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The Granger-Causality between Green Finance and Environmental Sustainability: Evidence from G7 Countries

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Abstract

Green finance plays a pivotal role in advancing sustainable development by channeling investments into renewable energy, sustainable agriculture, and energy-efficient technologies, thereby reducing greenhouse gas emissions and promoting resource conservation. This study investigates the causal relationship between green finance (GF) and environmental sustainability (ES) in G7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) over the period 1990–2021. The results highlight a bidirectional causality between GF and ES in Germany and the USA, indicating mutual reinforcement between green finance and environmental sustainability. For Canada and Japan, the analysis identifies unidirectional causality from GF to ES, suggesting that green finance drives improvements in environmental sustainability. Conversely, no causal relationships are observed for France, Italy, and the UK, pointing to heterogeneity in the GF-ES nexus across nations.

Keywords: Green Finance, Environmental Sustainability, G7 Countries, VAR Model

Jel Codes: G10, P18, Q56

Yeşil Finans ve Çevresel Sürdürülebilirlik Arasındaki Granger Nedenselliği: G7 Ülkelerinden Kanıtlar

Öz

Yeşil finans, yenilenebilir enerji, sürdürülebilir tarım ve enerji verimliliği sağlayan teknolojilere yapılan yatırımları yönlendirerek sera gazı emisyonlarını azaltmada ve kaynak korumayı teşvik ederek sürdürülebilir kalkınmayı ilerletmede önemli bir rol oynamaktadır. Bu çalışma, G7 ülkelerinde (Kanada, Fransa, Almanya, İtalya, Japonya, Birleşik Krallık ve Amerika Birleşik Devletleri) 1990-2021 döneminde yeşil finans (GF) ile çevresel sürdürülebilirlik (ES) arasındaki nedensel ilişkiyi incelemektedir. Sonuçlar, Almanya ve ABD'de GF ile ES arasında çift yönlü bir nedensellik olduğunu, yani yeşil finans ve çevresel sürdürülebilirliğin birbirini karşılıklı olarak güçlendirdiğini göstermektedir. Kanada ve Japonya için yapılan analiz, GF'den ES'ye tek yönlü bir nedensellik olduğunu, yani yeşil finansın çevresel sürdürülebilirliği iyileştirdiğini ortaya koymaktadır. Buna karşılık, Fransa, İtalya ve Birleşik Krallık için GF-ES bağlantısında herhangi bir nedensel ilişki gözlenmemiştir; bu da ülkeler arasında bu ilişki açısından heterojenlik olduğunu göstermektedir.

Anahtar Kelimeler: Yeşil Finans, Çevresel Sürdürülebilirlik, G7 Ülkeleri, VAR Modeli

Jel Kodları: G10, P18, Q56

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INTRODUCTION

The depletion of underground water resources, deforestation through forest fires, global warming, and various forms of pollution have collectively created an urgent need for humanity to transition toward renewable energy sources, such as solar and wind energy. These sustainable alternatives are imperative for restoring the balance of nature, which has been disrupted due to an over-reliance on fossil fuels. Beyond this, conserving natural resources, reducing pollution, and curbing the release of toxic gases into the atmosphere necessitate widespread adoption of energy-efficient products. The financing and promotion of such products must now be a priority for both individuals and institutions to foster sustainable living (Ozili, 2022; Falcone, 2020).

Green finance has emerged as a vital mechanism for transforming traditional economic models into sustainable and environmentally conscious frameworks. It encompasses the development and promotion of financial products and services that prioritize environmental stewardship. The primary aim of green finance is to combat climate change, ensure the sustainable use of natural resources, and support eco-friendly economic activities through financial instruments such as green loans, bonds, and mortgages. To encourage adoption, offering competitive product rates, minimizing banking fees, and facilitating contributions to environmentally friendly organizations are essential strategies. Today, green finance is recognized as a cornerstone of sustainable global development, driving efforts to mitigate environmental degradation and advance sustainable economic practices (Berrou et al, 2019; Grunow and Zender, 2020; Wang et al., 2021).

Moreover, green finance plays a pivotal role in fostering environmental sustainability by directing investments toward eco-friendly projects and encouraging sustainable practices. It facilitates funding for initiatives in renewable energy, sustainable agriculture, and energy efficiency, thereby reducing greenhouse gas emissions and preserving natural resources. By integrating Environmental, Social, and Governance (ESG) criteria into financial decision-making, green finance ensures that environmental considerations are prioritized, and resources are allocated to projects with positive ecological impacts. This approach not only supports innovation in clean technologies but also aligns economic activities with global sustainability objectives, such as the Paris Agreement and the United Nations Sustainable Development Goals. Consequently, green finance serves as a critical bridge between economic growth and environmental protection, enabling the transition to a resilient, low-carbon global economy (Xing et al., 2024; Bakry et al., 2023; Lee, 2020).

The global financial ecosystem has increasingly embraced green finance as a fundamental component of climate action strategies. The European Union, for instance, has implemented the EU Taxonomy, a comprehensive framework designed to classify and standardize sustainable economic activities. This taxonomy provides a clear guideline for investments, ensuring that financial flows are channeled toward initiatives that genuinely contribute to environmental objectives (European Commission, 2020). Similarly, developing nations are recognizing the potential of green finance in addressing environmental challenges while fostering economic resilience. China's green bond market, for example, has emerged as one of the largest globally, showcasing how financial mechanisms can accelerate the transition to a green economy (Wang et al., 2021).

In addition, significant challenges remain in scaling green finance globally. barriers include a lack of standardized metrics for assessing sustainability impacts, insufficient regulatory frameworks in certain regions, and the limited availability of affordable green financial products. Addressing these challenges will require concerted efforts from governments, financial institutions, and international organizations. Collaborative initiatives, such as the Green Climate Fund and the Global Green Growth Institute, demonstrate the importance of multilateral partnerships in driving progress (Rahman et al., 2023; Lv, 2023).

This study aims to explore the causal relationship between green finance and environmental sustainability in the context of G7 countries. By examining the interplay between these two domains, this research seeks to contribute to a deeper understanding of how green financial mechanisms can drive sustainable development and support global efforts to address environmental challenges. Specifically, the analysis will focus on key areas such as the impact of green bonds, the role of ESG criteria in investment decisions, and the potential of innovative financial instruments to advance sustainability objectives.

LITERATURE REVIEW

The literature on green finance reveals a dynamic and multifaceted field, with policies and practices aimed at integrating environmental and financial goals to foster sustainable development. Green finance has emerged as a crucial tool to address global climate challenges by mitigating risks, promoting low-carbon initiatives, and ensuring economic resilience. However, the effectiveness of these measures continues to be a subject of debate, requiring nuanced examination.

Khan et al. (2024) review 507 scholarly articles from 2013 to 2023 to analyze the relationship between green finance and environmental sustainability, revealing exponential growth in research, with notable contributions from China and Asia. The findings suggest areas for future research, including broadening the geographical scope, exploring fintech synergies, and developing robust metrics to measure green finance's socioeconomic impacts and performance.

Wu et al. (2024) explores the impact of green finance on carbon emission efficiency using data from Chinese cities (2006–2022), revealing that green finance significantly enhances carbon emission efficiency. Additionally, the sensitivity of carbon emission efficiency to the green finance index follows an inverted U-shaped trend, with the green support dimension having the most substantial impact.

Sadiq et al. (2024) adopted the cross-sectional autoregressive distributed lag (CS-ARDL) technique to study green finance and its impact on CO2 emissions in BRICS countries for the period 2001 to 2020. The results show that green finance to bear a negative and significant relationship with carbon emissions, which portrays their effectiveness in reducing environmental degradation.

Shi et al. (2024) investigate the effectiveness of green finance (GF) in reducing greenhouse gas (GHG) emissions and enhancing environmental sustainability (ES) across 37 Asian countries during the period 2000 to 2020. The results indicate that GF plays a significant role in mitigating GHG emissions and advancing ES.

Using Method of Moments Quantile Regression, Han et al. (2024) explore the impact of green financing on environmental sustainability in BICST economies from 2000 to 2021. Results show that green financing significantly helps in the management and reduction of CO2 emissions

Ma et al. (2023) examine the role of green finance and environmental sustainability on green economic growth for G-20 countries during the period 2010-2020. The results show that green finance leads to significantly better energy-environment performance in underdeveloped credit and capital markets in countries with more advanced technologies and sustainability policies outside the developing country category.

In their study, Udeagha and Muchapondwa (2023) scrutinize the nexus between green finance and the realization of carbon neutrality objectives in BRICS nations for the period 1990–2020 and results reveal that GFN contributes positively to sustainability.

Zakari (2022) assesses the contribution of green finance to economic and environmental development in 26 OECD countries from 2000 to 2018 applying an autoregressive fixed-effect model to deal with the issue of autocorrelation and unbalanced data, finding that green finance supports sustainable development significantly.

Lastly, a study has been conducted by Fu and İrfan (2022) to explore the implications of green finance on environmental sustainability and economic growth of the ASEAN economies for the period 2012-2019. The empirical results indicate that CO2 emissions have a negative relationship with green financing, which proves the effectiveness of green financing in reducing environmental damage.

DATASET AND ECONOMETRIC METHODOLOGY

Dataset

This study investigates the relationship between green finance (GF) and environmental sustainability (ES) using data from G7 countries (USA, Germany, UK, France, Italy, Japan, and Canada) for the period 1990–2021. The data were obtained from the Organisation for Economic Cooperation and Development (OECD) database. Table 1 presents key statistics for green finance (GF) and environmental sustainability (ES) in the G7 countries. YF shows significant variability, with Canada having the highest mean (3.805) and Japan the largest standard deviation (1.048). Skewness varies considerably, with strong positive skewness observed in Italy (1.164) and Japan (1.257), and negative skewness in Canada (-1.232). Kurtosis values indicate a leptokurtic distribution in Italy (4.058) and Japan (3.328). In contrast, ES exhibits lower variability, with Canada having the highest mean (0.519) and France the lowest mean (0.206). The standard deviation is minimal across countries, and the distribution shows slight positive skewness in Germany (0.418) and the UK (0.334) but negative skewness in Italy (-0.458) and Japan (-0.414).

TABLE 1 Descriptive Statistics

		Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis
Canada	GF	3.805	4.880	1.710	0.864	-1.232	3.534
	ES	0.519	0.627	0.397	0.072	0.037	1.679
France	GF	2.013	3.320	0.660	0.678	0.077	2.459
	ES	0.206	0.285	0.142	0.043	0.182	1.807

		Mean	Max.	Min.	Std. Dev.	Skewness	Kurtosis
Germany	GF	3.172	3.760	0.423	0.358	0.135	1.666
	ES	0.274	0.267	0.174	0.066	0.418	2.290
Italy	GF	2.745	4.090	2.190	0.440	1.164	4.058
	ES	0.206	0.247	0.157	0.028	-0.458	1.798
Japan	GF	1.375	4.140	0.470	1.048	1.257	3.328
	ES	0.285	0.329	0.227	0.029	-0.414	2.224
UK	GF	2.142	3.020	1.370	0.484	0.288	2.130
	ES	0.271	0.450	0.141	0.096	0.334	1.947
USA	GF	0.576	0.810	0.330	0.149	-0.031	1.737
	ES	0.444	0.610	0.280	0.106	0.074	1.162

Econometric Methodology

This study examines the relationship between green finance (GF) and environmental sustainability (ES) using the Vector Autoregressive (VAR) model. The VAR methodology models a system of equations where each and every time series is taken as an endogenous factor and lagged values of the different variables act as predictors. A crucial prerequisite for using the VAR model is that the time series should be stationary. This requires that they should not have a unit root and should become stationary after first differencing. Rather than focusing on precise parameter estimates, the primary goal of the VAR analysis is to provide an overview of the dynamics between variables and understand how they influence each other over time.

Since we use two variables, a bivariate $(m = 2)$ VAR*(p)* model of order *p* can be written by following the approach in Gökçe (2002):

$$GF_t = A(L)GF_t + B(L)ES_t + u_{1t} \quad (1)$$

$$ES_t = C(L)GF_t + D(L)ES_t + u_{2t} \quad (2)$$

where A,B,C, and DDD represent the model parameters. L denotes the lag operator, and u_{1t} and u_{2t} are the regression residuals.

The analysis of the VAR model follows the steps below:

(1) Checking Stationary Condition

To perform the VAR analysis, the stationarity of the series used in the study must be confirmed through unit root testing. Non-stationary series can lead to spurious regressions and unreliable results. In this study, stationarity was tested using the Augmented Dickey-Fuller (ADF) test, with the following hypotheses:

H_0: The series has a unit root (non-stationary)

H_A: The series does not have a unit root (stationary)

According to unit root analysis results, if the p-value of the series under examination at its level value is above 0.05, then it indicates that the series is non-stationary and has to be differenced. However, if the p-value of the series at its level is less than 0.05, then it implies that the series is stationary.

(2) Determining Appropriate Lag Lengths

Once the stationarity of the series is confirmed, the optimal lag length is determined using information criteria such as the Akaike Information Criterion (AIC), Schwarz Information Criterion (SIC), Hannan-Quinn Criterion (HQ), and Final Prediction Error (FPE). In this process, the lag length that is most frequently supported (indicated by the highest number of * symbols) across the information criteria is selected as the optimal lag.

(3) Granger Causality Test

The Granger causality test is a statistical method used to examine whether one time series has a causal influence on another. It determines the direction of causality by analyzing lagged relationships. If including the past values of X improves the prediction of Y beyond using Y's own past values, then X is said to "Granger-cause" Y.

For two variables, the test produces four possible outcomes:

(i) X Granger-causes Y.
(ii) Y Granger-causes X.
(iii) No Granger causality exists between X and Y.
(iv) There is bi-directional (feedback) Granger causality between X and Y.

The test provides a p-value. If the p-value is smaller than the chosen significance level (commonly 0.05), the null hypothesis (H_0) is rejected, indicating that X Granger-causes Y.

EMPIRICAL FINDINGS

Unit Root Test Results

Before conducting the VAR model analysis, it is essential to test whether the series used in the study are stationary (do not contain unit roots). This was done using the

Augmented Dickey-Fuller (ADF) test developed by Dickey and Fuller (1981). The results are presented in Table 2.

The results show that for all countries, both variables are non-stationary at their level (contain unit roots). However, they become stationary after taking their first differences. These findings meet the first requirement for VAR analysis, which is that the variables used in the study must be first-order stationary.

TABLE 2 ADF Unit Root Test

	Variables	Level		1st Diffrence	
		t-stat	p-value	t-stat	p-value
Canada	GF	-2.644	0.0952	**-7.861*** **	0.0000
	ES	0.658	0.9891	**-5.574*** **	0.0001
France	GF	-3.158	0.1113	**-7.577*** **	0.0000
	ES	-3.293	0.0860	**-4.930*** **	0.0029
Germany	GF	-1.480	0.5298	**-5.221*** **	0.0002
	ES	-2.820	0.0669	**-5.277*** **	0.0002
Italy	GF	-3.306	0.0839	**-6.053*** **	0.0001
	ES	-1.547	0.7904	**-5.181*** **	0.0012
Japan	GF	1.201	0.9971	**-3.873*** **	0.0073
	ES	0.256	0.9719	**-4.758*** **	0.0006
UK	GF	-1.827	0.3607	**-4.271*** **	0.0022
	ES	-1.499	0.5204	**-6.238*** **	0.0000
USA	GF	0.320	0.9750	**-6.147*** **	0.0000
	ES	-0.492	0.8790	**-6.822*** **	0.0000

Determining the Optimal Lag Length

After confirming the stationarity of the variables, the next step in VAR analysis is to determine the optimal lag length. Various information criteria tests are used for this purpose. The results for the optimal lag length are shown in Table 3. As seen in Table 3, all information criteria, except the LogL criterion, identify 1 as the optimal lag length. At this lag length, no problems such as heteroscedasticity, serial correlation, or deviations from normality are observed across all countries.

TABLE 3 Optimal Lag Length Selection

Canada						
Lag length	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	16.710	NA	0.0001	-1.050	-0.955	-1.021
1	**85.925**	**123.598**	**1.14e-05***	**-5.708***	**-5.423***	**-5.621***
2	89.468	5.820	1.18e-05	-5.676	-5.200	-5.530
France						
Lag length	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	29.763	NA	0.0004	-1.983	-1.887	-1.954
1	**92.843**	**112.643***	**6.95e-06***	**-6.203***	**-5.917***	**-6.115***
2	94.160	2.162	8.47e-06	-6.011	-5.535	-5.866
Germany						
Lag length	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	55.582	NA	7.46e-05	-3.827	-3.732	-3.798
1	**115.876**	**107.667***	**1.34e-06***	**-7.848***	**-7.562***	**-7.761***
2	116.904	1.688	1.67e-06	-7.636	-7.160	-7.490
Italy						
Lag length	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	45.906	NA	0.0001	-3.136	-3.040	-3.107
1	**102.110**	**100.364***	**3.58e-06***	**-6.864***	**-6.579***	**-6.777***
2	104.840	4.485	3.95e-06	-6.774	-6.298	-6.628
Japan						
Lag length	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	33.840	NA	0.0003	-2.274	-2.179	-2.245
1	**83.364**	**88.436***	**1.37e-05***	**-5.526***	**-5.240***	**-5.438***
2	84.625	2.071	1.67e-05	-5.330	-4.854	-5.184

UK						
Lag length	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	15.075	NA	0.001	-0.933	-0.838	-0.904
1	98.720	149.364*	4.57e-06*	-6.622*	-6.337*	-6.535*
2	101.314	4.261	5.08e-06	-6.522	-6.046	-6.376
USA						
Lag length	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	76.403	NA	2.40e-05	-4.960	-4.866	-4.930
1	**159.221**	**149.072***	**1.26e-07***	**-10.214***	**-9.934***	**-10.125***
2	160.176	1.592	1.55e-07	-10.011	-9.544	-9.862
*: Appropriate lag length						

Granger-Causality between Green Finance and Environmental Sustainability

Table 4 reports the Granger causality test results. Given these results, at the optimal lag length, the null hypotheses stating, “Green finance does not Granger-cause environmental sustainability” and “Environmental sustainability does not Granger-cause green finance” are rejected with high confidence for Germany and USA. These results suggests that a bidirectional relationship, where changes in green finance are influenced by environmental sustainability, and changes in environmental sustainability are influenced by green finance. For Canada and Japan, we observe causality running from GF to ES, indicating that changes in green finance drive changes in environmental sustainability. Lastly, for France, Italy, and the UK, no causal relationship is observed between green finance (GF) and environmental sustainability (ES) in either direction.

TABLE 4 **Granger causality analysis of GF and ES**

Country	Causality from GF to ES	Causality from ES to GF	Direction
Canada	5.527**	0.054	GF to ES
France	0.783	0.636	No causality
Germany	3.361*	4.187**	Bi-directional
Italy	2.166	0.087	No causality
Japan	4.991**	2.661	GF to ES
UK	0.657	0.885	No causality
USA	4.030***	18.141***	Bi-directional
***Reject H0 at 1% level of significance, **Reject H0 at 5% level of significance, *Reject H0 at 10% level of significance.			

CONCLUDING REMARKS

Green finance provides the most potent tool for advancing environmental sustainability. Investments in areas such as renewable energy, sustainable agriculture, and energy-efficient technologies contribute to reducing the carbon footprint and adopting cleaner production methods. Integrating environmental factors into financial decision-making processes helps mitigate climate risks while supporting economic growth, highlighting the strong connection between sustainability and prosperity. This impact underscores the critical importance of green finance in building a more resilient and environmentally responsible global economy.

One of the fundamental pillars of green finance is its endorsement of Environmental, Social and Governance (ESG) mandates. These offer a responsible and transparent criterion of not just the likely environmental impact of financial activities but also the actual impact. It thus ensures that financial resources are utilized towards projects which eventually bear great ecological fruits while lessening adverse environmental impacts. Further, monetary tools like green bonds, carbon credits, and sustainable investments are effective in bridging economic goals with ecological purposes. Thus, they ensure cleaner technology and innovation by forcing a trade-off between immediate economic benefit and long-term health of the planet.

Global collaboration is necessary for the effectiveness of green finance. The governments of this world together with private sectors and civil societies come together under international frameworks such as the Paris Agreement to pursue common sustainability objectives. Such collaborations promote international cooperation by offering collective solutions to the global environmental challenge. In sum, green finance is an essentially critical enabler of an environmentally-sound, low-carbon, resource-efficient, and inclusive global economy that guarantees ecological protection and economic resiliency.

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