed by Brown, Durbin, and Evans (1975), the fact that the line remains within these bounds indicates that the model's coefficient estimates remain stable over the estimation period. This finding provides additional and important evidence for the reliability of both the long-run and short-run estimates obtained from the ARDL model.

5. CONCLUSION

In this study, which examines the effect of green bond issuances on renewable energy, an indicator that can be considered as sustainability performance, no impact of green bonds was identified. In this respect, the findings of the study reveal that, in Türkiye as a developing country case, green bond issuances have not yet become an effective financing instrument capable of triggering renewable energy investments. This finding does not point to the ineffectiveness of green bonds per se; rather, it indicates deficiencies in the institutional,

regulatory, and financial infrastructure of the sustainable finance ecosystem. Therefore, the ability of green bonds to play an effective role in the renewable energy transition depends not only on the existence of financial instruments but also on strong regulations, transparency, and policy coordination.

These findings provide important implications for policymakers. As is well known, the long-term and capital-intensive nature of renewable energy investments makes it difficult for the private sector to finance such projects on its own. Based on this, policymakers may increase the attractiveness of green bonds by providing partial guarantees, offering interest subsidies or tax incentives for highly sustainable projects financed through green bond proceeds, or developing blended finance models through cooperation between development banks and the private sector. In Türkiye, there seems to be a hesitation toward issuing these bonds. This situation could be linked to current policies; given the high interest rates, alternative investments might not provide attractive returns for investors. Furthermore, the long-term borrowing costs could create a heavier financial burden for firms. Thus, while there is a visible increase in renewable energy investments, bond issuances remain limited. In addition, the need to establish a project-based and auditable framework that mandates the allocation of funds obtained from green bonds to sustainable areas such as renewable energy investments comes to the forefront.

On the other hand, it should be taken into account that sustainability-related legal regulations in Türkiye are still at an early stage. Although legal regulations and mandatory sustainability reporting frameworks have recently been introduced, a complete taxonomy and mature standards are still developing.

The results suggest that firms often use green bonds to meet general liquidity needs. However, green bonds remain a crucial financial tool for supporting sustainability goals. At the same time, company owners and managers need to develop their perspectives on green bonds within this framework.

According to the results based on the data set of this study, which can be considered short-term in nature, although green bond issuances do not create an observable effect on

renewable energy, they remain important for firms in terms of long-term financing, reputation, and investor base.

The findings obtained for Türkiye may represent a generalizable phenomenon for developing countries. However, the results of the study should be approached with caution due to the limitations of the data set. In future studies, it would be possible to derive new insights by including, in addition to Türkiye, similar developing countries through panel ARDL analyses, or by incorporating different variables such as institutional quality, financial depth, relevant legal regulations, or their interaction terms.

A major limitation of this study is the 37-month sample size, which is constrained by the short history of the Turkish green bond market. Although the ARDL method is reliable for small samples, future research should re-examine these dynamics over longer horizons as the market matures.

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