-RESEARCH ARTICLE-

THE ROLE OF GREEN TRADE, GREEN ENERGY TECHNOLOGIES, AND GREEN FINANCE ON ENVIRONMENTAL DEGRADATION: EVIDENCE FROM ASEAN COUNTRIES

Trung Kien Tran

School of Public Finance, College of Economics, Law, and Government, University of Economics Ho Chi Minh City, Vietnam
Email: kientt@ueh.edu.vn
https://orcid.org/0000-0002-1205-3746

─**Abstract**─

This paper aims to assess the effect of green trade, green energy technologies, and green finance on greenhouse gas (GHG) emissions in ASEAN nations. ASEAN nations are chosen because their economies have a high capacity to mitigate their environmental impact. In addition, the evidence from these nations is highly likely to enhance the existing theoretical subsidy for sustainable practices. Using MMQR methodology, data from 2001 to 2019 have been analyzed, revealing that green trade, energy production from solar and hydropower resources, green finance, and REC significantly reduce greenhouse gas emissions. It is important to note that the empirical view of such practices from an ASEAN perspective can guide economies eager to improve the present state of the environment.

Keywords: Green trade, green energy technologies, green finance, greenhouse gas (GHG) emissions, renewable energy consumption, industrialization

1. INTRODUCTION

Climate change is currently one of humanity's most severe concerns. Scientists concur that greenhouse gas emissions cause the problem. Since 1900, GHG emissions and increased atmospheric GHG concentration have caused irreversible and catastrophic changes to the climate system, resulting in more frequent and intense weather events. If current emission trajectories continue in conformance with the "business as usual" scenario, it is anticipated that global average temperatures will increase by more than 3.5 °C (Hussain & Dogan, 2021). Given the destruction caused by this temperature rise,

it is imperative to decarbonize the global economy. At the Paris Conference of the UN Framework Convention on Climate Change (UNFCCC), parties pledged to reduce GHG emissions in 2015. However, if the agreements are fully implemented, global warming will be limited to 2,7 °C by 2100, which is still catastrophic for humanity (Muhammad et al., 2021). Therefore, the world must take more significant action to achieve carbon neutrality and avert climate-related catastrophes.

The nations that emit the most carbon dioxide into the atmosphere are the ASEAN nations. In recent decades, their emissions have increased significantly (Naseem et al., 2021). This is one of the reasons why ASEAN economies were chosen to study environmental degradation. In addition, the COVID-19 epidemic gained center stage in 2020 as nations debated how to pursue net-zero emission pathways (Adebayo et al., 2022). The pandemic spread rapidly across the globe, murdering millions of people and crippling economies.

In consequence, the epidemic received greater attention than macroeconomic and environmental issues. To combat the epidemic, COVID-19 mandated implementing various severe measures, including strict lockdowns, mask use, and social isolation. Their actions impeded economic, social, and physical activity worldwide. In addition, the lockdowns necessitated the temporary partial or complete closure of GHG-emitting sectors and other vital links in their supply chains (Riti et al., 2022). The trend in CO2 emissions in the ASEAN region is depicted in Figure 1.
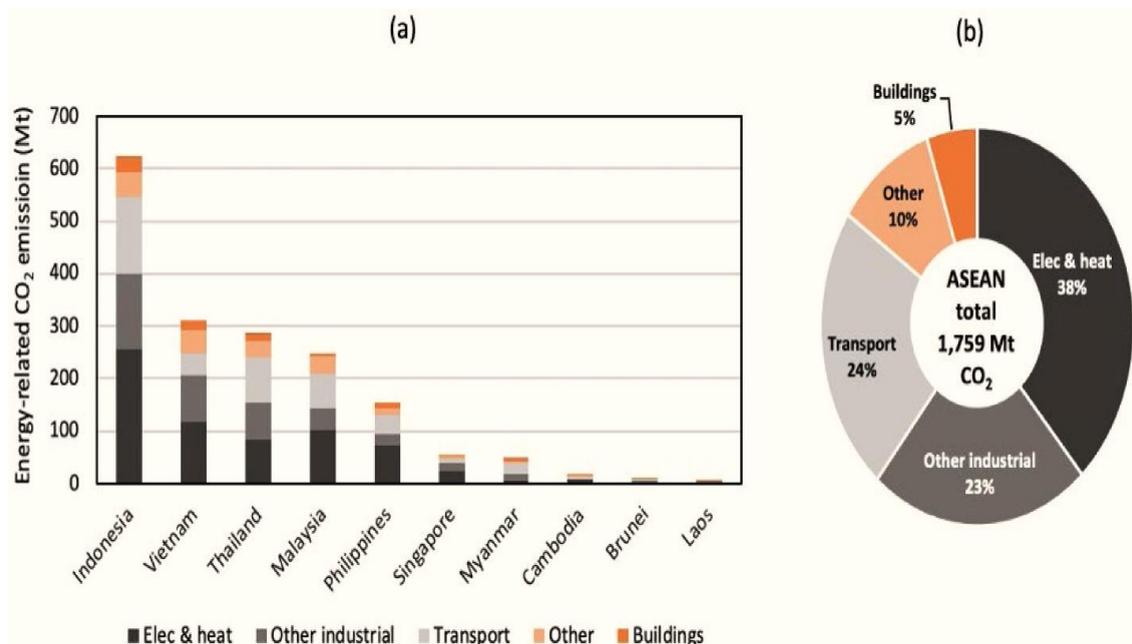

Figure 1. Energy-related CO2 emission (a) by country and (b) by sector in ASEAN countries in 2019 (IRENA, 2022)
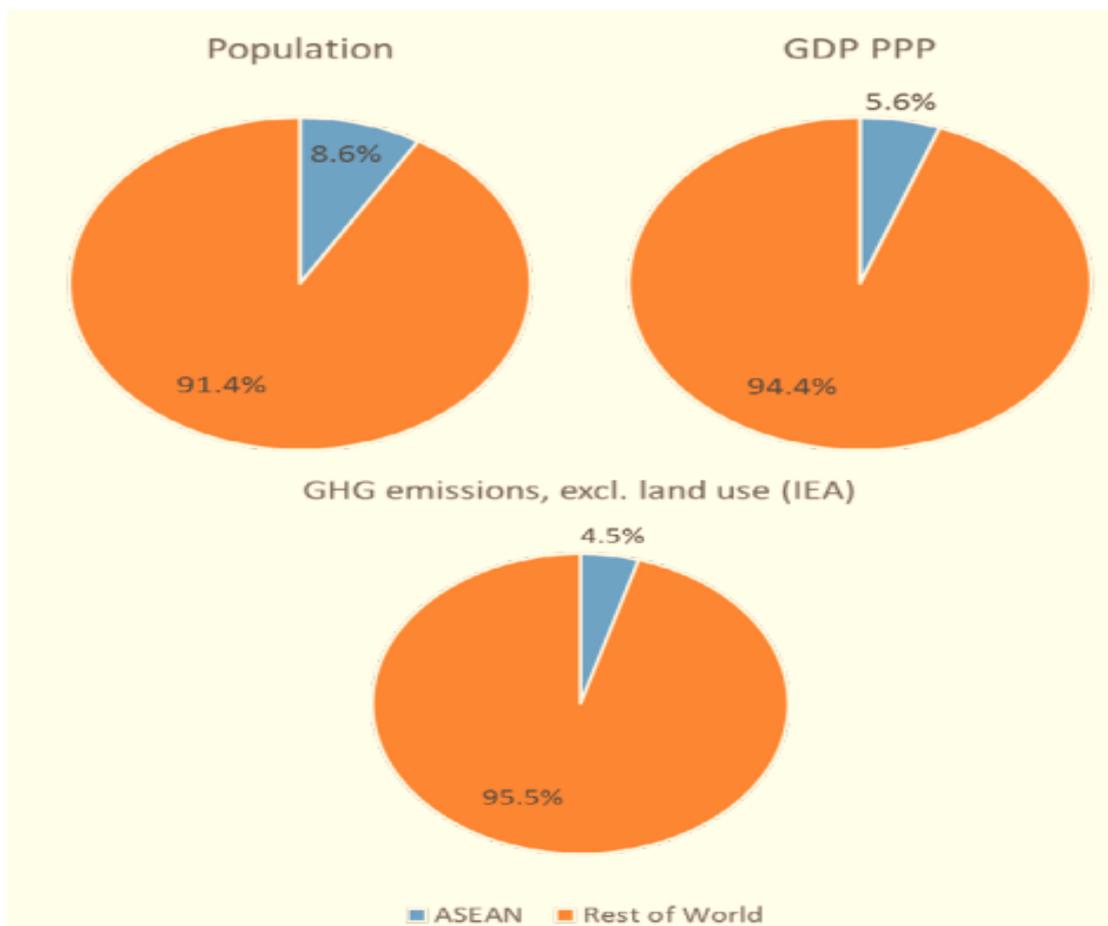
Figure 2. Share of ASEAN region in global population, GDP, and GHG emissions

There is a great deal of literature on greenhouse gas emissions in ASEAN economies, but there are still several gaps in the literature that this study seeks to fill. These gaps include the following: 1) Although the environment in terms of GHGs emission has been studied from different perspectives, at different times, and in different economies, the research has not yet reached its full potential, as there are still several aspects about GHG emission that need to be explored: i. 2) the equation includes greenhouse gas emissions, green trade, energy production, green finance, renewable energy certificates, and industrialization. The ASEAN economies have not been challenged in recent years. 3) Lima et al. (2020) and Yu et al. (2023) investigated whether there are a relationship between solar energy and greenhouse gas (GHG) emissions; however, the current investigation will also focus on green trade, energy production from hydropower sources, green finance, renewable energy certificates (REC), and industrialization in ASEAN economies with a new data set. 4) Bilgili et al. (2021) and Ope Olabiwonnu et al. (2022) investigated whether or not there is a relationship between energy produced

from hydroelectric sources and GHG emission; however, the current study will also work on it alongside other variables such as green trade, energy production from solar sources, green finance, renewable consumption, and industrialization with a new sample set. 5) Meo and Abd Karim (2022), Lin et al. (2022), and Tian and Li (2022) examined whether green finance affected GHG emissions in the recent past. In contrast, using a new data set, the current study examines it with the addition of variables such as green trade, energy production from solar and hydropower sources, REC, and industrialization. 6) Waheed et al. (2018) and K. Dong et al. (2020) examined the relationship between REC consumption and GHG emissions. In contrast, the current study will examine this relationship in addition to green trade, energy production from solar and hydropower sources, green finance, and industrialization in ASEAN economies. 7) Liu and Bae (2018) and Li and Lin (2015) researched industrialization and GHG emission environmental sustainability. In contrast, using a new data set, the current study will examine GHGs emissions in addition to green trade, energy production from solar and hydropower sources, green finance, and industrialization. 1) being one of the most important topics of the modern era, i.e., the environment in terms of the impact of GHG emissions, the present investigation will highlight the need to investigate it, particularly in the context of green trade, energy production from solar and hydropower sources, green finance, REC, and industrialization perspective, 2) will also add literature on the subject of GHG emission; 3) will provide a guideline as well as assistance to ecological professionals to evaluate and upgrade their policies to mitigate GHGs emission, particularly in the ASEAN economy; and 4) will be updated annually. 4) even though numerous aspects of the environment in terms of GHG emissions have been explored to date, many remain unexplored; therefore, the present investigation will also aid academics in exploring new aspects.

2. LITERATURE REVIEW

The research investigates the effects of green trade, energy production from solar and hydropower resources, green finance, renewable energy certificates (REC), and industrialization on greenhouse gas emissions in ASEAN nations. The world environment is growing worse and worse. A contributing factor is global warming. Global warming is induced by energy consumption. Energy production resources have a warming effect on the planet. Global warming is a result of the emission of hazardous gases. The transition to renewable energy sources reduces greenhouse gas emissions. In this context, Yu et al. (2022) examined whether there is a correlation between greenhouse gas emissions and solar energy production. The investigation was conducted on the ten countries that consume the most solar energy. Analysis suggested a clear and substantial relationship between greenhouse gas emissions and solar energy production. In addition, Wang et al. (2020) investigated whether there is a correlation between greenhouse gas emissions and solar energy production. The study concluded that a distinct and significant relationship exists between greenhouse gas emissions and solar

energy production. In addition, Razmjoo et al. (2021) examined whether there is a correlation between greenhouse gas emissions and solar energy production. The analysis sampled information from the past 45 years. The specified sample spans the years 2000 through 2015. The analysis results indicated that a different and significant relationship exists between greenhouse gas emissions and solar energy production.

Similarly, Moumin et al. (2020) examined whether or not there is a correlation between GHG emissions and solar energy production. The survey sampled information from 22 years. The specified sample spans the years 1995 through 2017. The analysis results indicated that a different and significant relationship exists between greenhouse gas emissions and the production of energy from solar resources. In addition, Sharif et al. (2021) investigated whether there is a correlation between GHG emissions and solar energy production. The analysis results indicated a special and significant relationship between greenhouse gas emissions and energy production from solar resources. In addition, M. A. Lima et al. (2020) examined whether or not there is a correlation between GHG emissions and solar energy production. The survey sampled information from three years. The specified sample spans the years 2012 through 2015. The collected sample was evaluated using the cross-angiogram method. The analysis results indicated a unique and significant relationship between greenhouse gas emissions and energy production from solar resources.

According to Moslehpour et al. (2022), green trading is one of the most critical resources for mitigating environmental degradation. There is a strong correlation between greenhouse gas emissions and green commerce. In this context, Asongu and Odhiambo (2021) examined the relationship between greenhouse gas emissions and trade in 44 economies. Results demonstrate a distinct and significant connection between GHG emissions and international trade. Moreover, in this regard, Dou et al. (2021) investigated whether or not GHG emissions and trade in Pakistan are related. According to the findings, there is a distinct and significant relationship between GHG emissions and trade. Similarly, X. Tian et al. (2019) examined the relationship between GHG missions and China's trade. Results indicate a distinct and significant correlation between GHG emissions and international trade.

The production of energy from conventional resources resulted in the emission of hazardous substances. These dangerous gases have an impact on the environment. Xu et al. (2023) suggested that producing renewable energy solves these environmental issues. A strong correlation exists between greenhouse gas emissions and renewable energy, such as hydropower. In this context, Bilgili et al. (2021) examined the possibility of a correlation between greenhouse gas emissions and hydropower energy production. The survey sampled information from 47 years. The specified sample spans the years 1980 through 2017. The results of the analysis indicated that there is a distinct and significant relationship between greenhouse gas emissions and hydropower energy production.

Moreover, in this regard, Ope Olabiwonnu et al. (2022) examined the possibility of a correlation between GHG emissions and hydropower energy production. The study utilized articles from various historical periods. The results indicated a distinct and significant relationship between greenhouse gas emissions and hydropower energy production. In addition, Ummalla et al. (2019) investigated whether or not there is a correlation between GHG emissions and hydropower energy production. The survey sampled information from 26 years. The specified sample spans the years 1990 through 2016. The results of the analysis indicated that there is a distinct and significant relationship between greenhouse gas emissions and hydropower energy production. In addition, Jahangir et al. (2022) examined whether there is a correlation between greenhouse gas emissions and hydropower energy production. The survey sampled information from 53 years. The selected sample spans the years 1965 through 2018. The collected sample was evaluated using the cross-angiogram method. The results of the analysis indicated that there is a distinct and significant relationship between greenhouse gas emissions and hydropower energy production. In addition, Hdom and Fuinhas (2020) investigated whether there is a correlation between GHG emissions and hydropower energy production. The survey sampled information from 35 years. The specified sample spans the period from 1985 to 2020. The analysis results show a distinct and significant relationship between greenhouse gas emissions and hydropower energy production.

The global community is supporting green finance to protect the environment. The green finance initiatives support the production of energy from renewable resources. There is a strong correlation between greenhouse gas emissions and green finance. In this context, Meo and Abd Karim (2022) examined whether a relationship exists between greenhouse gas emissions and green finance. The research sampled data from two years. The specified sample spans the period from 2018 to 2019. The analysis shows a different and significant relationship between greenhouse gas emissions and green finance. In addition, Y. Tian and Li (2022) examined the relationship between GHG emissions and green finance in China over a sample period of 22 years. Mngumi et al. (2022) investigated whether there is a correlation between greenhouse gas emissions and green finance. As a sample, the research utilized data from 14 years. The specified sample spans the years 2005 through 2019. The collected sample was evaluated using the regression method.

The analysis shows a different and significant relationship between greenhouse gas emissions and green finance. In addition, F. Wang et al. (2021) investigated the possibility of a relationship between GHG emissions and green finance. The analysis shows a different and significant relationship between greenhouse gas emissions and green finance. Similarly, Zhao et al. (2023) investigated whether a relationship exists between greenhouse gas emissions and green finance. As a sample, the research utilized data from 14 years. The specified sample spans the years 2004 through 2018. The

collected sample was evaluated using the ARDL method. The analysis shows a different and significant relationship between greenhouse gas emissions and green finance.

This globalization has increased energy consumption. This has increased the demand for energy production. Greater energy consumption increased greenhouse gas emissions. Therefore, there is a substantial relationship between GHG emissions and REC. In this context, Waheed et al. (2018) investigated whether a correlation exists between GHG emissions and REC. The survey sampled information from 24 years. The specified sample spans the years 1990 through 2014. The collected sample was evaluated using the ARDL method. The analysis results show a distinct and significant relationship between GHG emissions and REC. In addition, K. Dong et al. (2020) investigated whether there is a correlation between GHG emissions and REC. The study included both developing and developed economies. The sample for the investigation consisted of twenty-year-old data. The specified sample spans the years 1995 through 2015. The analysis results show a distinct and significant relationship between GHG emissions and REC. In addition, Dogan and Ozturk (2017) examined the possibility of a correlation between GHG emissions and REC. It was administered in the United States. As a sample, the research utilized data from 44 years. The specified sample spans the years 1980 through 2014. The analysis results show a distinct and significant relationship between GHG emissions and REC. In addition, K. Dong et al. (2017) investigated the possibility of a relationship between GHG emissions and REC. The survey sampled information from 31 years. The specified sample spans the period from 1985 to 2016. The collected sample was evaluated using the regression method. The analysis results show a distinct and significant relationship between GHG emissions and REC.

Similarly, Sharif et al. (2019) investigated whether a correlation exists between GHG emissions and REC. The survey sampled information from 25 years. The specified sample spans the years 1990 through 2015. The analysis results show a distinct and significant relationship between GHG emissions and REC.

As a consequence of globalization, the business sector is growing. The focus of the business is the expansion of the industry. The expansion of industry increases energy consumption. This consumption of energy results in increased energy production. This energy generation produces greenhouse gas emissions. Therefore, there is a strong correlation between greenhouse gas emissions and industrialization. In this context, Liu and Bae (2018) examined the possibility of a relationship between GHG emissions and industrialization. Their analysis concluded that a distinct and significant relationship exists between GHG emissions and industrialization. In addition, Li and Lin (2015) investigated the possibility of a correlation between GHG emissions and industrialization. The correlation between industrialization and GHG emissions has been confirmed by analysis.

In addition, F. Dong et al. (2019) examined the possibility of a relationship between GHG emissions and industrialization. Their findings indicated a significant relationship between GHG emissions and industrialization. As a follow-up, Aslam et al. (2021) examined whether a correlation exists between GHG emissions and industrialization. The research was performed in China. Thirty years worth of data was utilized for the investigation as a sample. The specified sample spans the years 1990 through 2020. According to the analysis results, a distinct and significant correlation exists between GHG emissions and industrialization. Likewise, Mahmood et al. (2020) investigated whether or not there is a correlation between GHG emissions and industrialization in Saudi Arabia. The analysis results show a distinct and significant relationship between GHG emissions and industrialization.

3. RESEARCH METHODS

The research investigates the effects of green trade, energy production from solar and hydropower resources, green finance, renewable energy certificates (REC), and industrialization on greenhouse gas emissions in ASEAN nations. Using secondary sources such as WDI and the central banks of ASEAN countries, the researchers extracted data from 2001 to 2021. The study's developed model is presented below:

$$GHGE_{it} = \alpha_0 + \beta_1 GT_{it} + \beta_2 EPSR_{it} + \beta_3 EPHR_{it} + \beta_4 GF_{it} + \beta_5 REC_{it} + \beta_6 IND_{it} + e_{it}$$

Table 1. Measurements of Variables

S#	Variables	Definition & Measurement	Sources
01	Environmental Degradation	GHG emissions (% change from 1990)	WDI
02	Green Trade	Trade (% of GDP)	WDI
03	Green Energy Technologies	Electricity production from solar resources (% of total)	WDI
		Electricity production from hydropower resources (% of total)	WDI
04	Green Finance	The percentage of green finance to total finance	Central Banks
05	Renewable Energy Consumption	REC (% of total energy consumption)	WDI
06	Industrialization	Industry value added (% of GDP)	WDI

The study began by employing fundamental tests to identify data nature, correlation, and multicollinearity issues. This was accomplished using descriptive statistics, correlation, and VIF tests. The MMQR technique, which is the study's primary method, was subsequently employed to verify the association. This is a recently developed method

for analyzing panel data introduced by Machado and Silva (2019). This method has the characteristic of being "robust to outliers." This method also addresses the panel heterogeneity issues that arise. In addition, this method has the features of conditional heterogeneous covariance influence of GHGE issues to affect the entire distribution, which only permits shifting means (Ike et al., 2020). In addition, this method provides dynamic assessments in various circumstances, even if the framework is nonlinear (Aziz et al., 2020). Finally, because it controls the effects of endogeneity and heterogeneity, this method provides the most accurate estimation for panel articles (An et al., 2021).

Hence, the conditional quantile estimation is $Q\tau(\tau/X)$ for the locational-scale alternate model is given as:

$$Y_{it} = \alpha_i + X_{it}\beta + (\delta_i + Z_{it}\lambda)U_{it} \tag{1}$$

Where $P\{\delta_i + Z_{it}\lambda > 0\} = 1.$ represented "the probability," $\alpha, \beta, \lambda \ and \ \delta$ represented "the parameters," α_i, δ_i i $= 1, \dots, $ n represented "the individual fixed-effect," and z represented the "k-vector" of component X. So, the components are malformed with element l mentioned as:

$$Zl = Zl\ (X), l = 1, \dots \dots, k \tag{2}$$

Where, U_{it} represents the orthogonal to X_{it} and reliable for instant conditions that do not include stringent heterogeneity. So, the conditional quantile of Y is mentioned below:

$$Q\tau(\tau/X_{it})\ = (\alpha_i + \delta_i q(\tau)) + X_{it}\beta + Z_{it}\ \lambda\ q(\tau) \tag{3}$$

Where, X_{it} represents the predictive constructs such as GT, EPSR, EPHR, GF, REC, and IND. In contrast, Y_{it} is the dependent construct like GHGE. Due to time invariants, their heterogeneous effects are permissible to alteration across the quantiles of the predictive variable Y. Therefore, $Q(\tau)$ is estimated as given under:

$$Min_q = \textstyle\sum_t \sum_i p\tau\ (R_{it} - (\delta_i +\ Z_{it}\ \lambda\ )q) \tag{4}$$

4. FINDINGS OF THE STUDY

4.1 Descriptives

According to Tables 2 and 3, the average GHGE value was 283,999 percent, the average EPSR value was 14.113 percent, the average EPHR value was 23.922 percent, and the average GF value was 89,217 percent. In addition, the results revealed that the average value for REC was 22.597 percent, the average value for IND was 29.767 percent, and the average value for GT was 44.519 percent. In addition, year-by-year descriptors reveal that the highest GHGE value was recorded in 2021, the highest EPSR value was in 2021, the highest EPHR value was in 2005, and the highest GF value was recorded in 2021. The results also revealed that the maximum value for REC was recorded in 2001, the highest for IND in 2008, and the highest for GT in 2008.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
GHGE	105	283.999	338.169	-124.419	1178.342
EPSR	105	14.113	17.916	0.254	54.037
EPHR	105	23.922	26.097	0.270	84.021
GF	105	89.217	15.261	58.110	126.447
REC	105	22.597	16.525	3.180	48.920
IND	105	29.767	7.929	17.702	47.557
GT	105	44.519	11.535	22.106	65.975

5. CORRELATIONS

The correlation results (see Table 3) revealed that green trade, energy production from solar and hydropower resources, green finance, renewable energy certificates (REC), and industrialization have a positive and statistically significant relationship with GHG emissions in ASEAN nations.

Table 3. Correlation

Variables	GHGE	EPSR	EPHR	GF	REC	IND	GT
GHGE	1.000						
EPSR	-0.525	1.000					
EPHR	-0.514	-0.070	1.000				
GF	-0.067	0.132	-0.002	1.000			
REC	-0.304	-0.459	0.659	-0.138	1.000		
IND	-0.102	-0.072	-0.360	-0.104	-0.405	1.000	
GT	-0.396	0.206	-0.776	-0.032	-0.732	0.391	1.000

5.1 MMQR Approach

Finally, the researchers employed the "MMQR approach" to examine the relationship between the variable under investigation. The results revealed a positive correlation between green trade, energy production from solar and hydropower resources, green finance, REC, IND, and greenhouse gas emissions. The results indicated that the REC is significantly associated with quartiles 1 through 9 of GHGE. GT is associated substantially with quartiles 1-8 of GHGE. Furthermore, EPHR is significantly associated with all quartiles except the seventh. EPSR is considerably associated with GHGE in the first six and eighth quartiles. IND is significantly associated with all quartiles except 6. Lastly, the GF is substantially associated with quartiles 1-4 and 7-8 of GHGE.

Table 4. MMQR Results

Variables	Method of Moments Quantile Regression (MMQR)											
	Location	Scale	Quartiles									
			.1	.2	.3	.4	.5	.6	.7	.8	.9
REC	.657***	.394*	-.456**	-.674**	-.564*	-.784**	-.554*	-.392*	-.643*	-.373*	-.784*
GT	.688**	.509*	-.904*	-.392*	-.599*	-.442*	-.320**	-.643**	-.202**	-.674*	-.011
EPHR	.584**	.474**	-.474*	-.483*	-.403	-.309*	-.740*	-.302*	-.022	-.289**	-.043*
EPSR	.500**	.403*	-.483*	-.443**	-.321*	-.303**	-.302*	-.338*	-.122	-.383*	-.098
IND	.494**	.490*	-.594*	-.844*	-.732**	-.654*	-.387*	-.022	-.382*	-.574**	-.483**
GF	.549*	.440**	-.392*	-.684**	-.449**	-.430*	-.102	-.012	-.748*	-.948*	-.202

***, **, and * represent significant level at 1%, 5%, and 10%, respectively

6. DISCUSSIONS

The research investigates the effects of green trade, energy production from solar and hydropower resources, green finance, renewable energy certificates (REC), and industrialization on greenhouse gas emissions in ASEAN nations. The results demonstrated a negative relationship between green trade and environmental degradation. These findings are consistent with the research conducted by R. Ahmad et al. (2020). According to researchers' findings, integrating a green concept into trade practices, such as the quality of products and services traded, marketing channels, transportation, advertising, and customer interaction, reduces the GHG emissions from these practices. Therefore, it prevents environmental degradation. These results concur with Kang's (2020) study, which suggests that the trade of eco-friendly products and services increases the use of products and services that do not emit greenhouse gases and are safe for environmental quality. Thus, green trade reduces environmental degradation. These are also supported by Sarkis and Tamarkin (2005), who state that the work preserves the environment and its resources against GHG emissions by utilizing green resources and green transportation. Therefore, green trade reduces environmental degradation.

The findings demonstrated that EPSR has a negative correlation with environmental degradation. These findings are consistent with M. Lima et al. (2020), which show that solar system installation is a pure energy source. Therefore, when energy is produced in large quantities from solar sources, businesses can access pure energy sources and eliminate greenhouse gas emissions. Thus, reducing greenhouse gas emissions mitigates environmental degradation. In addition, these findings are consistent with Shahsavari et al.'s (2019) conclusion that the supply of renewable energy increases when solar systems generate more energy. In this scenario, the energy transition is implemented, and the reduced pollution from economic processes resulting from using renewable energy mitigates greenhouse gas emissions. Thus, the production of solar energy reduces environmental degradation. These are also supported by Irfan et al. (2020), who note that greenhouse gas emissions and environmental degradation decrease in nations where businesses are more likely to obtain energy from solar sources.

The results demonstrated a negative relationship between EPHR and environmental degradation. These findings are consistent with the research conducted by Tiwari, Kocoglu, Banday, and Awan in 2022. The study suggests that governments are prioritizing establishing hydroelectric systems and producing vast quantities of renewable energy. The large quantity of energy produced by these systems increases the use of energy sources with a lower potential to emit greenhouse gases and a high capacity to meet infrastructure requirements. Reducing greenhouse gas emissions reverses environmental degradation. These findings concur with Pata and Kumar's (2021) examination of the function of solar energy production in mitigating environmental degradation. The study hypothesizes that when hydropower systems produce significant

amounts of energy and successfully meet domestic energy demands, the use of renewable energy within the country increases. This decreases greenhouse gas emissions and environmental degradation. These are also supported by Alsaleh and Abdul-Rahim (2022), who assert that hydropower energy generation does not release harmful substances such as greenhouse gases into the atmosphere and protects the environment.

The results demonstrated a negative relationship between green finance and environmental degradation. These findings are consistent with the findings of Xiong and Sun's (2022) study, which asserts that the issuance of green finance encourages green practices in societies and business organizations to lessen the environmental impacts of human activities. Due to green practices, GHG emissions from the economy and society decrease, and the environment is protected from pollution. Furthermore, these findings concur with Zhou et al.'s (2020) study, which suggests that the provision of green finance increases the financial resources in an economy and enhances the capacity of economic actors to implement environmentally favorable practices. This decreases greenhouse gas emissions and prevents environmental degradation. These are also supported by Sharif et al. (2020), who assert that green initiatives are initiated when green finance is available, and environmental degradation is mitigated.

The results demonstrated a negative relationship between solar RE consumption and environmental degradation. These results are consistent with Adekoya et al.'s (2022) research. The study suggests that using clean and renewable energy sources to generate light, heat, ventilation, or motion for various economic processes ensures a clean workplace with fewer greenhouse gas emissions. According to the research conducted by F. Ahmad et al. (2020), using renewable energy promotes the growth and conservation of natural resources. This mitigates environmental degradation by removing the effects of GHG emissions from the atmosphere. These are also supported by Chien et al. (2022), who assert that replacing fossil fuels with renewable energy reduces greenhouse gas emissions and mitigates the environmental degradation caused by the greenhouse effect.

The results demonstrated a negative relationship between industrialization and environmental degradation. These findings are consistent with Opoku and Aluko (2001) research. This study indicates that using technical processes based on conventional methods results in the emission of greenhouse gases that contribute to climate change. Industrialization encourages innovative green technologies for more efficient business operations. Utilizing these technologies prevents environmental degradation. These results concur with the findings of Munir and Ameer (2019), which also suggest that an increase in industrialization raises awareness among the local populace. The environmentally favorable procedures reduce GHG emissions and prevent GHG emissions from polluting the environment. Aluko et al. (2021) provide additional evidence that industrialization promotes area development and results in the use of

environmentally favorable resources and processes. Consequently, GHG emissions and environmental degradation decrease.

7. IMPLICATIONS

The significance of this research to environmental regulators, both public and private, is substantial. It provides guidelines for mitigating environmental degradation, which is necessary for an economy to achieve sustainable development. To reduce GHG emissions and environmental degradation, the study recommends that economic policies be designed to promote green trade. It also suggests that efforts should be made to enhance EPSR to combat GHG emissions. It would reduce environmental deterioration. Similarly, policymakers must strengthen EPHR to prevent environmental deterioration. The study also suggests that green financing should be available to reduce GHG emissions from human activities to mitigate environmental degradation. The study advises policymakers on controlling environmental degradation through green trade, green energy technologies, and green finance. There is a suggestion that environmental regulations should promote RE consumption and that environmental degradation must be prevented. In addition, the study suggests that industrialization must be appropriately managed to avoid environmental degradation.

8. FINAL CONSIDERATION

This study aimed to investigate the effects of green trade, EPSR, EPHR, and green finance on preventing environmental degradation. It was also intended to examine the role of RE consumption and industrialization in preventing environmental degradation. The results demonstrated that green modifications to trade practices, such as the quality of traded products and services, marketing channels, transportation, advertising, and customer interaction, reduce the GHG emissions from these practices. Thus, it mitigates environmental degradation. When solar systems generate more energy, the supply of renewable energy increases. Utilizing renewable energy reduces greenhouse gas emissions and protects the environment. Similarly, when hydropower systems produce a large amount of energy, the nation's use of renewable energy increases. This decreases greenhouse gas emissions and mitigates environmental damage. The study concluded that if businesses and individuals have access to green financing, green programs can be implemented, and there will be less environmental degradation. In addition, the results demonstrated that an increase in industrialization stimulates regional development, technological advancement, and environmental consciousness. All of this serves to mitigate environmental degradation.

8.1 Direction for Future Work

The research investigates the effects of green trade, energy production from solar and hydropower resources, green finance, renewable energy certificates (REC), and industrialization on greenhouse gas emissions in ASEAN nations. There are also some

limitations associated with this article, which are anticipated to be eliminated by future researchers. First, the authors have only illuminated the role of a few factors, such as green trade, EPSR, EPHR, green finance, RE consumption, and industrialization, in preventing environmental degradation. Second, numerous management, regulatory, and organizational factors not mentioned here could aid in the fight against environmental degradation. These factors must also be recorded for comprehensive research. Third, this study utilizes GHG emissions to estimate environmental degradation. Future researchers should use a more appropriate measurement, such as CO_2 emissions, to present precise results pertinent to a larger area.

9. ACKNOWLEDGMENT

REFERENCES

Adebayo, T. S., Akadiri, S. S., Akanni, E. O., & Sadiq-Bamgbopa, Y. (2022). Does political risk drive environmental degradation in BRICS countries? Evidence from method of moments quantile regression. *Environmental Science and Pollution Research, 29*(21), 32287-32297. doi: https://doi.org/10.1007/s11356-022-20002-w

Adekoya, O. B., Ajayi, G. E., Suhrab, M., & Oliyide, J. A. (2022). How critical are resource rents, agriculture, growth, and renewable energy to environmental degradation in the resource-rich African countries? The role of institutional quality. *Energy Policy, 164*, 112-128. doi: https://doi.org/10.1016/j.enpol.2022.112888

Ahmad, F., Draz, M. U., Ozturk, I., Su, L., & Rauf, A. (2020). Looking for asymmetries and nonlinearities: the nexus between renewable energy and environmental degradation in the Northwestern provinces of China. *Journal of Cleaner Production, 266*, 1217-1235. doi: https://doi.org/10.1016/j.jclepro.2020.121714

Ahmad, R., Ahmad, M. J., Farhan, M., & Arshad, M. A. (2020). The Relationship within Green Marketing Strategies and Market Performance of Pakistan SME's. *Hamdard Islamicus, 43*(2), 204-216. doi: https://doi.org/10.17051/ilkonline.2021.05.435

Alsaleh, M., & Abdul-Rahim, A. (2022). Moving toward sustainable environment: The effects of hydropower industry on water quality in EU economies. *Energy & Environment, 33*(7), 1304-1325. doi: https://doi.org/10.1177/0958305X211039452

Aluko, O. A., Opoku, E. E. O., & Ibrahim, M. (2021). Investigating the environmental effect of globalization: Insights from selected industrialized countries. *Journal of Environmental Management, 281*, 118-136. doi: https://doi.org/10.1016/j.jenvman.2020.111892

An, H., Razzaq, A., Haseeb, M., & Mihardjo, L. W. (2021). The role of technology innovation and people's connectivity in testing environmental Kuznets curve and pollution heaven hypotheses across the Belt and Road host countries: new evidence from Method of Moments Quantile Regression. *Environmental Science and Pollution Research, 28*(5), 5254-5270. doi: https://doi.org/10.1007/s11356-020-10775-3

Aslam, B., Hu, J., Shahab, S., Ahmad, A., Saleem, M., Shah, S. S. A., . . . Hassan, M. (2021). The nexus of industrialization, GDP per capita and CO2 emission in China. *Environmental Technology & Innovation, 23*, 101674. doi: https://doi.org/10.1016/j.eti.2021.101674

Asongu, S., & Odhiambo, N. M. (2021). Trade and FDI thresholds of CO2 emissions for a Green economy in sub-Saharan Africa. *International Journal of Energy Sector Management, 15*(1), 227-245. doi: https://doi.org/10.1108/IJESM-06-2020-0006

Aziz, N., Mihardjo, L. W., Sharif, A., & Jermsittiparsert, K. (2020). The role of tourism and renewable energy in testing the environmental Kuznets curve in the BRICS countries: fresh evidence from methods of moments quantile regression. *Environmental Science and Pollution Research, 27*(31), 39427-39441. doi: https://doi.org/10.1007/s11356-020-10011-y

Bilgili, F., Lorente, D. B., Kuşkaya, S., Ünlü, F., Gençoğlu, P., & Rosha, P. (2021). The role of hydropower energy in the level of CO2 emissions: An application of continuous wavelet transform. *Renewable Energy, 178*, 283-294. doi: https://doi.org/10.1016/j.renene.2021.06.015

Chien, F., Hsu, C.-C., Ozturk, I., Sharif, A., & Sadiq, M. (2022). The role of renewable energy and urbanization towards greenhouse gas emission in top Asian countries: Evidence from advance panel estimations. *Renewable Energy, 186*, 207-216. doi: https://doi.org/10.1016/j.renene.2021.12.118

Dogan, E., & Ozturk, I. (2017). The influence of renewable and non-renewable energy consumption and real income on CO 2 emissions in the USA: evidence from structural break tests. *Environmental Science and Pollution Research, 24*, 10846-10854. doi: https://doi.org/10.1007/s11356-017-8786-y

Dong, F., Wang, Y., Su, B., Hua, Y., & Zhang, Y. (2019). The process of peak CO2 emissions in developed economies: A perspective of industrialization and urbanization. *Resources, Conservation and Recycling, 141*, 61-75. doi: https://doi.org/10.1016/j.resconrec.2018.10.010

Dong, K., Dong, X., & Jiang, Q. (2020). How renewable energy consumption lower global CO2 emissions? Evidence from countries with different income levels. *The World Economy, 43*(6), 1665-1698. doi: https://doi.org/10.1111/twec.12898

Dong, K., Sun, R., & Hochman, G. (2017). Do natural gas and renewable energy consumption lead to less CO2 emission? Empirical evidence from a panel of BRICS countries. *Energy, 141*, 1466-1478. doi: https://doi.org/10.1016/j.energy.2017.11.092

Dou, Y., Zhao, J., Malik, M. N., & Dong, K. (2021). Assessing the impact of trade openness on CO2 emissions: evidence from China-Japan-ROK FTA countries. *Journal of Environmental Management, 296*, 113241. doi: https://doi.org/10.1016/j.jenvman.2021.113241

Hdom, H. A. D., & Fuinhas, J. A. (2020). Energy production and trade openness: Assessing economic growth, CO2 emissions and the applicability of the cointegration analysis. *Energy Strategy Reviews, 30*, 100-119. doi: https://doi.org/10.1016/j.esr.2020.100488

Hussain, M., & Dogan, E. (2021). The role of institutional quality and environment-related technologies in environmental degradation for BRICS. *Journal of Cleaner Production, 304*, 127-141. doi: https://doi.org/10.1016/j.jclepro.2021.127059

Ike, G. N., Usman, O., & Sarkodie, S. A. (2020). Testing the role of oil production in the environmental Kuznets curve of oil producing countries: New insights from Method of Moments Quantile Regression. *Science of the Total Environment, 711*, 135-148. doi: https://doi.org/10.1016/j.scitotenv.2019.135208

Irfan, M., Zhao, Z.-Y., Ikram, M., Gilal, N. G., Li, H., & Rehman, A. (2020). Assessment of India's energy dynamics: Prospects of solar energy. *Journal of Renewable and Sustainable Energy, 12*(5), 537-549. doi: https://doi.org/10.1063/1.5140236

Jahanger, A., Yu, Y., Awan, A., Chishti, M. Z., Radulescu, M., & Balsalobre-Lorente, D. (2022). The impact of hydropower energy in malaysia under the EKC hypothesis: Evidence from quantile ARDL approach. *SAGE Open, 12*(3), 21-39. doi: https://doi.org/10.1177/21582440221109580

Kang, S. J. (2020). Green trade patterns and the transboundary transmission of greenhouse gas emissions. *Asian Development Review, 37*(1), 119-139. doi: https://doi.org/10.1162/adev_a_00143

Li, K., & Lin, B. (2015). Impacts of urbanization and industrialization on energy consumption/CO2 emissions: does the level of development matter? *Renewable and Sustainable Energy Reviews, 52*, 1107-1122. doi: https://doi.org/10.1016/j.rser.2015.07.185

Lima, M., Mendes, L., Mothé, G., Linhares, F., de Castro, M., Da Silva, M., & Sthel, M. (2020). Renewable energy in reducing greenhouse gas emissions: Reaching the goals of the Paris agreement in Brazil. *Environmental Development, 33*, 101-120. doi: https://doi.org/10.1016/j.envdev.2020.100504

Lima, M. A., Mendes, L. F. R., Mothé, G. A., Linhares, F. G., de Castro, M. P. P., da Silva, M. G., & Sthel, M. S. (2020). Renewable energy in reducing greenhouse gas emissions: Reaching the goals of the Paris agreement in Brazil. *Environmental Development, 33*, 100-116. doi: https://doi.org/10.1016/j.envdev.2020.100504

Lin, C. Y., Chau, K. Y., Moslehpour, M., Linh, H. V., Duong, K. D., & Ngo, T. Q. (2022). Factors influencing the sustainable energy technologies adaptation in

ASEAN countries. *Sustainable Energy Technologies and Assessments*, *53*, 102668. doi: https://doi.org/10.1016/j.seta.2022.102668

Liu, X., & Bae, J. (2018). Urbanization and industrialization impact of CO2 emissions in China. *Journal of Cleaner Production, 172*, 178-186. doi: https://doi.org/10.1016/j.jclepro.2017.10.156

Machado, J. A., & Silva, J. S. (2019). Quantiles via moments. *Journal of Econometrics, 213*(1), 145-173. doi: https://doi.org/10.1016/j.jeconom.2019.04.009

Mahmood, H., Alkhateeb, T. T. Y., & Furqan, M. (2020). Industrialization, urbanization and CO2 emissions in Saudi Arabia: Asymmetry analysis. *Energy Reports, 6*, 1553-1560. doi: https://doi.org/10.1016/j.egyr.2020.06.004

Meo, M. S., & Abd Karim, M. Z. (2022). The role of green finance in reducing CO2 emissions: An empirical analysis. *Borsa Istanbul Review, 22*(1), 169-178. doi: https://doi.org/10.1016/j.bir.2021.03.002

Mngumi, F., Shaorong, S., Shair, F., & Waqas, M. (2022). Does green finance mitigate the effects of climate variability: role of renewable energy investment and infrastructure. *Environmental Science and Pollution Research, 29*(39), 59287-59299. doi: https://doi.org/10.1007/s11356-022-19839-y

Moslehpour, M., Chau, K. Y., Du, L., Qiu, R., Lin, C. Y., & Batbayar, B. (2022). Predictors of green purchase intention toward eco-innovation and green products: Evidence from Taiwan. *Economic Research-Ekonomska Istraživanja, 36*(2), 1-22. doi: https://doi.org/10.1080/1331677X.2022.2121934

Moumin, G., Ryssel, M., Zhao, L., Markewitz, P., Sattler, C., Robinius, M., & Stolten, D. (2020). CO2 emission reduction in the cement industry by using a solar calciner. *Renewable Energy, 145*, 1578-1596. doi: https://doi.org/10.1016/j.renene.2019.07.045

Muhammad, B., Khan, M. K., Khan, M. I., & Khan, S. (2021). Impact of foreign direct investment, natural resources, renewable energy consumption, and economic growth on environmental degradation: evidence from BRICS, developing, developed and global countries. *Environmental Science and Pollution Research, 28*, 21789-21798. doi: https://doi.org/10.1007/s11356-020-12084-1

Munir, K., & Ameer, A. (2019). Nonlinear effect of FDI, economic growth, and industrialization on environmental quality: evidence from Pakistan. *Management of Environmental Quality: An International Journal, 31*(1), 223-234. doi: https://doi.org/10.1108/MEQ-10-2018-0186

Naseem, S., Mohsin, M., Zia-Ur-Rehman, M., Baig, S. A., & Sarfraz, M. (2021). The influence of energy consumption and economic growth on environmental degradation in BRICS countries: an application of the ARDL model and decoupling index. *Environmental Science and Pollution Research, 2*, 1-14. doi: https://doi.org/10.1007/s11356-021-16533-3

Ope Olabiwonnu, F., Haakon Bakken, T., & Anthony Jnr, B. (2022). The role of hydropower in renewable energy sector toward co2 emission reduction during

the COVID-19 pandemic. *International Journal of Green Energy, 19*(1), 52-61. doi: https://doi.org/10.1080/15435075.2021.1930005

Opoku, E. E. O., & Aluko, O. A. (2021). Heterogeneous effects of industrialization on the environment: Evidence from panel quantile regression. *Structural Change and Economic Dynamics, 59*, 174-184. doi: https://doi.org/10.1016/j.strueco.2021.08.015

Pata, U. K., & Kumar, A. (2021). The influence of hydropower and coal consumption on greenhouse gas emissions: a comparison between China and India. *Water, 13*(10), 1387-1402. doi: https://doi.org/10.3390/w13101387

Razmjoo, A., Gakenia Kaigutha, L., Vaziri Rad, M. A., Marzband, M., Davarpanah, A., & Denai, M. (2021). A Technical analysis investigating energy sustainability utilizing reliable renewable energy sources to reduce CO2 emissions in a high potential area. *Renewable Energy, 164*, 46-57. doi: https://doi.org/10.1016/j.renene.2020.09.042

Riti, J. S., Shu, Y., & Riti, M.-K. J. (2022). Geopolitical risk and environmental degradation in BRICS: Aggregation bias and policy inference. *Energy Policy, 166*, 113-129.

Sarkis, J., & Tamarkin, M. (2005). Real options analysis for "green trading": the case of greenhouse gases. *The Engineering Economist, 50*(3), 273-294. doi: https://doi.org/10.1080/00137910500227208

Shahsavari, A., Yazdi, F., & Yazdi, H. (2019). Potential of solar energy in Iran for carbon dioxide mitigation. *International Journal of Environmental Science and Technology, 16*, 507-524. doi: https://doi.org/10.1007/s13762-018-1779-7

Sharif, A., Bhattacharya, M., Afshan, S., & Shahbaz, M. (2021). Disaggregated renewable energy sources in mitigating CO2 emissions: new evidence from the USA using quantile regressions. *Environmental Science and Pollution Research, 28*(41), 57582-57601. doi: https://doi.org/10.1007/s11356-021-13829-2

Sharif, A., Mishra, S., Sinha, A., Jiao, Z., Shahbaz, M., & Afshan, S. (2020). The renewable energy consumption-environmental degradation nexus in Top-10 polluted countries: Fresh insights from quantile-on-quantile regression approach. *Renewable Energy, 150*, 670-690. doi: https://doi.org/10.1016/j.renene.2019.12.149

Sharif, A., Raza, S. A., Ozturk, I., & Afshan, S. (2019). The dynamic relationship of renewable and nonrenewable energy consumption with carbon emission: a global study with the application of heterogeneous panel estimations. *Renewable Energy, 133*, 685-691. doi: https://doi.org/10.1016/j.renene.2018.10.052

Tian, X., Bai, F., Jia, J., Liu, Y., & Shi, F. (2019). Realizing low-carbon development in a developing and industrializing region: Impacts of industrial structure change on CO2 emissions in southwest China. *Journal of Environmental Management, 233*, 728-738. doi: https://doi.org/10.1016/j.jenvman.2018.11.078

Tian, Y., & Li, L. (2022). Will COVID-19 affect China's peak CO2 emissions in 2030? An analysis based on the systems dynamics model of green finance. *Journal of*

Cleaner Production, 356, 131-149. doi: https://doi.org/10.1016/j.jclepro.2022.131777

Tiwari, A. K., Kocoglu, M., Banday, U. J., & Awan, A. (2022). Hydropower, human capital, urbanization and ecological footprints nexus in China and Brazil: evidence from quantile ARDL. *Environmental Science and Pollution Research, 29*(45), 68923-68940. doi: https://doi.org/10.1007/s11356-022-20320-z

Ummalla, M., Samal, A., & Goyari, P. (2019). Nexus among the hydropower energy consumption, economic growth, and CO 2 emissions: evidence from BRICS countries. *Environmental Science and Pollution Research, 26*, 35010-35022. doi: https://doi.org/10.1007/s11356-019-06638-1

Waheed, R., Chang, D., Sarwar, S., & Chen, W. (2018). Forest, agriculture, renewable energy, and CO2 emission. *Journal of Cleaner Production, 172*, 4231-4238. doi: https://doi.org/10.1016/j.jclepro.2017.10.287

Wang, F., Cai, W., & Elahi, E. (2021). Do Green Finance and Environmental Regulation Play a Crucial Role in the Reduction of CO2 Emissions? An Empirical Analysis of 126 Chinese Cities. *Sustainability, 13*, 56-70. doi: https://doi.org/10.3390/su132313014

Wang, Z.-j., Song, H., Liu, H., & Ye, J. (2020). Coupling of Solar Energy and Thermal Energy for Carbon Dioxide Reduction: Status and Prospects. *Angewandte Chemie International Edition, 59*(21), 8016-8035. doi: https://doi.org/10.1002/anie.201907443

Xiong, Q., & Sun, D. (2022). Influence analysis of green finance development impact on carbon emissions: an exploratory study based on fsQCA. *Environmental Science and Pollution Research, 5*, 1-12. doi: https://doi.org/10.1007/s11356-021-18351-z

Xu, J., Moslehpour, M., Tran, T. K., Dinh, K. C., Ngo, T. Q., & Huy, P. Q. (2023). The role of institutional quality, renewable energy development and trade openness in green finance: Empirical evidence from South Asian countries. *Renewable Energy*, *207*, 687-692. doi: https://doi.org/10.1016/j.renene.2023.03.015

Yu, C., Moslehpour, M., Tran, T. K., Trung, L. M., Ou, J. P., & Tien, N. H. (2023). Impact of non-renewable energy and natural resources on economic recovery: Empirical evidence from selected developing economies. *Resources Policy*, *80*, 103221. doi: https://doi.org/10.1016/j.resourpol.2022.103221

Yu, J., Tang, Y. M., Chau, K. Y., Nazar, R., Ali, S., & Iqbal, W. (2022). Role of solar-based renewable energy in mitigating CO2 emissions: Evidence from quantile-on-quantile estimation. *Renewable Energy, 182*, 216-226. doi: https://doi.org/10.1016/j.renene.2021.10.002

Zhao, J., Taghizadeh-Hesary, F., Dong, K., & Dong, X. (2023). How green growth affects carbon emissions in China: the role of green finance. *Economic Research-Ekonomska Istraživanja, 36*(1), 2090-2111. doi: https://doi.org/10.1080/1331677X.2022.2095522