THE CAUSALITY ANALYSIS BETWEEN THE STOCK PRICES OF RENEWABLE ENERGY COMPANIES AND CARBON EMISSION PRICES: BASED ON GERMANY, TURKEY, USA AND BRAZIL

YENİLENEBİLİR ENERJİ ŞİRKETLERİ HİSSE SENEDİ FİYATLARI İLE KARBON EMİSYON FİYATLARI ARASINDAKİ NEDENSELLİK ANALİZİ: ALMANYA, TÜRKİYE, ABD VE BREZİLYA ÖRNEĞİ

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ABSTRACT

With the increase in world population and consumption and the acceleration of industrialization, the limited resources decrease to meet the increasing needs. It has became inevitable to cause more damage to the environment. For this reason, there is an increasing interest in renewable energy in countries. This study aims to analyze the impact of the countries' activities towards sustainable development movements by using stock prices and carbon emission price data of energy companies in Germany, USA, Brazil and Turkey. In this study, the Granger Causality method has been applied to explain the causality between the share prices of RWE, Sunpower (SPWR), CPFL Energia (CPFE3) and Zorlu Enerji (ZOREN) and carbon emission price (CO2_EMS) for the 2012-2022 period. Granger causality analysis reveals that SPWR significantly causes CO2_EMS, while CO2_EMS affects RWE. According to the findings, this study can help investors and policymakers in the energy sector make decisions based on stock and carbon emission price analysis to promote sustainable development-oriented initiatives.

Keywords: Granger Causality, CO2 Emissions, Stock Price, Energy.

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ÖZ

Dünya nüfusunun ve tüketiminin artması ve sanayileşmenin hızlanmasıyla birlikte artan ihtiyaçları karşılamak için sınırlı olan kaynaklar azalmaktadır. Çevreye daha fazla zarar verilmesi kaçınılmaz hale gelmektedir. Bu nedenle ülkelerde yenilenebilir enerjiye ilgi giderek artmaktadır. Bu çalışma, Almanya, ABD, Brezilya ve Türkiye'deki enerji şirketlerinin hisse senedi fiyatları ve karbon emisyon fiyatı verilerini kullanarak ülkelerin sürdürülebilir kalkınma hareketlerine yönelik faaliyetlerinin etkisini analiz etmeyi amaçlamaktadır. Bu çalışmada 2012-2022 yılları arasındaki RWE, Sunpower (SPWR), CPFL Energia (CPFE3) ve Zorlu Enerji (ZOREN) hisse fiyatları ile karbon emisyon fiyatı (CO2_EMS) arasındaki nedenselliği açıklamak için Granger Nedensellik yöntemi uygulanmıştır. Granger nedensellik analizi, SPWR'nin önemli ölçüde CO2_EMS'ye neden olduğunu, CO2_EMS'nin ise RWE'yi etkilediğini ortaya koymaktadır. Bulgulara göre çalışma, enerji sektöründeki yatırımcıların ve politika yapıcıların sürdürülebilir kalkınma odaklı girişimleri teşvik etmek için stok ve karbon emisyon fiyat analizine dayalı kararlar almasına yardımcı olabilir.

Anahtar Kelimeler: Granger Nedenselliği, CO2 Emisyonu, Hisse Senedi Fiyatı, Enerji

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Introduction

Climate change, especially greenhouse gas emissions, is an important problem of the 21st century and the future. Global warming has detrimental effects on human health, increasing the urgency of joint efforts to reduce carbon emissions and transition to sustainable energy sources. This requires raising awareness about the consequences of carbon emissions, as well as encouraging investments in clean energy technologies. In addition, research and studies on carbon emissions and energy stock prices provide valuable information for politicians, investors and stakeholders in shaping a sustainable future.

The fact that carbon emissions can be bought and sold as carbon credits make the existence of a fundamental relationship between energy stocks and carbon emissions questionable and are an important motivation in this regard. This provides an opportunity to sell credits to renewable energy companies with low energy emissions. Biotrend is among the best examples that can be given in this regard. According to Biotrend's annual report (2023), Biotrend is a company that has already earned $2 million in revenue from the sale of carbon credits in the first quarter of 2023. With this example, companies engaged in sustainable practices can exploit the potential financial benefits and realize the importance of the relationship between energy stocks and the price of carbon emissions.

The main objective of this paper is to critically examine the relationship between energy stocks and carbon emission prices in countries with different levels of development which are Turkey, USA, Brazil and Germany. These countries have been chosen because they have different levels of development and macroeconomic factors. By revealing the causal links between these two parameters, this paper aims to raise awareness of the environmental impacts of carbon emissions, encourage companies to invest in sustainable practices and contribute to the growing body of knowledge and research in this field.

1. Literature Review

Stretesky et al. (2009) examined the relationship between per capita carbon dioxide emissions and exports for 169 countries. They used the repeated measurement data on CO2 emissions per capita and exports. They conducted the analysis for exports to the world and to the USA simultaneously, and for only exports to the USA. The results showed that the only exports correlated with carbon dioxide emissions are those provided by the United States. They additionally emphasized that a concerning trend in global carbon dioxide emissions may be indicated by inefficient manufacturing practices among nations that export goods to the USA. Tsai and Pau (2011) presented multivariate granger causality between CO2 emissions, energy consumption, FDI (foreign direct investment) and GDP (gross domestic product) for BRIC (Brazil, Russian Federation, India, and China) countries. The results appeared to support the Environmental Kuznets Curve (EKC) theory, with CO2 emissions appearing to be inelastic in long-run equilibrium and energy consumption elastic in terms of foreign direct investment. According to the causality results, there is a strong unidirectional strong causal relationship extending from output to FDI and a strong bidirectional causal relationship between emissions and FDI. Ozturk and Acaravci (2013) presented the causal relationship between financial development, trade, economic growth, energy consumption and carbon emissions in Turkey for the 1960–2007 period. The results of the study indicated that rising foreign trade to GDP ratios raise per capita carbon emissions, but financial development variables have no long-term discernible impact on per capita carbon emissions. Tucker (2015) examined per capita income and CO2 emissions of 137 countries over 21 years. Carbon dioxide emissions are the most

significant greenhouse gas (GHG) implicated in global warming, and there is a positive association between them and GDP. Additionally, global emissions rises generally tend to slow down as per capita incomes rise. It's possible that affluence drives up demand for environmental conservation. Proposals for reducing emissions that guarantee earnings have been negatively impacted, especially for less developed nations, have the best chance of being implemented. Ateş et al. (2015) presented the necessity of the Green Growth concept for Turkey using the multiple perspective analysis method. They discussed application examples of similar countries and discussed what kind of contributions the concept could make to Turkey's economy and welfare. They also revealed the paths to be followed to implement this concept. Jacobson et al. (2015) presented the roadmaps for 50 states in the process of transitioning to 100 percent clean energy by 2050. These plans aimed to replace 80-85 per cent of existing energy with wind, water, and sunlight sources by 2030. The proposed energy mix included different renewable sources such as wind, solar, geothermal, wave, tidal and hydropower. They pointed out that savings from reduced global warming impacts are projected to average $3.3 trillion per year by 2050 by using these roadmaps. Marjanovic et al. (2016) presented computational models to forecast GDP depending on CO2 emissions. The results of the Extreme Learning Machine (ELM) was compared with Genetic Programming (GP) and Artificial Neural Network (ANN) approaches as a prediction algorithm. According to the results, ELM was applicable for forecasting GDP. They depicted that CO2 emissions and economic growth are inextricably linked, with economic expansion driving both energy consumption and CO2 emissions. Paramati et al. (2017) examined the causality between renewable energy consumption and CO2 emission prices in the stock market in G20 countries, known as developing countrie. They stated that using renewable energy resources reduces the CO2 emission price. They claimed that using renewable energy in developing countries causes economic growth. Li et al. (2018) estimated the macroeconomic and potential costs of Beijing's CO2 emission reduction. Multiobjective programming and evolutionary algorithms are incorporated into the input–output analysis using the industrial economy as the basis. They presented a mathematical method to rationalize the process of designing policies that impose emission targets and suggests practical ways to reduce emissions at a reasonable cost. Yazdi and Beygi (2018) presented the dynamic impact of renewable energy consumption and financial development on CO2 emissions for selected African countries. They examined the relationship between CO2 emissions and trade openness, financial advancements, energy consumption, urbanization expansion, and renewable energy sources. They used the Pooled Mean Group (PMG) approach and Granger Causality to analyse data set over the period 1985-2015. The findings demonstrated that rising trade openness and the use of renewable energy both reduce CO2 emissions, supporting the EKC hypothesis for the African nations. According to Granger's causality studies, there is a bidirectional causal relationship between CO2 emissions and financial development as well as economic growth. Chang et al. (2020) investigated the causality between CO2 emissions and stock prices, and emphasized that the consumption and share of fossil fuels increases, and it directly affects the CO2 emission price. However, they stated there is no share increase if the CO2 emission price increases. Khan and Oztürk (2022) investigated the relationship between financial development and CO2 emissions of developing economies. They stated that almost 60% of greenhouse gas consists of CO2 emissions and emphasized emissions pose a threat to human health with the great damage and they cause to the environment, developing countries endanger their economic sustainability by spending a lot of money to resolve this threat.

This study differs from the existing studies in the literature in that it analyses the share prices of firms in the carbon emission and renewable energy sectors in multiple ways on the basis of different countries. Our aim fo this study is to analyze the consistency and causality in the fluctuations considering the standard time-frequency interval between the carbon emission price in a certain period and the share price of renewable energy-producing firms in that period.

2. Methods

In this study, the Granger causality test method has been applied to examine the relationship betweem the stock prices of renewable energy companies and carbon emission prices. This situation could also be explained by linear regression. However, the linear regression model does not produce correct results in data with stationary data. On the contrary, Granger causality test method consideres the dependent and independent variables and also makes mathematical modelling of the dependent variable as an independent variable. This leads to more detailed and accurate results. However, VAR Analysis has been performed before the Granger Causality test. VAR analysis, also known as value-at-risk analysis, is a statistical method used to identify and compare the risk encountered in the data within a certain time frequency range. The main reason for using VAR analysis in our research is to examine the potential loss in the risk exposure with VAR analysis and to determine the lag length before building the Granger Causality model. Moreover, Danyal and Gümüş (2022) emphasized that there are no limitations in the use of the VAR analysis model and the VAR analysis should be used to identify the limitations of the Granger causality test. Thus, our data set would be examined in more detail. The VAR Test includes the Unit Root Test to measure the stationarity of the unit roots of the data, Lag length, Variance decomposition/ Impulse-Response, CUSUM and Granger Causality test to evaluate the VAR analysis in the data. Furthermore, the Ordinary Least Squares regression (OLS) test will perform to formulate the analysis of the relationship between the dependent and independent variables.

- **Unit root test:** The structural breaks in a time series are analyzed by applying the unit root test in causality models. For this reason, the Augmented Dickey-Fuller Test is applied as the first step in the causality method by correlating whether the data is stationary within itself. There are three main formulas:

$$\Delta Y_t = yY_{t-1} + \sum_{j=1}^{p}(\delta_J \Delta Y_{t-J}) + e_t \quad (1)$$

$$\Delta Y_t = \alpha + yY_{t-1} + \sum_{j=1}^{p}(\delta_J \Delta Y_{t-J}) + e_t \quad (2)$$

$$\Delta Y_t = \alpha + \beta_t + yY_{t-1} + \sum_{j=1}^{p}(\delta_J \Delta Y_{t-J}) + e_t \quad (3)$$

The most crucial point is that the formulation is stable as a result of the ADF test applied to the data. If it is not stable, the first difference or the secondary difference determines according to the priority order of the trend data in the deterministic functions of the data by applying the unit root test. Thus, the data becomes stable.

- **OLS:** Regression tests can be considered an easy causality method that simply explains whether there is a significant relationship between two or more variables. In a time series, it cannot give an accurate result because it cannot fully analyze the change between time and frequency. Ordinary Least Squares regression specifies the coefficient of multiple variables in the linear regression set. For this reason, it is a type of method that we use to analyze whether

there is a significant relationship between the data as dependent and independent or within itself. (Danyal &Gümüş, 2022). The formula is:

$Y = \beta_0 + \beta_1 . X_i + \varepsilon_i$ (Error)

(4)

In order to formulate it in this context, the data are named as follows: Carbon emission price: CO2;RWE Stock price: RWE.DE; Sun Power stock price: SPWR.USA; CPFL stock price: CPFL3.SA; Zorlu Energy stock price: ZOREN.TR.

CO2 = β0 +β1 x RWE.DE + β2 x SPWR.USA + β3 x CPFL3.SA + β4 x ZOREN.TR + Error

(5)

- **Lag Structure:** Lag length is the answer to the question of whether it is appropriate to evaluate the data in a specific time interval as a group or individual. Considering the lag length for the analysis of causality between two or more variables leads to a decrease in the margin of error between the data. For this reason, the Akaike Information Criterion (AIC) or Schwarz Information Criterion (SIC) on the lag length is examined before applying the Granger Test. Depending on the grouping in the lag length, these criteria indicate how crucial the data are to each other.
- **Variance Decomposition/ Impulse-Response/CUSUM Test:** Variance Decomposition, Impulse-Response and CUSUM, which are essential processes of VAR analysis, indicate how variables affect each other. In particular, Variance Decomposition analyzes how a data set affects itself and how other data sets affect it, while Impulse-Response explains this situation graphically. The data set with a large number of breaks in the graph explains that a shock in independent data a greatly affects the dependent variable b. In the CUSUM Test, the data is evaluated by performing a general structural break analysis.
- **Granger Causality:** The explanation of the relationship between stable data in a time series depending on the lag length is called Granger causality. With this method, it is analysed whether there is a significant relationship between the data determined by both correlations and assumptions. The formulation is given as follows (Shojaie & Fox, 2022).

Granger = Correlation + Assumptions

(6)

In this direction, based on the hypotheses and mathematical modelling, it is expressed whether the causality is significant or not. This situation is explained as follows: (an independent variable - b dependent variable).

H0: Dataset a is not the Granger cause of dataset b.

H1: Data set a is the Granger cause of data set b.

The mathematical modelling of the Granger Causality test is OLS regression modelling. Accordingly, its formulated form is;

$$Y_t = \sum_{i=1}^{n}(\alpha_i Y_{t-i}) + \sum_{j=1}^{n}(\beta_j X_{t-j}) + u_{1t} \quad (7)$$

i and j: lag length

u: error

n: time

α and β: regression coefficient

CO2 = α x CO2 + β1 x RWE.DE + β2 x SPWR.USA + β3 x CPFL3.SA + β4 x ZOREN.TR + Error

(8)

Considering all these conditions, the Granger causality hypothesis of our research is determined as follows:

H0: There is no significant causal effect of stock prices of sustainable energy companies on carbon emission prices.

H1: Stock prices of sustainable energy companies have a significant causal effect on carbon emission prices.

In this direction, in order to prove research hypothesis, the experimental analysis has been conducted to solve our model with the econometric and statistical programming language.

3. Experimental Study

With the development of technology, the awareness towards energy consumption tends to be cleaner and more sustainable. The companies in Germany, the USA, Brazil and Turkey, which started working on clean energy production, have been discussed in the study. The relationship between the stock prices of these companies and carbon emission prices has been examined. The Granger causality test method has been used to analyse the relationship. The data consists of the carbon emission price, the share price of RWE, a renewable energy-producing company in Germany, the share price of Sun Power, a solar energy producing-selling company in the USA, the share price of CPFL Energia SA, a renewable energy producing company in Brazil, and the share price of Zorlu Enerji, one of the renewable energy producing companies in Turkey, on a monthly basis between 2012-2022. In this direction, Hatzigeorgiou et al. (2011) made a general analysis from an econometric and statistical point of view by using the Eviews5 software programme. For this reason, the econometric and statistical programming language called Eviews12, one of the latest versions of Eviews, is utilized to conduct the analysis. First of all, the share prices and carbon emission prices in the period of 2012-2022, which is the time period determined to make the data available in the Eviews program, have been taken from Yahoo Finance. Afterwards, the data has been arranged in Excel and presented the following form.

Table 1: *General Data*

Date	CO2 EMS	CPFE3.SA	RWE.DE	SPWR.USA	ZOREN.TR
1.12.2021	80,65	22,138	34,179298	20,870001	1,66
1.11.2021	75,73	21,93033	32,677017	28,65	1,7
1.10.2021	59,08	21,85556	31,834976	33,66	1,64
1.09.2021	62,16	21,21368	29,232294	22,68	1,53
1.08.2021	61,07	22,8758	31,662739	21,549999	1,57
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1.06.2012	8,2	13,42918	21,693773	3,143418	0,837715
1.05.2012	6,27	13,04851	19,913771	3,280943	0,775662
1.04.2012	7,48	13,67721	20,670059	3,67387	1,031318
1.03.2012	6,98	14,08779	22,789581	4,178127	1,149558
1.02.2012	8,34	14,20069	21,768011	4,931238	1,116713
1.01.2012	7,84	13,24098	18,611013	4,48592	0,985335

First of all, the most significant part of the Granger test is to analyze whether the data are stable or not. If the data are not stable, the Granger causality test cannot be applied. For this reason, the data are uploaded one by one in the programme and the stability of the data is checked in the Unit Root Test section from the “view” section. Another essential part to be considered in this section is the "test for unit level in" in the measurement of the stability of the data as stated in the method. Our data is not stable. For this reason, the data in the “1st diff” section has been examined. At this stage, the results show that the data is stationary. The next application is OLS. For this application, the entire data set is selected and the "OPEN as EQUATION" is made. Since the purpose of OLS is to find the relationship between dependent and independent variables, the “Least Squares” application has been chosen. After this process, the correlation of the dependent and independent variables in the OLS formula and the r square values are given. The next step is to find the lag length in the Granger analysis. In this case, VAR analysis has been conducted. All data are selected through the Eviews programme as in other processes. Automatic VAR analysis has been performed with the "OPEN as VAR" option available in programming. However, the process steps for lag structure should be followed as "LagStructre →Lag Lenght Criteria" in the "view" section of the VAR Analysis. The system automatically determines the number of lags in these processes. In our application, 8 lag steps are specified. The result that appears after this step indicates the lag length as AIC and SC by staring. On the other hand, the Variance Decomposition and Impulse/responses step in the VAR Analysis for Granger for a more general analysis is also performed from the "view" screen as in the VAR Analysis screen. Especially in impulse response analysis, the CO2 value, which is our dependent variable, is written in the response part. The arguments RWE.DE, ZOREN.TR, CPFE3.DE and SPWR.USA is written in the impulse part. After all these procedures, the most important application step is the Granger Causality Test phase. All these above steps actually has been performed to prepare the basis for Granger, causing both the result and the process to proceed in a meaningful way. In this direction, the Granger causality test has been evaluated as a group as stated in the mathematical model. For this reason, all data is opened as "OPEN AS GROUP" in the Eviews programme. Then the "View→Granger Causality Test" operation has been performed. The programme displays the Lag Specification panel. The important application in this process is to write the Lag Length Criterion found as a result of VAR analysis. If this criterion is not written, the result is wrong. In this direction, the Lag Specification of the previous result is specified as 1. For this reason, it is written as 1 on the screen and the Granger Causality result is reached. The last application step is CUSUM Test. This analysis is the last step in VAR analysis. In CUSUM, which analyses the structural break of the data in general in a certain time interval, it is possible to examine the structural breaks of the data in a certain equation. For this reason, All data are opened as "OPEN AS EQUATION". CUSUM Test is performed by making Recursive Estimation from the Stability Diagnostics application. Based on all these application steps, the result panels that we encounter reveal analyses examining the relationships of the data in detail. Thus, it helps us to make a detailed analysis of whether there is a significant relationship between the carbon emission price and the renewable energy stock, which is our subject.

4. Results and Discussions

The experimental results show that the Prob value is 0.000 and the data is stationary. Also, based on these results, the H0 hypothesis test is rejected in that the data sets have a unit root. As a result of the OLS analysis, it is determined that there is a perfect relationship between the

variables. R-squared is taken as the main indicator in this field and the value of 0.713 supports the hypothesis. In addition, the regression modelling is given as follows:

CO2=(2.40*CPFE3)+(0.54*RWE)+(0.49*SPWR)+(-3.3*ZOREN)-32.96 (9)

In the causal significance test based on the OLS results, the Prob column has been taken into consideration. CPFE3 and SPWR, which have a value of 0 in the Prob row, are found to be significant within themselves, while other firms (RWE, ZOREN) are found to be insignificant within themselves.

The results of the var lag structure criterion have been analyzed. The results show that the most appropriate lag length interval of the data set is determined as the lag 1 interval, because this is the interval where the significant values intersect. The purpose of this section is to find the appropriate SC and AIC interval for the Granger method. Variance decomposition analysis determines which of the independent variables given a shock has the most effect on the dependent variable. This analysis presents that it is observed that the firm with the highest variance effect in the time period is SPWR. Although the variance effect of the dependent variables varies within the time period, the high to low impact list are as follows, SPWR, ZOREN, RWE, CPFE3.

Figure 1 presents the impulse response graph between the stocks, i.e. the independent variable and the dependent variable carbon emission price. When the graph has been analyzed, SPRWR is the independent variable that generates the most reaction in the dependent variable. On the other hand, although ZOREN had a low impact in the first 3 time periods, it became the 2nd company with the highest impact afterwards. Another firm, RWE, was the firm that created the highest reaction in the first 3 periods, but there was a loss of momentum in the reaction trend afterwards. Finally, the independent variable that created the least reaction on the carbon emission price was CPFE3.

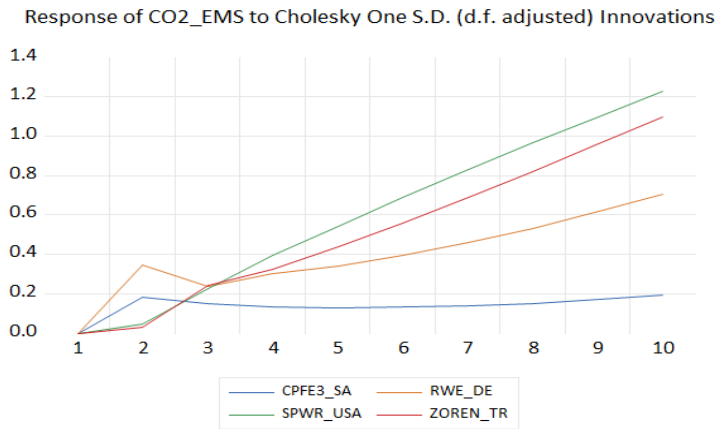

Figure 1: *Impulse/Responses Result*

The results of the Granger analysis have been presented in Table 2. In this table, the Granger significance of the independent variables on the dependent variable in terms of the Granger method has been analyzed. In addition, the Granger significance of the dependent variable on the independent variables has been also analyzed. Prob values have been considered in establishing the causality relationship. When the prob value results and Table 2 have been analyzed, it is seen that SPWR has a significantly granger causality on CO2_EMS with a prob

value of 0.0182. In addition, another significant Granger causality is observed in the effect of CO2_EMS on RWE with a prob value of 0.05. So H1 is accepted in this causality. However, in the remaining observations, H0 is accepted because no Granger causality was found in these relationships.

Table 2: *Granger Causality Test Result*

Null Hypothesis:	Obs	F-Statistic	Prob.
CPFE3_SA does not Granger Cause CO2_EMS	119	0.32067	0.5723
CO2_EMS does not Granger Cause CPFE3_SA		1.87797	0.1732
RWE_DE does not Granger Cause CO2_EMS	119	0.14596	0.7031
CO2_EMS does not Granger Cause RWE_DE		3.90963	0.0504
SPWR_USA does not Granger Cause CO2_EMS	119	5.73612	0.0182
CO2_EMS does not Granger Cause SPWR_USA		0.31914	0.5732
ZOREN_TR does not Granger Cause CO2_EMS	119	1.38424	0.2418
CO2_EMS does not Granger Cause ZOREN_TR		0.01163	0.9143

Figure 2 depicts the structural stability of the data set with CUSUM analysis. It's observed that structural stability is maintained until 2019. Afterwards, it is observed that there is a structural break until 2022. As a result, from 2012 to 2019, hypothesis H0: there is structural stability in the data set is accepted, and between 2019 and 2022, hypothesis H1: there is a structural break in the data set is accepted. The reason for the structural break to deteriorate in 2019 and 2022 can be shown as the shocks in the macro environment rather than the change in the stocks themselves. Because of the outbreak of the Covid-19 pandemic in 2019, many stocks have moved away from price stability in a negative way. In line with the results drawn from the analyses, although semantic causality has been between stock prices and carbon prices, it has been also observed that there were deviations in these impulse response ratios in some time periods due to various reasons.

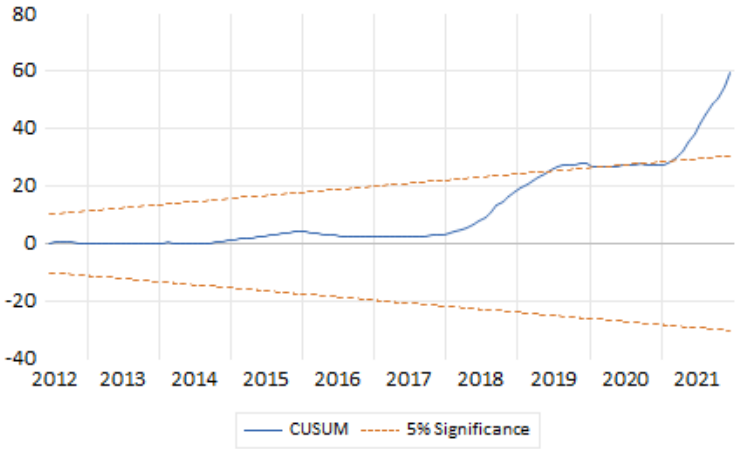

Figure 2: *CUSUM analysis*

5. Conclusions

This study presents the relationship between energy stocks and carbon emission prices for four companies. These selected companies operate in different macroeconomic environments in different countries. Li et al. (2018) stated that CO2 emissions, in connection with the industrialization and energy consumption of countries, have a positive relationship with GDP,

one of the macroeconomic elements. For that reason, the selected countries have been selected from different GDP levels. For the stock data of 4 different companies selected for the analysis to be unaffected by temporal fluctuations, a long time interval of 10 years has been selected. The selected data set consists of the closing prices of share prices between 2012 and 2022, and the range of the carbon price is between 2012 and 2022. The Eviews program has been used to conduct the analysis. Yazdi and Beygi (2017) mentioned that incentives and environmentalist regulations should be made in the long term to reduce CO2 emissions in the study which concluded that there is a significant relationship between economic growth and CO2 emissions. Similarly, according to the analysis results, there is a statistical significance between renewable energy company stock prices and carbon emission prices in the context of renewable energy companies. This situation changes in some periods since the companies are located in different macro and micro environments. ZOREN didnot have enough impact on carbon prices in the first 3 time periods, but an increase in the rate of its impact on carbon prices has been observed in the following periods. Even though the results are statistically explained, there is a possibility of certain errors in this study. The main one of which is the macroenvironment in which the companies are located, because many factors affect company prices. For example, GDP, inflation, incentive packages, etc.

This study contributes to the existing scientific literature on the subject, thereby providing a better understanding of the complex interaction between energy stocks and carbon emissions. This study examines countries with different levels of development and thus considers the various economic, social and environmental contexts in which carbon emissions occur. With this research providing valuable information to politicians charged with formulating effective climate change mitigation strategies, by the relationship between energy stocks and carbon emission prices, they can design regulations that facilitate the transition to low-carbon economies that promote sustainable practices. These arrangements may be tax incentives for renewable energy investments, emission reduction targets or implementation of carbon pricing mechanisms.

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