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The impact of financial tools in environmental degradation management: the relationship between Co_2 emission and ESG funds

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Abstract
This study aims to determine whether ESG funds can be used as an effective tool for environmental sustainability. ESG funds, which first appeared in the 2000s and were exported by environmentally friendly companies, are among the most effective tools for increasing firm value and managing environmental degradation. The causality relationship between the ESG funds, one of the environmentally friendly investment instruments, and the CO_2 emission values, which are used as an environmental degradation criterion, was investigated in this study. The study used 209 daily data sets from July 31, 2020, to May 28, 2021. The symmetric developed by Hacker and Hatemi-J (Appl Econ 38:1489–1500, 2006), the asymmetric developed by Hatemi-J (Empir Econ 43:447–456, 2012), and time-varying asymmetric causality tests were used as models. According to the study results, while there is no symmetric causality between CO_2 emissions and ESG funds, there is causality between CO_2 emissions and ESG funds prices for negative shocks and between CO_2 emissions and ESG funds trade volume for positive shocks. The results of a time-varying asymmetric causality test also support that this causality relationship varies by period. As a result, ESG funds can be used as a strategic financial tool to improve environmental quality during the COVID-19 period; however, this may vary for different sub-sample periods.

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Keywords CO_2 emission · Environmental degradation · ESG funds · Sustainable finance

Abbreviations

ESG	Environmental, social and governance disclosure
CO_2	Carbon dioxide
CH_4	Methane
NO_X	Nitrogen oxide
GHG	Total greenhouse gas
ADF Unit Root Test	Augmented dickey–fuller unit root test
ESG ETFs	Environmental, social and governance exchange traded funds
ESG Price	Price Value for S&P 500 ESG ETFs
ESG Trade Volume	Trade volume for S&P 500 ESG ETFs

1 Introduction

One of the most pressing global issues is environmental degradation (Desta, 1999; Aggrey et al., 2010). The Paris Agreement, signed in 2015, requires all countries that are party to the agreement with strict climate policies to take measures to reduce climate change and environmental degradation. Environmental degradation is caused by gases containing methane (CH4) and nitrogen oxide (NO_X), animal droppings, fertilizer use, and CO_2 emissions (Tyagi et al., 2014). The main source of CO_2 emissions is fossil fuels such as coal, oil, and gas that used by business. The new climate policies implemented with this agreement, on the other hand, put pressure on businesses as they aim to reduce carbon emissions from production. (Bartram et al., 2022). Because there is a positive relationship between the amount of production and CO_2, NO_X, CH_4, and total greenhouse gas (GHG) emissions (Majeed & Mazhar, 2019). For this reason, businesses can hasten environmental degradation by increasing production activities; it can also reduced environmental degradation by enacting environmental policies (Choudhary et al., 2015; Suki et al., 2022). In the other hand, sustainability requires that the emissions of the businesses are below an acceptable limit. Therefore, changing the emission values of businesses requires major changes in their current production strategies (Kump, 2021). At this point, the Paris Agreement aims to force businesses to act more responsibly for the public interest with new climate policies. For this reason, businesses give great reactions to the Paris Agreement in terms of sustainability (Hoang, 2023). Because, sudden emission cuts of emission-intensive businesses may have a negative effect on the production activities of the businesses, and may cause the businesses' performance to be adversely affected in the future. (Nguyen & Phan, 2020).

ESG scores, which are an indicator of a businesses's sustainability performance, are an important tool for determining investment strategies. The Global Sustainable Investment Association states that "ESG scores are the second most used strategy in investment decisions," and thus sustainability or ESG scores for businesses are made public (Unruh et al., 2016). This information support the conclusion that reducing environmental degradation through businesses ESG scores can be faster and more effective than other mechanisms in society (Karim et al., 2021). Compliance between sustainable development goals and business sustainability goals is critical for effective environmental degradation management. Businesses are an effective factor in CO_2 emissions with the planning processes, production activities and financial initiatives

to increase businesses value. As a result, the following research question is being addressed: "*Can ESG Funds, which are created based on a businsses's environmental sensitivity, be used as an effective financial tool in the management of environmental degradation?"*.

It is hoped to that this study will make three significant contributions to the literature. The most significant contribution to the literature is the lack of research on the effectiveness of financial instruments in managing environmental degradation. As far as we know, research in literature is related to the following financial asset prices, capital costs, firm value, public offering, financial performance, mergers, corporate social responsibility strategies, investments, and brand value interact in businesses. But, there was no research on the usability of financial instruments as a tool in the management of environmental degradation found in the literature review. As a result, it is anticipated that this study, which presents preliminary findings on whether ESG funds can be used as a tool for environmental degradation, will fill a significant gap in the literature.

The data set is one of the research's other significant contributions to the literature. The research data set is daily, which contributes to obtaining results with low estimation error. It is also significant because the examined period includes the COVID-19 pandemic, which affected the entire world. Because the long-term and short-term effects of the COVID-19 pandemic on financial markets differ. For example, while the COVID-19 pandemic has a long-term impact on oil prices, it has a short-term impact on gold and stock markets (Tuna & Tuna, 2022). As a result, it is critical for both investors and policymakers that the research provides new information about the effects of environmentally friendly business practices in financial markets during the pandemic period.

Another significant contribution to the literature concerns the method employed. The effects of environmentally friendly business practices on business performance are widely investigated in the current literature using traditional methods (such as simple regression, causality). The relationship between ESG funds and CO_2 emissions was investigated in this study using asymmetric and time-varying asymmetric causality tests, different from the traditional symmetric causality analysis. In traditional causality analysis, both positive and negative changes in variables are considered. However, investors' reactions to positive and negative shocks differ (Tuna et al., 2022). Because, positive and negative shocks have different effects on the variables at the same time. As a result, understanding the asymmetric relationship between the variables is critical (Shahbaz et al., 2017). At this point, the research findings are critical in terms of providing new information on the used of ESG funds in environmental management as an effective tool for environmental sustainability, as well as how to develop a strategy in falling or rising market conditions. Furthermore, the time-varying asymmetric causality test was used to try to obtain new information about the existence of a causal relationship in different sub-sample periods. In other words, by dividing the examined period into sub-sample periods, the validity of the causality relationship in positive and negative shocks could be thoroughly examined for each sub-sample period (Tuna et al., 2021). It is anticipated that the findings of this study, which investigates the effect of CO_2 emission values on the price and transaction volume of ESG funds, will provide significant new information to policymakers and researchers.

As a result, the research is divided into five sections. Following the introduction, the second section contains the literature, the third section contains the used data set and methodology, the fourth section contains the obtained empirical findings, and the final section contains the evaluations.

2 Literature review

In reviewed literature for this study, there was no research found that directly examined the effect of ESG funds on environmental degradation. As a result, the relevant literature in the research was divided into two groups: the literature on the relationship between ESG disclosures and firm value and the literature on the relationship between ESG disclosures and economic activities.

2.1 Examining the literature on the relationship between ESG disclosures and firm value

Sustainability means carrying out production and consumption activities in accordance with ethical principles while meeting the needs of today's population without interfering with future generations' ability to meet their own needs. According to sustainable finance, which considers environmental, social, and governance factors in financing investors, businesses should consider not only profit but also other societal factors (Soppe, 2004). Environmental, social, and governmental declarations should be included in annual reports as a strategic tool, according to the Shareholder Theory and Legitimacy Theory. According to the Legitimacy Theory, voluntary environmental, social, and governmental disclosures are effective tools that businesses can use to gain legitimacy and protect themselves by demonstrating that they comply with the expectations, rules, values, and beliefs of the society in which they operate. Similarly, the Shareholder Theory, which bases business success on effective management of all shareholders' relationships, expresses that voluntary environmental disclosures can be used as a strategy to positively manage shareholders' perceptions (Almagtome, 2015). Thus, risks related to stakeholders can be reduced with ESG disclosures that lead to an increase in firm value (Cho & Patten, 2007). The impact of businesses on environmental degradation also includes the whole economy through stakeholders. Therefore, the ESG disclosures of businesses have a much more lasting impact on stakeholders and economies. (Hoang, 2023). According to these two theories, companies that share information about environmental, social, or governmental disclosures can benefit from positive consumer and investor behavior in the long run (Yıldız et al., 2016).

As a result, ESG disclosures are used as a requirement for sustainable finance and to maximize business value. Early studies on ESG disclosures viewed them as business costs, and it was claimed that they had a negative impact on firm values (Fatemi et al., 2018). However, according to sustainable finance, ESG disclosures increases the firm value and is viewed positively in terms of businesses' social standing (Mervelskemper & Streit, 2017). As a result, ESG disclosures may have an impact on current and future investments, causing the firm value to change. ESG disclosures affects the firm value by providing benefits such as risk reduction, creating a trusting environment with stakeholders, or taking on an insurance role.

While it is widely accepted in the literature that ESG disclosures has a positive impact on firm value (Wang, 2018; Giese et al., 2019; Duque-Grisales & Aguliera-Caracuel, 2021), some findings suggest that it has a negative impact (Fatemi, 2018). So businesses' ESG disclosures is regarded as a significant competitive advantage (Husted & Sousa-Filhp, 2017). Another method used by businesses seeking to increase firm value is to increase business activities in order to maximize profits. Increasing business activities may result in increased energy consumption and CO_2 emissions. As a result of increased production

activity, the environment suffers (Choudhary et al., 2015). Governments are taking measures to force businesses to implement sustainable environmental policies in order to manage the environmental degradation elements caused by production activities and to encourage the use of renewable energy (Fox & Alldred, 2020). At this stage, it is important for business management to focus on reducing direct and indirect CO_2 emissions for high ESG performance (Johnson et al., 2022).

2.2 Examining the literature on the relationship between ESG disclosures and economic activities

ESG scores are important indicators of the effectiveness of sustainable finance in business. Environmental, social, and governance disclosures are three critical dimensions of the ESG score. Emission, innovation, and resource use compounds comprise the environmental dimension. Human rights, product responsibility, and workforce components comprise the social community dimension. Management, and shareholder components comprise the governance dimension (Thomson, 2020 (www.endnote.com)).

Environmental degradation has been shown in studies to have an impact on economic activity. In their studies, Hafeez et al. (2018) investigated the relationship between finance and environmental degradation using data from countries participating in the "One Belt-One Road Project"(www.investopedia.com, 25.12.2021). According to some research findings, businesses finance plays a critical role in environmental degradation. Based on these findings concluded that the green finance approach could be a useful tool for environmental and financial authorities (Hafeez et al., 2018).

Businesses must also provide ESG funds, one of the green finance and environmental finance practices, to investors in order to contribute to the management of environmental degradation. ESG funds hold portfolio companies with higher average ESG scores. (Raghunandan & Rajgopal, 2022). businesses' ESG scores are critical for both internal and external stakeholders when it comes to ESG funds. In the literature, the interaction between businesses and its ESG scores are discussed from a comprehensive perspective by associating with financial asset prices (Bofinger et al., 2021; Avramov et al., 2021; Pedersen et al., 2021; Fuente et al., 2021; Shanaev & Ghimire, 2021; Feng et al., 2021; Diiaz et al., 2020; Chen & Yang, 2020), capital costs and firm value (Barros et al., 2021a; Azmi et al., 2021; Bofinger et al., 2022), public offering (Baker et al., 2021), financial performance (DasGupta, 2021; Shakil, 2021; Yoo & Managi, 2021; Escrig-Olmedo et al., 2017; Auer and Schuhmacher, 2016; Khaled et al., 2021), mergers (Barros et al., 2021b), corporate social responsibility strategies (Rajesh et al., 2021), investments (Singhania and Saini, 2020), brand value (Lee et al., 2022) and even financial irregularities that may be witnessed (Yuan et al., 2022).

According to the literature, the reflection of a businesses' ESG score on the prices of financial assets can vary. For instance, it is stated that the businesses' high ESG score may lead to overpricing of stocks (Bofinger et al., 2021; Fuente et al., 2021; Shanaev and Ghimire, 2021; Feng et al., 2021; Chen & Yang, 2020). It is also stated that the uncertainty of a businesses' compliance with the ESG criteria may also cause a decrease in demand for the businesses' financial assets by ESG sensitive investors (Avramov et al., 2021). This affects the management of ESG funds and asset selection processes as well (Alda, 2020). In addition, the relationship between ESG scores and stocks also affects the investment and asset selection processes of conventional funds (Alda, 2020).

While some investors focus primarily on returns, some investors may be willing to pay the price to invest by ESG criteria (Auer & Schuhmacher, 2016).

3 Data and metodology

3.1 Data

Daily CO_2 emission values were used as an environmental degradation criterion in this study, and daily ESG funds closing prices and trade volume values were used as a sustainability indicator. S&P500 ESG ETFs were used in the study for funds consisting of stocks of environmentally friendly businesses for ESG funds. CO_2 emission values are used as an environmental degradation criterion because they are widely used and the daily data set is available (Sarkodie & Ozturk, 2020; Shahbaz, et al., 2019; Kang, et al., 2016). Although using CO_2 emissions as an environmental degradation criterion is not appropriate in all cases (Ulucak & Lin, 2017), the main reason for using it in this study is that it has a daily data set. Furthermore, because the study's goal was to see if ESG funds could be used as a tool in environmental management, particularly during the COVID-19 period, CO_2 emission values, which have a daily data set and can be used as an environmental degradation criterion were chosen.

For all analyses in the study, 209 data sets were collected between July 31st, 2020 and May 28th, 2021. The chosen time frame also allows the results to be linked to the COVID-19 Pandemic. The data on CO_2 emission values came from www.us.carbonmonitor.com, and the data on S&P500 ESG ETFs came from www.nvesting.com. All analyses were carried out using the data set whose logarithm was calculated. Descriptive statistical values belonging to all variables examined in the research are as in Table 1.

According to Table 1, ESG is traded at an average of 34.780 USD, with an average trade volume of 2143.10^4. The CO_2 emission value in the US is on average 1140.368 Mt CO_2. Also, ESG funds price and trade volume values have a positive skewness value, and it is seen that the series are right-skewed. CO_2 emission values have a negative skewness value, and it is seen that the series are left-skewed. Kurtosis values are positive and all series show leptokurtic features.

Table 1 Descriptive statistic values for used variable

	ESG ETFs Price	ESG ETFs TV	CO2 Emission
Mean	34.780	2143.104	1140.368
Median	34.700	307.104	1172.855
Maximum	39.530	307.104	1648.116
Minimum	30.270	4.104	298.678
Std. Dev	2.611	9211.103	225.556
Skewness	0.168	6.673	−0.875
Kurtosis	1.901	49.397	4.457

TV: Trade Volume

4 Methodology

Hacker and Hatemi-J (2006)'s symmetric, Hatemi-J (2012)'s asymmetric, and time-varying asymmetric causality tests were used as research methods. Because causality is crucial in determining whether the variables provide useful information about one another.

In Hacker-Hatemi-J (2006) test, the causality relationship between variables is analyzed through Toda-Yamamoto test. Critical values in this test are obtianed through bootstrap in case possible abnormal distribution of the errors. In Hacker-Hatemi-J (2006) test the causality relationship between two series is tested by (VAR) model at Eq. 1:

$$y_t = \propto + A_1 y_{t-1} + \ldots\ldots\ldots\ldots\ldots\cdots + A_p y_{p-1} + u_t \tag{1}$$

Here, yt is the variable vector in 2–1 dimension, A is the parameter vector. In order to test the main hypothesis indicating that there is no Granger causality between series. Wald statistics is used. The main hypothesis is there is no Granger causality. This is be tested through Wald test statistics is used. In order to obtain Wald statistics, VAR model indicated in this Eq. 2 is expressed as the following:

$$Y = \mathrm{DZ} + \delta \tag{2}$$

The statements in this model can be detailed as the following Eq. 3:

$$\begin{aligned} Y &:= \left(y_1^+, y_2^+, y_3^+, ..., y_T^+\right) \\ D &:= \left(\alpha, A_1, A_2, A_3, ..., A_p\right) \\ Z &:= \left(Z_0, Z_1, Z_2, ..., Z_{T-1}\right) \\ Z_t &:= \begin{bmatrix} 1 \\ y_t^+ \\ y_{t-1}^+ \\ . \\ . \\ y_{t-p+1}^+ \end{bmatrix} \\ \delta &:= \left(u_1^t, u_2^t, u_3^t, ..., u_T^t\right) \end{aligned} \tag{3}$$

Accordingly, Wald statistic is calculated as in Eq. 4.

$$W = (C\beta)' \left[C\left(\left(Z'Z\right)^{-1} \otimes S_u\right)C'\right]^{-1} (C\beta) \tag{4}$$

Here:

$\otimes$:Kronecker multiplication,

C:The indicator function including the limitations, $\beta = vec\ (D)$. (*vec* indicates the column-accumulation operatör), q: The number of lag in VAR equilibrium.

In Hacker and Hatemi-J (2006) bootstrap Granger causality test cannot distinguish the positive and negative shocks. Hatemi-J (2012) causality test is the positive and negative shocks' decomposed form of Hacker and Hatemi-J (2006) test (Tuna & Bektur, 2015).

In Hatemi-J (2012), tends the article of Granger & Yoon (2002) to causality analysis and refers to it as asymmetric causality testing. According to Hatemi-J (2012), it is asymmetric in the sense which positive and negative shocks may have different causal impacts. Positive

shocks represent only cumulative increases, while negative shocks represent decreases. It is assumed that the casual relationship between two integrated variables and defined as the following random walk processes:

According to Hatemi-J (2012), it is asymmetric in the sense which positive and negative shocks may have different causal impacts. Positive and negative shocks are defined as Eq. 5:

$$\varepsilon_{1i}^{+} = maks\left(\varepsilon_{1i}, 0\right), \varepsilon_{1i}^{-} = min\left(\varepsilon_{1i}, 0\right), \varepsilon_{2i}^{+} = maks\left(\varepsilon_{2i}, 0\right), \varepsilon_{2i}^{-} = min\left(\varepsilon_{2i}, 0\right) \tag{5}$$

respectively. It can be expressed $\varepsilon_{1i} = \varepsilon_{1i}^{+} + \varepsilon_{1i}^{-}, \varepsilon_{2i} = \varepsilon_{2i}^{+} + \varepsilon_{2i}^{-}$, and Equation can be rewritten as Eq. 6:

$$y_{1t} = y_{1t-1} + \varepsilon_{1t} = y_{1,0} + \sum_{i=1}^{t} \varepsilon_{1i}^{+} + \sum_{i=1}^{t} \varepsilon_{1i}^{-}$$

$$y_{2t} = y_{2t-1} + \varepsilon_{2t} = y_{2,0} + \sum_{i=1}^{t} \varepsilon_{2i}^{+} + \sum_{i=1}^{t} \varepsilon_{2i}^{-} \tag{6}$$

Finally, the positive and negative shocks of each variable can be defined in a cumulative form as Eq. 7:

$$y_{1i}^{+} = \sum_{i=1}^{t} \varepsilon_{1i}^{+}, y_{1i}^{-} = \sum_{i=1}^{t} \varepsilon_{1i}^{-}, y_{2i}^{+} = \sum_{i=1}^{t} \varepsilon_{2i}^{+}, y_{2i}^{-} = \sum_{i=1}^{t} \varepsilon_{2i}^{-} \tag{7}$$

In Hacker and Hatemi-J (2006) bootstrap Granger causality test, the lack side of this model is that cannot distinguish the positive and negative shocks. In this content, in asymmetric causality test developed by Hatemi-J (2012), in case there is existence of asymmetric information in financial markets and are heterogeneous participants, because the participants do not give similar reactions to same identical positive and negative shocks, the results of this test may be fallacious. In this content, Hatemi-J (2012) causality test is the positive and negative shocks' decomposed form of Hacker & Hatemi-J (2006) bootstrap Granger causality test. So, this method is pretty available for those researches at which financial time sequences are used (Tuna & Bektur, 2015; Tuna & Tuna, 2019).

In the time-varying asymmetric causality test, firstly the Hatemi-J (2012) causality test is applied for observations. After, the sample period is divided into sub-sample periods. The causality test is carried out by sub-sample periods. The length of the sub-period (The number of Windows) for this research was determined as 1, which means performing Hatemi-J (2012) causality test for 181 day sub-periods (Erdoğan et al., 2019). At every new step of the test, the first observation is disregarded and continued till the last observation existing in data range, by adding a new observation to the last one at each step. In order to interpret the obtained Wald test statistics, graphs are plotted from these values. According to this, in the graph, the values above "1" line shows the necessity of rejecting the main hypothesis. This means that there is not asymmetric Granger causality (Yılancı & Bozoklu, 2014).

Table 2 Results of ADF unit root test

	Level		I.Difference	
Variable	t Stat	Prob	*t* Stat	Prob
ESG Price	1.625	0.974	− 16.099*	0.000
ESGTradeVolume	− 1.310	0.176	− 31.084*	0.000
CO_2	− 0.4273	0.529	− 10.429*	0.000

*, **, *** indicate the significance at %1, %5, %10 levels, respectively

Table 3 Results of Non-asymmetric and Asymmetric Causality Test

Variable	Hypothesis	Wald test statistic	Bootstrap critical values		
			%1	%5	%10
Symmetric causality test					
ESG Price	$CO_2 \neq >$ ESGP	2.114	9.440	5.955	4.691
ESGTrade Volume	CO2 ≠ > ESGTV	0.391	11.063	6.745	4.861
Asymmetric causality test					
ESG Price	$CO_2+ \neq >$ ESGP +	0.411	6.155	4.038	2.829
	$CO_2- \neq >$ ESGP −	11.022**	13.829	7.920	6.271
ESGTrade Volume	$CO_2+ \neq >$ ESGTV +	11.022**	13.829	7.920	6.271
	$CO_2- \neq >$ ESGTV −	1.866	14.288	8.378	6.082

*, **, *** indicate the significance at %1, %5, %10 levels, respectively

5 Empirical results

Symmetric, asymmetric, and time-varying asymmetric causality tests were used separately in the study to investigate the effect of the ESG fund's price and trade volume values on CO_2 emission values. CO_2 will be used in the following section of the research for the price values of S&P500 ESG ETFs, ESG Price, the trade volume of S&P500 ESG ETFs, ESG Trade Volume, and CO_2 emission values, which is an environmental degradation criterion. First, all variables were unit rooted. As a result, variables were ready for analysis. Table 2 shows the ADF Unit Root Test results for the variables under consideration.

According to Table 2, all variables used in the study are unit rooted for level values. All series were made stationary by taking their first differences. All first differenced series are stationary.

Symmetric and asymmetric causality test results implemented for the examined variables in the research are as in Table 3.

According to the results of the symmetric causality test in Table 3, there is no causality relationship from CO_2 emissions to ESG prices or ESG trade volume. According to this result, CO_2 emission values do not provide meaningful information to explain the changes in ESG funds prices and trade volume.

However, in the results of symmetric causality analysis, the inability to differentiate the effects of positive and negative shocks is an important limitation. For this reason, the importance of asymmetric tests, in which the causality relationship between the examined variables can be evaluated separately for both positive and negative shocks, is increasing.

Accordingly, the asymmetric causality test results in Table 3 show that there is a causal relationship from CO_2 emissions to ESG funds prices for negative shocks. At the same time, for positive shocks, there is a causal relationship from CO_2 emissions to the trade volume of ESG funds. According to the asymmetric causality test results, reductions in CO_2 emissions provide meaningful useful information to explain the changes that occur in decreasing prices of ESG funds. At the same time, positive changes in CO_2 emissions provide meaningful information in explaining positive changes in the trade volume of ESG funds. This result also supports the results of Karim et al. (2021) and Avromov et al. (2021) studies. In other words, investors who use ESG criteria as an investment strategy also affect ESG funds prices depending on the change in their demands. In addition, the causality relationship between the increase in CO_2 emissions and the increase in the trade volume of ESG funds can be considered as an indicator of the investor's reaction to environmental degradation in financial markets. In other words, during periods of increased environmental degradation, investors show more interest in environmental friendly ESG funds and make more transactions. This supports the conclusion that these funds can be used as a tool by which eco-friendly investors can show their response to environmental degradation through financial markets. Therefore, financial market investors can have a faster and more active effect on businesses in reducing environmental degradation with their fund preferences.

However, what is important here is "Are these causal relationships between CO_2 emissions and the price and trade volume of ESG funds valid in all time periods?" is the question. If ESG funds are to be used as a tool to manage environmental degradation, it is very important to know in which time periods these relationships revealed by asymmetric causality tests are valid. To that end, a time-varying asymmetric causality test was implemented to determine which periods the asymmetric causality test results are valid. As a result, the results of the time-varying asymmetric causality test from CO_2 emission values to ESG prices are depicted in Fig. 1.

According to Fig. 1, the time-varying causality relationship from CO_2 emissions to ESG fund prices; applies to both positive and negative shocks for different sub-sample periods. The causality relationship, which is consistent for positive shocks, is valid for 31 sub-sample periods between December 23, 2020 and February 5, 2021. In positive shocks, there is no consistent causal relationship for other sub-sample periods. Causality for negative shocks; it is especially evident for 65 sub-sample periods between February 5, 2021 and October 5, 2021. According to this result, the decrease in CO_2 emissions in

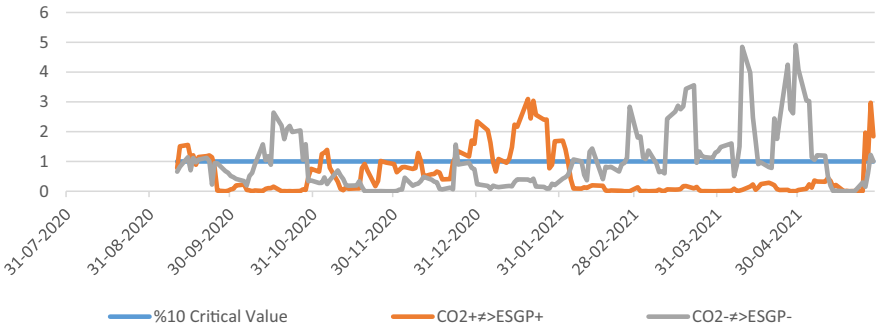

Fig. 1 Results of Time Varying Asymmetric Causality Test for ESG's Price

each sub-sample period between February 5, 2021 and May 10, 2021 provides meaningful information in explaining the decrease in ESG fund prices. For the 31 sub-sample periods between December 23, 2020 and February 5, 2021, the increase in CO_2 emissions provides meaningful information in explaining the increase in ESG fund prices. It can be evaluated that this result is a consequence of the increase in the interest of investors in environment-friendly investment tools when environmental degradation increases. Just the contrary is also true.

The second wave of the COVID-19 pandemic in April 2021 increased lockdowns between April 2021 and June 2021. This situation, which occurred during this time period as a result of COVID-19, resulted in a reduction in CO_2 emissions (Nicolini et al., 2022). In terms of financial markets, the decrease in CO_2 emissions during this time period, as well as the decrease in the prices of ESG funds, is also noteworthy. However, the decrease in CO_2 emissions during the COVID-19 period is only temporary (Ray et al., 2022). This research also supports the reflection of this situation on financial markets, with an increase in CO_2 emissions and ESG prices in the period of May 2021.

The results of the time varying asymmetric causality test applied for positive and negative shocks from CO_2 emission values to the ESG fund trade volume are as in Fig. 2.

According to Fig. 2, there is no consistent causal relationship from CO_2 emission to ESG fund trade volume in negative shocks. In other words, the decrease in CO_2 emission does not provide meaningful information to explain the decrease in the ESG fund trade volume. In positive shocks, the time-varying causality relationship from CO_2 emission to the trade volume of ESG fund is found for 24 different sub-sample periods between September 10, 2020 and October 13, 2020, for 20 different sub-sample periods between December 21, 2020 and January 20, 2021. It is available for 23 different sub-sample periods between March 24, 2021 and April 26, 2021. This result supports the conclusion that the interest in ESG fund has increased in times of increased environmental degradation. It also supports the conclusion that ESG fund can be used as a strategic financial tool to improve environmental quality.

The results of the time-varying causality test for ESG prices and trade volume also support the studies of Karim et al. (2021), Avramov et al. (2021) and Hafeez et al. (2018). Therefore, businesses play a faster and more effective role in societies in the process of the

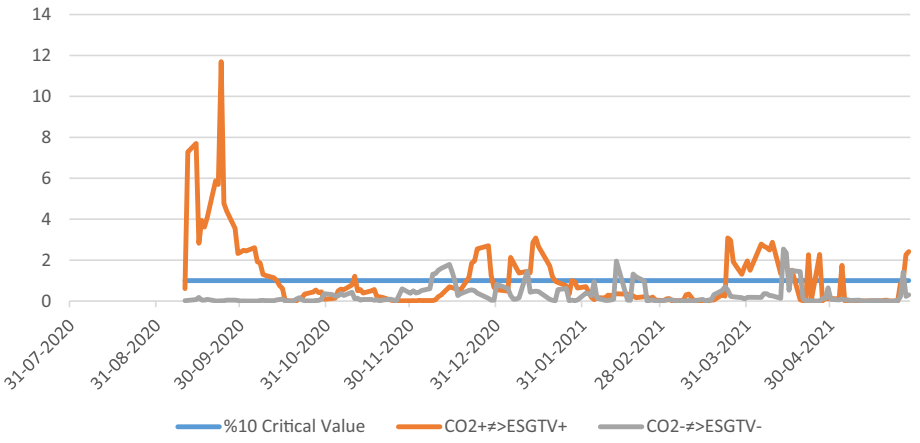

Fig. 2 Results of Time-Varying Asymmetric Causality Test for ESG's Trade Volume

management of environmental degradation. In addition, ESG fund have a positive effect on decreasing environmental degradation.

6 Conclusion and policy ımplications

The concept of environmental sustainability is critical for both social and economic development. Various sustainable development goals are established around the world for environmental sustainability, and additional tools are developed to help these goals be met. At that point, ESG funds comprised of investment tools of environmentally friendly businesses are among the most effective financial tools for ensuring individual investors' participation in environmental sustainability. As it can be reached a large number of investors quickly and effectively in capital markets, individuals are indirectly involved in environmental management.

According to the results of the asymmetric causality test, there is causality relationship from CO_2 emission to ESG fund prices and trade volume. According to the results of asymmetric causality test, the causal relationship from CO_2 emission to ESG funds price for negative shocks shows that the decreasing amount of CO_2 emissions negatively affects the interest in these funds. Likewise, there is causality from CO_2 emissions to the ESG trade volume for positive shocks. This can be considered as an indication that the increasing amount of CO_2 emissions has started to prefer these environmentally friendly funds more and more to the investors. As a result, the ESG fund can be used to reduce environmental degradation and contribute to long-term environmental sustainability. This finding supports the findings of Hafeez et al. (2018), Avramov et al. (2021), and Karim et al. (2021). However, an important point to note here is that causality relationships are not stable for every period. For this reason, if policymakers are going to use financial market instruments in the management of environmental degradation, it should be determined under which market conditions they are effective and their use should be preferred accordingly.

The findings of this study are critical for governments and businesses. Because governments, with the support of the masses, to achieve their environmental sustainability goals; They can take strategic decisions that encourage enterprises to export financial instruments such as ESG funds. For this purpose, governments can contribute to the companies that will issue ESG funds to take an active role in reducing environmental degradation by providing applications such as tax and investment incentives and employment support. Furthermore, businesses that want to take advantage of the incentives that governments can offer in this field may be able to attract new funding sources from the financial markets with the environmentally friendly funds they issue, all while contributing to a reduction in environmental degradation. At the same time, businesses will be able to obtain opportunities that can increase their production capacity and contribute to the development of exports with the employment-investment incentive applications they will obtain. Thus, with the opportunity to invest more in production factors, it will be able to make a positive contribution to the development of the country's economy. At the same time, with these practices, businesses will be able to contribute to the reduction of environmental degradation at the national and international level and to the expansion of environmentally friendly production activities. When conducting future studies in this field, regional values rather than global-scale variables can be used to obtain more specific results. In addition, new results that can contribute to the literature can be obtained by using different econometric and statistical methods.

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Declarations

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