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THE NEW AGE FOR THE DYNAMICS OF LOW-CARBON TRANSITIONS IN MENA COUNTRIES: THE NOVEL EVIDENCE OF GREEN TECHNOLOGY INNOVATION, RENEWABLE ENERGY, AND GREEN GROWTH

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Abstract

Improvements in green technology, renewable energy, and green growth are anticipated to usher in a new era in the dynamics of the transition to low-carbon. However, the role of these dynamics in MENA countries that incorporate clean energy top places as the strategic initiative has not yet been explored in the literature. Unlike many previous studies to identify determinants of environmental degradation in MENA countries, the present research extends the existing literature by discovering the effectiveness of green innovation, renewable energy, and green growth in this disruption. The aim of current analysis is to put to the proof the effect of green technology innovation, renewable energy and green growth on CO_2 emissions of 13 MENA countries, based on the period 2010-2018. The panel data results of estimated Driscoll-Kraay robust standard estimator show that the effects of green technology and renewable energy on CO_2 emissions are negative and statistically significant. Also, green growth has a positive and significant effect on emissions. The results of the paper are important in terms of addressing the effects of the relevant variables for the first time in the MENA countries.

Keywords: *Green Technology, Renewable energy, Green Growth, Panel Regression*

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1. INTRODUCTION

Globally, environmental challenges and the accompanying climate crisis have been exposing their impact in ever-growing detail. Climate-disrupting activities, both human- and economic-induced, accelerate this process, making it even more essential. On the contrary, the mindful harmony of these two sources may trigger a rapid and permanent decarbonization process. The rapidly advancing climate crisis makes itself felt by increasing weather temperatures, droughts, fires, water-food crisis, decreasing rains, and flood disasters. With ongoing climate-disrupting activities, it is very probable that the intensity and frequency of such natural disasters are to worsen. However, rising early deaths, healthcare costs, and job losses are among the other future social and economic costs of these climate-disrupting activities.

Along with all changing dynamics, last year's Russia-Ukraine war has highlighted the dimensions of the world's energy crisis and brought countries' dependence on energy supply to a turning point. The war also economically underlined the importance of energy prices in terms of global inflation. While challenges and solutions are common in this regard, large differences in practices exist among countries. Although many countries have started to switch to green energy and renewable energy as alternative energy sources, these breakthroughs are still not enough to meet the global energy needs (Sharif et al., 2023). Green technology innovations, frequently passed as greentech, green growth policies, and a smooth transition from non-renewable to renewable energy have been seen as among the leading components of new climate change solutions that can be seen as the clef to unravel the alarming environmental disaster. According to the International Energy Agency (IEA), the biggest harbinger of this transition is the entering of the world into a new age of clean technology manufacturing (IEA, 2023).

The Middle East and North Africa (MENA), a highly diverse region both economically and politically, has one of the world's most abundant fields of energy. Because of its well-endowed reserves of natural gas and crude oil, the region plays a strategic role as a cornerstone of global trade and a major exporter of energy. On the other hand, globally, the MENA is one of the vital regions maintaining produce the highest per-capita CO_2. Moreover, the oil and gas-opulent region confronts a strong need to diversify its greener energy sources in order to satisfy the rising local demand for electricity, tackle the increasing CO_2 emissions, and foster economic growth just like any other nation. Whereas the region has two crucial regional climatic superiority arguments to support renewable energy attempts, primarily solar and wind energy, nowadays renewable energy sources have performed poorly in addressing the region's expanding energy demand.

The countries in the MENA, which manage to incorporate clean energy top places as the strategic initiative, took important ventures to push forward their climate change scenario in this parallel. Shifting to low-emissions solutions such as hydrogen strategies, solar and wind power, natural gas reserves for blue hydrogen, and seawater has become a climacteric task for the region to sustain innovative and ambitious renewable energy strategies. Also, with healthy regional coordination, the adoption of greentech, and green growth coordinated with the utilization of rising renewable energy sources are becoming more and more vital to acquire a long-term goal of decarbonization as a result of this escalating necessity.

Given current global advancements, a number of obstacles still prevent the widespread sprawl of green energy in the MENA region and globally (Awijen et al., 2022). The region does not appear to have made as big of a difference as it could in the energy transition yet. So, future projections reveal that the main source of energy for the region still depends heavily on fossil fuels by 2050 (DNV, 2022). The good thing is that in the process, countries in the region have been able to adapt green technologies such as vertical farming, carbon capture and storage, green buildings, electric vehicles, algae biofuel, waste electricity generators, and plastic roads to take this decarbonization transition to the next level. Having a tremendous opportunity waiting to be explored by green technologies is another important long-term advantage of the decarbonization strategy in the MENA region.

For economies navigating a fertile transition to clean-environment requirements parallel with the Sustainable Development Goals (SDGs), green growth is another paramount strategiy of green dynamics. Therefore, meticulous planning of every stage of green growth for lower and more efficient energy consumption plays a supreme role in the transition to a net-zero economy. In fact, green growth supported by GTI can greatly support the efficient production of energy while minimizing carbon emissions (Yikun et al., 2022). At this stage, it seems quite possible that the accelerated GTI provides a double benefit in the transition to a net-zero economy. Countries in MENA are willing to allocate green resources such as technological innovation and clean energy to this region to maximize green growth and take advantage of abundant and cost-effective renewable energy sources due to the two significant regional benefits described above. Therefore, meticulous planning of every stage of green growth for lower and more efficient consumption of energy acts a supreme role in rapid decarbonization.

Despite the rising body of research on the factors that affect CO_2 in MENA nations, the studies on these countries do not provide enough proof of the relationship between GTI, GGR, and carbon quality (Kahia et al., 2019; Jalil, 2014; Awijen et al., 2022; Belaid et al., 2021; Razi and Dincer, 2022). Futher, many indicators such as patent and trademark applications, the number of research studies, technical cooperation grants, and R&D expenditure by governments have been used to represent technology innovation in the literature. However, although these indicators pertain to technological innovation, they are not specific to environmental innovation This could not reflect technological advancement in technology pertaining to the environment. (Adebayo and Kirikkaleli, 2021; Sinha et al., 2020; Bilal et al., 2021).

This analysis is contributing to the existing literature in the following ways: First, the literature presented above exposes a vast gap in the body of knowledge on greentech, green growth, and renewable energy in the MENA region, which is also of tremendous value to low-carbon transition dynamics. We concentrate on the MENA region because of its ongoing fundamental efforts for green transition and green technology leaps, as well as its strategic role in the energy supply. Therefore, this paper try to fill the gap in the literature by simultaneously investigating the effects of GTI, REN, and GGR variables on carbon emissions for MENA countries. Secondly, As mentioned above, green patent data has not been used to represent greentech. Therefore, this analysis aims to contribute to the literature by including green patent data for MENA countries in the analysis. According to the author's knowledge, green growth data is an extremely rare dataset for MENA countries. In addition, despite the data limitations, the goal was to include as many MENA countries as possible in the analysis.

Given the above discussion, the core grail of the prevailing research study is to examine the effect of GTI, REN, and GGR on CO_2 emissions by using the Driscoll-Kraay robust standard estimators for the case of 13 MENA countries over the period 2010–2018.

The current study is organized under the following headings: literature, methodology and data. After the results section, we handle the conclusion part in the study's last section.

2. LITERATURE

With growing global climate concerns, the discovery of low-carbon transition dynamics has been substituted as much more than just a prominent research area in recent years. Some fresh papers highlighted the significance of greentech (GTI), green growth (GGR), and the role of renewable energy (REN) as the key to mitigating CO_2 emissions. Over time, it can be said that three major literature trends have emerged about these dynamics. While a minority of these studies addressed GTI and REN, and GTI and GGR together, the majority focused on REN. However, studies dealing with GTI and GGR together are still in their infancy and open the door to a very important research topic for the literature. Few research have focused on the impact of GTI and GGR both together and separately (Guo et al., 2021; Zhang et al., 2022; Razzaq et al., 2023; Abid et al., 2022; Yu et al., 2022; Razzaq et al., 2021; Afshan et al., 2022; Sun et al., 2021; Yunzhao, 2022; Cao, 2022; Irfan et al., 2022; Chien et al., 2021a; Xia, 2022; Zhang et al., 2022; Du et al., 2019; Santra, 2017; Suki et al., 2022a; Köseoğlu et al., 2022; Oguzturk and Özbay, 2022) on environmental degradation, but the number of studies, in growing literature, has not yet reached a sufficient level.

The paper exerted by Shan et al. (2021) on the cointegration relationship between GTI, REN, and CO_2 reveals the reducing effects of GTI and REN on CO_2 in Turkey. For the N-11 economies, the negative long-term effects of GTI and REN on CO_2 emissions are proved by the paper of Shao et al., (2021). Also, empirical evidence shows that the impact of GTI on CO_2 emissions in the short-term is insignificant. In the case of Malaysia, in their recent paper, Suki et al., (2022b) show that, both in the short and long terms, GTI has a positive and negative association with growth and CO_2 emissions, respectively. For G10 economies, Jian and Afshan (2022) reported that both the long-term and short-term results confirm that GTI promotes carbon neutrality. Using load capacity factor as a new proxy for Brazil, Kirikkaleli and Adebayo (2023) exhibit that there exists a time-varying feedback causality between political risk, GTI, green financing, economic growth, social globalization, and environmental quality. The empirical results in the paper of Sharif et al., (2022) demonstrate that both GTI and green financing have a negative and significant impact on CO_2 emissions in the context of G7 countries. In another paper for 57 developing countries, Wang et al., (2022) report the presence of cointegration relationships among GTI, green financing and environmental performance.

Another result for G7 countries, in Hao et al., (2021)'s paper, demonstrated the reducing effects of GGR and REN on CO_2 emissions. One of the research that addresses both GTI and GGR simultaneously is that of Yikun et al., (2022). They proved the encouragement of GTI and GGR for environmental sustainability in the long-term for G7 economies. The newest results of Chien et al., (2021b) for US economy exhibited that there are significant and negative effects of GGR, GGR^2, GTI, and environmental taxes on determining CO_2 emissions.

As evidenced by the above studies, the studies for MENA countries are lacking in sufficient evidence on the relationship between GTI, GGR, and carbon quality. Despite the growing literature especially for the MENA countries (Issa and Jabbouri, 2022; Gorus and Aydin, 2019; Taghvaee et al., 2022; Kahia et al., 2017; Yilanci and Gorus, 2020), there is a huge lack of evidence on the effects of GTI, GGR and REN on CO_2 emission. Because so little is discovered about the MENA region, the aim of this study is to provide evidence for the mentioned dynamics for MENA countries.

3. METHODOLOGY AND DATA

This paper employs panel regression analysis for 13 MENA (Algeria, Egypt, Jordan, Iran, Israel, Lebanon, Malta, Morocco, Qatar, Saudi Arabia, Tunisia, United Arab Emirates, and Turkey) countries in which the selection is based on data availability. The panel annual data set shrouds a time span of 2010–2018. The description of variables used in the analysis is summarized in Table 1.

Variables	**Definitions**	**Sources**
CO_2	Carbon emissions (metric tons per capita)	World Bank
GTI	Green technology innovations (the number of patent applications in technologies related to environment)	OECD database
REN	Renewable energy (% of primary energy supply)	OECD database
GGR	Green growth (production-based CO2 emissions, tonnes, millions)	OECD database

The most determining factor in the selection of countries and periods was the accessibility of the data. Following Du et al., (2019), Sharif et al., (2023), Ali et al., (2022), the number of patent applications in technologies related to environment is used as the proxy of GTI. For proxy of GGR, the paper of Wei et al., (2023) is followed. Since the time series of GTI is quite fresh for some countries such as Qatar in MENA region, it restricted the sample size and the time period of the examination. Given the availability of data, it is crucial to note that this study encompasses the greatest number of countries, with the longest period for the variables evaluated. The sample of the MENA region is one of these examples.

In order to establish the impacts of GTI, REN and GGR on CO_2 emissions, we estimate the following model in Equation (1) and (2) (Wei et al., (2023).

$$LCO_2 = f(LGTI, LREN, LGGR) \tag{1}$$

$$LCO_{2_{it}} = \beta_i + \alpha\, LGTI_{it} + \delta LREN_{it} + \theta LGGR_{it} + \varepsilon_{it} \tag{2}$$

in Equation (2), the term, i, denotes the countries, whereas the term, t, shows the period taken for the analysis. Also, β_i shows the constant term of the countries, α, δ ve θ indicate the coefficients to be estimated. ε_{it} stands for the error term. L stands for variables with measured by natural logarithms. Both green technological innovations and green growth are also expected to be crucial for lowering CO_2 emissions and raising environmental standards (Acemoglu et al., 2016; Saleem et al., 2022).

At the beginning of the panel data analysis, determining whether the model (2) would be estimated with a one-way model with only unit effects or only time effects, or with a two-way model where unit and time effects were present at the same time is important (Karış and Tandoğan, 2019; Kaynak et al., 2021; Erdem et al., 2019). Another important process that follows the identification of these models is to determine whether the effects are constant or random. Therefore, these tests are generally considered as a three-stage process. Firstly, homogeneity tests including F-test are performed to decide between Common effects (pooled, CE) and Fixed effects (FE) models. Secondly, Breusch-Pagan Lagrange Multiplier (LM) and the likelihood ratio (LR) type tests are used to choose between CE and Random Effects (RE) models. Finally, the Hausman test is used to choose between FE and RE models (Gujarati ve Porter, 2012; Çınar, 2021). In addition, the assumption of cross-sectional dependence in panel regression analysis was examined with the Pesaran (2004) test. The existence of the heteroskedasticity problem in the estimation regression equation was tested using the Modified Wald statistic, and also the fact of the autocorrelation problem was determined using the Baltagi-Wu LBI statistic. Finally, a robust estimator approach of Driscoll-Kraay standard errors suggested by Driscoll and Kraay (1998) was adopted for the estimation regression equation because of the exhibiting the existence of the problems determined in the regression estimation equation (Yamak et al., 2016).

Table 2 holds forth the statistical details of the variables. The details of descriptive statistics show that LCO_2 takes a mean value of 8.798 ranging from a minimum value of 1.594 to a maximum value of 39.398. While the lowest mean value belongs to LREN with 3.782, the highest one is 161.55 for LGGR. The lowest standard deviation value is seen for LREN, which is 4.063, while the highest one is obtained 174.75 for LGGR.

Table 2. Descriptive Statistics of Variables

Variables	Mean	Standart Deviation	Minimum	Maximum	Observation
LCO_2	8.798	9.506	1.594	39.398	117
LGTI	35.926	66.865	0.200	280.72	117
LREN	3.782	4.063	0.004	13.253	117
LGGR	161.55	174.75	1.350	586.23	117

4. RESULTS

In this study, Equation (2), which was developed to determine the effects of LGTI, LREN and LGGT on LCO_2 emissions, was estimated by panel regression analysis. The test results for the mentioned three-stage process are shown in Table 3. As seen in Table 3, the findings from both the F-test and the LR test statistic (523.26 and 396.19, respectively) have shown that unit and time effects are present in the estimation regression model. But the statistical values (0.06 and 0.00, respectively) of two tests for determining whether individual effects, only the existence of unit effects, or only the existence of time effects, exhibit that there is no time effect in the regression model. According to these results, it is determined that the estimation regression model contains only the unit effects. In the one-way regression model in which the presence of unit effects is detected, Hausman test was used to determine whether these effects were fixed or random and this test's statistical value was obtained as 23.78. This result demonstrates that H_0 hypothesis is rejected at 1% level of significance. The Hausman test statistic disclosed that the most suitable model to estimate is the unit-effect FE model.

Table 3. The Determination Results of Panel Regression Estimator for Equation (2)

Tests	Statistics	H_0 Hypothesis	Results
F_{unit} FE	477.70^{***}	No unit effect	Unit-effect FE
F_{time} FE	0.06	No time effect	Unit-effect FE
$F_{unit-time}$ FE	523.26^{***}	No unit and/or time effect	Unit-time Effect FE
LM_{unit} REM	365.22^{***}	No time effect	Unit-effect RE
LM_{time} REM	0.00	No unit effect	CE

$LM_{unit-time}$ REM	396.19***	No unit and/or time effect	Unit-time Effect RE
Hausman	23.78***	RE	FEM

Note: ***, p<0,01.

Table 4 show the diagnostic test statistics of Pesaran, Modified Wald and Baltagi Wu LBI for cross-sectional dependence, heteroskedasticity and autocorrelation problems, respectively. The value of the Pesaran test statistic was calculated as 4.694 in the regression equation in which the cross-sectional dependence was examined for the one-way fixed effects model, and this result verified the subsistence of a strong correlation at the 1% significance level. Modified Wald and Baltagi Wu LBI test statistics calculated to detect the heteroskedasticity and autocorrelation problems in the model were 9838.75 and 0.683, respectively. Obtained statistics confirm that there is both heteroskedasticity and autocorrelation problem in the model.

Table 4. Diagnostic Test Results

Assumption tested	Test used	Test Statistics
Cross-Sectional Dependence	Pesaran CD LM	4.694***
Heteroskedasticity	Modified Wald	9838.75***
Autocorrelation	Baltagi Wu LBI	0.683

Since the econometric problems detected in the previous stage are detected in the relevant estimation regression model, using approaches that reveal robust estimators may provide more reliable results. For this purpose, the fixed effect regression equation was estimated by the Driscoll-Kraay robust estimator in the study and the estimation results are presented in Table 5.

Tablo 5. Results of Driscoll-Kraay Robust Estimator

LCO_2	Coefficient	Driscoll/Kraay Standard Errors	t	P>|t|
LGTI	-0.019	0.0100	-1.97	0.072
LREN	-0.090	0.0257	-3.51	0.004
LGGR	0.569	0.0529	10.76	0.000
Constant	-0.679	0.2487	-2.73	0.018
R^2 = 0.90	F-stat = 94.27***	Number of observation =117	Number of groups= 13	

The calculated F-statistic for the regression equation estimated under fixed effects is statistically significant at the 1% level. Furthermore, the value of R^2 is 0.90. The estimated coefficient of LGTI is negative and statistically significant at 10% level. Green tecnology innovation negatively affects carbon dioxide emissions. The results indicate that a 1% rise in green tecnology innovation results in a 0.019% decrease in environmental degradation. Moreover, it can be said that green innovation significantly ameliorates the environment's quality in MENA countries. LREN affected LCO_2 negatively at 1% level of statistical significance. Likewise, a 1% increase in LREN leads to a decrease in environmental degradation by 0.090%. Although the effect sizes of LGTI and LREN seem relatively small, it can be said that these dynamics have started to contribute positively to the decarbonization process in MENA countries. Empirical findings from current paper for LGTI and LREN support the results of Shan et al. (2021), Jian and Afshan (2022). Green growth has a statistically significant and effective role on LCO_2. But this effect is positive contrary to expectations. A 1% change rises in LGGR results in a 0.569% increase in environmental degradation. As growth in green increases, environmental degradation increases. This result does not support that of Hao et al., (2021), Chien et al., (2021b).

5. CONCLUSION

The increasing economic activities of countries in the industrialization period, particularly since the Industrial Revolution, have significantly contributed to air pollution and climate change. In this regard, global product demand is increasing on the one hand, while environmental degradation and environmental threats are increasing on the other. As environmental degradation and threats worsen, green technology innovations, green growth, and the use of renewable energy sources appear to be the best way to mitigate the negative effects of environmental degradation.

New climate change solutions that can be seen as the clef to unravel the alarming environmental disaster have been seen to include green technology innovations, green growth policies, and transition from non-renewable to renewable energy. Recent studies have brought attention to the phenomenon of green growth, which is defined as producing goods and services with the fewest amount of emissions possible. This is done by implementing environmentally friendly technologies that transform the current supply chain and result in comparatively cleaner production. Improved operational effectiveness and productivity are among the green technology innovations, which are complemented by the use of renewable energy.

This research examines the effect of green technology innovation, renewable energy and green growth on CO_2 emissions of 13 MENA countries using a panel data set over the period 2010-2018. Because of data availability, this time period was chosen. The estimated Driscoll-Kraay robust standard estimator panel data results show that the effects of green technology and renewable energy on CO_2 emissions are negative and statistically significant. Green growth also has a positive and significant impact on emissions.

Green innovation and renewable energy significantly ameliorates the environment's quality in MENA countries. The finding for green technology innovation is consistent with the paper of Jian and Afshan (2022), Wei et al., (2023), but this study's results for green growth does not show parallelism with the results obtained in the study of Chien et al., (2021b), Hao et al., (2021). CO_2 emissions from production still have negative impacts on environmental degradation in the MENA region. This effect may be due to the fact that green growth encourages economic development and financial growth. Green growth, like green innovation and renewable energy, is a vital tool in reaching decarbonization, and also SDGs goals. Therefore, it is essential for this region to use dynamics that have the effect of reducing carbon emissions level while planning simultaneous policy practices that support both green growth and economic growth.

REFERENCES

Abid, N., Ceci, F. & Ikram, M. (2022). Green growth and sustainable development: dynamic linkage between technological innovation, ISO 14001, and environmental challenges. *Environmental Science and Pollution Research*, *29*(17), 25428-25447.

Acemoglu, D., Akcigit, U., Hanley, D. & Kerr, W. (2016). Transition to clean technology. *J. political Econ*. *124*(1), 52-104.

Adebayo, T. S. & Kirikkaleli, D. (2021). Impact of renewable energy consumption, globalization, and technological innovation on environmental degradation in Japan: Application of wavelet tools. *Environ. Dev. Sustain*. *23*(11), 16057-16082.

Afshan, S., Yaqoob, T., Meo, M. S. & Hamid, B. (2022). Can green finance, green technologies, and environmental policy stringency leverage sustainability in China: Evidence from Quantile-ARDL estimation. https://doi.org/10.21203/rs.3.rs-2228067/v1

Ali, N., Phoungthong, K., Techato, K., Ali, W., Abbas, S., Dhanraj, J. A. & Khan, A. (2022). FDI, Green Innovation and Environmental Quality Nexus: New Insights from BRICS Economies. *Sustainability, 14*(4), 2181.

Awijen, H., Belaïd, F., Zaied, Y. B., Hussain, N. & Lahouel, B. B. (2022). Renewable energy deployment in the MENA region: Does innovation matter? *Technological Forecasting and Social Change, 179*, 121633.

Belaïd, F., Elsayed, A. H. & Omri, A. (2021). Key drivers of renewable energy deployment in the MENA Region: Empirical evidence using panel quantile regression. *Structural Change and Economic Dynamics, 57*, 225-238.

Bilal, A., Li, X., Zhu, N., Sharma, R. & Jahanger, A. (2021). Green Technology Innovation, Globalization, and CO2 Emissions: Recent Insights from the OBOR Economies. *Sustainability, 14*(1), 236.

Cao, J. (2022). The dynamic coupling nexus among inclusive green growth: a case study in Anhui province, China. *Environmental Science and Pollution Research, 29*(32), 49194-49213.

Chien, F., Ajaz, T., Andlib, Z., Chau, K. Y., Ahmad, P. & Sharif, A. (2021a). The role of technology innovation, renewable energy and globalization in reducing environmental degradation in Pakistan: a step towards sustainable environment. *Renewable Energy, 177*, 308-317.

Chien, F., Ananzeh, M., Mirza, F., Bakar, A., Vu, H. M. & Ngo, T. Q. (2021b). The effects of green growth, environmental-related tax, and eco-innovation towards carbon neutrality target in the US economy. *Journal of Environmental Management, 299*, 113633.

Çınar, M. (2021). *Panel veri ekonometrisi: Stata ve Eviews uygulamalı*. Ekin Yayınevi.

DNV, (2022). https://www.dnv.com/about/index.html

Driscoll, J. C. & Kraay, A. C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of Economics and Statistics, 80*(4), 549-560.

Du, K., Li, P. & Yan, Z. (2019). Do green technology innovations contribute to carbon dioxide emission reduction? Empirical evidence from patent data. *Technological Forecasting and Social Change, 146*, 297-303.

Erdem, H. F., Demirel, S. K. & Erkan, E. (2019). Genç işsizliğin intihar oranları üzerindeki olası etkisi: panel veri analizi ile bölgesel karşılaştırma. *Anadolu İktisat ve İşletme Dergisi, 3*(2), 76-92.

Gorus, M. S. & Aydin, M. (2019). The relationship between energy consumption, economic growth, and CO2 emission in MENA countries: causality analysis in the frequency domain. *Energy, 168*, 815-822.

Gujarati, D. N. & Porter, D. (2012). *Basic Econometrics*. (Çev. Ü. Şenesen, & GG Şenesen), Literatür Yayıncılık, İstanbul.

Guo, J., Zhou, Y., Ali, S., Shahzad, U. & Cui, L. (2021). Exploring the role of green innovation and investment in energy for environmental quality: An empirical appraisal from provincial data of China. *Journal of Environmental Management, 292*, 112779.

Hao, L. N., Umar, M., Khan, Z. & Ali, W. (2021). Green growth and low carbon emission in G7 countries: how critical the network of environmental taxes, renewable energy and human capital is?. *Science of The Total Environment, 752*, 141853.

IEA (2023). Energy Technology Perspectives 2023, https://www.iea.org/reports/energy-technology-perspectives-2023

Irfan, M., Razzaq, A., Sharif, A. & Yang, X. (2022). Influence mechanism between green finance and green innovation: Exploring regional policy intervention effects in China. *Technological Forecasting and Social Change*, *182*, 121882.

Issa, H. & Jabbouri, R. (2022). Green Innovation in the MENA Healthcare Industry: A Knowledge-Based View. *International Journal of Technology and Human Interaction (IJTHI), 18*(1), 1-26.

Jalil, S. A. (2014). Carbon dioxide emission in the Middle East and North African (MENA) region: a dynamic panel data study. *Journal of Emerging Economies and Islamic Research*, *2*(3), 5-14.

Jian, X. & Afshan, S. (2022). *Dynamic effect of green financing and green technology innovation on carbon neutrality in G10 countries: fresh insights from CS-ARDL approach.* Economic Research-Ekonomska Istraživanja, 1-18.

Kahia, M., Aïssa, M. S. B. & Lanouar, C. (2017). Renewable and non-renewable energy use-economic growth nexus: The case of MENA Net Oil Importing Countries. *Renewable and Sustainable Energy Reviews, 71*, 127-140.

Kahia, M., Ben Jebli, M., & Belloumi, M. (2019). Analysis of the impact of renewable energy consumption and economic growth on carbon dioxide emissions in 12 MENA countries. *Clean Technologies and Environmental Policy, 21*(4), 871-885.

Karış, Ç., & Tandoğan, D. (2019). The Effect of Education on Democracy: Panel Data Analysis of High Income Countries. *Universal Journal of Educational Research, 7*(11), 2425-2431.

Kaynak, S., Ekinci, A. & Kaya, H. F. (2021). The effect of COVID-19 pandemic on residential real estate prices: Turkish case. *Quantitative Finance and Economics, 5*(4), 623-639.

Kirikkaleli, D. & Adebayo, T. S. (2023). Political risk and environmental quality in Brazil: Role of green finance and green innovation. *International Journal of Finance & Economics, 5*(9).

Köseoğlu, A., Yücel, A. G. & Ulucak, R., (2022). Green innovation and ecological footprint relationship for a sustainable development: Evidence from top 20 green innovator countries. *Sustainable Development*, *30*(5), 976-988.

Oguzturk, B. S. & Özbay, F. (2022). The Relationship between Green Innovation, CO2 Emissions, Gross Domestic Product, and Renewable Energy Supply: A Panel Data Analysis for BRICS Countries and Turkey. *Istanbul Business Research, 51*(1), 237-256.

Pesaran, M. H. (2004). *General diagnostic tests for cross section dependence in panels.* University of Cambridge, Faculty of Economics, Cambridge Working Papers in Economics No. 0435. Cent. Econ. Stud. Ifo Inst. Econ. Res. CESifo, 41.

Razi, F. & Dincer, I. (2022). Renewable energy development and hydrogen economy in MENA region: A review. *Renewable and Sustainable Energy Reviews, 168*, 112763.

Razzaq, A., Wang, Y., Chupradit, S., Suksatan, W. & Shahzad, F. (2021). Asymmetric inter-linkages between green technology innovation and consumption-based carbon emissions in BRICS countries using quantile-on-quantile framework. *Technology in Society, 66*, 101656.

Razzaq, Asif & Sharif, Arshian & Afshan, Sahar & Li, Claire J., (2023). Do climate technologies and recycling asymmetrically mitigate consumption-based carbon emissions in the United States? New insights from Quantile ARDL. *Technological Forecasting and Social Change, Elsevier, 186*.

Saleem, H., Khan, M. B. & Mahdavian, S. M. (2022). The role of green growth, green financing, and eco-friendly technology in achieving environmental quality: Evidence from selected asian economies. *Environ. Sci. Pollut. Res. 29*, 57720–57739.

Santra, S. (2017). The effect of technological innovation on production-based energy and CO2 emission productivity: evidence from BRICS countries. *African Journal of Science, Technology, Innovation and Development*, *9*(5), 503-512.

Shan, S., Genç, S. Y., Kamran, H. W. & Dinca, G. (2021). Role of green technology innovation and renewable energy in carbon neutrality: A sustainable investigation from Turkey. *Journal of Environmental Management*, *294*, 113004.

Shao, X., Zhong, Y., Liu, W. & Li, R. Y. M. (2021). Modeling the effect of green technology innovation and renewable energy on carbon neutrality in N-11 countries? Evidence from advance panel estimations. *Journal of Environmental Management*, *296*, 113189.

Sharif, A., Kocak, S., Khan, H. H. A., Uzuner, G. & Tiwari, S. (2023). Demystifying the links between green technology innovation, economic growth, and environmental tax in ASEAN-6 countries: The dynamic role of green energy and green investment. *Gondwana Research, 115*, 98-106.

Sharif, A., Saqib, N., Dong, K. & Khan, S. A. R. (2022). Nexus between green technology innovation, green financing, and CO2 emissions in the G7 countries: the moderating role of social globalisation. *Sustainable Development*.

Sinha, A., Shah, M. I., Sengupta, T. & Jiao, Z. (2020). Analyzing technology-emissions association in Top-10 polluted MENA countries: How to ascertain sustainable development by quantile modeling approach. *Journal of Environmental Management*, *267*, 110602.

Suki, N. M., Suki, N. M., Afshan, S., Sharif, A. & Meo, M. S. (2022a). The paradigms of technological innovation and renewables as a panacea for sustainable development: A pathway of going green. *Renewable Energy*, *181*, 1431-1439.

Suki, N. M., Suki, N. M., Sharif, A., Afshan, S. & Jermsittiparsert, K. (2022b). The role of technology innovation and renewable energy in reducing environmental degradation in Malaysia: A step towards sustainable environment. *Renewable Energy, 182*, 245-253.

Sun, Y., Duru, O. A., Razzaq, A. & Dinca, M. S. (2021). The asymmetric effect eco-innovation and tourism towards carbon neutrality target in Turkey. *Journal of Environmental Management*, *299*, 113653.

Taghvaee, V. M., Arani, A. A. & Agheli, L. (2022). Sustainable development spillover effects between North America and MENA: Analyzing the integrated sustainability perspective. *Environmental and Sustainability Indicators, 14*, 100182.

Wang, Q. J., Wang, H. J. & Chang, C. P. (2022). Environmental performance, green finance and green innovation: What's the long-run relationships among variables?. *Energy Economics, 110*, 106004.

Wei S, JiandongWand Saleem H (2023), The impact of renewable energy transition, green growth, green trade and green innovation on environmental quality: Evidence from top 10 green future countries. *Front. Environ. Sci*. *10*, 1076859.

Xia, Q. (2022). Does green technology advancement and renewable electricity standard impact on carbon emissions in China: role of green finance. *Environmental Science and Pollution Research*, 1-14.

Yamak N., Gürel F. & Koçak S (2016). Socio-economics and demographic determinants of theft crime: Panel data analysis. *TİSK Akademi, 11*(21), 56-69.

Yikun, Z., Woon Leong, L., Cong, P. T., Abu-Rumman, A., Al Shraah, A. & Hishan, S. S. (2022). Green growth, governance, and green technology innovation. How effective towards SDGs in G7 countries?. *Economic Research-Ekonomska Istraživanja*, 1-19.

Yilanci, V. & Gorus, M. S. (2020). Does economic globalization have predictive power for ecological footprint in MENA counties? A panel causality test with a Fourier function. *Environmental Science And Pollution Research, 27*(32), 40552-40562.

Yu, Y., Radulescu, M., Ifelunini, A. I., Ogwu, S. O., Onwe, J. C. & Jahanger, A. (2022). Achieving carbon neutrality pledge through clean energy transition: Linking the role of green innovation and environmental policy in E7 countries. *Energies, 15*(17), 6456.

Yunzhao, L. (2022). Modelling the role of eco innovation, renewable energy, and environmental taxes in carbon emissions reduction in E− 7 economies: Evidence from advance panel estimations. *Renewable Energy, 190*, 309-318.

Zhang, K. Q., Chen, H. H., Tang, L. Z. & Qiao, S. (2022). Green finance, innovation and the energy-environment-climate nexus. *Frontiers in Environmental Science*, *602*.

Zhang, S., Luo, S. & Afshan, S. (2022). Role of climate technologies, financial development, and renewable energy in the facilitation of social, economic, and environmental goals. *Renewable Energy*, *199*, 169-178.