JOEEP

e-ISSN: 2651-5318
Journal Homepage: http://dergipark.org.tr/joeep

Araştırma Makalesi ● Research Article

A Research on Türkiye, the United States, and Germany Stock Markets from the Environmental Social Governance (ESG) and Sustainability Perspective

Çevresel Sosyal Yönetişim (ÇSY) ve Sürdürülebilirlik Perspektifinden Türkiye, Amerika Birleşik Devletleri ve Almanya Hisse Senedi Piyasaları Üzerine Bir Araştırma

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MAKALE BİLGİSİ

Makale Geçmişi:
Başvuru tarihi: 28 Mayıs 2024
Düzeltme tarihi: 13 Ocak 2025
Kabul tarihi: 2 Mart 2025

Anahtar Kelimeler:
Sürdürülebilirlik
Çevresel Sosyal Yönetişim
Hisse Senedi Endeksleri

ÖZ

Çevresel, Sosyal ve Yönetişim (ÇSY) pratikleri gelişmiş piyasalardan diğer pazarlara doğru yayılım göstermektedir. Bu çalışmada seçili hisse senedi piyasalarındaki ÇSY endeksleri ile piyasa endeksleri arasındaki ilişkiler incelenmiştir. Bu çalışmanın amacı; 2014 Aralık ile 2024 Aralık arasındaki dönemde, seçili borsa endekslerindeki değişimlerin bu borsalardaki ÇSY endeksleri üzerindeki muhtemel etkilerinin yönü ve şiddetinin araştırılmasıdır. Borsa İstanbul, Standart & Poor's ve Frankfurt Menkul Kıymetler Borsası ana endeksleri ile ÇSY endeksleri arasındaki ilişkiler her bir piyasa için üç farklı basit doğrusal regresyon modeli tahmin edilerek incelenmiş ve üç modele ait sonuçlar karşılaştırılmıştır. Çalışmanın sonucunda seçili üç piyasaya ait ESG endeksleriyle piyasa endeksleri arasında pozitif yönde ilişkinin var olduğu, Frankfurt Menkul Kıymetler Borsası ÇSY endeksinin piyasa endeksine karşı en düşür duyarlılık seviyesine sahip olduğu tespit edilmiştir.

ARTICLE INFO

Article history:
Received: May 28, 2024
Received in revised form: Jan 13, 2024
Accepted: March 2, 2024

Keywords:
Sustainability
Environment Social Governance
Stock Markets Indices

ABSTRACT

Environmental, Social, and Governance (ESG) practices are spreading from developed markets to other markets. This study examines the relationships between ESG indices and market indices in selected stock markets. The aim of this study is to investigate the direction and intensity of the potential effects of changes in selected stock market indices on their respective ESG indices during the period from December 2014 to December 2024. The relationships between the main indices of Borsa Istanbul, Standard & Poor's, and the Frankfurt Stock Exchange and their ESG indices were examined for each market by estimating three different simple linear regression models, and the results of the three models were compared. As a result of the study, it was determined that there is a positive relationship between the ESG indices of the selected three markets and the market indices, and that the Frankfurt Stock Exchange's ESG index has the lowest sensitivity level to the market index.

1. Introduction

In the historical progress of human civilization, new problems have emerged in different areas of life along with many economic and social developments. Uncontrolled population growth, injustice in the sharing of scarce resources, wars and conflicts in different regions around the world, global economic crises, and epidemic diseases have gained a deeper structure than in the past. In addition, the increase in production capacities after the first industrial revolution led to an increase in consumption levels worldwide along with the increase in population. This situation has had a significant impact on the unconscious use of resources by all parties aiming to obtain higher returns in economic business processes and the increase in environmental pollution and degradation. The effects of economic and social injustice and environmental and

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Atıf/Cite as: Kaymak, O. (2025). A Research on Türkiye, the United States, and Germany Stock Markets from the Environmental Social Governance (ESG) and Sustainability Perspective. *Journal of Emerging Economies and Policy*, 10(1), 44-53.

climatic degradation have begun to be clearly seen in recent years. Globalization, which has accelerated with the development of communication technologies, has resulted in the spread of awareness in environmental and social areas around the world. This situation forces the transformation of economic and financial business processes, as in many social practices. As a result of all this, the concept of Environmental Social Governance has begun to be accepted and discussed in wider circles day by day.

The most important reason for the increase in carbon emission levels is the rising in the number of industrial and economic activities. The Academy and policy makers have focused on the development of tools and regulations such as carbon capture systems, electric vehicles and biomass technologies, to be used to establish economic and ecological sustainability through technological innovations (Kartal, et al, 2023). These technological innovations have the potential to contribute significantly to financial and economic development. Additionally, these innovative methods and tools can play an active role in reducing ecological degradation and pollution. There are observational academic studies showing meaningful results between technological innovations and the increase in ecological quality. Researchers using different indicators to measure ecological quality argue that technological innovation has a strong impact on the level of ecological quality (Zhao, et al, 2023).

Various industries have undergone a significant adaptation investment process in recent years to comply with and improve environmental, social, and governance (ESG) standards. With the deepening economic and financial impacts of the Covid-19 pandemic, corporate environments have begun to focus more on ESG activities (Diaz et al. 2021). Financial institutions have begun to integrate ESG activities into their corporate strategies, resulting in significant financial investments being directed towards ESG stocks (Daugaard, 2020).

Whether firms' ESG activities have positive effects on corporate performance has not been definitively established in the finance literature (Flammer, 2015). In some studies, it is noted that firms' ESG activities cause agency problems and that managers continue ESG activities despite shareholders' negative attitudes (Krüger, 2015). There are also studies that support the hypothesis that firms with high management quality that prioritize ESG policies can achieve high profitability and, at the same time, have better social conditions (Ferrel et al. 2016; Servaes & Tamayo, 2013). In addition, there are no common and definitive results from studies on the relationships between firms' ESG activities and stock performance. Some studies have suggested that firms with good ESG scores can achieve high stock returns during periods of economic recession and crisis (Albuquerque et al. 2020; Lins et al. 2017; Ding et al. 2020). Conversely, some studies suggest that there are no significant relationships between firms' ESG scores and stock performance after periods of economic recession and crisis (Bae et al. 2021; Demers et al. 2020).

ESG ratings and ESG scores are parameters used as a reference for evaluating a company's ESG performance. In financial markets, companies whose ESG activities meet specified criteria are included in ESG or other sustainability indices. The performance of financial assets belonging to these firms determines the time-based variation of the respective index (Dhasmana et al. 2023). The main focus of this study is to investigate the direction and strength of the potential relationships between market indices, which represent the overall performance of financial markets, and ESG indices. In other words, it is the investigation of the impact strength of indices representing the performance of all or a large majority of financial assets in the market on ESG indices.

In this study, the potential relationships between the main index movements of Borsa İstanbul (BIST), Standard & Poor's, and the Frankfurt Stock Exchange markets and ESG indices have been examined. For each market, time series consisting of 120 observations of the monthly change values of the indices were created for the 10-year period from December 2014 to December 2024. For each of the three markets, different regression models were examined using the least squares method, with the ESG index as the dependent variable and the main indices as the independent variables. Through the values of the intercept coefficients and slope parameters of the estimated equations, the potential effects of changes in the main indices on the ESG indices were examined. The specifications of the estimated models were evaluated by applying normality tests, autocorrelation tests, heteroscedasticity tests, and multicollinearity tests. Additionally, the presence of structural breaks in the time series of ESG and main indices over the relevant 10-year period was investigated, and the break dates were examined. According to the study's results, the impacts of index movements in selected financial markets on ESG indices were compared..

2. Literature Review

Dhasmana et al. (2023) examined the relationships between ESG indices and market performance in Indian markets from the perspective of investor sentiment. The study's results revealed significant connections between ESG indices and market performance, but showed that changes in ESG indices did not have a significant impact on investors.

Li et al. (2023) examined the change in ESG performance of Group A stocks in Chinese stock markets after they were included in the Morgan Stanley Capital International (MSCI) index. As a result of the analysis, it was stated that the ESG performances of the stocks included in the MSCI index increased. They also argue that companies' ESG performance is affected due to external audit and environmental green innovation pressure.

Wang et al. (2023) examined the reactions of selected stock exchanges to the ESG law that came into force in 2021,

which is about the companies to publicly disclose their ESG ratings in the United States of America. As a result of the study, the stocks of all companies examined in the first five days after the law was enacted decreased by 1.1%. They also stated that companies in sectors that pollute the environment more are affected more by this situation.

Gao et al. (2022) examined whether the movements of ESG indices over time truly affect other markets and cause risk dispersion. As a result of the study, they found that ESG indices in North American markets caused a misleading risk distribution on ESG indices in other international markets.

Kılıç et al. (2022), They examined the relationship between stock market returns and returns on ESG investments. They examined the stocks of companies in 19 developed countries and 19 developing countries. They stated that there are significant cointegration relationships between ESG returns and firm returns when financial markets are high-frequency. They also stated that there is a strong relationship between the returns obtained from ESG practices and company returns in developing countries.

Lua (2022) examined the effects of ESG practices on stock prices in the London Stock Exchange. As a result of the study, it was stated that the share prices of companies that support activities for the protection of the environment provide more profit than other selected companies. Lua also claimed that stocks of companies with low liquidity achieved higher returns than other stocks, thanks to their ESG practices.

Shanaev and Ghimire (2022) examined the impact of changes in ESG ratings of 748 American companies on stock returns between 2016 and 2022. As a result of the study, they stated that the share price of selected companies increased by 0.5 units in response to a one-point increase in ESG ratings. They stated that this rate is higher in companies with higher ESG scores than others.

Rubbaniy et al. (2022) compared the risk levels of companies with high ESG ratings and other companies in situations similar to the Covid-19 epidemic in emerging global stock markets. As a result of the study, they claimed that the Covid-19 fear index and ESG indices are cointegrated. According to this result, they stated that ESG indices can be used in hedging.

Feng et al. (2022) investigated the relationships between environmental, social, and governance (ESG) ratings of companies operating in China and the risk of stock price collapse. As a result of the study, they argue that they found a statistically and economically significant negative relationship between the ESG ratings of Chinese companies and the price changes of these companies' stocks.

Gao et al. (2022) examined the risk spread characteristics of international ESG equity markets over time. As a result of the study, they stated that developed stock markets in the United States are the center of the external spread of risk in ESG stocks. They also noted that the international ESG market has a strong time frequency spread.

Avramov et al. (2022) examined the accuracy levels in pricing of assets belonging to companies with unclear ESG profiles and the portfolio performances of these assets. As a result of the study, they suggested that the uncertainty of companies' ESG degrees affects the risk and return balance, the level of social interaction, and the economic development of the company.

Bofinger et al. (2022) examined whether there is a relationship between the ESG ratings of selected US companies and the frequency of mistakes made in the evaluation of companies. As a result of the study, they argue that if there is an increase in the ESG ratings of selected companies, the results obtained in calculating the company value are more realistic.

Spiegeleer et al. (2021) examined the relationships between the ESG performances of firms included in the STOXX Europe 600 or Russell 1000 indices by comparing the periods before and after the inclusion of ESG criteria. As a result of the study, they found that ESG criteria did not have a significant impact on the market.

Andersson et al. (2020) examined the relationships between ESG portfolios and stock prices, exchange rates, and commodity prices through causal analyses. As a result of the study, they found that ESG portfolios do not have a significant relationship with exchange rates and commodity prices, but they do have a bidirectional significant causal relationship with stock prices.

Cornel (2020) compared the stock returns of companies with high ESG ratings to others. As a result of the study, he stated that companies with high ESG scores are more preferred by investors and thus reduce their capital costs, but the expected returns of these companies are lower than others. It is also unclear whether ESG ratings have a significant impact on firm risk.

Khemir et al. (2019) examined the effects of firms' ESG activities on firm and stock value and the overall market in the Tunis stock markets. As a result of the study, they determined that ESG information affects investment allocation decisions in Tunisia, and this situation could lead to changes in market indices.

Bae et al. (2019) examined whether there is a relationship between companies' ESG ratings and the level of interaction with customers and competitors and whether companies' ESG ratings have an effect on financial leverage costs. As a result of the study, they argue that losses in market share decrease as ESG ratings increase in companies with high levels of financial leverage.

Fatemi et al. (2018) examined the relationships between ESG scores and firm value. As a result of the study, they found that an increase in ESG scores could lead to an increase in firm value and the firm's shares, and consequently, market indicators were also affected by this situation.

Capelle-Blancard and Petit (2017) examined the reactions of stock exchanges to news about ESG practices. In the study, they examined ESG news about 100 different companies between 2002 and 2010. They stated that the market value of the shares of companies that encountered negative news regarding ESG practices decreased by 0.1%.

Bhandari and Javakhadze (2017) examined the relationship between corporate social responsibility (CSR) and capital allocation efficiency at the firm level. They examined the relationship between the market value of a company, the Q coefficient, which represents the ratio of its assets to the replacement cost, and Corporate Social Responsibility (CSR) investments. As a result of the study, they concluded that CSR activities negatively affected the Q coefficient of financing and caused investments to become more sensitive to cash flows.

3. Materials and Methods

In this study, it is aimed to determine the direction and strength of the relationship between the sustainability indices of Borsa Istanbul (BIST), Standart & Poor's stock market index (S&P 500) and Frankfurt Stock Exchange (DAX) stock market indices. By accessing the monthly value data of the main indices of selected stock exchanges and ESG indices between December 2014 and December 2024, time series for the variables have been created. Constant and slope coefficients representing the direction and strength of the relationship between the stock exchange indices and the sustainability indices of these stock exchanges will be realized by estimating simple linear regression models using the least squares method. Regression equations representing the relationships between the main index and ESG indices for all three stock markets were estimated by the least squares method. By comparing the intercept coefficients and slope parameters of the estimated models, the effects of the changes in the stock market index on the ESG indices were compared.

The least squares method (LSC) is a statistical method that allows finding the most appropriate parameter values by minimizing the sum of the squares of the residuals, defined as the differences between the actual values and predicted values of the variables in the estimated regression equation (Dekking, 2005). Heteroskedasticity, autocorrelation, normativity, and multicollinearity tests were performed to determine the reliability of the estimated models.

$$S = \sum_{i=1}^{n} ų_i^2 \quad (1)$$

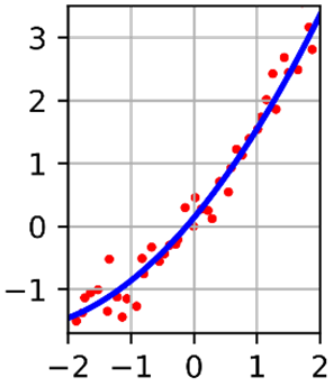
S = Sum of Squares of Errors

n = Number of Observations

ų = Error Value

When the real values of the series exhibit a linear distribution, a simple linear regression model is estimated with the LCM method. Parameter values, including the constant and slope coefficients of the two-variable model, provide information about the direction and strength of the relationship between the variables. However, this relationship between the dependent and independent variables is not a mathematical relationship but a random relationship. This is because the model contains error terms (Cox, 1972). Figure 1 shows the graph of the model between series that exhibits a linear distribution with two variables.

Figure 1: Simple Linear Distribution



The simple linear regression equation is as follows.

$$Y_t = \frac{E_t - E_{t-1}}{E_{t-1}} \quad (2)$$

$\hat{Y}$ = Predicted Value of the Dependent Variable

β_0 = Constant Parameter of Regression Model

β_1 = Slope Parameter of the Regression Model

X_i = Observed Value of the Independent Variable

After estimating the simple linear regression model between two variables, the effect of the independent variable on the dependent variable and the direction of the relationship between these two variables can be interpreted according to the constant and slope parameter values. Before making these evaluations, normality test, heteroskedasticity test, autocorrelation test and multicollinearity tests of the estimated regression model must be applied. After significant results are obtained from the benchmark tests, the estimated regression model can be considered reliable.

Three different regression models were estimated for each stock market, where changes in the ESG index are the dependent variable and changes in the main index are the independent variable. Model 1 is the regression equation between the changes in the Stock Exchange Sustainability index (XUSRD) and the changes in the Borsa Istanbul 100 index (XU100). Model 2: It is the regression equation between the Standard & Poor's ESG index (SPESG) and the Standard & Poor's main index (S&P 500). If Model 3, it is the regression equation between the Frankfurt Stock Exchange ESG index (SOBIGESG) and the main index (GDAXI). All three models consist of time series of monthly index values consisting of 120 observations in the 10-year period between December 2014 and December 2024. Simple linear regression models for the relationship

between all three market indices and the sustainability indices of these markets were estimated using the least squares method. In order to examine the reliability of the simple linear regression models, Jarque-Bera Normality Test, Breusch-Godfrey Auto Correlation LM Test, Breusch-Pagan-Godfrey Heteroskedasticity Test and Multiple Linear Association (VIF) Test were applied. As a result of the trial tests, it was determined that there was no specification error in the estimated models, the data of the series had a normal distribution, and there were no heteroscedasticity, autocorrelation and multicollinearity errors in the estimated models.

4. Results and Discussion

In this part of the study, return calculations for the sustainability indices and main indices of selected stock exchanges were made. The calculated return values and the distributions where the returns of the sustainability indices are dependent and the stock market index is the independent variable were examined with the help of graphics. Natural logarithmic transformations of the necessary series were made.

First of all, Augmented Dickey-Fuller Structural Break tests were applied to determine whether the series were subject to structural breaks within the specified date range and their degree of stationarity. Thus, structural breaks in the series were identified, and the break dates were compared. The results are in Table 1.

Table 1. Augmented Dickey-Fuller Breakpoint Unit Root Test of Series

Series	t-statistic	Prob.	Break Date
RXU100	-4.949133	< 0.01	2022/10
RXUSRD	-4.949133	< 0.01	2023/06
RSPX	-4.949133	< 0.01	2020/02
RSPESG	-4.443649	< 0.01	2020/02
RGDAXI	-4.443649	< 0.01	2020/02
RSOBIGESG	-4.949133	< 0.01	2022/08

In Table 1, the Augmented Dickey Fuller Breakpoint Unit Root Test was performed according to the trend model. Break dates were selected based on the criterion that the Dickey-Fuller t-statistic value was minimum. According to the results, the probabilities of t-statistic values of all series are calculated to be less than 5%. This shows that the series are stationary at level. In addition (Dickey & Fuller, 1979).

Simple linear regression model estimations of the series were made and separate models were estimated for each three stock markets.

Simple Linear Regression Model between Borsa Istanbul Sustainability Index (XUSRD) and Borsa Istanbul 100 Index (XU100)

In estimating this model, a data set consisting of 120 observations was created for each series consisting of the monthly values of the XUSRD and XU100 indices between January 2014 and January 2024. The return values of the XUSRD and XU100 indices are calculated as follows.

$$Y_t = \frac{E_t - E_{t-1}}{E_{t-1}} \quad (3)$$

Y_t: Return in period t

E_t: The value of the index in period t

E_{t-1}: Value of the index in the previous period

In order to make a preliminary evaluation of the relationship between the series, a scatter plot was created with a representative regression line in which XUSRD was defined as the dependent variable and XU100 was defined as the independent variable. It is shown in Figure 2.

Figure 2: RXU100 RXUSRD Scatter Graph

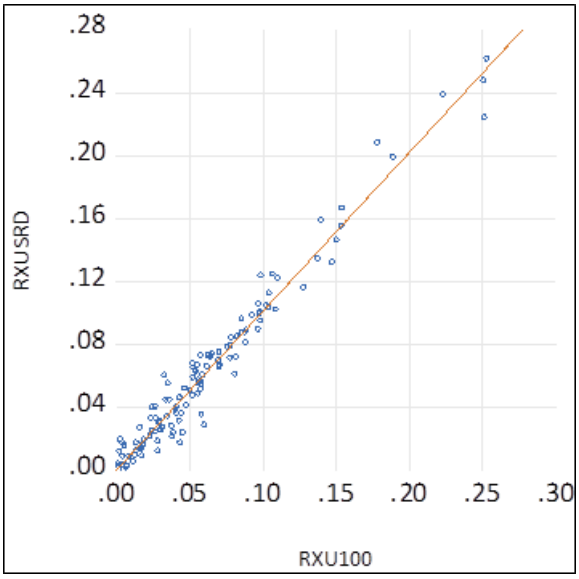


Figure 2. shows, it is predicted that a linear simple regression relationship may exist between the series. For this reason, a simple linear regression model between the series was estimated using the least squares method. When Figure 2. is examined, it was predicted that a simple linear regression relationship might exist between the RXUSRD and RXU100 series. Therefore, a simple linear regression model with RXUSRD as the dependent variable and RXU100 series as the independent variable was estimated by the least squares method. The estimated model is named Model (1). The fixed regression equation of Model (1) is as follows

$$RXUSRD = 0.000636 + 1.008082\, RXU100 \quad \text{Model (1)}$$

The statistical values of the estimated Model (1) are given in Table 1.

Table 2: Statistical Values of Model (1) of RXUSRD and RXU100 Series

Variables	Coeff.	Std. Err.	t-Stat.	Prob.
RXU100	1.008	0.018	54.495	0.000
C	0.001	0.002	0.418	0.037
R-squared	0.961			
F-statistic	2969.688			
Prob (F-statistic)	0.000			

The coefficient of determination (R-squared) of the Model (1) linear regression model is 0.961472. This result shows that 96% of the change in the dependent variable RXUSRD can be explained by the independent variable RXU100. A Prob (F-statistic) value of 0.0000 (<5%) represents that the slope coefficient of the model is statistically significant. In addition, the constant coefficient (C) and the t-Statistic probability values of the RXU100 independent variable were 0.0367 and 0.0000 (<5%), which revealed that the constant coefficient and slope coefficients were statistically significant. According to the results, while RXU100 is constant, RXUSRD is 1.008082 units on average. Increasing RXU100 by one unit increases RXUSRD by 1.008082 units.

In Model (1) Jarque-Bera Normality Test, Skewness is -0.2903106 and Kurtosis is 3.944. It was determined that the series were normally distributed because the Skewness value was between +3 and -3 and the Kurtosis value was between +7 and -7 (George and Mallery, 2010), (Hair et al, 2010).

Breusch-Godfrey Autocorrelation LM Test was applied to investigate whether Model (1) has an autocorrelation problem. In the LM test estimated with 2 lags (lag=2), the probability Chi-Square(2) value of multiplying the number of observations in the model and the R2 values (OBS*R2) is 0.8936. In this case, the H0 hypothesis is rejected in the Breusch-Godfrey Autocorrelation LM Test. In other words, Model (1) has no autocorrelation problem (Asteriou & Hall, 2011).

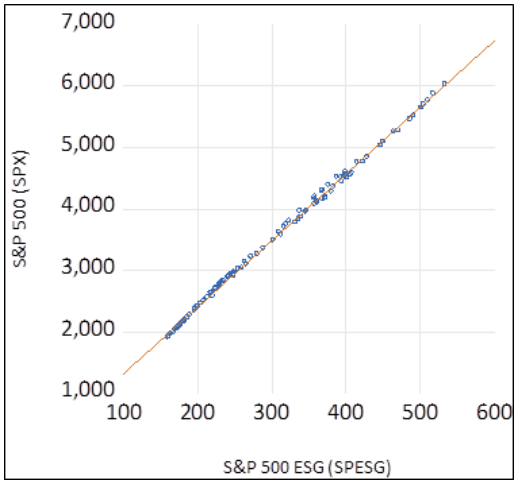
The Breush-Pagan-Godfrey Heteroskedasticity Test applied to Model (1) tested whether the heteroscedasticity problem existed. The probability Chi-Square(2) value of multiplying the number of observations in the model and the R2 values (OBS*R2) is 0.2089. In this case, the H0 hypothesis cannot be rejected in Model (1). In other words, there is no heteroscedasticity problem in Model (1). In the Breush-Pagan-Godfrey Heteroskedasticity Test of the estimated new model, the probability Chi-Square(2) of multiplying the number of observations and R2 values (OBS*R2) is 0.2089. This result showed that the H0 hypothesis was rejected in the Breush-Pagan-Godfrey Heteroskedasticity Test in Model (1), in other words, that there was no heteroscedasticity problem in the model (Breusch & Pagan, 1979).

In Model (1), Variance Inflation Factors (VIF) test was applied to determine whether there was a multicollinearity problem between the variables belonging to the series. This test measures the amount of multicollinearity in the estimated regression model. Multicollinearity exists when there is a correlation between more than one independent variable in a multiple regression model. In such a case, the parameter values in the regression model will change and the results will be misleading. When VIF = 1, there is no multicollinearity problem between variables (Kutner et al, 2004). As a result of the VIF test applied for Model (1), RXU100 Centered VIF is 1.00. that means there is no multicollinearity problem in Model (1).

Simple Linear Regression Model between Standard & Poor's ESG Index (SPESG) and Standard & Poor's 500 index (S&P 500)

Data consisting of 120 observations of the monthly change values of the Standard & Poor's ESG Index (SPESG) and Standard & Poor's 500 index (S&P 500) indices between January 2014 and January 2024 were accessed from the websites of brokerage firms. The changes of the accessed index data in the same date range were calculated. A scatter chart was created with RS&P 500 as the independent variable and RSPESG as the dependent variable. It is envisaged that a simple linear regression model between the series can be established by the least squares method.

Figure 3: Scatter Chart of RS&P500 and RSPESG Series



When the scatter plot of the RS&P500 and RSPESG series was examined, it was predicted that the possible relationship between the variables could be determined by estimating the simple linear regression model using the least squares method. In the simple regression model to be estimated, the RS&P500 series will be modeled as the independent RSPESG series as the dependent variable. After the estimation, the simple linear regression model between the series was named Model (2).

$$RSPESG = 0.000617 + 0.923317\ RS\&P500 \quad \text{Model (2)}$$

Statistical values of Model (2) estimated by the least squares method are given in Table 3.

Table 3: Statistical Values of Model 2 of RSPESG and RS&P500 Series

Variables	Coeff.	Std. Err.	t-Stat.	Prob.
RS&P500	0.923	0.011	9.293.294	0.000
C	0.001	0.000	1.284.231	0.020
R-squared	0.920			
F-statistic	8636.531			
Prob(F-statistic)	0.000			

The coefficient of determination (R-squared) of the Model (2) linear regression model is 0.91970. This result shows that 92% of the change in the dependent variable RSPESG can be explained by the independent variable RS&P500. Prob (F-statistic) value of 0.0000 (<5%) represents that the slope coefficient of the model is statistically significant. In addition, the constant coefficient (c) and the t-Statistic probability values of the RS&P500 independent variable were obtained as 0.0000 (<5%), which revealed that the constant coefficient and slope coefficients were statistically significant. According to the results, while RS&P500 is constant, RSPESG is 0.000617 units on average. Increasing RS&P500 by one unit increases RSPESG by 0.923317units.

In Model (2) Jarque-Bera Normality Test, Skewness is 0,430012 and Kurtosis is 4.67546. It was determined that the series were normally distributed because the Skewness value was between +3 and -3 and the Kurtosis value was between +7 and -7 (George and Mallery, 2010), (Hair, et al, 2010).

In the estimated model, the probability Chi-Square(2) of multiplying the number of observations and R2 values (OBS*R2) was calculated as 0.4512. According to this result, the H0 hypothesis is rejected in the Breusch-Godfrey Autocorrelation LM Test. In other words, there is no autocorrelation problem between the series (Asteriou, & Hall, 2011).

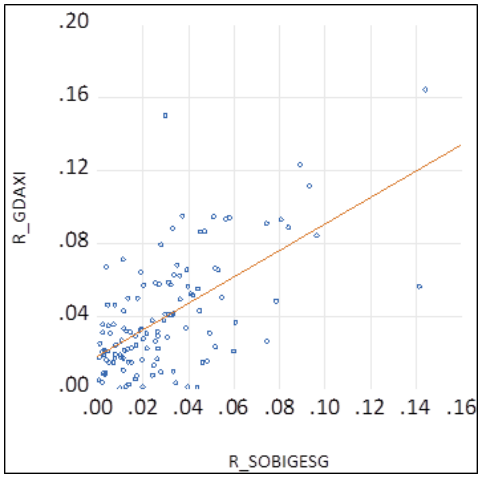
The Breush-Pagan-Godfrey Heteroskedasticity Test applied to Model (2) tested whether the heteroscedasticity problem existed. In the model, the probability Chi-Square(2) of multiplying the number of observations and R2 values (OBS*R2) was 0.0011. In this case, the H0 hypothesis cannot be rejected in Model (2). In other words, there is a heteroscedasticity problem in Model (2). To eliminate this problem, Model (2) was re-estimated. First of all, the resid_S&P series consisting of the errors of Model (2) was created. Then, in the re-estimation phase of the model, Model (2) was re-estimated by weighting the errors of the model according to the variance value of the model. In the Breush-Pagan-Godfrey Heteroskedasticity Test of the estimated new model, the probability Chi-Square(2) of multiplying the number of observations and R2 values (OBS*R2) is 0.9061. Thus, in Model (2), the H0 hypothesis is rejected in the Breush-Pagan-Godfrey Heteroskedasticity Test. In other words, the heteroscedasticity problem has been eliminated in Model (2) (Breusch & Pagan, 1979).

In Model (2), Variance Inflation Factors (VIF) test was applied to determine whether there was a multicollinearity problem between the variables of the series. If VIF = 1, there is no multicollinearity problem between variables (Kutner et al, 2004). As a result of the VIF test applied for Model (2), RS&P500 Centered VIF was calculated as 1.00. In this case, there is no multicollinearity problem in Model (2).

Simple Linear Regression between Frankfurt Stock Exchange ESG Index (SOBIGESG) and DAX Composite (GDAXI) Indices

Data consisting of 120 observations of the monthly values of the Frankfurt Stock Exchange ESG index (SOBIGESG) and DAX Composite (GDAXI) indices between January 2014 and January 2024 were accessed from the websites of the brokerage firms. The returns of the accessed index data in the same date range were calculated and a scatter chart was created with RGDAXI as the independent variable and RSOBIGESG as the dependent variable. It is envisaged that a simple linear regression model between the series can be established by the least squares method. The scatter plot where the dependent variable is GDAXI and the independent variable is SOBIGESG is shown in Figure 4.

Figure 3: Scatter Plot of RGDAXI and RSOBIGESG Series



It is predicted that the possible relationship between the series can be estimated with a simple linear regression model when the scatter of the RSOBIGESG and RGDAXI series created with the data on the returns of the SOBIGESG and GDAXI indices are examined. Thus, using the least squares method, it was named Model (3), which is a simple linear regression model in which the dependent variable is RSOBIGESG and the independent variable is RGDAXI. The estimated regression equation for Model (3) is as follows.

$$RSOBIGESG = 0.008852 + 0.518788\ \text{RGDAXI}$$

Model (3)

Statistical values of Model (3), which is a simple linear regression equation estimated by the least squares method, with RSOBIGESG as the dependent variable and RGDAXI as the independent variable, are given in Table 4.

Table 4: Statistical Values of RSOBIGESG and RGDAXI Series for Model (3)

Variable	Coeff.	Std. Err.	t-Stat.	Prob.
RGDAXI	0.519	0.061	8.479	0.000
C	0.009	0.003	2878643.000	0.005
R-squared	0.777			
F-statistic	71.901			
Prob(F-statistic)	0.000			

The coefficient of determination (R-squared) of the Model (3) linear regression model of RSOBIGESG and RGDAXI series was calculated as 0.776639. This result shows that 77.6% of the variation in the RSOBIGESG dependent variable can be explained by the RGDAXI independent variable. Calculating the Prob(F-statistic) value as 0.0000 (<5%) represents that the slope coefficient of the model is statistically significant. In addition, obtaining the constant coefficient (c) and t-Statistic probability values is 0.0047 and the independent variable RGDAXI as 0.0000 (<5%) revealed that the constant coefficient and slope coefficients are statistically significant. According to the results, while RGDAXI is constant, RSOBIGESG is 0.008852 units on average. Increasing RGDAXI by one unit increases the RSOBIGESG variable by 0.518788 units.

In Model (3) Jarque-Bera Normality Test, Skewness is as -0.01686 and Kurtosis is calculated as 2.5533. It is determined that the series are normally distributed because the Skewness value is between +3 and -3 and the Kurtosis value is between +7 and -7 (George and Mallery, 2010), (Hair et al, 2010).

The Breusch-Godfrey Autocorrelation LM Test applied for Model (3) was estimated with 2 lags (lag=2). In Model (3), the probability Chi-Square(2) of multiplying the number of observations and R2 values (OBS*R2) is 0.1002. Thus, the H0 hypothesis is rejected in the Breusch-Godfrey Autocorrelation LM Test. In other words, there is no autocorrelation problem between the series in Model (3) (Asteriou and Hall, 2011).

In the Breush-Pagan-Godfrey Heteroskedasticity Test of Model (3), the probability Chi-Square(2) value of the product of the number of observations and R2 values (OBS*R2) is calculated as 0.7104. In this case, the H0 hypothesis is rejected in the Breush-Pagan-Godfrey Heteroskedasticity Test in Model (3). In other words, there is no heteroscedasticity problem in Model (3) (Breusch and Pagan, 1979).

Variance Inflation Factors (VIF) test is applied to determine whether there was a multicollinearity problem between the variables of the RSOBIGESG and RGDAXI series In Model (3). If VIF = 1, there is no multicollinearity problem between variables (Kutner et al, 2004). As a result of the VIF test applied for Model (3), RGDAXI Centered VIF is 1.00. Therefore, there is no multicollinearity problem in Model (3).

5. Conclusions

In this study, the sensitivities of Borsa Istanbul (BIST), Standard & Poor's (S&P) and Frankfurt Stock Exchange (DAX) towards environmental, social governance and sustainability activities were determined and compared. While making this comparison, it is aimed to determine the direction and strength of the relationship between the index series of all three markets (XU100, S&P500, GDAXI) and the sustainability index of each market (XUSRD, SPESG, SOBIGESG). Index returns were calculated based on the monthly values of the index data between January 2014 and January 2024. Simple linear regression models were estimated between each market's main index and sustainability indices. After performing the trial tests, the results obtained were found to be statistically significant.

According to the results, if the Borsa Istanbul 100 Index (XU100) does not change, the Borsa Istanbul Sustainability index (XUSRD) will take the value of 0.000636. Additionally, when XU100 changes by one unit, XUSRD will change by 1.008082 units. According to the constant parameter and slope coefficients of the estimated regression model, it can be said that the XU100 index and the XUESG index moved quite closely during the relevant date range. According to the estimated regression equation, there is a positive relationship between XU100 and XUSRD. In other words, XUSRD will also increase in response to a shot occurring in XU100. The results of this form of relationship are compared with the US stock markets. Standard & Poor's ESG (SPESG) is 0.000617 units while the Standard & Poor's 500 index (S&P500) is constant. Additionally, when S&P500 increases by one unit, the SPESG ESG index increases by 0.993317. It can be said that there is a positive and strong relationship between both indices. Frankfurt Stock Exchange ESG index (SOBIGESG) is 0.008852 units while the GDAXI index is constant. Additionally, if GDAXI increases by one unit, SOBIGESG increases by 0.518788 units. There is a positive relationship between both indices.

According to the parameters of the three predicted models, it has been determined that there are positive relationships between the main indices and the ESG indices. In the 10-year period examined, the upward trend of selected stock market indices is likely related to the rise in ESG indices. Additionally, it is also related to the fact that the stocks included in the ESG index in all three markets are simultaneously present in the main market index. The estimated model parameters for the selected indices have shown that the weakest relationship between the ESG index and the main market index is between the DAX and SOBIGESG indices. The results of the BIST and S&P models have shown that there is a very close and parallel relationship between the ESG indices and the market index. This showed that, among the three models estimated, the market with the least sensitivity of the ESG index to the market index was the Frankfurt Stock Exchange. This may

be due to the fact that the majority of companies included in the ESG index in the BIST and US markets have stocks with high trading volumes, and these stocks have a significant impact on the main market index.

Environmental pollution, global climate change and social injustices have been considered as important problems on a global scale in recent years. Different disciplines develop their own tools and methods to solve these problems. This situation has begun to cause business processes to be subject to change. In developed societies and economies, profit-oriented or non-profit institutions are trying to develop business processes that will not cause environmental degradation and ensure social equality. This situation has started to create shocking effects in many sectors. In order to solve the problems of environmental degradation, global climate change and social injustice, innovative ideas and products, coordination of corporate and public policies, and the understanding of Environmental, Social Governance and sustainability have begun to become widespread in the practices of business processes around the world.

Just as many sectors are affected by ESG processes, it also forces the financial product and service sectors to undergo change. Savers and those demanding funds have developed environmental and social sustainability perspectives in addition to their economic priorities when choosing between alternatives in their business practices. This situation has started to directly affect the pricing patterns of financial assets. Since ESG and sustainability activities are considered important parameters in company and financial asset valuation around the world, financial markets have begun to attach great importance to these issues in recent years. ESG and sustainability ratings of companies have begun to be made and the rating results are shared with the public. Financial markets calculate sustainability indices along with financial indices and monitor the minimum obligations that companies wishing to be included in this index must fulfill on a company and financial asset basis.

It is expected that the effects of environmental degradation, global climate change, and social and economic inequalities will begin to be felt more in the near future. Products, services and policies that are more sensitive to environmental and social issues will begin to attract more and more attention all over the world. This situation tends to spread throughout the world from economically and socially developed societies. The level of environmental and social sensitivity and awareness will increase in the management of business processes, purchasing of goods and services and investment preferences. Therefore, faster adaptation of policy makers, companies, non-governmental organizations and public institutions to ESG and sustainability processes may enable them to create meaningful social, environmental and economic benefits for themselves and society in the near future. It may be recommended that future research on this subject should be conducted using indices in a larger number of markets and different regions. Examining the direction and intensity of the relationships between market indices and sustainability indices in different regions and their changes over time will make a meaningful contribution to the literature.

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