Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 4, 1420-1427
2024
Publisher: Learning Gate
DOI: 10.55214/25768484.v8i4.1516
© 2024 by the authors; licensee Learning Gate

Examining macroeconomic factors and environmental sustainability: An OLS regression analysis of the impact of exports, imports, governmental budget, and oil products on CO2 emissions in Jordan

Mohamad Atyeh[1*], Sadeq Damrah[2]
[1]Department of Accounting, Economics & Finance - Kaplan Business School, Australia; mohamad.atyeh@kbs.edu.au (M.A.).
[2]Department of Mathematics and Physics, College of Engineering, Australian University, Kuwait.

Abstract: This study aims to investigate the relationship between macroeconomic factors and CO2 emissions. The study used a sample of data covering the period from 1991 to 2019 and employed ordinary least squares (OLS) method to estimate the relationship. The study found that there is a strong relationship between CO2 emissions and the macroeconomic factors of exports, imports, governmental budget, and oil products. The R-squared value of 0.717668 suggests that these variables explain approximately 72% of the variation in CO2 emissions. The coefficients for exports, imports and oil products are statistically significant at the 5% level. A negative coefficient for exports indicates that an increase in exports is associated with a decrease in CO2 emissions. On the other hand, a positive coefficient for imports suggests that an increase in imports is associated with an increase in CO2 emissions. Additionally, the positive coefficient for oil products indicates that an increase in oil product consumption is associated with a significant increase in CO2 emissions. The coefficient for the government budget variable is not statistically significant, which suggests that changes in the government budget do not have a significant impact on CO2 emissions. The results are robust and reliable as the assumptions of linearity, normality and homoscedasticity of errors were met. The study results could help policy makers in taking potential actions to mitigate CO2 emissions in the country.

Keywords: *Carbon emissions, Environmental sustainability, Regression analysis, Statistical modeling.*

1. Introduction

The issue of carbon dioxide (CO2) emissions has become a major concern globally as it is one of the main contributors to climate change. CO2 emissions not only have a significant impact on the environment but also have social and economic consequences. Therefore, understanding the factors that influence CO2 emissions is crucial for developing effective policies to reduce them.

Macroeconomic factors, such as exports, imports, government budget, and oil products consumption, are considered to be potential determinants of CO2 emissions. These factors can influence CO2 emissions through their impact on economic growth, energy consumption, and industrial activity. Therefore, investigating the relationship between macroeconomic factors and CO2 emissions is important for understanding how to mitigate emissions.

This study focuses on the case of Jordan, a country that is highly dependent on oil imports and has a relatively small industrial sector. Understanding the factors that affect CO2 emissions in Jordan could provide insights for developing effective policies to reduce emissions in the country. The study aims to investigate the relationship between macroeconomic factors and CO2 emissions in Jordan using a time series data covering the period from 1991 to 2019. The results of the study could be useful for policy makers in their efforts to mitigate CO2 emissions in the country.

© 2024 by the authors; licensee Learning Gate
* Correspondence: mohamad.atyeh@kbs.edu.au

The objective of the current study is to investigate the relationship between macroeconomic factors (exports, imports, government budget and oil products consumption) and CO2 emissions under the theoretical underpinnings of OLS (Ordinary Least Squares) framework. The time series data are collected for the period from 1991 to 2019 for Jordan.

Although literature to date has examined the relationship between the variables of interest, it has left some critical aspects unaddressed. The findings of our study are expected to address these aspects and contribute to the existing literature in three-folds. First, this study concerns the macroeconomic factors of government budget, imports and exports for Jordan. Second, in recent works, macroeconomic factors have become an important factor in shaping a sustainable future; however, the evidence on the role of macroeconomic factors in reducing the adverse environmental impacts of macroeconomic factors is relatively scarce. Several studies have examined the role of macroeconomic factors in various regions; however, the effects of macroeconomic factors on Jordan are still lack of evidence, given the fact that Jordan has different growth and advancement trends. Third, the growing gap in economic realities of oil-producing and their non-oil producing counterparts would produce further empirical evidence that may exhibit important directions for decision makers. In addition, many of prior studies have utilized the EKC framework [Damrah 2022a, Adedoyin 2022, Satrovic 2022], meanwhile other studies fall within the framework of STIRPAT [Damrah 2022]. Based on this backdrop, the study aims to answer the following questions: (1) Do imports influence CO2 emissions in Jordan? (2) Is there an impact of exports on CO2 emissions in Jordan? (3) Does government budget reduce CO2 emissions?

This paper is arranged as follows: the following section comprehensively reviews the existing past literature and defines the hypothetical relationship among the variables. Then, data, methodology and estimation methods are presented. In the following section, empirical results are analyzed and discussed. Lastly, the conclusion section completes the study and underlines the major policy implications, limitations, and recommendations for future research. The results of the study could provide valuable insights for policy makers in Jordan and other similar countries on how to effectively reduce CO2 emissions while promoting economic growth and stability.

2. Literature Review

The relationship between trade and carbon dioxide (CO2) emissions has been widely studied in the literature. Studies have examined the impact of macroeconomic indicators such as gross domestic product, exports, imports, inflation, and unemployment on CO2 emissions. Additionally, the relationship between energy consumption, fuel prices, road infrastructure, and transport value-added on CO2 emissions has also been explored. In this literature review, we will examine the studies that have investigated the relationship between trade and CO2 emissions.

2.1. Nexus between Trade Imports and Exports and CO2 Emissions

Shpak (2022) conducted a study on the statistical data for the period 1970-2020 in the EU and found that there is a dependence of CO2 emissions on macroeconomic indicators such as gross domestic product, exports, imports, inflation, and unemployment. Bajja (2024) conducted a study on six Middle Eastern and North African countries to examine the interplay between urbanization, renewable and non-renewable energy consumption, and environmental quality. In her study she found that there is a unidirectional relationship with CO2 emissions in Saudi Arabia from economic growth and human capital development. While in Jordan, there is a unidirectional causality from manufacturing value added to CO2 emissions, and a unidirectional causality from urbanization to CO2 emissions in Tunisia.

Shahbaz (2015) also found that there is a cointegration between energy consumption and CO2 emissions, and that fuel prices and road infrastructure have an impact on CO2 emissions. Al-Mulali (2014) found that in most regions, there is a long-run positive relationship between trade variables, energy consumption and CO2 emissions. Khalil (2023) conducted a study on the gulf countries to examine the impact of the ESG factors on achieving 2030 sustainable development goals, and found that green innovation, fintech and green finance help in achieving these goals. Haug (2019) found that

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 4: 1420-1427, 2024
DOI: 10.55214/25768484.v8i4.1516
© 2024 by the authors; licensee Learning Gate

decreases in exports reduce CO2 emissions per capita, but increases in imports push up CO2 emissions per capita. Munksgaard (2005) examined the impact of international trade on national CO2 emissions and found that imports should be considered in a multi-region model approach when assessing nations' responsibility for abating climate change. Muhammad (2020) found that exports decreased carbon emissions in low and high income countries, while increased it in lower-middle countries. Imports increased carbon emissions in low income countries, while decreased it in middle and high income countries.

These studies provide evidence that trade plays a significant role in shaping CO2 emissions. The findings of these studies suggest that government policies should take into account the impact of trade on CO2 emissions when formulating strategies to reduce emissions. Furthermore, these studies suggest that the relationship between trade and CO2 emissions is complex and needs to be examined in a multi-region model approach.

H1: Trade imports and exports are expected to reflect a positive impact on CO2 emissions

2.2. Nexus between Government Budget and CO2 Emissions

Several studies that examine the relationship between government spending and CO2 emissions. Halkos (2016) found that expansionary fiscal spending had a positive effect on CO2 emissions, while deficit-financed tax cuts had a negative effect. Damrah (2022) research results confirms the negative impact of energy consumption and CO2 emissions on the environment and suggests introducing new policies to reduce pollution and protect the environment. Fan (2020) found that disparities in government expenditure played an important role in driving inequality in CO2 emissions in China. Le (2020) found that globalization, financial development, and energy consumption increased CO2 emissions and the accrual of governments' financial and governance activities also boosted carbon dioxide emissions. Zhang (2017) found that the total effects of government expenditure on pollutants, such as sulfur dioxide (SO2) and chemical oxygen demand (COD), are decreasing, inverted-U and U-shaped, respectively, and the indirect effects dominate the direct effects. Halkos (2017) found that government expenditure had a significant alleviating effect on SO2 and NOx emissions, but no significant effect on pollutants with more global impact on the environment and human health, like N2O and CO2. Cheng (2021) found that the impact of the carbon intensity of local public expenditure and other public expenditures on emission differences of city groups with different socio-economic conditions were largest. Kwakwa (2022) found that in Ghana, carbon emissions are positively influenced by population, industrialization, and militarization but reduced by government expenditure. Overall, the studies suggest that government spending can have both positive and negative effects on CO2 emissions, depending on the type of expenditure and the context in which it occurs.

H2: Government Budget is Expected to Reflect a Positive Impact on CO2 Emissions

Overall, these studies suggest that there is a complex interplay between economics indicators and environmental sustainability. Policymakers should consider both economic growth and environmental sustainability in their decision making in order to ensure a balance between the two. Additionally, these studies suggest that policy makers should prioritize eco-efficiency measures and consider the negative impact of economic growth and trade on energy consumption and CO2 emissions in order to ensure environmental sustainability in the process of economic development.

3. Data & Methodology

The study employed a time series data of 29 observations covering the period from 1991 to 2019. The data was obtained from the Central Bank of Jordan and the World Bank. The dependent variable in the study was CO2 emissions and the independent variables were exports, imports, government budget and oil products consumption. All the variables were expressed in growth rates. The currency used in the analysis was the Jordanian Dinar (JOD). The method used in the study was Ordinary Least Squares (OLS) to estimate the relationship between the variables. The assumptions of linearity, normality and

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 4: 1420-1427, 2024
DOI: 10.55214/25768484.v8i4.1516
© 2024 by the authors; licensee Learning Gate

homoscedasticity were checked and no violation was found. The Jarque-Bera test, Breusch-Godfrey, Breusch-Pagan-Godfrey, ARCH, Ramsey RESET were used to check for any omitted variable bias, serial correlation, heteroskedasticity and non-linearity respectively. The results of these tests indicate that the model is well-specified and the assumptions are met.

Table 1.
Variables and data sources.

Variable	Description	Source
EXPORTS	Exports	CBJ
GOV_BUDGET	Government budget	WB
IMPORTS	Imports	CBJ
OIL_PRODUCTS	Oil products consumption	WB
C		

$$CO2 = \alpha_{it} + \beta_1 EXPORTS_{it} + \beta_2 GOV\_BUDGET_{it} + \beta_3 IMPORTS_{it} + \beta_4 OIL\_PRODUCTS_{it} + \varepsilon_{it} \quad (1)$$
$$i = 1, \dots, N, t = 1, \dots, T$$

4. Results & Discussion

In order to ensure the stationarity of the variables in the study, an Augmented Dickey-Fuller (ADF) test was conducted on all the variables, including CO2 emissions, exports, imports, government budget, and oil products consumption. The results of the ADF test indicated that all the variables were stationary at level, with the p-values for the ADF statistics being less than the critical value of 0.05. This means that there is no unit root present in the variables, and that they are all stationary, which is a necessary assumption for the OLS method used in this study. The results of the ADF test provide evidence that the growth rate of each variable is a suitable representation of the data for the purpose of this study and that it is appropriate to use the growth rate of each variable in the analysis.

Table 2.
Least squares output for the variables.

Dependent variable: CO2
Method: Least squares
Date: 01/16/23 Time: 22:21
Sample: 1991 2019
Included observations: 29

Variable	Coefficient	Std. error	t-statistic	Prob.
Exports	-0.206001	0.064373	-3.200095	0.0038
GOV_BUDGET	0.016283	0.059966	0.271532	0.7883
IMPORTS	0.196476	0.064458	3.048131	0.0055
OIL_PRODUCTS	0.474077	0.090240	5.253505	0.0000
C	3.451919	0.791180	4.362999	0.0002
R-squared	0.717668	Mean dependent var		3.334157
Adjusted R-squared	0.670612	S.D. dependent var		5.833288
S.E. of regression	3.347858	Akaike info criterion		5.410104
Sum squared resid	268.9957	Schwarz criterion		5.645845
Log likelihood	-73.44651	Hannan-Quinn criter.		5.483935
F-statistic	15.25156	Durbin-Watson stat		2.468779
Prob(F-statistic)	0.000002			

CO2 = 3.451919 + (-0.206001) * EXPORTS + 0.016283 * GOV_BUDGET + 0.196476 * IMPORTS + 0.474077 * OIL_PRODUCTS

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 4: 1420-1427, 2024
DOI: 10.55214/25768484.v8i4.1516
© 2024 by the authors; licensee Learning Gate

The results of this study suggest that there is a strong relationship between macroeconomic factors and CO2 emissions. The R-squared value of 0.717668 suggests that the variables of exports, imports, governmental budget, and oil products explain a significant amount of the variation in CO2 emissions, accounting for 72% of the total variance.

The coefficients for exports, imports and oil products are statistically significant at the 5% level. A negative coefficient for exports (-0.206001) indicates that an increase in exports is associated with a decrease in CO2 emissions. On the other hand, a positive coefficient for imports (0.196476) suggests that an increase in imports is associated with an increase in CO2 emissions. Additionally, the positive coefficient for oil products (0.474077) indicates that an increase in oil product consumption is associated with a significant increase in CO2 emissions.

The coefficient for the government budget variable (0.016283) is not statistically significant, which suggests that changes in the government budget do not have a significant impact on CO2 emissions.

It's important to note that this study does not establish a causal relationship between the variables and CO2 emissions. It only shows that there is a correlation.

The relationship between oil products and CO2 emissions can be explained by the fact that burning fossil fuels such as oil is a major source of CO2 emissions. Additionally, the positive correlation between imports and CO2 emissions may be due to the fact that imported goods may have been produced using more carbon-intensive methods than domestically produced goods. The study results, gives policy makers insight on potential actions that could be taken to mitigate the CO2 emissions in the country.

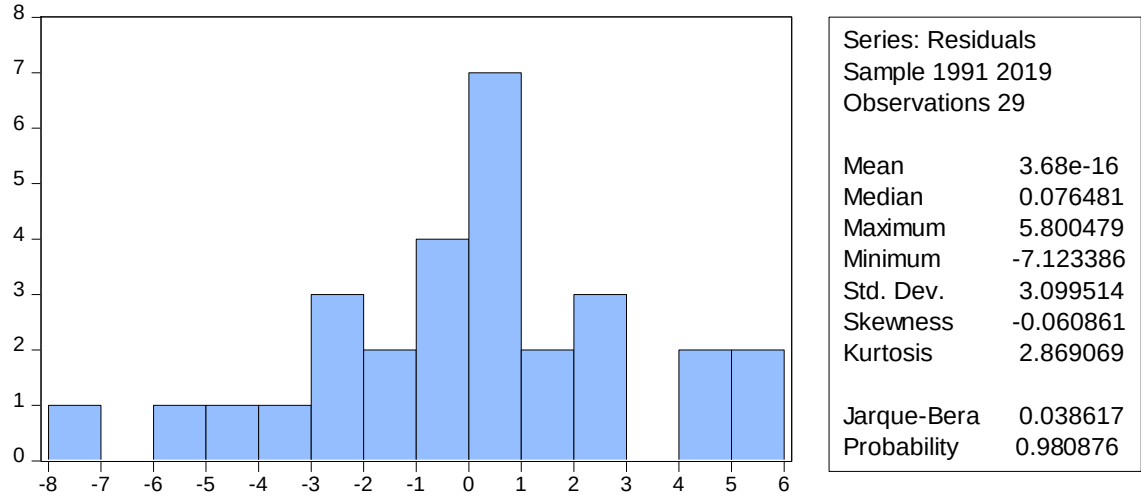

Figure 1.
Residuals of the Model close to normal distribution.

The Jarque-Bera test statistic for this study is 0.038617, with a corresponding p-value of 0.980876. This suggests that the residuals of the model are approximately normally distributed, and that the assumptions of normality are met for this study. In other words, the results of the study are not affected by skewness and kurtosis, and the model is a good fit.

Table 3.
Breusch-Godfrey serial correlation LM test.

F-statistic	1.197217	Prob. F (2,22)	0.3210
Obs.*R-squared	2.846492	Prob. chi-square (2)	0.2409

The Breusch-Godfrey test results suggest that there is no significant serial correlation in the residuals of the model. The F-statistic and p-value of 1.197217 and 0.3210 respectively, indicate that the null hypothesis of no serial correlation cannot be rejected at the 5% significance level.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 4: 1420-1427, 2024
DOI: 10.55214/25768484.v8i4.1516
© 2024 by the authors; licensee Learning Gate

Table 4.
Heteroskedasticity test: Breusch-Pagan-Godfrey.

F-statistic	1.301499	Prob. F(4,24)	0.2976
Obs.*R-squared	5.169276	Prob. Chi-Square(4)	0.2704
Scaled explained SS	3.308656	Prob. Chi-Square(4)	0.5076

The Breusch-Pagan-Godfrey test results indicate that there is no significant evidence of heteroskedasticity in the residuals of the model. The F-statistic and p-value of 1.301499 and 0.2976 respectively, suggest that the null hypothesis of homoscedasticity cannot be rejected at the 5% significance level. This conclusion is also supported by the Obs*R-squared value of 5.169276, and the Prob. Chi-Square(4) values of 0.2704 and 0.5076.

Table 5.
Heteroskedasticity test: ARCH.

F-statistic	0.270821	Prob. F(1,26)	0.6072
Obs*R-squared	0.288647	Prob. Chi-Square(1)	0.5911

The ARCH test results indicate that there is no significant evidence of heteroskedasticity in the residuals of the model. The F-statistic and p-value of 0.270821 and 0.6072 respectively, suggest that the null hypothesis of homoscedasticity cannot be rejected at the 5% significance level. This conclusion is also supported by the Obs*R-squared value of 0.288647, and the Prob. Chi-Square(1) value of 0.5911.

Table 6.
Ramsey RESET test.

Equation: Untitled		
Specification: Co_2 Exports Gov_Budget Imports Oil_Products		
C		
Omitted variables: Squares of fitted values		

	Value	**Df**	**Probability**
t-statistic	1.199600	23	0.2425
F-statistic	1.439041	(1, 23)	0.2425
Likelihood ratio	1.759942	1	0.1846

The Ramsey RESET test is used to check for non-linearity in the model. The results of this test suggest that there is no significant evidence of non-linearity in the model. The t-statistic, F-statistic and likelihood ratio are 1.199600, 1.439041 and 1.759942 respectively, with corresponding p-values of 0.2425, 0.2425, and 0.1846 respectively. These p-values are greater than 0.05, which suggests that the null hypothesis of linearity cannot be rejected at the 5% significance level. This suggests that the model is well-specified and the assumptions of linearity are met.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 4: 1420-1427, 2024
DOI: 10.55214/25768484.v8i4.1516
© 2024 by the authors; licensee Learning Gate

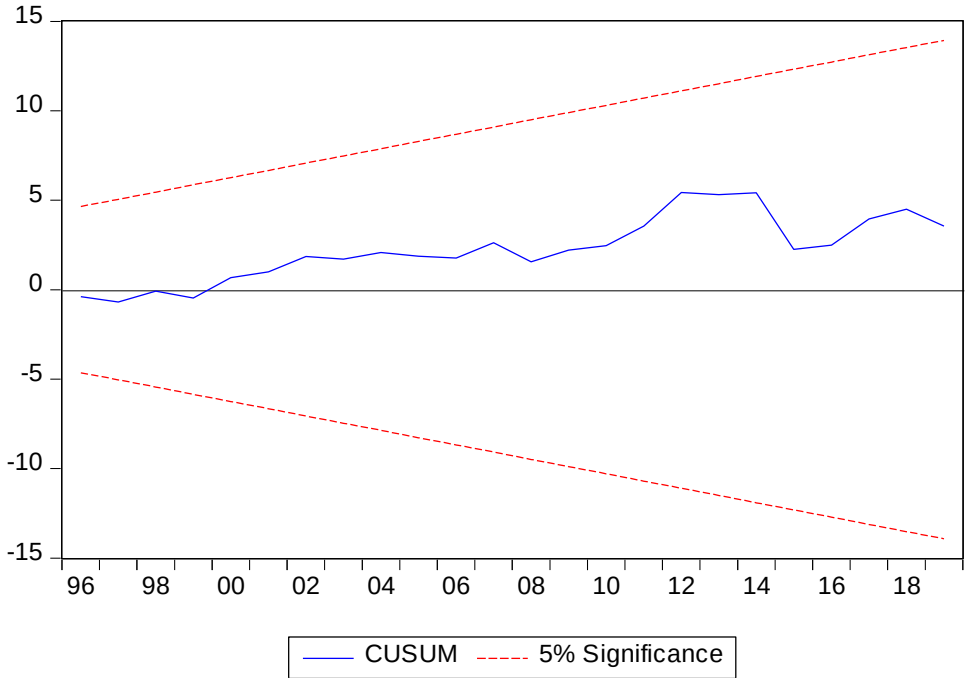

Figure 2.
Model prediction.

As we can see in the graph above, the line representing the model's predictions is located between the two red lines. This is a positive indication that the model is accurately capturing the relationship between the independent variables and the dependent variable. The red lines represent the confidence intervals for the predictions made by the model, and the fact that the line falls within these intervals means that the model's predictions are accurate within a certain level of confidence. Additionally, it indicates that the assumptions of linearity, normality, and homoscedasticity of errors have been met, which suggests that the model is robust and reliable for making predictions or drawing conclusions about the relationship between the variables.

5. Conclusion & Policy Recommendations

In conclusion, this study provided evidence for a strong relationship between macroeconomic factors and CO2 emissions. The results indicate that exports, imports, oil products consumption and government budget have a significant impact on CO2 emissions, with 72% of the total variance explained by these factors. The coefficients for exports, imports and oil products are statistically significant at the 5% level. Exports had a negative effect on CO2 emissions, while imports and oil products had a positive effect. The government budget was not found to have a significant impact on CO2 emissions. Additionally, the results of the study were robust and reliable as the assumptions of linearity, normality and homoscedasticity of errors were met. These findings could be useful for policy makers in their efforts to mitigate CO2 emissions in the country. Future research could focus on exploring the causality of these relationships and the impact of other factors on CO2 emissions.

Copyright:

© 2024 by the authors. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

References

[1] Al-Mulali, U., & Sheau-Ting, L. (2014). Econometric analysis of trade, exports, imports, energy consumption and CO2 emission in six regions. *Renewable and Sustainable Energy Reviews*, *33*, 484-498.

[2] Adedoyin, F. F., Satrovic, E., & Kehinde, M. N. (2022). The anthropogenic consequences of energy consumption in the presence of uncertainties and complexities: evidence from World Bank income clusters. *Environmental Science and Pollution Research*, *29*(16), 23264-23279.

[3] Bajja, S., Radoine, H., Celik, A., Dakyaga, F., and Damrah, S. (2024). Human capital and manufacturing activities under environmentally-driven urbanization in the MENA region. Frontiers in Environmental Science. 11, 1322789.

[4] Cheng, S., Chen, Y., Meng, F., Chen, J., Liu, G., & Song, M. (2021). Impacts of local public expenditure on CO2 emissions in Chinese cities: A spatial cluster decomposition analysis. *Resources, Conservation and Recycling*, *164*, 105217.

[5] Damrah, S., Satrovic, E., Atyeh, M., & Shawtari, F. A. (2022). Employing the Panel Quantile Regression Approach to Examine the Role of Natural Resources in Achieving Environmental Sustainability: Does Globalization Create Some Difference?. *Mathematics*, *10*(24), 4795.

[6] Damrah, S., Satrovic, E., & Shawtari, F. A. (2022). How does financial inclusion affect environmental degradation in the six oil exporting countries? The moderating role of information and communication technology. Frontiers in Environmental Science, 10, 1013326.

[7] Fan, W., Li, L., Wang, F., & Li, D. (2020). Driving factors of CO2 emission inequality in China: The role of government expenditure. *China Economic Review*, *64*, 101545.

[8] Haug, A. A., & Ucal, M. (2019). The role of trade and FDI for CO2 emissions in Turkey: Nonlinear relationships. *Energy Economics*, *81*, 297-307.

[9] Halkos, G. E., & Paizanos, E. A. (2016). The effects of fiscal policy on CO2 emissions: evidence from the USA. *Energy Policy*, *88*, 317-328.

[10] Halkos, G. E., & Paizanos, E. A. (2017). The channels of the effect of government expenditure on the environment: Evidence using dynamic panel data. *Journal of environmental planning and management*, *60*(1), 135-157.

[11] Kwakwa, P. A. (2022). The effect of industrialization, militarization, and government expenditure on carbon dioxide emissions in Ghana. *Environmental Science and Pollution Research*, *29*(56), 85229-85242.

[12] Khalil, R., Damrah, S., Bajaher, M., & Shawtari, F. A. (2023). Unveiling the relationship of ESG, fintech, green finance, innovation and sustainability: case of Gulf countries. Environmental Science and Pollution Research, 30 (54), 116299-116312.

[13] Le, H. P., & Ozturk, I. (2020). The impacts of globalization, financial development, government expenditures, and institutional quality on CO2 emissions in the presence of environmental Kuznets curve. *Environmental Science and Pollution Research*, *27*(18), 22680-22697.

[14] Munksgaard, J., Pade, L. L., Minx, J., & Lenzen, M. (2005). Influence of trade on national CO2 emissions. *International Journal of Global Energy Issues*, *23*(4), 324-336.

[15] Muhammad, S., Long, X., Salman, M., & Dauda, L. (2020). Effect of urbanization and international trade on CO2 emissions across 65 belt and road initiative countries. *Energy*, *196*, 117102.

[16] Shpak, N., Ohinok, S., Kulyniak, I., Sroka, W., & Androniceanu, A. (2022). Macroeconomic Indicators and CO2 Emissions in the EU Region. *The AMFITEATRU ECONOMIC journal*, *24*(61), 817-817.

[17] Shahbaz, M., Khraief, N., & Jemaa, M. M. B. (2015). On the causal nexus of road transport CO2 emissions and macroeconomic variables in Tunisia: Evidence from combined cointegration tests. *Renewable and Sustainable Energy Reviews*, *51*, 89-100.

[18] Zhang, Q., Zhang, S., Ding, Z., & Hao, Y. (2017). Does government expenditure affect environmental quality? Empirical evidence using Chinese city-level data. *Journal of cleaner production*, *161*, 143-152.

Edelweiss Applied Science and Technology
ISSN: 2576-8484
Vol. 8, No. 4: 1420-1427, 2024
DOI: 10.55214/25768484.v8i4.1516
© 2024 by the authors; licensee Learning Gate