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Performance of the ESG Investments: The Risk and Return Difference in Capital Markets of Developed and Emerging Economies

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Abstract

This work aims to verify the performance of financial assets classified as ESG, comparing the risk and return of the ESG Index with the financial assets index benchmark traded in the reference market. The purpose is to verify the performance of the ESG Index compared to the market. The measurement of volatility and returns, as well as tests of hypotheses of cointegration and causality between the time series of returns on quotations of selected ESG Indices and their respective benchmarks, were used. Besides that, autoregressive vector and heteroscedastic conditional autoregressive volatility models were estimated. The data used are weekly quotations of the ESG equity indices and their respective market benchmark. The results revealed a difference in the risk and return behavior of assets traded in emerging and developed economy markets caused by ESG practices. The results indicate a difference in the risk and return behavior of assets traded in emerging and developed markets caused by ESG practices. It can be inferred that emerging markets have seen a risk reduction that makes up ESG indices concerning their benchmarks.

JEL Classification: C58, D53, M21, Q01, Q50
Keywords: ESG Assets, VECM Models, Volatility Models.

Rendimiento de las inversiones ESG: diferencia de riesgo y rendimiento en los mercados de capitales de economías desarrolladas y emergentes

Resumen

Este trabajo tiene como objetivo verificar el desempeño de los activos financieros clasificados como ESG, comparando el riesgo y el retorno del índice ESG con el índice de activos financieros de referencia negociados en el mercado de referencia. El propósito es verificar el desempeño del índice ESG en comparación con el mercado. Se utilizó la medición de volatilidad y retornos, así como pruebas de hipótesis de cointegración y causalidad entre las series temporales de retornos de las cotizaciones de índices ESG seleccionados y sus respectivos índices de referencia. Además de eso, se estimaron modelos autorregresivos vectoriales y modelos de volatilidad autorregresivos condicionales. Los datos utilizados son cotizaciones semanales de los índices de acciones ESG y su respectivo índice de referencia del mercado. Los resultados revelaron una diferencia en el comportamiento de riesgo y retorno de los activos negociados en mercados de economías emergentes y desarrolladas causadas por prácticas ESG. Se puede inferir que los mercados emergentes han visto una reducción del riesgo que compone los índices ESG con respecto a sus índices de referencia.

Clasificación JEL: C58, D53, M21, Q01, Q50
Palabras clave: activos ESG, modelos VECM, modelos de volatilidad.

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1. Introduction

According to Lehemen (2021), the acronym ESG (Environmental, Social and Governance), drawn up by financial institutions at the beginning of this century, refers to the performance of companies concerning environmental, social and governance concerns in their businesses. In this way, financial assets classified as ESG consider environmental, social and governance criteria for selecting and managing portfolios of productive projects or financial assets. The work by Gillan et al. (2021) points out that before the emergence of the acronym ESG, these matters were reported using the acronym CSR, which refers to corporate social responsibility without including corporate governance. La Tore et al. (2020) noted that the importance of ESG factors in investment decisions has grown in recent years, given the interest of investors and regulators in socially responsible investments. It is worth highlighting the relevance of investments in firms' decarbonization linked to climate change concerns. These concerns related to sustainability can generate additional returns for firms. The recent work of Zairis et al. (2024) noted that climate change is the second most cited topic based on keywords from the sustainability research works.

In recent decades, the importance of firms' ESG practices has been the subject of many studies and research. Some of these studies have been developed to study the behaviour of ESG financial assets traded in the capital markets. Many researchers have dedicated themselves to comparing sustainability indices with conventional indices based on their respective comparative analyses of financial indicators. Among these studies on the subject, the work of Skare and Golja (2012) can be highlighted, which presents an analysis of the similarity between the financial performances of 45 companies listed on the Dow Jones Sustainability World Index in the years 2009 and 2010 and shows that companies listed on this sustainability index generally enjoy better financial performance than non-listed companies. Edmans (2011) and Edmans (2012) show that companies classified as ESG provide satisfaction to employees and obtain greater productivity and profitability.

Furthermore, from the work of Skare and Golja (2012), it can be inferred that assets with an ESG rating have a superior financial performance than other assets in the market. Gaspar et al. (2013) note that corporate social responsibility can attract shareholders with long-term investment objectives, reducing pressure on managers to generate profits in the short term and allowing investments in projects that generate returns over a longer time horizon. The study of the relationship between companies' sustainable behavior and financial performance by Martinez-Ferrero and Frias-Aceituno (2015) concludes a positive bidirectional causal relationship between corporate social responsibility and financial performance. Marti et al. (2015), in turn, examined the effect, in the short and long term, of social projects and strategies on the financial performance of corporations, concluding that the level of economic development of a country and the size of the company directly influence the financial performance of corporations.

In another work of interest on the subject addressed here, Cornett (2016) presents a study on the financial performance of the banking sector during the 2008 financial crisis. The results obtained by Cornett (2016) show that banks generally are rewarded for being socially responsible, as the financial performance of the banking sector is positively associated with CSR rating scores. The work by Ferrell et al. (2016) points out that better governance standards are related to better management practices and better long-term performance. With information on the returns of more than 1,500 North American companies during the 2008 financial crisis, Lins et al. (2017) showed that companies committed to corporate social responsibility (CSR) showed greater profitability, growth and sales per employee compared to companies with low CSR commitment. As a result, the shares of these companies earned returns of 4 to 7 percentage points above the market average. Corroborating with previous research, Albuquerque et al. (2019) point out that higher ESG standards can increase consumer loyalty by signaling product quality, market share and profits with less volatility.

More recently, many studies, such as the works of Ionecu et al. (2019), Shaikh (2022) and Gao (2023), have sought to verify the increase in the value of the firm in its capital investment and its consequences in the investment and financing decision given by the practice of ESG precepts in companies open. In an interesting study, Jain et al. (2019) verified the performance of several conventional and ESG indices and did not point out significant differences, including indicators of emerging markets. The research developed by Hubel et al. (2020) and La Torre et al. (2020) investigated the impact of ESG investments on portfolio performance. Furthermore, based on an extensive bibliographic review presented by Gillan et al. (2021), it observed that most of the studies carried out to investigate the relationship between the cost of capital and the ESG rating of companies allow it to be inferred that a better CSR or ESG rating of companies has a direct influence on their cost of capital. Given the weight of its investors' preferences, most prefer sustainable investments, even if equity costs or required returns are lower in the short term.

To contribute to the literature on the performance of ESG investments in emerging markets, Sosa et al. (2022) present a study on the Mexican ESG index. The work of Sosa et al. (2022) points out evidence of the difference between ESG investments and conventional investments concerning volatility, which significantly influences markets when volatility increases but not in periods of market stability. Based on a sample of data from European stock markets, Kurnoga et al. (2022) sought to verify the difference between ESG equity indexes and the indexes the authors designated conventional stock indexes. The results of Kurnoga et al. (2022) did not indicate significant differences in the performance of the indexes given the firm's inclusion of ESG practices.

According to Yin (2023), ESG investments are concentrated in European markets, that is, in developed countries. Thus, studies related to the performance of ESG investments are primarily focused on developed countries. Among the many recent works on the subject discussed here, Zaires et al. (2024) highlighted that the financial sector provides various investment products. However, the degree to which ESG factors are integrated differs. In this work, Zaires et al. (2024) present a literature review with a critical analysis of research on sustainable development from a financial perspective. Another extensive broad revision of the literature about the related topics is presented by Citalán et al. (2025). In this work, the results regarding ESG returns differ in performance compared to conventional asset returns. Furthermore, except for the Chinese capital market, most of the research refers to developed financial markets compared to emerging or developing economies. This work aims to verify the performance of ESG financial assets concerning the average of financial assets traded in their respective markets. For this purpose, the measurement of volatility and returns, as well as tests of hypotheses of cointegration and causality between the time series of returns on quotations of selected ESG financial assets and their respective benchmarks, were used.

In addition to this introduction, this paper presents four other sections. Section 2 and Section 3 describe, respectively, the applied methodology and the sample used in this research. In Section 4, the results obtained are presented. Finally, Section 5 deals with this work's conclusion and final comments, followed by the bibliographic references.

2. Applied Methodological Approach

Cointegration tests were performed concurrently with the implementation and estimation of vector autoregressive models, or VAR models, to study the stochastic relationship between the time series mentioned earlier and the causal relationship between these time series. To verify the cointegration between the returns of ESG financial assets and the returns of their reference assets, the test by Johansen and Juselius (1990) was used. The cointegration test of Johansen and Juselius (1990) can be described considering an estimated p-order VAR model, or VAR(p), described as follows:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + B x_t + \varepsilon_t \ , \quad (1)$$

where y_t is a vector of non-stationary variables of dimension k, x_t is a vector of deterministic variables of dimension d, and ε_t is a vector of innovations. The VAR(p) model described above can be rewritten as follows:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-1} \ B x_t + \varepsilon_t \text{ , where } \Pi = \sum_{i=1}^{p} A_i - \mathrm{I} \text{ and } \Gamma_i = -\sum_{j=i+1}^{p} A_j . \quad (2)$$

As Salles and Oliveira (2014) point out, the Granger representation theorem states that if the coefficient of the matrix Π has full rank reduced $r < k$, then there are matrices α and β of dimension k × r, each with full rank r so that Π = αβ' and β'y_t are stationary. Where r is the number of cointegration relations, and each column β is the cointegration vector. The elements of α are known as the fit parameters in the vector autoregressive model with error correction (VECM) that will be presented later. Johansen's method estimates the matrix Π from an unconstrained VAR and tests whether the restrictions applied by the reduced full rank of Π are rejected. The hypothesis tests associated with the likelihood ratio verify the number of statistically significant characteristic roots of the matrix of coefficients with distributions that converge to two test statistics: the matrix trace and the maximum eigenvalue. Thus, as detailed in Enders (2014), the Johansen and Juselius test brings together two statistical tests of hypotheses. The first test considers the null hypothesis of the existence of r cointegration relations and tests against the alternative hypothesis of k cointegration relations, where k is the number of integrated endogenous variables of order 1, where r = 0, 1, .. ., k – 1. This test statistic can be described as follows:

$$LR_{tracer}(r|k) = -T \sum_{i=r+1}^{k} log\ (1 - \lambda_i) \quad (3)$$

where λ_i represents the largest eigenvalue of the matrix of coefficients Π and T is the number of time series observations included in the analysis. The second test verifies the null hypothesis of the existence of r cointegration relations against the alternative hypothesis of r + 1 cointegration relations. In this way, the test statistic is called the maximum eigenvalue and can be represented by the expression:

$$LR_{max}(r|r+1) = -\mathrm{T}\log(1-\lambda_{r+1}) \\ = LR_{trace}(r|k) - LR_{trace}(r+1|k)\ , \qquad r = 0, 1, \ldots, k-1. \tag{4}$$

In addition to the cointegration test described, the methodological approach uses vector autoregressive or VAR models, as described by Gujarati and Porter (2011). Presented in the literature by Sims (1980), VAR models consider or are interested in all the variables involved. That is, they do not distinguish between endogenous and exogenous variables. Thus, the study of the relationship between two or more stochastic variables concerning innovations or shocks that one variable can transmit to another and their short- and long-term causal relationship is allowed (see Granger (1969)). The VAR model can be described through equations that relate the variables of interest with the lagged observations of the variable itself and another variable of interest in the case of bivariate models. Thus, the VAR model can be described by the following system of equations in the particular case of 1-order VAR model, or VAR(1):

$$Y_t = \beta_1 + \beta_2 Y_{t-1} + \beta_3 Z_{t-1} + \varepsilon_{1t} \\ Z_t = \beta_4 + \beta_5 Z_{t-1} + \beta_6 Y_{t-1} + \varepsilon_{2t} \quad , \tag{5}$$

Yt e Zt are stationary variables, Ɛ1t, and Ɛ2t are innovations or orthogonal shocks with an expected zero value. Salles and Almeida (2017) observed that an error correction mechanism must be included in the autoregressive vector model without rejecting the cointegration hypothesis between the VAR model variables. Therefore, the model indicated for examining the causal relationships between ESG financial assets and their respective reference indicators is the VECM model. In its simplest form, the bivariate case can be described as follows:

$$Y_t = \beta_1 + \beta_2 ECM + \beta_3 Y_{t-1} + \beta_4 Z_{t-1} + \varepsilon_{1t} \\ Z_t = \beta_5 + \beta_6 ECM + \beta_7 Z_{t-1} + \beta_8 Y_{t-1} + \varepsilon_{2t} \tag{6}$$

To achieve the objectives of this work, in addition to verifying cointegration and causality test performance, volatility models were estimated for the selected ESG financial assets returns time series using the autoregressive conditional heteroskedastic models from ARCH family from the model presented by Engle (1982), according to the descriptions detailed in Bollerslev (1998) and Brooks (2014). The ARCH(p) -- the autoregressive conditional heteroskedastic model of order p, the simplest form can be described by the following expression:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_t^2 + \cdots + \alpha_q \varepsilon_{t-p}^2 \quad . \tag{7}$$

Bollerslev (1986) constructed the ARCH model generalization, including the conditional variance, which also depends on previous lags q. A GARCH(p, q) model can be described as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{i=q} \alpha_i \varepsilon_{t-1} + \sum_{j=1}^{j=p} \beta_j \sigma_{t-j}^2 \quad . \tag{8}$$

The GARCH models are premised on the symmetry of returns; that is, volatility has a symmetric response to positive or negative price shocks. In general, a negative shock to the financial time series returns causes a more significant increase in volatility than a positive shock of the same magnitude. Such asymmetries in the stock market are generally attributed to leverage effects. A fall in the market value of a firm causes the company's debt-to-equity ratio to increase. Considering these asymmetries in the volatility estimate, the Exponential GARCH model was proposed by Nelson (1991). In the EGARCH model estimation, given the transformation of the dependent variable using logarithms, the results of the variance σt^2 are positive even with negative parameters. Therefore, the asymmetries between returns and volatilities are considered in this way. The EGARCH (p, q, r) model, in general form, can be described by the following expression:

$$ln\sigma_t^2 = \alpha_0 + \sum_{j=1}^{p} \beta_j ln\sigma_{t-j}^2 + \sum_{i=1}^{q} \alpha_i \left| \frac{e_{t-i}}{\sigma_{t-i}} - E\left(\frac{e_{t-i}}{\sigma_{t-i}}\right) \right| + \sum_{k=1}^{r} \gamma_k \frac{e_{t-i}}{\sigma_{t-i}} \quad . \qquad (9)$$

Selection model criteria are required to select the autoregressive vector models and the most appropriate volatility models. In addition to verifying the sum of squared errors, the Akaike and Schwarz information criteria were used for model selection criteria, according to the description presented in Gujarati and Porter (2011). Next, in Section 3, the data sample and the methodological approach used to achieve the objectives of this work are described.

3. Sample - Data Used

The sample consisted of ESG stock indices and their respective benchmark market indicators. These ratios were selected following the ESG Leaders ranking of ratios calculated and reported by financial services firm Morgan Stanley Capital International (MSCI). The rating is used to filter companies with ESG ratings greater than “BB” according to the MSCI scale that ranges ratings from “AAA” to “CCC”, where “AAA” is the highest rating and “CCC” the worst. Among these indices, from developed and emerging markets, the following indicators were selected for this work: (i) World ESG, (ii) USA ESG, (iii) Europe ESG, (iv) Japan ESG, (v) Brazil ESG, (vi) China ESG and (vii) India ESG. The selection of reference indicators was carried out while considering each reference market. Thus, the references used in the case of ESG World and ESG USA were, respectively, MSCI World and MSCI USA, as suggested by the MSCI reports. In the case of ESG Japan and ESG Europe, the reference indicator, the MSCI G7, was used. In the case of ESG Brazil, ESG China and ESG India, an equity portfolio representative of emerging equity markets indicator, the MSCI EM was used.

Figure 1 presents each ESG index plot and its respective benchmarks. These charts were constructed with different quotes on the ordinates, on the left and right, to facilitate the comparison of the behavior of the quotes of the related indices. From Figure 1, it can be inferred that the behavior of the ESG indices follows the pattern of their benchmarks. That occurs mainly in the world, the USA, and the European indices. In the case of the Japan ESG index, despite lower prices, the behavior is similar to that of the reference index. The India ESG index has a similar behavior, following its benchmark until the beginning of 2012, when it started to show higher quotations.

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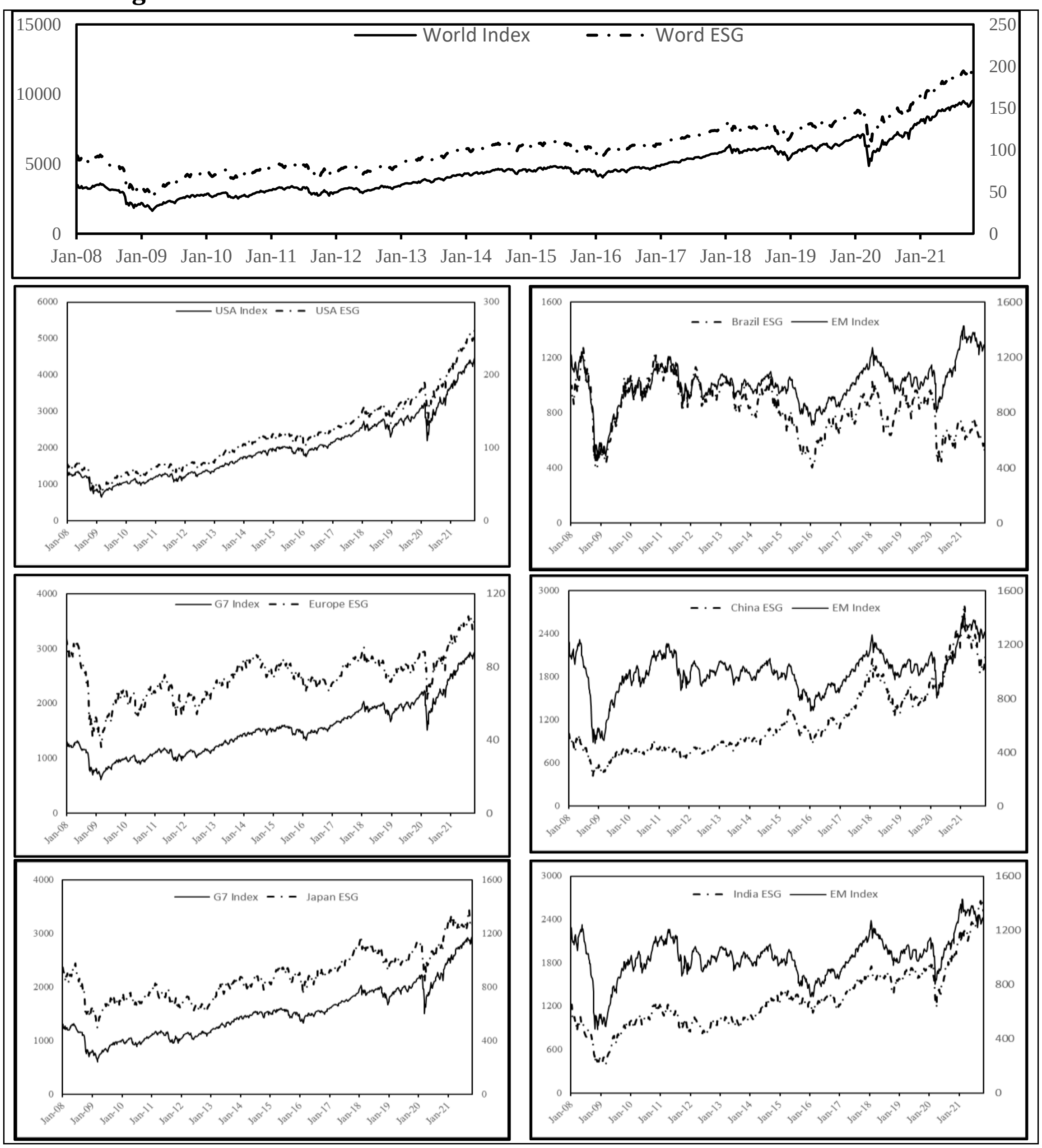
Concerning emerging markets, the indicator for the Brazilian market differs from what happens in the Japanese market; the ESG index has higher quotations than the reference index until 2014, and the two indices are similar in the weaker movements between 2017 and 2018, which does not allow us to state that there is the same pattern. Regarding China, the ESG index presented lower quotes than the benchmarks until 2014. The ESG index increased and moved far from the reference index in the following period. It is worth observing that the quote presented peaks and valleys in the same period as the reference indicator, the emerging market index. The impacts of the economic crises on the capital market are evident in the plots in late 2008, early 2009, and early 2020.

Figure 1. Time Series of the ESG Indices and Their Reference Indices



Source: Authors' estimations with EViews from MSCI data.

The index returns were calculated through the natural logarithm of the ratio between the index quotation in period t and the index quotation in period t -1, where the period t corresponds to the week or the weekly closing price to assess the ESG index returns and their respective reference indices.

Table 1 presents the returns time series statistical summary of ESG indices and their benchmarks. Among all the analysed ESG indices, it can be seen that only Europe, Japan, and Brazil had a negative average return in the analysed period, and the time series of the US indicator gave the highest average return. Regarding volatility, measured by the standard deviation, as expected, the indices of emerging market economies, i.e. Brazil, China and India, show higher volatility than the other indicators. Regarding relative fluctuations, measured by the coefficient of variation, the highest volatility is for the ESG World index, followed by ESG Brazil and ESG China.

From the return series behavior of each ESG index and their respective benchmarks, it can be inferred that the ESG index weekly returns generally vary with their respective benchmarks, which happens more significantly with the World and US indices. The considerable increase in volatility of all returns time series must be observed in the critical periods of the two main crises of the century, the subprime financial crisis and the health crisis caused by the Covid-19 pandemic, in 2008, 2009 and 2020. Concerning the hypothesis of normality of returns, it can be inferred that the all-time series of returns showed some asymmetry. While the ESG World, ESG Japan, ESG India and ESG Europe indices show negative asymmetry, the ESG USA, ESG Brazil and ESG China indices show positive asymmetry.

Table 1. Statistical Summary of ESG Stock Indices Returns and their Benchmarks

Index / *Statistics*	ESG World	ESG Japan	ESG USA	ESG Europe	ESG China	ESG Índia	ESG Brazil	World Index	USA Index	G7 Index	EM Index
Mean	0.0001	-0.0005	0.0006	-0.0003	0.0003	0.0013	-0.0003	0.0001	0.0004	0.0001	-0.0001
Median	0.0007	0.0005	0.0011	-0.0004	0.0001	0.0016	0.0003	0.0006	0.0012	0.0009	0.0003
Minimum	-0.0565	-0.0699	-0.0457	-0.0890	-0.0833	-0.1118	-0.1064	-0.0510	-0.0436	-0.0495	-0.0829
Maximum	0.0569	0.0520	0.0865	0.0779	0.1477	0.0953	0.1317	0.0576	0.0871	0.0638	0.0964
Std. Dev.	0.0096	0.0129	0.0112	0.0134	0.0159	0.0170	0.0213	0.0095	0.0112	0.0097	0.0113
Skewness	-0.3291	-0.7039	0.3391	-0.7044	0.8896	-0.2158	0.1814	-0.1678	0.4281	-0.0262	0.2230
Kurtosis	9.2629	6.905	10.030	10.406	15.157	8.817	8.194	9.089	10.297	8.876	14.797
JB test	1195.1	518.1	1500.7	1709.4	4541.1	1023.4	815.5	1118.6	1623.7	1038.8	4192.3
(p value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ADF test	-28.825	-27.137	-9.740	-9.558	-14.505	-5.516	-12.151	-28.631	-10.231	-28.823	-14.134
(p value)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Source: Authors' estimations with EViews from MSCI data.

While the ESG World, ESG Japan, ESG India and ESG Europe indices show negative skewness, the ESG USA, ESG Brazil and ESG China indices show positive skewness. As for the kurtosis coefficient, it can be observed that all the time series of returns have leptokurtic distributions or are less flattened than the normal distribution. The results of the Jarque-Bera tests present p-values close to zero, which confirms the non-acceptance of the hypothesis of normality of all time series of the returns of the analysed indicators. Regarding the stationarity hypothesis of the returns time series, the Augmented Dickey-Fuller (ADF) tests show that this hypothesis cannot be rejected for any ESG indices and their respective benchmarks and p-values close to zero confirm this inference. Using the Ljung-Box test,

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for up to seventy lags, it can be inferred that the autocorrelation hypothesis should be rejected for all returns time series studied. The next section presents the results obtained with the sample described using the methodology adopted in this work.

4. Analysis of Obtained Results

From the tests of the cointegration hypothesis performed, it can be inferred that for the seven pairs of return time series, the cointegration hypothesis cannot be rejected with a p-value close to zero. Thus, error correction mechanisms obtained from the cointegration equations were included in the estimated VAR models that became VECM models. In constructing the VECM models, up to two lags were considered, but some estimated parameters did not show statistical significance. Thus, one lag was considered when creating all models, with the estimated parameters statistically significant.

The equations shown below are a generalization of the estimated VECM models, where ESG_t is the return of the ESG index in period t, and Z_{it} is the return of the reference index i in period t, where i represents each of the seven selected ESG indices for this work. Thus, the estimated VECM models for each Index can be described with the following expressions:

$$\begin{aligned} ESG_t &= \beta_1 ECM + \beta_2 ESG_{t-1} + \beta_3 Z_{it-1} \\ Z_{i,t} &= \beta_4 ECM + \beta_5 ESG_{t-1} + \beta_6 Z_{i,t-1} \\ ECM_t &= ESG_t + \delta\, Z_t \end{aligned} \quad (10)$$

It must be highlighted that for the China model, the coefficients of the two lagged variables β_2 and β_3 of the ESG index and its benchmark, the emerging markets index, the p-value was 8% and 15 %, respectively. In the India model, the β_6 coefficient of the lagged benchmark, or the MSCI EM index, statistical significance is accepted at 9%. For the other models, the significance level was lower than 5%. Table 2 shows the parameter estimates for each of the seven VECM estimated. Furthermore, Table 2 presents the metrics related to the adjustment of the estimated models.

Table 2. Estimates of VECM Models for each Selected Indicator

parameters		World		USA		Europe		Japan		Brazil		China		India	
ESG_t	$Z_{i,t}$	ESG_t	Z_t	ESG_t	Z_t	ESG_t	Z_t	ESG_t	Z_t	ESG_t	Z_t	ESG_t	Z_t	ESG_t	Z_t
β_1	β_4	1.11 0.00	1.14 0.00	1.63 0.00	1.92 0.00	-0.17 0.00	-0.16 0.00	-0.36 0.00	0.42 0.00	-1.16 0.00	-0.27 0.00	-1.28 0.00	-0.66 0.00	-0.20 0.00	-0.16 0.00
β_2	β_5	-1.43 0.00	-0.86 0.00	-1.34 0.00	-0.98 0.00	-0.54 0.00	0.08 0.00	-0.31 0.00	-0.19 0.00	0.12 0.00	0.17 0.00	0.10 0.08	0.35 0.00	-0.41 0.00	0.08 0.00
β_2	β_6	1.41 0.00	0.85 0.00	1.14 0.00	0.84 0.00	0.65 0.00	-0.09 0.04	-0.38 0.00	-0.16 0.00	-0.14 0.00	-0.52 0.00	-0.09 0,15	-0.61 0.00	0.59 0.00	-0.07 0.09
δ *(p value)*		-1.93 (0.00)		-1.42 (0.00)		5.70 (0.00)		-1.82 (0.00)		-0.24 (0.00)		-0.38 (0.00)		4.90 (0.00)	
DRC		9.21E-11		9.27E-10		9.60E-09		1.95E-11		4.90E-08		1.43E-08		2.5E-08	
Adjusted R^2		0.52	0.53	0.44	0.50	0.48	0.54	0.32	0.44	0.50	0.27	0.49	0.36	0.40	0.46
RSS		0.07	0.07	0.11	0.10	0.15	0.07	0.16	0.08	0.33	0.13	0.18	0.11	0.24	0.09
F-statistic		390	400	284	353	324	412	168	278	358	133	338	198	243	305
AIC		-6.44	-6.46	-5.96	-6.05	-5.64	-6.45	-5.54	-6.26	-4.85	-5.79	-5.45	-5.92	-5.16	-6.09
BIC		-6.42	-6.44	-5.94	-6.03	-5.63	-6.43	-5.52	-6.42	-4.83	-5.78	-5.43	-5.90	-5.14	-6.07

Source: Authors' estimations with EViews from MSCI data.

The results presented in Table 2 show that the returns of the USA ESG indices have a positive relationship with ECM, a negative relationship with the series of returns lagged by one unit and a positive relationship with the reference index return lagged by one unit. The USA benchmark index returns have a positive relationship with the cointegration equation, a negative relationship with the one-unit lagged return series itself, and a positive relationship with the one-unit lagged ESG index return series. It can be observed that the US ESG index is affected by any variation of the lagged variables of the model with a magnitude greater than unity once all coefficients in absolute value are greater than one. For the reference index return, only the EMC variation causes greater variation once the other lagged variables' coefficients are less than unity. About the model that involves the European market indicators and the reference index or the MSCI G7 returns time series, it can be inferred that the returns of the Europe ESG indices have a negative relationship with the ECM and the ESG index return time series lagged by one unit and positive with the benchmark return time series lagged by one unit.

The time series of returns of the reference index has a negative relationship with the cointegration equation, a positive relationship with the returns lagged by one unit and a negative relationship with the Europe ESG index returns lagged by one unit. In addition, it can be inferred that any variation in the lagged variables causes a smaller magnitude variation in absolute value in the returns of the Europa ESG index. This same behaviour happens with the returns of the reference indicator. From the estimations obtained for the parameters of the autoregressive vector models, one can observe the magnitude of the influence on one of the indicators, ESG and its benchmark, of the lagged variables. In addition, it is essential to emphasize that for all the estimates of the models presented, the bidirectional causal relationship between the ESG indices and their reference indices in the short and long term is evident. That is, the hypothesis of bidirectional Granger causality between the ESG indices and their respective reference indices is not rejected. From the metrics listed in Table 2 to verify the quality of the adjustment of the estimated models, it can be inferred through the Determinant Residual Covariance -- DRC, which presents values very close to zero for all the models, that the models are estimated satisfactorily. It can be inferred from the F-statistic that all the models are statistically significant. The RSS, AIC, and BIC model selection criteria allow comparative observation of the estimated models. Thus, it can be inferred that among the assets of developed markets, the ESG World model presents a better fit to the data than the USA ESG model. In contrast, the model dealing with the ESG Europe indicator better fits the model that includes the ESG Japan index. Concerning emerging markets, it can be inferred that the model that includes the ESG China indicator was the one that presented the best adjustment. Among all the estimated models, the one that contains ESG World was the one that presented the best fit, while the model that includes ESG Brazil was the model with the worst quality of adjustment.

In addition to the estimates of the VECM models described above, volatility models were built and estimated for each indicator selected to compare the volatility of the ESG indices with their respective benchmarks in the period studied, a total of 11 indicators. Three different types of models from the ARCH family were considered for constructing the volatility models: the ARCH model, the GARCH model and the EGARCH model. Student's t distribution was considered in addition to the normal distribution for the probability distribution of the models. Together, the average of the

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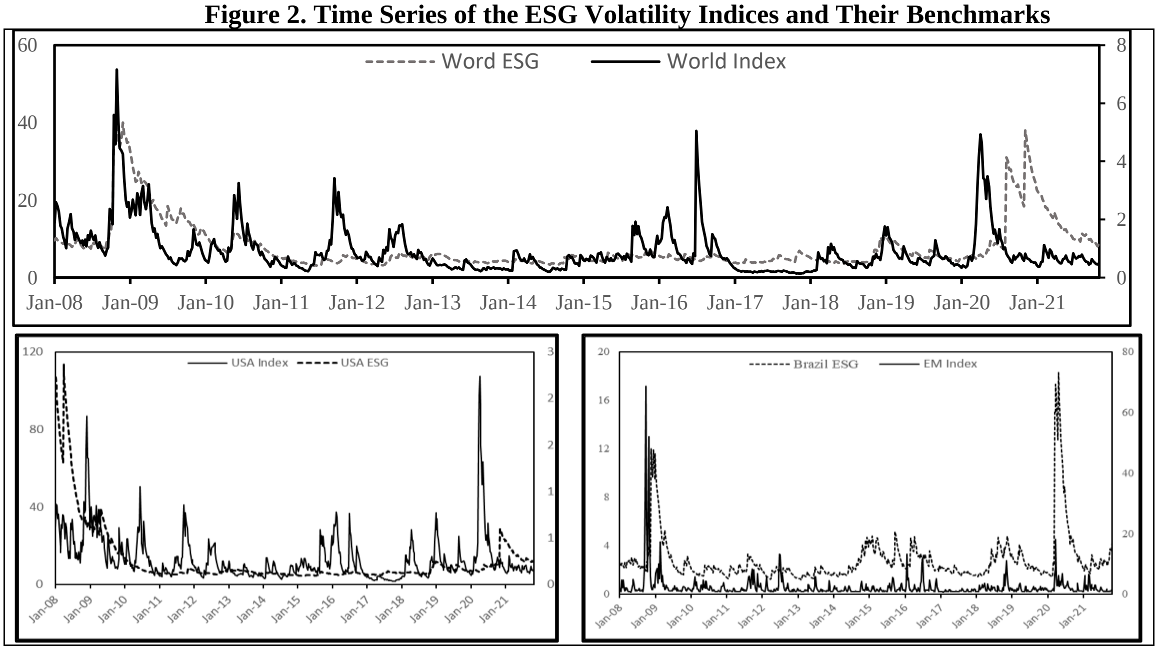
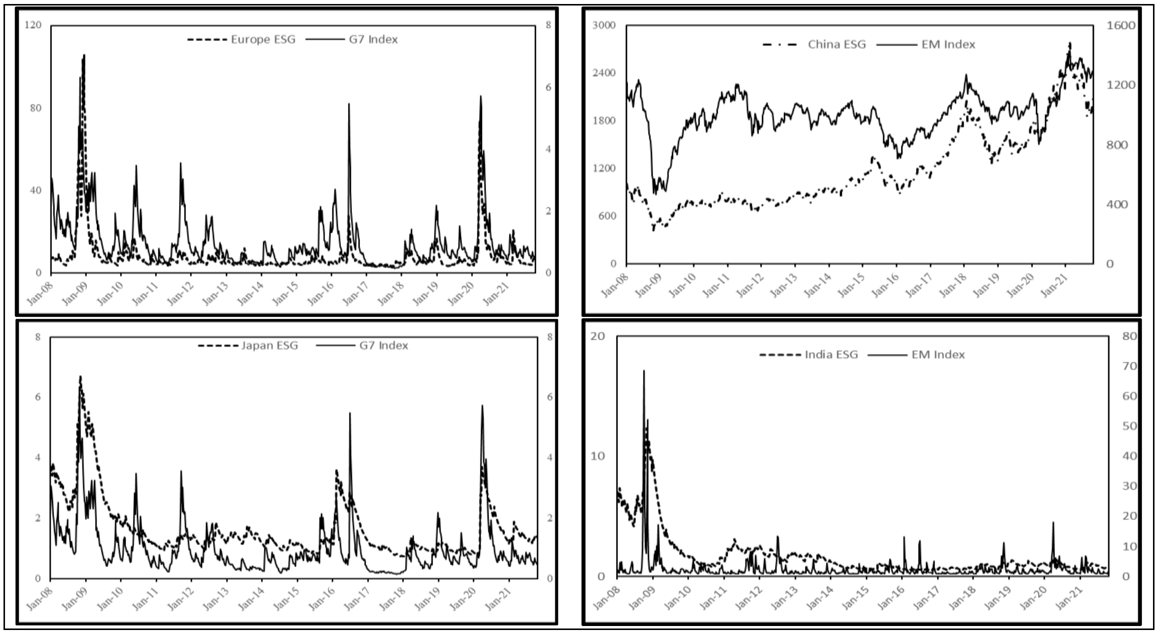
returns of each selected indicator was estimated with three variations, which are shown below. In this way, eighteen models were estimated for each indicator, making a total of 126 models estimated to obtain the volatility time series of the ESG indices and their respective reference indices. The following model was considered for the mean returns for the ESG indices: $Y_t = \beta_1 + \beta_2 Y_{t-1} + \beta_3 Z_t$. Where $Y_{t-1} =$ return of each ESG index lagged by one unit, and $Z_t =$ return of the index is viewed as a reference for the ESG index. As for the reference indices, the model considered for the average returns was given by the expression: $Z_t = \beta_1 + \beta_2 Z_{t-1}$. For the selection of models, only models with statistical significance for all estimated parameters were selected. For all selected parameters, the sum of squares of the residuals and the model selection criteria of Akaike and Schwarz were used to choose models. Among the indicators, the indices of emerging economies, the volatility model that proved to be the most appropriate was the GARCH(1,1) model for ESG Brazil, ESG China and MSCI EM. The selected model for the ESG India index was the EGARCH(1,1,1). Among the developed economies indices indicators: for ESG Europe, ESG Japan and ESG World, the selected volatility model was GARCH(1,1); for ESG USA, the TGARCH(1,1,1) model; for the reference indices G7, USA and World, the selected volatility model was the EGARCH(1,1,1). In estimating all volatility models, normal probability distributions and Student's t distribution were considered, with Student's t distribution being the one that best fitted all estimated volatility models.

Figure 2 presents the volatility plots based on the results obtained with the estimations of the volatility models of the indices studied. The behavior of the time series of the volatilities of all the ESG indicators and their respective benchmarks in the analyzed period was examined. The ESG World and ESG US indices exhibit much lower volatility than their benchmark indices. Furthermore, these indices do not show volatility behavior similar to their benchmarks. It must be noted that in the case of Japan, the ESG index presents a greater risk than the reference index in many periods. Concerning Europe, the ESG index demonstrates a behavior close to its benchmark in magnitude and variations across distinct periods.

Figure 2. Time Series of the ESG Volatility Indices and Their Benchmarks





Source: Authors' estimations with EViews from MSCI data.

Concerning the ESG indices of the emerging countries analyzed, from the Figure 2 it can be observed that all indices show lower volatility than the general index of emerging markets. Thus, it can be inferred that for emerging countries, there is a more significant benefit for ESG assets investors given by the reduction in risk related to the shares of companies that carry out their management with a focus on environmental and governance issues. In the case of China, this difference in volatility between the ESG index and the reference indicator is more evident: the ESG index has significantly lower volatility than the reference or the emerging markets index, with a very different behavior between the ESG index and the reference index. Thus, when examining the time series of the indexes studied, three distinct periods can be highlighted for analysis: during the 2008 crisis, the period without crisis from 2009 to 2019 and the period during the crisis caused by Covid-19, to evaluate changes in the behavior of the volatilities of the indices studied during periods of economic crisis. During the 2008 financial crisis and the crisis caused by the Covid-19 pandemic, the ESG World index volatilities were higher than in the preceding period.

However, the same effect on the benchmark index is not observed. In addition, volatility increased in the 2008 financial crisis but did not increase as significantly during the Covid-19 crisis. Regarding the Japanese index, it is possible to observe a significant difference in the volatility of the ESG index and its benchmark, mainly during the 2008 crisis, a period without crises. During the Covid-19 pandemic crisis, the same impacts on volatility, which, despite being greater, do not have such an expressive difference. Concerning the North American index, it is possible to observe a significant difference in the ESG index volatility, mainly during the 2008 crisis. The reference index has a similar behavior, but the impact on volatility was more minor during the 2008 crisis. For the indices of emerging countries, it can be observed that, in the cases of India and China, the 2008 crisis caused a much higher volatility than the other periods, contrary to the pandemic caused by Covid-19, when India experienced a lower volatility than in the different periods and China the volatility did not change significantly, following the benchmark of emerging countries. In the case of Brazil, the movement was the opposite: the index did not suffer much impact from the economic crisis that occurred in 2008, with only a slight increase. Nonetheless, during the crisis provoked by the Covid-19 pandemic, the index recorded significant increases in volatility. The work's final comments are presented below, followed by the bibliographical references used.

5. Final Comments

This work aimed at examining ESG financial assets' performance, considering reference assets' return and risk. Based on the estimates of bivariate autoregressive and volatility models, it was possible to infer that the studied ESG stock market indices have a long-term stochastic relationship with the benchmarks of the respective markets. In addition, it can be inferred that there is a bidirectional causal relationship between the selected ESG indices and their benchmarks in the short and long term. It should be noted that the Japanese market differs from the others analyzed by presenting a negative relationship with the lagged data series.

Regarding the impact of the crises that affected the world economy in the period studied, it was found that both the 2008 financial crisis and the health crisis arising from the Covid-19 pandemic caused an increase in volatility in all financial market indicators, international. Furthermore, it should be noted that the performance indicators of ESG assets were more sensitive to these crises than their respective benchmarks.

Concerning this study's limitations, it is important to highlight the difficulty of obtaining an available database related to the returns of ESG assets, hence the relevance of the topic and the interest of related research. Many studies have been developed on the impact of practices associated with sustainability precepts on the returns of firms in the capital markets of national economies. Despite the significant theoretical developments in financial econometrics, another limitation observed in studies and research is obtaining optimal estimates of the returns and volatility of financial, particularly emerging financial markets.

A more significant deepening of the analysis presented should be considered in future research, which should give continuity to this work. Future work should expand the sample and compare regional indicators to verify whether regional differences influence the returns and volatilities of firms classified as ESG. Furthermore, the topic can be further explored using econometric methods, determining impulse response functions and variance decomposition from the estimated VECM models. Finally, it is worth noting that to assess the performance of ESG financial assets, in addition to using market metrics, as in this work, other metrics can be considered, as well as dynamic correlation estimates. Furthermore, to assess the impact of social, environmental, and governance returns on the financial performance of ESG financial assets, performance indicators of these financial assets by industrial sectors or companies in industrial sectors of interest should be observed. Thus, this work or its future developments can contribute to decision-making regarding investments and production financing.

References

[1] Akhtaruzzaman, M., Boubaker, S., Chiah, M., & Zhong, A. (2020). COVID–19 and oil price risk exposure. Finance Research Letters, 42(2), 1-7. https://doi.org/10.1016/j.frl.2020.101882

[2] Albuquerque, R., Koskinen, Y., & Zhang, C. (2019). Corporate Social Responsibility and Firm Risk: theory and empirical evidence. Management Science, 65(10), 4451-4469. https://doi.org/ 10.1287/mnsc.2018.3043

[3] Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroskedasticity. Journal of Econometrics, 31(3), 307-327. https://doi.org/10.1016/0304-4076(86)90063-1

[4] Brooks, C. (2019). Introductory Econometrics for Finance. 4th Edition, Cambridge University Press, Cambridge. https://doi.org/ 10.11017/9781108524872

[5] Cornett, M., Erhemjamts, O., & Tehranian, H. (2016). Greed or Good Deeds: An Examination of the Relation Between Corporate Social Responsibility and the Financial Performance of U.S. Commercial Banks Around the Financial Crisis, Journal of Banking & Finance, 70, 137-159. https://doi.org/ 10.1016/j.jbankfin.2016.04.024

[6] Edmans, A. (2011). Does the stock market fully value intangibles? Employee satisfaction and equity prices. Journal of Financial Economics, 101(3), 621-640. https://doi.org/10.1016/j.jfineco.2011.03.021

[7] Edmans, A. (2012). The link between job satisfaction and firm value, with implications for corporate social responsibility. Academy of Management Perspectives, 26(4), 1-19. https://doi.org/10.5465/amp.2012.0046

[8] Enders, W. (2014). Applied Econometric Time Series. 4th Edition. John Wiley, New York.

[9] Engle, R. (1982). Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation. Econometrica, 50(4), 987-1007. https://doi.org/10.2307/1912773

[10] Ferrell, A., Liang, H., &Renneboog, L. (2016). Socially responsible firms. Journal of Financial Economics, 122(3), 585-606. https://doi.org/10.1016/j.jfineco.2015.12.003

[11] Gao, S. (2023). ESG Performance and Capital Investment. Academic Journal of Management and Social Sciences, 2(1), 119-123. https://doi.org/10.54097/ajmss.v2i1.6501

[12] Gaspar, J., Massa, M., Matos, P., Patgiri, R., & Rehman, Z. (2013). Payout Policy Choices and Shareholder Investment Horizons. Review of Finance, 17(1), 261-320. https://doi.org/10.1093/rof/rfr040

[13] Gillan, S., Koch, A., & Starks, L. (2021). Firms and social responsibility: A review of ESG and CSR research in corporate finance. Journal of Corporate Finance, 66, 1-16. https://doi.org/10.1016/j.jcorpfin.2021.101889

[14] Granger, C. (1969). Investigating Causal Relations by Econometric Models and Cross-spectral Methods. Econometrica, 37(3), 424-438. https://doi.org/10.2307/1912791

[15] Gujarati, D., & Porter, D. (2011). Basic Econometrics. 5th Edition. McGraw-Hill, New York.

[16] Hübel, B., Scholz, & H., Webersinke, N. (2020). Performance of S&P 500 ESG Indices: The Impact of Weighting Methodologies and ESG Ratings. Retrieved from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3528309

[17] Ionescu, G. H., Firoiu, D., Pirvu, R., & Vilag, R. D. (2019). The impact of ESG factors on market value of companies from travel and tourism industry. Technological and Economic Development of Economy, 25(5), 820-849. https://doi.org/10.3846/tede.2019.10294

[18] Jain, M., Sharma, G. D., & Srivastava, M. (2019). Can Sustainable Investment Yield Better Financial Returns: A Comparative Study of ESG Indices and MSCI Indices, Risks, 7(1), 1-18. https://doi.org/10.3390/risks7010015

[19] Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with applications to the demand for money. Oxford Bulletin of Economics and Statistics, 52(2), 169–210. https://doi.org/10.1111/j.1468-0084.1990.mp52002003

[20] Kurnoga, N., Šimurina, N. & Fučkan, F. (2022). Performance Differences between ESG Indices and Conventional Market Indices: a Multivariate Analysis of Indices. Zagreb International Review of Economics and Business, Sciendo, 25(1), 85-103. https://doi.org/10.2478/zireb-2022-0026

[21] Zairis, G., Liargovas, P., & Apostolopoulos, N. (2024). Sustainable Finance and ESG Importance: A Systematic Literature Review and Research Agenda. Sustainability, 16(7), 2878. https://doi.org/10.3390/su16072878

[22] La Torre, M., Mango, F., Cafaro, A. & Leo, S. (2020). Does the ESG Index Affect Stock Return? Evidence from the Eurostoxx50. Sustainability, 12(16), 1-12. https://doi.org/10.3390/su12166387

[23] Lehmen, A. (2021). The rise of ESG Law: in search of lost time. Academia Letters, Article 1906. https://doi.org/10.20935/AL1906

[24] Lins, V., Servaes, H., & Tamayo, A. (2017). Social Capital, Trust, and Firm Performance: the value of corporate social responsibility during the financial crisis. Journal of Finance, 72(4), 1785-1824. https://doi.org/10.1111/jofi.12505

[25] Martínez-Ferrero, J., & Frías-Aceituno, J. (2013). Relationship Between Sustainable Development and Financial Performance: International Empirical Research. Business Strategy and the Environment, 24(1), 20-39. https://doi.org/10.1002/bse.1803

[26] Martí-Ballester, C., Val, M. R., & Drescher, L. (2015). Are Firms that Contribute to Sustainable Development Better Financially? Corporate Social Responsibility and Environmental Management, 22(5), 257-319. https://doi.org/10.1002/csr.1347

[27] Monzón Citalán, R., Díaz Tinoco, J., & Morales Castro, A. (2024). Revisión de la Literatura sobre el Rendimiento de la Inversión ESG: Un Estudio Bibliométrico. Revista Mexicana de Economía y Finanzas Nueva Época REMEF, 20(1), e1210. https://doi.org/10.21919/remef.v20i1.1210

[28] Nelson, D. (1991). Conditional Heteroscedasticity in Asset Returns: A New Approach. Econometrica. 59(2), 347-370. https://doi.org/10.2307/2938260

[29] Salles, A. A., & Almeida, P. H. A. (2017). The Crude Oil Price Influence on the Brazilian Industrial Production. Open Journal of Business and Management, 5, 401-414. https://doi.org/10.4236/ojbm.2017.52034

[30] Salles, A., & Oliveira, E. (2014). Relevance of Future Contracts on Spot Price Formation in Crude Oil Markets. Advances in Social Sciences Research Journal, 1(3), pp. 45-56. https://doi.org/10.14738/assrj.13.204

[31] Shaikh, I. (2022). Environmental, Social, and Governance (ESG) Practice And Firm Performance: An International Evidence. Journal of Business Economics and Management, 23(2), 218-237. https://doi.org/10.3846/jbem.2022.16202

[32] Sims, C. A. (1980) Macroeconomics and Reality. Econometrica, 48, 1-48. https://doi.org/10.2307/1912017

[33] Skare, M., Golja, T. (2012). Corporate Social Responsibility and Corporate Financial Performance – Is There A Link? Ekonomska Istraživanja / Economic Research, 25 (1), 215-242. https://doi.org/ 10.1080/1331677X.2012.11517563

[34] Sosa, M., Ortiz, E., & Cabello, A. (2022). ESG Green Equity Finance Risk and Links in Mexico: Conditional Volatility and Markov Switching Vector Analyses. Revista Mexicana de Economía y Finanzas Nueva Época REMEF, 17(4), e788. https://doi.org/10.21919/remef.v17i4.788

[35] Yin, X.-N., Li, J.-P., & Su, C.-W. (2023). How does ESG performance affect stock returns? Empirical evidence from listed companies in China. Heliyon, 9(5), e16320, 1-12. https://doi.org/ 10.1016/j.heliyon.2023.e16320

[36] Zairis, G., Liargovas, P., & Apostolopoulos, N. (2024). Sustainable Finance and ESG Importance: A Systematic Literature Review and Research Agenda. Sustainability, 16(7), 2878, 1-13. https://doi.org/10.3390/su16072878