Journal of
Risk and Financial Management

MDPI

Article

GHG Emissions and Economic Growth in the European Union, Norway, and Iceland: A Validated Time-Series Approach Based on a Small Number of Observations

Sergej Gricar [1,2,*], Stefan Bojnec [3] and Tea Baldigara [2]

1 Faculty of Business and Management Sciences, University of Novo Mesto, Na Loko 2, SI-8000 Novo Mesto, Slovenia
2 Faculty of Tourism and Hospitality Management, The University of Rijeka, Naselje Ika, P.O. 97, Primorska 46, HR-51410 Opatija, Croatia
3 Faculty of Management, University of Primorska, Izolska Vrata 2, SI-6000 Koper, Slovenia
* Correspondence: sergej.gricar@gmail.com or sergej.gricar@uni-nm.si; Tel.: +386-739300637

Abstract: This research aims to ensure methodological conformance and to test the validity of its empirical application. To do so, the study analysed differentiation of the development patterns of four time-series variables. The relationships between greenhouse gas (GHG) emissions, employment, inflation, and gross domestic product (GDP) at constant prices were analysed, comparing the European Union (EU-27) and two European Free Trade Association countries. The study period covers twelve years of monthly and quarterly data from the beginning of 2010 to mid-2021, where the highest frequency of data was 138 observations. The methodology used included unit root testing and the vector autoregressive model (VAR). The study's main results show that GDP at constant prices significantly affected GHG emissions in the EU-27 countries. Meanwhile, the lag between inflation and employment did not have a considerable impact. This finding shows that inflation was not a stable variable and had a strong autocorrelation. Variable employment did not follow a normal distribution. It was necessary for this research to adopt a suitable model for the technical procedure.

Keywords: greenhouse gas emissions; green economic transformation; vector autoregressive model; European Union; European Free Trade Association; experimental economics; gross domestic product; general level of prices

Citation: Gricar, Sergej, Stefan Bojnec, and Tea Baldigara. 2022. GHG Emissions and Economic Growth in the European Union, Norway, and Iceland: A Validated Time-Series Approach Based on a Small Number of Observations. *Journal of Risk and Financial Management* 15: 518. https://doi.org/10.3390/jrfm15110518

Academic Editor: Thanasis Stengos

Received: 15 September 2022
Accepted: 3 November 2022
Published: 7 November 2022

1. Introduction

Green transformation and sustainable economic, social, and environmental development are often discussed in contemporary studies and research, capturing the attention of modern society (Guo et al. 2022; Pei et al. 2022). Issues such as micro-mobility (Dozza et al. 2022), self-dependence (Vitunskienė et al. 2022), car and flight shame (Lai et al. 2022), waste sorting and management, and zero emissions have been investigated from the perspective of sustainability (Köhler et al. 2022). This research refers to the United Nations' Sustainable Development Goals (UNSDH), particularly Goals 8 and 13. In the study, several activities relating to the UNSDH were tested: sustaining per capita economic growth in accordance with national circumstances, employment, green transition, and cooperation.

This study has two main objectives: first, to analyse previous research results, and second, to validate the normalities in time-series data. To achieve these objectives, secondary data from the Eurostat database were used. This research aims to provide insight into the direction of studied indicators of sustainable economic development and greenhouse gas emissions (GHG) (Vasylieva et al. 2019; da Silva et al. 2020). It also empirically tests the hypotheses comparing the activities of European Union (EU-27) and European Free Trade Association (EFTA-2) countries, using a reliable econometric model.

This research analyses four time-series variables to answer the research question regarding the policy actions of EU-27 and EFTA-2 (Norway and Iceland) countries in terms of GDP and employment. In this research, inflation is considered as an external variable when measuring overall price increases (usually called a deflator) and is viewed as an essential determinant of a healthy economy.

The research gap arises from previous research (Jun et al. 2022; Dogan et al. 2022 and others) that highlighted the problems caused by CO_2 (climate change), economic growth, employment, and inflation. The use of GHG as a critical factor for sustainable economic development in the third decade of the 21st century is investigated in this study. Additionally, this research provides added value resulting from a modelling procedure that stresses residual normality testing as a prerequisite of a reliable econometric modelling methodology (Juselius 2022).

The paper is organised as follows. The next section reviews previous empirical research on the presented issue. The third section presents data and methodology. The fourth section deals with the data and empirical analysis, and the subsequent section discusses the research phenomena. The final section summarises the research findings.

2. Literature Review and Hypotheses Development

2.1. Modelling Technique

The literature has widely addressed the research question regarding sustainability and economic growth (Arnaut and Lidman 2021; He et al. 2022; Hysa et al. 2020; Ioan et al. 2020; Saqib 2022), more often theoretically and less frequently empirically. Using regression analysis, Afzal et al. (2022) performed an empirical study of 40 European countries. Moreover, Sadiq et al. (2022) used regression analysis accompanied by Granger causality testing to study the case of Nepal. Therefore, a gap in the previous literature was detected during the research process, i.e., the omission of misspecification testing of variables from secondary data (Ye et al. 2022). Thus, the present study highlights the importance of testing the residuals' normality distribution. In contrast, Yuan et al. (2022) published one of the deficient studies that researched, discussed, and considered normalities when dealing with time series data.

Where volatility in time series data is high, GDP and employment could be treated as *I(0)* and inflation as *I(1)* (Juselius 2009). However, there are scarce theoretical findings approving the GHG emissions variable and its level of integration; hence, this study aims to provide insight to answer this hypothetical question. Additionally, a unique contribution is related to the possible impact of persistent inflation on economic growth, employment, and GHG emissions.

Researching sustainability and economic growth has never been more relevant than nowadays, as energy prices soar and inflation gallops (Figure 1). Almost one sixth of analysed published studies in the first quarter of 2022 were foucused on green energy, economic growth, carbon footprints, CO_2, and sustainability.

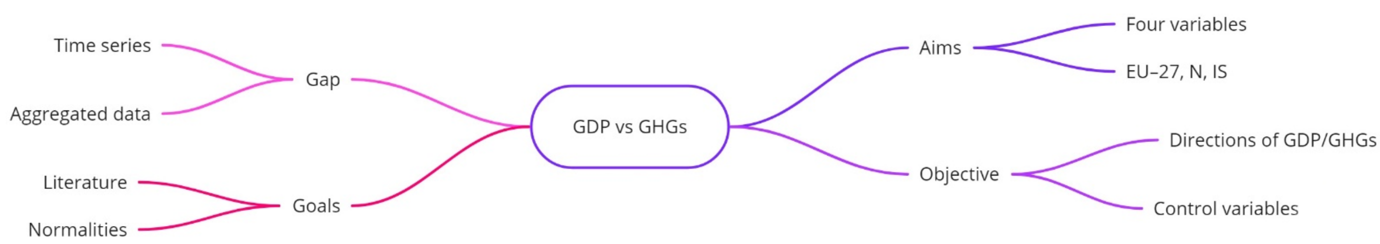


Figure 1. The research problem. Note: EU-27—27 European Union countries, N—Norway, IS—Iceland, GDP—GDP at constant prices, and GHG—air emissions accounting for greenhouse gases. Source: Authors' compilation.

2.2. Empirical Studies

Dogan et al. (2022) recognised that ecological tax, energy efficiency, and renewable energy are the most critical determinants for decreasing CO_2 emissions. Some studies have used panel data (Fernandes et al. 2021) and quantile regressions. Using the VAR model, Gedikli et al. (2022) did not find any causalities between economic growth and environmental pollution in OECD countries. Galiano Bastarrica et al. (2022) discussed natural resources and their stochastic properties in the EU-27 countries, using econometrics at the GDP level.

Additionally, some other studies have obtained results for emerging and developing countries (Kousar et al. 2022). Yuan et al. (2022) researched the nexus between energy pricing and carbon emissions in terms of the policy-mix response. They used well-standardised quantiles, e.g., normalities, to look for alternative energy sources to meet the growing demand for energy. Ma et al. (2022) applied quantile regression to panel data for exports and the digital economy, and identified a negative impact on carbon emissions. Ye et al. (2022) proposed a green credit method to enrich renewable energy, using an error correction model to achieve the results of their study. Li et al. (2022) applied quantile regression to research renewable energy consumption for BRICS (Brazil, Russia, India, China, and South Africa) countries, and Tu et al. (2022) took a similar approach for Regional Comprehensive Economic Partnership economies.

In contrast, Zhou et al. (2022) discussed the non-linear relationship in modelling the nexus between agricultural and energy production and CO_2 emissions. Furthermore, Jiang and Chang (2022) found that green output and renewable energy were positively associated with rising stock market prices in six Asian countries. Yan et al. (2022) researched green bonds, energy prices, gold prices, and green energy stocks using quantile regression. Finally, Zhang and Han (2022) correlated spillover effects in the carbon market and stock market.

Jun et al. (2022) discussed environmental consequences caused by industrialisation and economic development. Their research using panel data applied cointegration techniques and a cross-sectional augmented distributed lag model. The findings supported renewable electricity production. Zhang et al. (2022) discussed the effects of the COVID-19 pandemic on energy prices in the United States of America. Over the past four decades, there have been discussions regarding sustainable economics in (non-profit) organisations (Rosner and Cohen 1983). According to this stream of literature, interventions and urbanisation drive the global economy via increased spending and consumption of products and services (Ramakrishna 2021). Particularly in certain developing countries, strong links have been identified between food insecurity, population growth, urbanisation, and water availability (Kousar et al. 2021).

On the other hand, according to Bowden (2018), who researched the economics and sustainability of modernity, debt can never generate sufficient income. Modernity consists of finding human wellbeing in an environment that provides adventure, power, pleasure, growth, and the transformation of people in the changing world. Bojnec and Papler (2011) highlighted that the overexploitation of natural resources is one of the most critical problems in the EU-27 countries, and that countries' environmental management could be damaged in the future if governments fail to consider these issues more systematically.

2.3. Hypotheses Development

This paper investigates the associations between GDP, inflation, employment, and CO_2 emissions using the cointegration method developed by Juselius (2009, 2021). Understanding the behaviour of a macroeconomy can be crucial for better comprehension of policy implications and practice. The study develops a econometric time-series model applied to secondary data (Ross 2019).

The term GHG emissions refers to the amount in thousands of tonnes of CO_2, N_2O in CO_2 equivalent, CH_4 in CO_2 equivalent, HFC in CO_2 equivalent, PFC in CO_2 equivalent, SF_6 in CO_2 equivalent, and NF_3 in CO_2 equivalent (Eurostat 2022). In the current era of rapid economic development, with the world moving towards continuous expansion and economic growth, GHG emissions have increased significantly (Bilgili and Ozturk 2015). The issue of GHG emissions has been at the centre of research efforts, which have aimed to shed light on its impact on economic growth and environmental sustainability (Lan et al. 2012). However, the influence and role of employment in increasing GHG emission rates have often been neglected. The increasing GHG emission rate has become a vital issue for developed countries, due to environmental resource scarcity (Akram et al. 2019). GHG emissions relate not only to electricity as an energy resource but also to water, oil, coal, and natural gas. The EU-27 countries represent one of the fastest growing economies, with GDP at current prices worth 14,507,067.2 million euros in 2021, and the EFTA-2 countries had GDP of 429,186.4 million euros at current prices in 2021 (Eurostat 2022). Assuming that economic development directly affects greenhouse gas emissions, it can be stated that as production and economic growth increase, so does energy consumption. In this context, the study by Yu et al. (2020) implies that the growth of economic activities requires energy as a mandatory input to compel and increase the speed of the process, defined by the law of thermodynamics (Oppenheim 1996).

However, employment and labour are among the most critical drivers of the debate on GHG emissions (Hamit-Haggar 2012). Currently, developing countries are moving towards industrialisation, which substantially influences GHG emissions and leads to a scarcity of natural resources from which energy can be obtained (Sebri and Ben-Salha 2014). Bhattacharya et al. (2016) suggested that high-energy consumption threatens environmental sustainability and reduces resources for the future, which is a logical position. Liddle (2014) stated that employment is related to energy consumption, and economic growth can be considered a mediating factor for employment, thereby affecting energy consumption.

Yao et al. (2019) noted that employment has several meanings in contemporary literature. In business management, employees can be classified as an intangible asset representing the abilities, expertise, and temperaments of individuals who work together to create economic value for the entire population or customer base. Based on the findings from desk research and the goals of this study, three hypotheses were developed for the comparative analysis of EU-27 and EFTA-2 countries:

H1. *Employment has a significant upward trend impact on GHG emissions.*

H2. *GDP at constant prices has a significant reversible unstable impact on GHG emissions.*

H3. *Inflation has a significant positive impact on GHG emissions.*

Overall, this study aims to address two gaps in the literature by testing secondary data based on UNSDH activity and analysing quarterly data in a reliable, testable, and trustworthy model.

3. Materials and Methods

This paper's conceptual and theoretical goal is to describe volatilities in sustainability and economics, to show how they can be treated econometrically beyond misspecification tests. The empirical approach is developed in two stages: first, implementing the time series, and second, applying causalities to GHG. To analyse recent developments in economic activity by using strategically selected contemporary variables, the study applies the Juselius (2009) methodology. Variables were investigated to test the three hypotheses arguing that sustainable economic growth depends on GHG emissions and vice versa.

As a starting point, an illustrative example is introduced using two time series, X_t and Y_t, $t = 1, \ldots, T$, according to a substantive theory (Kulendran and Witt 2001):

$$Y = \beta \cdot X, \tag{1}$$

where X influences Y in a linear fashion.

The obtained data may not be directly comparable, and they are usually unsupported by theory. Haavelmo (1943) argued that some deterministic proposals and research problems are needed to overcome issue of stochastic properties, requiring methods which should be as elastic as possible, further developed by Hoover et al. (2008).

We introduce:

$$Y_t = \beta \cdot X_t + \varepsilon_t, \quad t = 1, \ldots, T, \tag{2}$$

with the error term ε_t which is a statistical relationship (Juselius 2009).

There is a widely known problem that normally distributed residuals ε_t are i.i.d. $N(0, \sigma^2)$ in regression analysis that does not link empirical regression to theoretical values (Brooks 2014). Furthermore, the issue exists of stationarity and X_t being nonstochastic (Johansen and Nielsen 2012). This study aimed to design a modelling process capable of further discussing the vulnerability of the econometric conclusions. At the same time, evaluating systems according to applied economic results is of practical importance to policy, and that importance increases after each negative shock. The vector autoregressive model (VAR) and the Granger causality model were used in the empirical part of this research.

The first stage of the time-series data analysis focused on the stochastic properties of variables by testing for the presence of unit roots. This step allowed the identification of stationary and non-stationary time series, to permit the specification of a model that should not produce spurious results provided that the variables are non-stationary, as is usually the case with time-series data. Therefore, the existence of a long-run equilibrium among variables was then tested, starting with the specification of a VAR model of order k:

$$z_t = a + B_0 z_t + B_1 z_{t-1} + \ldots + B_p z_{t-p} + \varepsilon_t, \quad t = 1, \ldots, T, \tag{3}$$

In Equation (3), z_t denotes the (4 × 1) vector of indices of the variables (Figure 2), and ε_t denotes the white-noise error term. A vital feature of the VAR model is that it does not impose any a *priori* restriction on the exogeneity of variables, attractive in the present context because of the possibility of bi-directional causality.

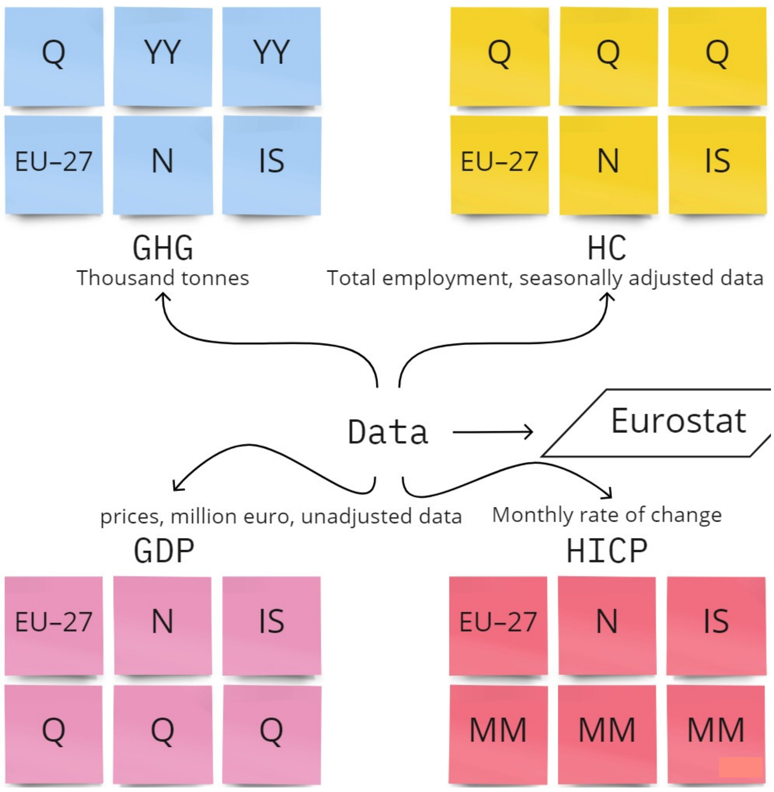


Figure 2. Data extraction procedure for the main objective aim of the research. Note: MM—monthly, Q—quarterly, YY—yearly, EU-27—27 European Union countries, N—Norway, IS—Iceland, GDP—GDP at constant prices, HICP—harmonised consumer price index, GHG—air emissions accounting for greenhouse gases, and HC—employment. Source: Compiled by the authors, based on Eurostat (2022).

Annual, quarterly, or monthly time-series variables from the beginning of 2010 to mid-2021 were used, and the highest frequency of data was 138 observations, as presented in Figure 2.

The specified variables were employment as a labour force in the economy (HC_t), GDP at constant prices (GDP_t), and air emissions accounting for greenhouse gases according to the European Classification of Economic Activities (NACE) (GHG_t) as quarterly data, and Consumer price index as a monthly inflation integer ($HICP_t$).

The data were collected separately in aggregated values for the EU-27 countries and the EFTA-2 countries (Alghalith 2007; Archontakis and Mosconi 2021; Baxa et al. 2015; Eurostat 2022). Additionally, the Granger representation theorem was applied to the studied relationships between researched variables and defined hypotheses:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum\nolimits_{i=1}^{\infty} \Gamma_i \Delta y_{t-i} + v_t, \tag{4}$$

$$\Pi = \alpha\beta', \tag{5}$$

where, in Equations (3)–(5), p is the number of time series, and its value is three; z_t is a dependent variable with restriction on β; z_{t-1} is the independent variable; Φ_i^* are extraordinary events (seasonal dummies, transitory, blip, and permanent dummies); Πx_{t-1} is the level matrix, called the error correction form; $\Gamma_1 \Delta y$ is a matrix describing pure transitory effects measured by lagged changes of the variables; i is a dimension of integration; Δy_t is the cointegrated vector autoregressive form; and Δy_{t-i} is the long-term causality process y_t of collected observations in the matrices Y_n of prediction error v_t.

4. Data and Empirical Results

The first step of the modelling process consisted of data description. The empirical results are presented in two steps, indicating the descriptive analysis of the variables and the VAR modelling using Granger causality.

This research analyses the direction of the association between three macroeconomic aggregates and greenhouse gas emissions (GHG). Gross domestic product (GDP) is expressed in chain-linked volumes in millions of euros at constant prices. Employment is defined as total employment of the resident population, conceptually based on the Labour Force Survey (LFS). Secondary data on inflation is isolated as a monthly rate of change.

4.1. Descriptive Analysis and Misspecification Testing

The first main result based on the summary of descriptive statistics in natural logarithm form shows that after the 2010 recession, GHG emissions declined in the EU-27 (Figure 3). This finding could align with a strategy for reducing emissions in Europe. Figures 3 and 4a,b also show that GDP at constant prices has increased in the EU-27 countries, Norway, and Iceland. On the other hand, GHG emissions in Norway and Iceland have slowly reduced, after a tendency to increase during the economic prosperity of the previous decade (Figure 4a,b).

The second notable finding that emerged from the unit root testing was that inflation has been led by employment (HC). Higher demand for employees and increased labour costs for enterprises could have contributed to this finding. Additionally, employment in the EU-27 countries [Equation (6)] and Norway [Equation (7)] was recognised as an integer of normality in the harmonised consumer price index (HICP). Moreover, the autocorrelation test identified serial autocorrelations either in HC or in HICP, and therefore the equations for the real variable (r) between inflation and employment can be expressed:

$$(hicp_{EU-27}/hc_{EU-27})_t^r + \varepsilon_t = HICP_{\substack{EU-27 \\ t}} / HC_{\substack{EU-27 \\ t}}, \tag{6}$$

$$(hicp_N/hc_N)_t^r + \varepsilon_t = HICP_{\substack{N, \\ t}} / HC_{\substack{N \\ t}}, \tag{7}$$

where ε_t is a random walk. The misspecification tests are depicted in Table 1, where lowercase letters define the real variables.

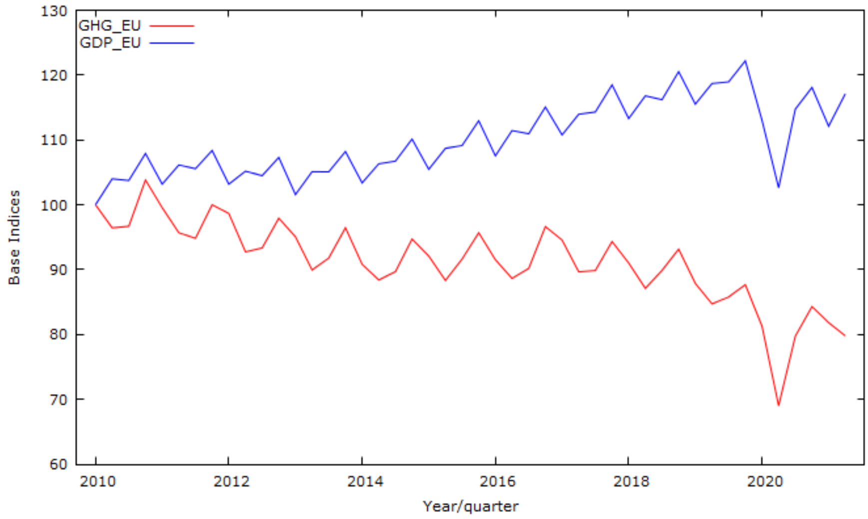
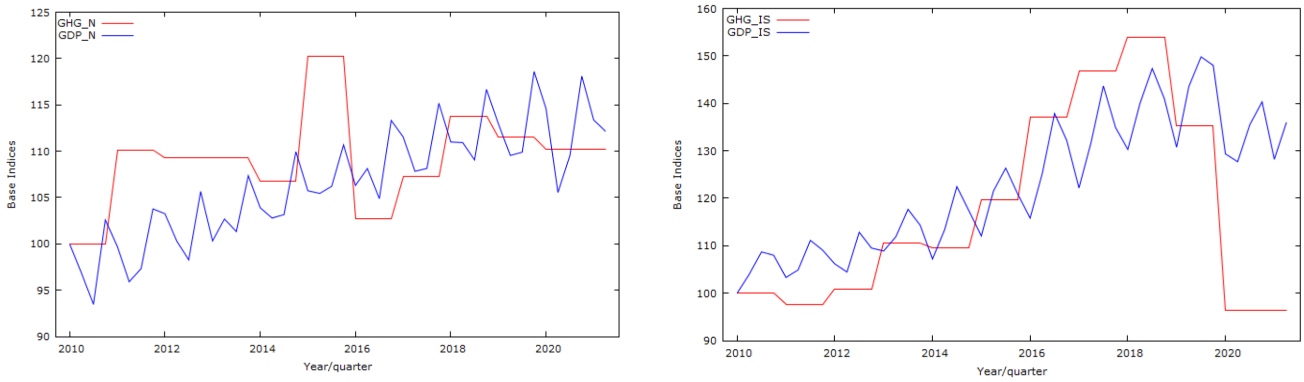


Figure 3. GDP over GHG in the EU-27 countries. Note: ln—natural logarithm, EU-27—27 European Union countries, GDP—GDP at constant prices, GHG—air emissions accounting for greenhouse gases. Source: Compiled by the authors, based on Eurostat (2022).



(**a**) (**b**)

Figure 4. GDP over GHG: (**a**) Norway; (**b**) Iceland. Note: ln—natural logarithm, N—Norway, IS—Iceland, GDP—GDP at constant prices, and GHG—air emissions accounting for greenhouse gases. Source: Compiled by the authors, based on Eurostat (2022).

This technical aspect of the work is essential to ensure a reliable econometric approach and provides theoretical added value for this research. In applied economics, this technological step is usually omitted and is not performed. Testing the unit root in a variable dataset is crucial because it determines whether the data are stationary or fall into the non-stationary range. The traditional method for evaluating the unit root in the data is the extended Augmented Dickey–Fuller (ADF) unit root. In the conclusion of the misspecification test, the data vector is employed for further analysis. The function of the VAR approach is to measure the cointegrated interrelation among the variables, where the standard linear function for calculating the interrelation between GHG, GDP, and the real variable between HICP and HC in the EU-27 countries is as follows:

$$ {}^{EU-27}_{\;r}[GDP\ GHG\ hicp/hc]^{\sim 1}_{t-1}, \quad (8) $$

where $t-1$ indicates differentiated time series of at least ~ 1 first order of integration, and r indicates real data, vector (8) recognises GDP at constant prices, GHG, and hicp/hc as relevant variables without serial autocorrelation, and non-normalities in the series for the EU-27 countries. On the other hand, as seen from Equation (8) and in Table 1, for Norway it can be expressed as data vector (9):

$$ {}^{N}_{r}[GDP\ hicp/hc]^{\sim 1}_{t-1}, \tag{9}$$

and for Iceland as data vector 10:

$$ {}^{IS}_{r}[GDP\ HICP]^{\sim 1}_{t-1}, \tag{10}$$

Table 1. Misspecification test.

Variable	Region	ADF Test Level	ADF Test Differences	Normality Test Level	Normality Test Differences
	EU-27	−0.5214	−2.3650 *, c	5.2720 *	408.8220 ***
HC_t	N	−2.3811	−2.1724 ***, c	4.0520 *	21.6478 ***
	IS	−1.2597	−3.2098 **, c,t	3.7066 *	122.203 ***
	EU-27	0.8046	−4.5084 ***, c	2.8032	2.5320
GDP_t	N	−2.2607	−17.1221 ***, c	0.7903	0.6879
	IS	−2.4661 *	−2.8538 **, c	4.5007 *	2.0056
	EU-27	−0.6308	−3.0827 **, c	12.0937 ***	0.1015
GHG_t	N	−2.1519	−4.5213 ***, c	0.7586	1.5649 ln
	IS	−1.2725	−2.8420 **, c	5.0096 *	0.4329 ln
	EU-27	−4.0740 ***	−2.6741 *	21.4932 ***	1.1379
$HICP_t$	N	1.3965	−6.0731 ***	4.4327 *	1.5449
	IS	−3.8984 ***	−2.0711	4.8153 *	2.5542
	EU-27	−2.7463 *	−3.5939 *, c, t^2	2.8442	250.032 ***
$\frac{HICP_t}{HC_t}$	N	−3.0091 *	−3.82973 ***, c	4.5768 *	13.5424 ***
	IS	−1.1586	−9.8196 ***, c, t^2	26.4987 ***	116.859 ***

HC_t—employment, GDP_t− GDP at constant prices, GHG_t—air emissions accounting for greenhouse gases, $HICP_t$—harmonised consumer price index, EU-27—27 European Union countries, N—Norway, IS—Iceland, c—constant, t—trend, ln—natural logarithm, *, **, ***—10, 5, 1% significance, respectively. Green—accepted, red—firmly declined.

Therefore, with data vectors (8)–(10) we are able to proceed to the VAR analysis. The symbols in the equations are include GDP—GDP at constant prices, GHG—air emissions accounting for greenhouse gases, real variable (r), N—Norway, IS—Iceland, $\sim$1—first order of integration, $t-1$—lagged time series, HICP—harmonised consumer price index, and $hicp/hc$ is a real variable between inflation and employment. As can be seen from Equations (6)–(9), inflation affects employment. As a result, there is no direct relationship between the employment variable and GDP at constant prices.

Table 2 presents the descriptive analysis results.

The mean value of GHG emissions was 91.15, which means that the average emissions in the EU-27 countries decreased with statistical significance during the observed period, by almost 9% on average. The result was calculated from 46 observations. The minimum value was estimated to be 69.03 for the second quarter of 2020, while the maximum value was 103.80 in the fourth quarter of 2010. The dispersion of the data was 6.4%, which means that GHG emissions in the EU-27 countries either increased or decreased by 12.12%.

The mean value of GDP at constant prices was calculated as 110.09 in the EU-27 countries, 106.61 in Norway, and 122.77 in Iceland, which indicated the average value of GDP. The maximum value of GDP at constant prices was calculated as 122.19 in the EU-27 countries, 118.60 in Norway, and 149.80 in Iceland, which means that GDP at constant prices was growing significantly. The standard deviation was calculated as 5.74, 6.03, and 14.16, respectively, indicating the dispersion of GDP at constant prices.

Table 2. Descriptive statistics.

Variable	Region	Mean	St. Deviation	Minimum	Maximum
GDP_t	EU-27	110.09	5.74	100.00	122.19
	N	106.61	6.03	93.48	118.60
	IS	122.77	14.16	100.00	149.80
GHG_t	EU-27	91.15	6.40	69.03	103.80
	N	109.30	5.05	100.00	120.30
	IS	117.90	20.30	96.46	153.90
$\left(\frac{hicp}{hc}\right)_t$	EU-27	−29.22	18.77	−44.64	30.07
	N	3.91	3.09	−0.17	9.19
$HICP_t$	IS	3.90	3.09	100.00	109.40

GDP_t—GDP at constant prices, GHG_t—air emissions accounting for greenhouse gases, $(hicp/hc)_t$—harmonised consumer price index over employment, EU-27—27 European Union countries, N—Norway, IS—Iceland.

The mean value of the ratio of inflation to employment was −29.22 in the EU-27 countries and 3.91 in Norway. The results show that stable or even decreased inflation is a consequence of full employment; in other words, it represents the impact of employment on the macroeconomic aggregate. It can be concluded that full employment leads to lower inflation. On the other hand, policy regulations for transport and industry aim at lower GHG emissions and higher GDP. Overall, the HICP in Iceland was uniquely stable, whereas employment was unstable and suffered from serial autocorrelation.

4.2. VAR Analysis

In VAR modelling, the null hypothesis indicates a possible relationship between the regressor and the regressed variable, as evidenced by the *F*-statistic (Table 3). If the value of the *F*-statistic is less than the critical value, the null hypothesis cannot be rejected. Where cointegration was established, the following procedure was applied to calculate the long- and short-term cointegration.

Based on the ADF unit root, it was found that all variables in the time-series data had a unit root; therefore, the VAR approach was performed to evaluate causality between factors. Table 3 shows the results of the VAR approach, in which GHG emissions are the regressive or dependent variable, and the other variables are the regressors. Regarding the significance of the model for EU-27 countries, the probability of the *F*-statistic was evaluated. The probability value was 9.02×10^{-10}, which is less than the threshold of 1%, which means that the model built by VAR was significant and had no statistical errors. The *R–squared* value was calculated as 87.81%, which means that the regressors can explain 87.92% of the variance in GHG emissions.

The main results show that the lag of GHG emissions, GDP at constant prices, and inflation over employment significantly affected GHG emissions. Each one-unit change in the lag of GHG emissions, GDP at constant prices, and the real variable between inflation and employment in the EU-27 countries resulted in a positive shift in GHG emissions, with coefficients of 0.40, −1.28, and 2.06, respectively. On the other hand, neither GDP at constant prices in Norway and Iceland nor the real variable between inflation and employment significantly impacted GHG emissions, because of degrees of freedom (annual data) (Figure 2, and Table 3). The Durbin–Watson statistic value was 2.02, which indicates that the model did not suffer from autocorrelation, and the lag selection was four, based on the Akaike information criteria (AIC). The asterisks in Table 3 show the significance of the coefficients at lag two. The probabilities are given in parenthesis. Therefore, the results based on two lags show the crucial negative influence on GHG emissions in the EU-27 countries. Nevertheless, in each second quarter, GHG emissions declined with statistical significance in a time-dependent manner. Overall, the VAR model did not suffer from autocorrelation, nor non-normality.

Table 3. VAR model.

Variable	Region	Coefficient	St. Error	t-Statistics	Probability
GHG_{t-1}	EU-27	0.40 (−0.96) ***	0.18	−2.18	0.04
ΔGHG_{t-1}	N	/	/	/	/
	IS	/	/	/	/
GDP_{t-1}	EU-27	−1.28 (0.55) ***	0.15	−3.31	0.00
	N	0.45 (−0.08)	0.19	2.40	0.02
	IS	0.15 (−0.37) **	0.21	0.82	0.47
$\left(\frac{hicp}{hc}\right)_t$	EU-27	2.16 (−0.29) ***	1.96	−3.46	0.00
	N	−4.18 (−0.01)	2.41	−1.75	0.09
$HICP_t$	IS	6.63 (9.91) *	5.39	1.23	0.23
lag	1	2	3	4	5
AIC information criteria EU-27	−98.54	−78.59 ***	−76.78 **	−70.90 ***	−70.65
Normality test of the VAR model	EU-27 [3.8834]	N [0.5958]	IS [20.76 ***]		
Autocorrelation test of the VAR model	EU-27 [8.17 ***]	N [0.34]	IS [2.94 **]		
D–W test	EU-27 [2.02]	N [1.85]	IS [1.69]		

GDP_{t-1}—gross domestic product, GHG_{t-1}—air emissions accounting for greenhouse gases, $(hicp/hc)_{t-1}$—harmonised consumer price index over employment, EU-27—27 European Union countries, N—Norway, IS—Iceland, Δ—natural logarithm, *, **, ***—10%, 5% and 1% significance level, respectively, green—accepted, AIC—Akaike information criteria.

The VAR model for Norway and Iceland followed Equations (6) and (7), and the procedure was performed without the GHG emissions variable due to the low R-squared values of 0.09 for Norway and 0.21 for Iceland. Additionally, several noteworthy findings are shown in the lower rows of Table 3. The diagnostic testing of the VAR model's results showed that the developed model for the EU-27 countries and Iceland was free of autocorrelation. Meanwhile, the model and its residuals were normally distributed for the EU-27 countries and Norway, but not for Iceland. It is noteworthy that $\left(\frac{hicp}{hc}\right)_t$ is a justification of the modelling process.

4.2.1. Hypothesis 1

After the results were gathered, the hypotheses were tested. The results for Hypothesis 1 are presented in Table 4. Hypothesis 1 could not be explained, due to the model's unreliability resulting from the non-normalities in the variable HC, as described in Section 4.1. Moreover, the Durbin–Watson statistic (D–W) was too high, at more than 2.24, meaning that the model suffered from negative autocorrelation.

Table 4. Testing Hypothesis 1.

H	Description	Region	Lag	Beta	Significance	Result	D–W	R^2
1	Employment (HC) has a significant upward trend impact on GHG emissions.	EU-27	1	−1.06	0.28	Vague	2.30	0.54
			2	0.94	0.34	Vague		

GHG—air emissions accounting for greenhouse gases, EU-27—27 European Union countries, H—Hypothesis, D–W—Durbin Watson statistics, R^2—deterministic coefficient.

4.2.2. Hypothesis 2

Hypothesis 2 (Table 5) is accepted for the EU-27 countries, where the D–W is 2.15. The results show that the model did not contain serial misspecification, while the probability in squared brackets is 0.07 and the adjusted coefficient of determination (R^2) is 0.58, meaning that Hypothesis 2 explained with statistical significance 57.9% of the total variance of the model.

Table 5. Testing Hypothesis 2.

H	Description	Region	Lag	Beta	Significance	Result	D–W	R^2
2	GDP at constant prices has a significant reversible impact on GHG emissions.	EU-27	1	$0.14_{GDP_{t-1}}$ $-0.31_{GHG_{t-1}}$	0.46 0.08	Accept [0.0207]	2.12	0.643
			2	$0.46_{GDP_{t-1}}$ $-0.99_{GHG_{t-1}}$	0.07 3.58×10^{-9}	*F*-statistics 2.89		

GDP_{t-1}—GDP at constant prices, GHG_{t-1}—air emissions account for greenhouse gases, EU-27—27 European Union countries, H—Hypothesis, D–W—Durbin Watson statistics, R^2—deterministic coefficient.

It can be concluded that GDP at constant prices had an insignificant positive impact on GHG emissions in the first lag, and a significant effect in the second lag. Moreover, the beta coefficient showed that GHG emissions were the most powerful factor. The negative beta coefficients could explain this inconsistency for GHG emissions, due to the sustainable strategy for transport and commuting within the EU-27 countries on the one hand and the lower carbon footprint of industry on the other. Overall, the direction of causality indicating that GDP at constant prices affects GHG emissions was confirmed by the *F*-test result of 2.89. This result thus confirms Hypothesis 2 for the EU-27 countries.

On the other hand, comparing Norway and Iceland was impossible due to the lack of observation data. Overall, Hypothesis 2 is accepted for the EU-27 countries. However, the main finding was that GDP at constant prices did not have a statistically significant effect on GHG emissions directly in the first quarter, and the effect was limited to the second quarter. At the same time, the indirect impact of GDP growth on sustainable development was more critical, as it had a positive effect on the reduction of GHG emissions.

4.2.3. Hypothesis 3

As described in Equations (6) and (7), to account for inflation, the real variable between inflation and employment was used. Hypothesis 3 (Table 6) is rejected for the EU-27 countries. The statistics showed negative autocorrelation at first, with a low *F*–statistic, which was not statistically significant. Moreover, almost all beta coefficients were statistically insignificant. The only considerable result was for GHG emissions, which were dependent on a second lag.

Table 6. Testing Hypothesis 3.

H	Description	Region	Lag	Beta	Significance	Result	D–W	R^2
3	Inflation has a significant positive impact on GHG emissions.	EU-27	1	$0.47_{hicp/hc_{t-1}}$ $-0.08_{GHG_{t-1}}$	0.37 0.50	Reject [0.5300]	2.42	0.53
			2	$-0.56_{hicp/hc_{t-1}}$ $-0.75_{GHG_{t-1}}$	0.30 1.76×10^{-8}	*F*-statistics 0.65		

GHG_{t-1}—air emissions accounting for greenhouse gases, $hicp/hc_{t-1}$—real variable between the harmonised consumer price index and employment, EU-27—27 European Union countries, H—Hypothesis, D–W—Durbin Watson statistics, R^2—deterministic coefficient.

5. Discussion

The main objective of the study was to assess the impact of three macroeconomic aggregates and GHG emissions (Niu et al. 2022), i.e., economic growth and greenhouse gas emissions, as previously described by Vasylieva et al. (2019), in the EU-27 countries and the EFTA-2 countries, i.e., Norway and Iceland. For research purposes, secondary data were collected, and the econometric VAR approach was applied to analyse the data (Figure 5).

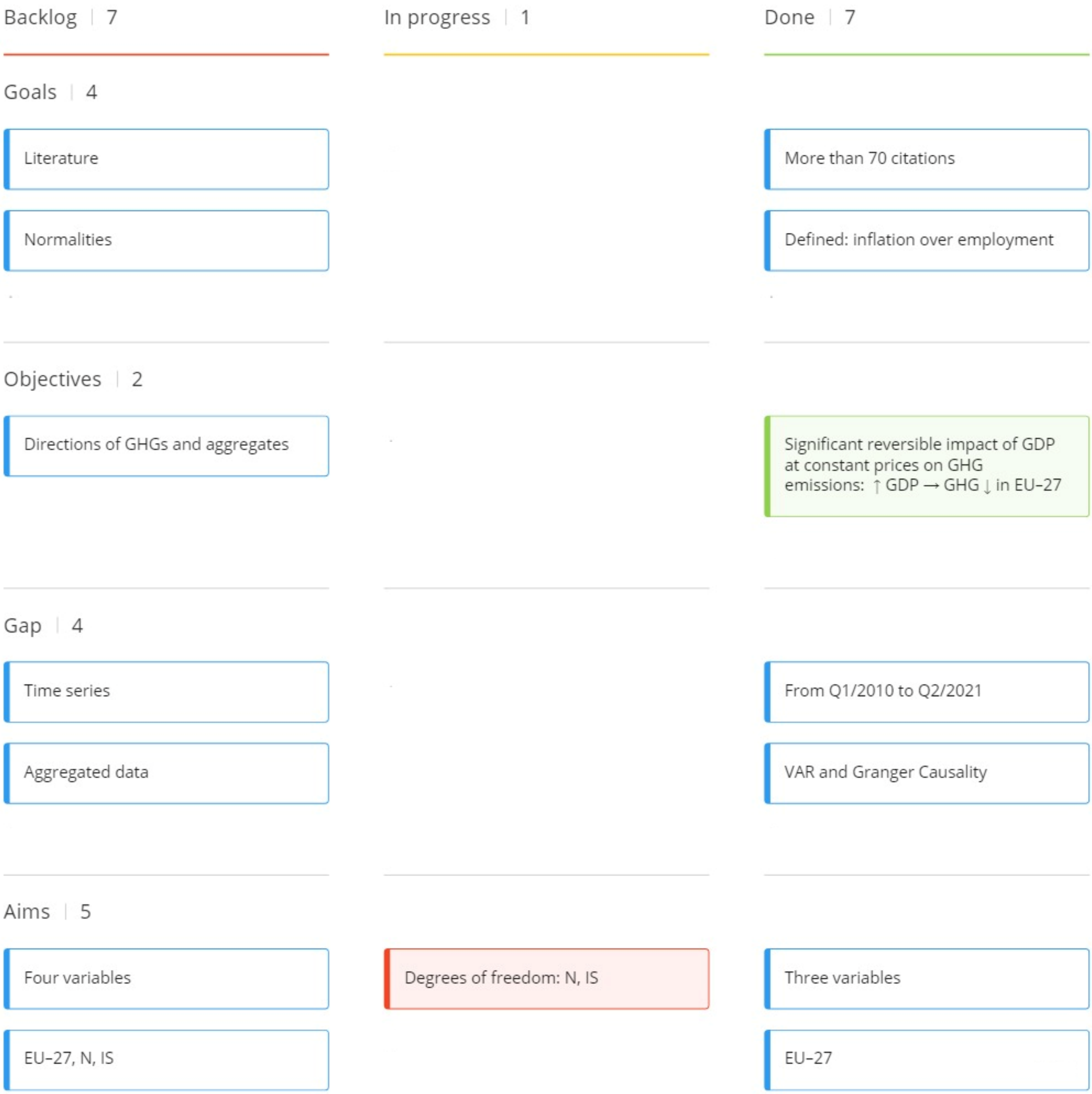


Figure 5. The key findings of the study. Note: EU-27—27 European Union countries, N—Norway, IS—Iceland, GDP—GDP at constant prices, GHG—air emissions accounting for greenhouse gases, VAR—vector autoregressive model. Source: Authors' compilation.

The research results are summarised in Figure 5. The VAR analysis was performed for the EU-27, Norway, and Iceland. Causalities and hypotheses testing were developed only for the EU-27 countries, while degrees of freedom were detected for Norway and Iceland.

The main findings resulting from the objectives and the VAR model showed that increased GDP at constant prices significantly affected the reduction of GHG emissions in EU-27 countries. This finding is in line with the environmental Kuznets curve (Dinda 2004; Jun et al. 2022; Arnaut and Lidman 2021), suggesting that despite trade-offs between economic growth and rising awareness about environmental pollution, higher rates of economic growth and thus higher levels of economic development can provide more resources for reducing environmental problems. This may indicate a need for countries to develop their green transformation towards a zero-emissions strategy, to further improve their GDP growth with overall sustainability objectives that consider economic, social, and environmental aspects that may be affected. This finding aligns with the most recent studies by Jun et al. (2022) and Saqib (2022).

In contrast, other economic aggregates involved in the modelling showed that employment had a slight impact on GHG emissions. The studies by Sharma et al. (2021) for the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC region) and Sarkodie et al. (2020) for China showed that employment affects GHG emissions. This recognition could provide a further research question about the causal relationship between the development status of a country and environmental aspects. However, it can also be related to variables which captures the stock and/or flow of employment.

Additionally, following the literature, non-normalities were thoroughly investigated. Therefore, by improving the modelling, the econometric dispersion can be expanded. Normalities in the residuals were not found in the aggregates of employment and inflation. Independently, both variables could lead to a (new) real variable when inflation is divided by employment., e.g., high employment is beneficial for lower inflation and vice versa. This groundbreaking finding should be explored further and is an essential issue for future research. This finding was found to be valid for the EU-27 countries and Norway, but not Iceland.

Finally, an additional hypothesis should be tested. This paper benefits from applied econometrics, and the subject matter relates to EU-27 enlargements (Coondoo and Dinda 2002):

1. Empirical: Lower GHG emissions cause higher inflation and lower employment; the alternative hypothesis is that lower GHG emissions cause lower inflation and higher employment.
2. Theoretical: Finding the real variable(s) and normalities within the goals and objectives of the study. The innovative results of the present research are highlighted:
3. Theoretical: The normalities in the residuals show that the variables of employment and inflation did not meet the misspecification criteria in terms of test results and probabilities. Therefore, the study highlights the defined real variable between inflation and employment ($\left(\frac{hicp}{hc}\right)_t$). The second goal has been reached.
4. Empirical: The upward direction of higher GDP at constant prices caused decreasing GHG emissions in the EU-27 countries, which validates the second hypothesis of this paper.

This study could be extended to additionally include variables such as micro-mobility (Sareen et al. 2021), self-dependence (Korphaibool et al. 2021), car and flight shame (Chiambaretto et al. 2021), waste sorting (Xiao et al. 2022), and zero emissions (Vieira et al. 2021), among others. These future research determinants are supported by Guan et al. (2022), who found that technological innovation significantly reduced GHG emissions resulting from tourism. The EU-27 countries' financing plan supports the environment, energy, and mobility (ConsultTech 2022).

Overall, higher employment is associated with lower inflation, as previously discussed by Samuelson and Solow (1960), and lower employment has a significant and positive impact on higher inflation, as addressed by Cottarelli et al. (1998). Additionally, Cottarelli (1998) argued that substantial relative price increases raise general prices in transition economies such as Slovenia. This effect may interact with the employment response; if the authorities offset the price increases by increasing the money supply—out of concern for depressed demand and lower employment—the inflationary effects of the relative price shock are amplified (Cottarelli 1998). The results obtained for the EU-27 countries and Norway were not in line with the explanation of the Phillips curve (Rudd and Whelan 2005), probably due to the money supply boom, as discussed by Liñán and Jaén (2020).

6. Conclusions

This research has addressed some crucial economic and environmental sustainability approaches for the EU-27 countries, Norway, and Iceland, where economic growth and CO2 emissions diverge. The findings are consistent with greening the energy sector. The contribution of the empirical testing is of considerable relevance for econometric modelling.

6.1. Technical Discussion

This study assessed the impact of GDP at constant prices, employment, and inflation on GHG emissions in the EU-27 and EFTA-2 countries. Employment is defined as a country's labour force that creates economic value. Understandably, employment has an impact on a country's economic development. However, the way that employment affects inflation has not yet been fully explored, especially in the case of normality in time-series residuals.

An added value of this study is geographically applicable to the EU-27 countries and Norway, but not for Iceland. This was the result of essential testing on normalities as illustrated in this study using data vectors. It is evident that the EU-27 member states are becoming greener and more energy efficient than the other two studied countries, which are endowed with energy resources and relatively low population density. The Kuznets hypothesis may also lead to a defensive solution when their respective GDPs grow to certain levels; they may start to pursue energy-efficient technologies, which may reduce their energy consumption. It is essential to mention that there is a significant reversible impact of a country's GDP at constant prices in terms of its effect on GHG emissions, as proven by the second hypothesis.

6.2. Findings

This study aimed to evaluate the effects of GDP at constant prices, GHG, employment, and inflation. Secondary data from twelve years and the econometric technique of VAR modelling were used. The macroeconomic aggregate with a significant but reversible impact on GHG emissions was found to be the lag of GDP at constant prices. Therefore, the study results indicated positive economic growth and lower GHG emissions in the EU-27 countries. The result could be interpreted as being because EU-27 countries had demonstrated sufficient movement towards zero emissions in the previous years, in line with UNSDH.

Finally, the study did not complete the hypothesis testing for Norway and Iceland. This decision was due to the Eurostat dataset's lack of GHG emissions observations. Low amounts of data lead to problems with degrees of freedom. Nevertheless, some essential illustrative findings can be noted. The EU-27 countries had growing GDP at constant prices and falling GHG emissions. The same was not true for Iceland or Norway. In addition, GDP at constant prices followed GHG emissions over the period studied, and started to fall significantly after 2019 in both Iceland and Norway. Overall, the EU-27 and EFTA-2 countries did not experience similar progress in sustainable economic development.

By comparing the nominal macro-economic data for GDP at constant prices, employment, and inflation, and reductions in GHG emissions in the three geolocations under study, Table A1 supports several findings. With the chain indices given in parenthesis, the EU-27 countries had the most success in reducing GHG emissions per capita in kilograms (kg) (78.40), followed by Norway (83.65), and Iceland (97.67). Similar trends were observed when comparing GHG emissions in tons per million euros of GDP. Norway was the leader with almost a 50% reduction in emissions (52.08), followed by the EU-27 countries (65.63). As assessed by GHG emissions, Iceland's pollution levels increased by 105.55 tons per million euros of GDP.

6.3. Limitations

Regarding the limitations of this study, it focused exclusively on the context of European integration, and there was a lack of time-series data from Eurostat datasets. Future studies could be conducted for other regional associations in different continents. In addition, this study included only a few variables, namely GDP at constant prices, inflation, GHG emissions, and employment. However, future studies should include other elements such as interest rates, industrial fees, tourism demand, or other factors (biodiversity, water quality, and local environmental pollution). An example in Appendix A shows that GHG significantly declines while tourism demand and economic growth increase.

There were limited data for the thirteen years from secondary sources other than Eurostat, which was our primary source, as presented in Appendix C. Therefore, expanding the sample timeframe could increase the robustness of the analysis. The methodology could be extended to a vector error correction model or for use with panel data.

Author Contributions: Conceptualisation, S.G. and S.B.; methodology, S.G.; software, S.G.; validation, S.G. and S.B.; formal analysis, S.G.; investigation, S.G.; resources, S.G.; data curation, S.G.; writing—original draft preparation, S.G.; writing—review and editing, S.G., S.B. and T.B.; visualisation, S.G.; supervision, S.B. and T.B.; project administration, S.G. and S.B.; funding acquisition, S.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data is in the public domain, and the relevant sources are cited in the text.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

The evolution of variables: (i) GHG, (ii) tourist arrivals, and (iii) GDP at constant prices, plotted in Figure A1. Annual data are from 2010 to 2019, obtained from Eurostat (2022) for EU-27 countries. Additional, variable (iv) is a six–month interest rate for the eurozone, which was obtained from Eurostat (2022).

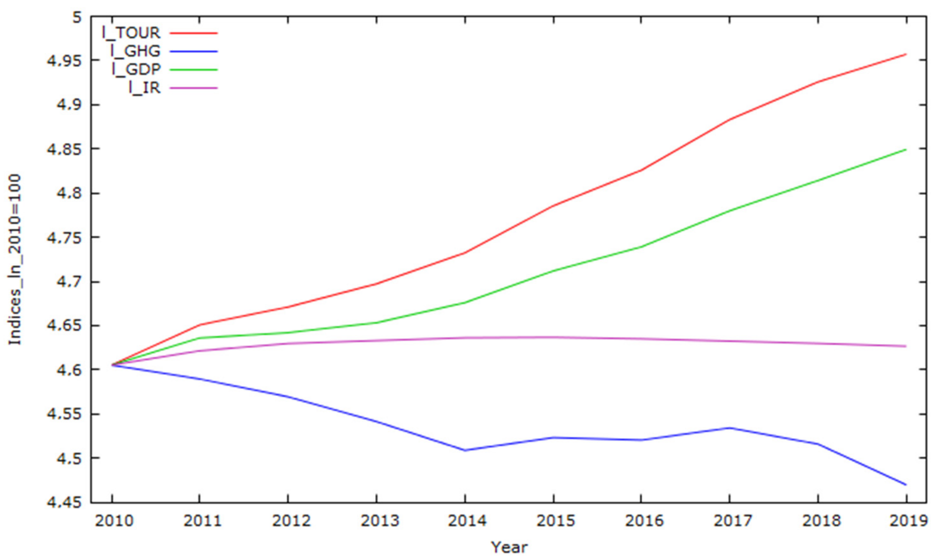


Figure A1. Evolution of factors for sustainability and economic growth. Note: GDP—gross domestic product, GHG—air emissions accounting for greenhouse gases, TOUR—tourist arrivals, IR—6-month interest rate, and ln—natural logarithm. Source: Authors' compilation based on Eurostat (2022) data.

Appendix B

Table A1. Differences in GHG emissions between analysed countries.

Geo	GHG Emissions Per Capita in kg			GHG (Tones) Per Million Euros of GDP		
Year	**2010**	**2020**	**I**	**2010**	**2020**	**I**
EU-27	8013.40	6282.23	78.40	0.32	0.21	65.63
Norway	15,538.17	12,998.43	83.65	0.48	0.25	52.08
Iceland	12,009.02	11,728.85	97.67	0.18	0.19	105.55

Note: I—chain index.

Appendix C

Table A2. Annual calculations of GHG for a prolonged period, accounting for Eurostat data availability.

Year	GHG Emissions in Tonnes		
	EU-27	**Iceland**	**Norway**
2008	3,783,845,903.93	5,421,167.59	59,116,362.76
2009	3,455,403,580.3	4,939,505.05	55,308,075.77
2010	3,534,241,525.23	4,941,776.58	58,715,115.33
2011	3,478,872,025.29	4,762,667.66	63,829,000.72
2012	3,409,615,623.74	4,914,979.34	63,329,246.75
2013	3,315,551,439.91	5,283,181.2	63,405,520.7
2014	3,209,407,796.91	5,297,447.01	62,083,589.74
2015	3,255,765,093.91	5,694,004.57	68,821,965.94
2016	3,246,862,018.79	6,383,878.96	59,860,006.97
2017	3,291,725,154.43	6,733,049.02	61,971,059.07
2018	3,232,177,718.3	6,919,991.36	65,136,534.62
2019	3,085,859,744.46	6,280,155.19	63,832,439.39
2020	2,810,332,080.55	4,763,444.99	63,095,043.42

References

Afzal, Ayesha, Ehsan Rasoulinezhad, and Zaki Malik. 2022. Green finance and sustainable development in Europe. *Economic Research-Ekonomska Istraživanja* 35: 5150–63. [CrossRef]

Akram, Vaseem, Bhushan Praveen Jangam, and Badri Narayan Rath. 2019. Does human capital matter for reduction in energy consumption in India? *International Journal of Energy Sector Management* 13: 359–76. [CrossRef]

Alghalith, Moawia. 2007. Estimation and econometric tests under price and output uncertainties. *Applied Stochastic Models in Business and Industry* 23: 531–36. [CrossRef]

Archontakis, Fragiskos, and Rocco Mosconi. 2021. Søren Johansen and Katarina Juselius: A bibliometric analysis of citations through multivariate bass models. *Econometrics* 9: 30. [CrossRef]

Arnaut, Javier, and Johanna Lidman. 2021. Environmental sustainability and economic growth in Greenland: Testing the environmental Kuznets Curve. *Sustainability* 13: 1228. [CrossRef]

Bhattacharya, Mita, Sudharshan Reddy Paramati, Ilhan Ozturk, and Sankar Bhattacharya. 2016. The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy* 162: 733–41. [CrossRef]

Baxa, Jaromír, Miroslav Plašil, and Bořek Vašíček. 2015. Changes in inflation dynamics under inflation targeting? Evidence from Central European countries. *Economic Modelling* 44: 116–30. [CrossRef]

Bilgili, Faik, and Ilhan Ozturk. 2015. Biomass energy and economic growth nexus in G7 countries: Evidence from dynamic panel data. *Renewable and Sustainable Energy Reviews* 49: 132–38. [CrossRef]

Bojnec, Štefan, and Drago Papler. 2011. Economic efficiency, energy consumption and sustainable development. *Journal of Business Economics and Management* 12: 353–74. [CrossRef]

Bowden, Bradley. 2018. Economics and modernity. In *Work, Wealth, and Postmodernism*. Cham: Palgrave Macmillan. [CrossRef]

Brooks, Chris. 2014. *Introductory Econometrics for Finance*, 3rd ed. Cambridge: Cambridge University Press.

Chiambaretto, Paul, Elodie Mayenc, Hervé Chappert, Juliane Engsig, Anne-Sophie Fernandez, and Frédéric Le Roy. 2021. Where does flygskam come from? The role of citizens' lack of knowledge of the environmental impact of air transport in explaining the development of flight shame. *Journal of Air Transport Management* 93: 102049. [CrossRef]

ConsultTech. 2022. Available online: https://www.consultech.de/en/grant-deadlines/eu-grants/?gclid=EAIaIQobChMIhZzvobTY-gIVCfZ3Ch18uwS8EAMYAiAAEgKqRfD_BwE (accessed on 9 October 2022).

Coondoo, Dipankor, and Soumyananda Dinda. 2002. Causality between income and emission: A country group-specific econometric analysis. *Ecological Economics* 40: 351–67. [CrossRef]

Cottarelli, Carlo, Mark Griffiths, and Reza Moghadam. 1998. *The Nonmonetary Determinants of Inflation: A Panel Data Study*. Washington, DC: International Monetary Fund.

Cottarelli, Carlo. 1998. *The Nonmonetary Determinants of Inflation: A Panel Data Study*. IMF Working Papers Issue 023. Washington, DC: International Monetary Fund. 29p. [CrossRef]

da Silva, Juvancir, Valdir Fernandes, Marcelo Limont, and William Bonino Rauen. 2020. Sustainable development assessment from a capitals perspective: Analytical structure and indicator selection criteria. *Journal of Environmental Management* 260: 110147. [CrossRef] [PubMed]

Dinda, Soumyananda. 2004. Environmental Kuznets curve hypothesis: A survey. *Ecological Economics* 49: 431–55. [CrossRef]

Dogan, Eyup, Sabina Hodžić, and Tanja Fatur Šikić. 2022. A way forward in reducing carbon emissions in environmentally friendly countries: The role of green growth and environmental taxes. *Economic Research-Ekonomska Istraživanja* 35: 5879–94. [CrossRef]

Dozza, Marco, Alessio Violin, and Alexander Rasch. 2022. A data-driven framework for the safe integration of micro–mobility into the transport system: Comparing bicycles and e-scooters in field trials. *Journal of Safety Research* 81: 67–77. [CrossRef]

Eurostat. 2022. Database. Available online: https://ec.europa.eu/eurostat/data/database (accessed on 28 January 2022).

Fernandes, Cristina, Pedro Mota Veiga, João Ferreira, and Mathew Hughes. 2021. Green growth versus economic growth: Do sustainable technology transfer and innovations lead to an imperfect choice? *Business Strategy and the Environment* 30: 2021–37. [CrossRef]

Galiano Bastarrica, Luis Antonio, Eva Buitrago Esquinas, María Ángeles Caraballo Pou, and Rocío Yñiguez Ovando. 2022. Environmental adjustment of the EU27 GDP: An econometric quantitative model. *Environment Systems and Decision*. *Ahead of Print*. [CrossRef]

Gedikli, Ayfer, Seyfettin Erdoğan, Emrah Ismail Çevik, Emre Çevik, Rui Alexandre Castanho, and Gualter Couto. 2022. Dynamic relationship between international tourism, economic growth and environmental pollution in the OECD countries: Evidence from panel VAR model. *Economic Research–Ekonomska Istraživanja* 35: 5907–23. [CrossRef]

Guan, Changchun, Tayyaba Rani, Zhao Yueqiang, Tahseen Ajaz, and Murat Ismet Haseki. 2022. Impact of tourism industry, globalisation, and technology innovation on ecological footprints in G–10 countries. *Economic Research-Ekonomska Istraživanja*. *Ahead of Print*. [CrossRef]

Guo, Qingke, Wang Zheng, Jinkun Shen, Taian Huang, and Kuanbin Ma. 2022. Social trust more strongly associated with well–being in individualistic societies. *Personality and Individual Differences* 188: 111451. [CrossRef]

Haavelmo, Trygve. 1943. The Statistical Implications of a System of Simultaneous Equations. *Econometrica* 11: 1–12. [CrossRef]

Hamit-Haggar, Mahamat. 2012. Greenhouse gas emissions, energy consumption and economic growth: A panel cointegration analysis from Canadian industrial sector perspective. *Energy Economics* 34: 358–64. [CrossRef]

He, Yugang, Xiang Li, Panpan Huang, and Jingnan Wang. 2022. Exploring the road toward environmental sustainability: Natural resources, renewable energy consumption, economic growth, and greenhouse gas emissions. *Sustainability* 14: 1579. [CrossRef]

Hoover, Kevin D., Soren Johansen, and Katarina Juselius. 2008. Allowing the data to speak freely: The macroeconometrics of the cointegrated vector autoregression. *American Economic Review* 98: 251–55. [CrossRef]

Hysa, Eglantina, Alba Kruja, Naqeeb Ur Rehman, and Rafael Laurenti. 2020. circular economy innovation and environmental sustainability impact on economic growth: An integrated model for sustainable development. *Sustainability* 12: 4831. [CrossRef]

Ioan, Batrancea, Rathnaswamy Malar Kumaran, Batrancea Larissa, Nichita Anca, Gaban Lucian, Fatacean Gheorghe, Tulai Horia, Bircea Ioan, and Rus Mircea-Iosif. 2020. A panel data analysis on sustainable economic growth in India, Brazil, and Romania. *Journal of Risk and Financial Management* 13: 170. [CrossRef]

Jiang, Chun, and Yaqi Chang. 2022. Clean energy projects in Asian economies: Does FDI and stock market matter for sustainable development? *Economic Research-Ekonomska Istraživanja* 35: 5843–57. [CrossRef]

Johansen, Søren, and Ørregaard Nielsen Nielsen. 2012. Likelihood inference for a fractionally cointegrated vector autoregressive model. *Econometrica* 80: 2667–732. [CrossRef]

Jun, Wen, Nafeesa Mughal, Prabjot Kaur, Zhaopeng Xing, Vipin Jain, and Phan The Cong. 2022. Achieving green environment targets in the world's top 10 emitter countries: The role of green innovations and renewable electricity production. *Economic Research-Ekonomska Istraživanja* 35: 5310–35. [CrossRef]

Juselius, Katarina. 2009. *The Cointegrated VAR Model*. Oxford: Oxfrod University Press.

Juselius, Katarina. 2021. Disequilibrium macroeconometrics. *Industrial and Corporate Change* 30: 357–76. [CrossRef]

Juselius, Katarina. 2022. A theory-consistent CVAR scenario for a monetary model with forward–looking expectations. *Econometrics* 10: 16. [CrossRef]

Köhler, Julia, Sönnich Dahl Sönnichsen, and Philip Beske-Jansen. 2022. Towards a collaboration framework for circular economy: The role of dynamic capabilities and open innovation. *Business Strategy and the Environment* 31: 2700–13. [CrossRef]

Korphaibool, Veerawin, Pattanaporn Chatjuthamard, and Sirimon Treepongkaruna. 2021. Scoring sufficiency economy philosophy through GRI standards and firm risk: A case study of Thai listed companies. *Sustainability* 13: 2321. [CrossRef]

Kousar, Shazia, Farhan Ahmed, Amber Pervaiz, and Štefan Bojnec. 2021. Food insecurity, population growth, urbanisation and water availability: The role of government stability. *Sustainability* 13: 12336. [CrossRef]

Kousar, Shazia, Muhammad Afzal, Farhan Ahmed, and Štefan Bojnec. 2022. Environmental awareness and air quality: The mediating role of environmental protective behaviors. *Sustainability* 14: 3138. [CrossRef]

Kulendran, Nada, and Stephen F. Witt. 2001. Cointegration versus least squares regression. *Annals of Tourism Research* 28: 291–311. [CrossRef]

Lai, Yat Yin, Emily Christley, Aneta Kulanovic, Chih-Chin Teng, Anna Björklund, Johan Nordensvärd, Emrah Karakaya, and Frauke Urban. 2022. Analysing the opportunities and challenges for mitigating the climate impact of aviation: A narrative review. *Renewable and Sustainable Energy Reviews* 156: 111972. [CrossRef]

Lan, Jing, Kakinaka Makoto, and Huang Xianguo. 2012. Foreign direct investment, human capital and environmental pollution in China. *Environmental and Resource Economics* 51: 255–75. [CrossRef]

Li, Xiaolong, Ilknur Ozturk, Qasim Raza Syed, Muhammad Hafeez, and Sidra Sohail. 2022. Does green environmental policy promote renewable energy consumption in BRICST? Fresh insights from panel quantile regression. *Economic Research-Ekonomska Istraživanja* 35: 5807–23. [CrossRef]

Liddle, Brantley. 2014. Impact of population, age structure, and urbanisation on carbon emissions/energy consumption: Evidence from macro-level, cross-country analyses. *Population and Environment* 35: 286–304. [CrossRef]

Liñán, Francisco, and Inmaculada Jaén. 2020. The COVID-19 pandemic and entrepreneurship: Some reflections. *International Journal of Emerging Markets* 17: 1165–74. [CrossRef]

Ma, Qiang, Zeeshan Khan, Muhammad Tariq, Hayriye IŞik, and Husam Rjoub. 2022. Sustainable digital economy and trade adjusted carbon emissions: Evidence from China's provincial data. *Economic Research–Ekonomska Istraživanja* 35: 5469–85. [CrossRef]

Niu, Muchuan, Sheng Zhang, Nannan Zhang, Zuhui Wen, Meng Xu, and Yifu Yang. 2022. Progress in the research of environmental macroeconomics. *Sustainability* 14: 1190. [CrossRef]

Oppenheim, Irwin. 1996. A survey of thermodynamics. *Journal of Statistical Physics* 83: 791–92. [CrossRef]

Pei, Yiru, Qing Pei, Harry F. Lee, Mengyuan Qiu, and Yuting Yang. 2022. Epidemics in pre–industrial Europe: Impacts of climate change, economic well–being, and population. *Anthropocene* 37: 100317. [CrossRef]

Ramakrishna, Seeram. 2021. Circular economy and sustainability pathways to build a new-modern society. *Drying Technology* 39: 711–12. [CrossRef]

Rosner, Menachem, and Nissim Cohen. 1983. Is direct democracy feasible in modern society? The lesson of the Kibbutz experience. In *The Sociology of the Kibbutz*. Edited by Ernest Krausz. New York: Routledge.

Ross, Williams. 2019. The development of econometrics in Australia: 1930–2000. *History of Economics Review* 74: 25–45. [CrossRef]

Rudd, Jeremy, and Karl Whelan. 2005. New tests of the new–Keynesian Phillips curve. *Journal of Monetary Economics* 52: 1167–81. [CrossRef]

Sadiq, Mishab, Desti Kannaiah, Ghulam Yahya Khan, Malik Shahzad Shabbir, Kanwal Bilal, and Aysha Zamir. 2022. Does sustainable environmental agenda matter? The role of globalisation toward energy consumption, economic growth, and carbon dioxide emissions in South Asian countries. *Environment, Development and Sustainability*. *Ahead of Print*. [CrossRef]

Samuelson, Paul A., and Robert M. Solow. 1960. Analytical aspects of anti–inflation policy. *The American Economic Review* 50: 177–94.

Saqib, Najia. 2022. Green energy, non–renewable energy, financial development and economic growth with carbon footprint: Heterogeneous panel evidence from cross-country. *Economic Research-Ekonomska Istraživanja* 35: 6945–64. [CrossRef]

Sareen, Siddharth, Devyn Remme, and Håvard Haarstad. 2021. E–scooter regulation: The micro–politics of market–making for micro-mobility in Bergen. *Environmental Innovation and Societal Transitions* 40: 461–73. [CrossRef]

Sarkodie, Samuel Asumadu, Samuel Adams, Phebe Asantewaa Owusu, Thomas Leirvik, and Ilhan Ozturk. 2020. Mitigating degradation and emissions in China: The role of environmental sustainability, human capital and renewable energy. *Science of The Total Environment* 719: 137530. [CrossRef] [PubMed]

Sebri, Maamar, and Ousama Ben-Salha. 2014. On the causal dynamics between economic growth, renewable energy consumption, CO2 emissions and trade openness: Fresh evidence from BRICS countries. *Renewable and Sustainable Energy Reviews* 39: 14–23. [CrossRef]

Sharma, Gagan Deep, Muhammad Ibrahim Shah, Umer Shahzad, Mansi Jain, and Ritika Chopra. 2021. Exploring the nexus between agriculture and greenhouse gas emissions in BIMSTEC region: The role of renewable energy and human capital as moderators. *Journal of Environmental Management* 297: 113316. [CrossRef]

Tu, Zhihui, Chen Feng, and Xin Zhao. 2022. Revisiting energy efficiency and energy related CO_2 emissions: Evidence from RCEP economies. *Economic Research-Ekonomska Istraživanja* 35: 5858–78. [CrossRef]

Vasylieva, Tetyana, Oleksii Lyulyov, Yuriy Bilan, and Dalia Streimikiene. 2019. Sustainable economic development and greenhouse gas emissions: The dynamic impact of renewable energy consumption, GDP, and corruption. *Energies* 12: 3289. [CrossRef]

Vieira, Leticia Canal, Mariolina Longo, and Matteo Mura. 2021. Are the European manufacturing and energy sectors on track for achieving net-zero emissions in 2050? An empirical analysis. *Energy Policy* 156: 112464. [CrossRef]

Vitunskienė, Vlada, Akvilė Aleksandravičienė, and Neringa Ramanauskė. 2022. Spatio-Temporal assessment of biomass self-sufficiency in the European Union. *Sustainability* 14: 1897. [CrossRef]

Xiao, Shijiang, Huijuan Dong, Yong Geng, and Xu Tian. 2022. Low carbon potential of urban symbiosis under different municipal solid waste sorting modes based on a system dynamic method. *Resources, Conservation and Recycling* 179: 106108. [CrossRef]

Yan, Lei, Haiyan Wang, Seyed Alireza Athari, and Faraz Atif. 2022. Driving green bond market through energy prices, gold prices and green energy stocks: Evidence from a non–linear approach. *Economic Research-Ekonomska Istraživanja* 35: 6479–99. [CrossRef]

Yao, Yao, Kris Ivanovski, John Inekwe, and Russell Smyth. 2019. Human capital and energy consumption: Evidence from OECD countries. *Energy Economics* 84: 104534. [CrossRef]

Ye, Jianhua, Ahmad Al-Fadly, Pham Quang Huy, Thanh Quang Ngo, Doan Dang Phi Hung, and Nguyen Hoang Tien. 2022. The nexus among green financial development and renewable energy: Investment in the wake of the COVID-19 pandemic. *Economic Research-Ekonomska Istraživanja* 35: 5650–75. [CrossRef]

Yu, Bolin, Debin Fang, and Feng Dong. 2020. Study on the evolution of thermal power generation and its nexus with economic growth: Evidence from EU regions. *Energy* 205: 118053. [CrossRef]

Yuan, Miao, Hele Hu, Majed Alharthi, Ishtiaq Ahmad, Qaiser Abbas, and Muhammad Taqi. 2022. Nexus between energy pricing and carbon emission. A policy mix response of developing economies. *Economic Research-Ekonomska Istraživanja* 35: 6541–57. [CrossRef]

Zhang, Junchao, and Wei Han. 2022. Carbon emission trading and equity markets in China: How liquidity is impacting carbon returns? *Economic Research-Ekonomska Istraživanja* 35: 6466–78. [CrossRef]

Zhang, Ke-Cheng, Mu-Wen Wang, Mehmet Altuntaş, and Sahar Afshan. 2022. Do energy prices, covid19, and financial uncertainty hinder the environment and social responsibility? *Economic Research-Ekonomska Istraživanja* 35: 6500–18. [CrossRef]

Zhou, Guangzhu, Hongping Li, Ilhan Ozturk, and Sana Ullah. 2022. Shocks in agricultural productivity and CO2 emissions: New environmental challenges for China in the green economy. *Economic Research-Ekonomska Istraživanja*. *Ahead of Print*. [CrossRef]