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Unveiling the Role of ESG in Ensuring Low-Carbon Energy Transition

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ABSTRACT

Currently, the position of ESG in energy transition is becoming one of the hot research topics in the academia. In this context, this work studies the impact of ESG on low-carbon energy risk in the panel of 148 nations over the period 2000-2023. As an econometric tool, Method of Moments Quantile Regression is employed which is robust method for heteroscedasticity. The estimations reveal that the promotion of ESG reduces low-carbon energy risk across all the quantiles from 10% to 90%. Furthermore, sub-dimension tests are conducted using environmental, social and governance indices of ESG separately. They also show the negative impact on low-carbon energy risk. Overall, the findings are aligned with both theoretical and economic linkages.

Keywords: Environmental, Social, and Governance, Low-Carbon Energy Risk, Method of Moments Quantile Regression
JEL Classifications: Q4, Q5, I00, J00, C33

1. INTRODUCTION

Over the past several years, Environmental, Social, and Governance (ESG) concept is regarded as one of the main parts of sustainable development. Initially, this theory conceptualized to be embedded within Corporate Social Responsibility (CSR), but now it has transformed into an independent and sophisticated system-based approach that deeply integrated with ecological governance, social responsibility, social responsibility, corporate governance as well as financial and strategic decisions (Friede et al., 2015). Ecological dimensions (E) urge the companies to reduce the emission of greenhouse gases, to use renewable energy sources and efficient consumption of natural resources (Xue et al., 2023). Research show that the companies with high ESG rating mostly invest in green technologies. Social component (S) mainly based on labor law, diversity, impact on local communities and justifiable criteria on supply chain (Ahmad et al., 2024). And Governance factor includes internal governance of structure of the organization, independence of Board of Directors, systematic engagement with stakeholders, and these are the crucial basis for corporations to reach their sustainable and strategic goals (Bel-Oms et al., 2025). International organizations also confirm the importance of ESG. For instance, International Energy agency highlighted that the standards of ESG are the main mechanisms to direct the capital flows into green projects (IEA, 2024).

As a consequence of global climate change, low-carbon energy transition has become an indispensable part of sustainable energy policy. This transformation process is the main tool not only to preserve the environment, but also to ensure social and economic sustainability. For example, Saraji and Streimikiene (2023) examine 123 articles related to this topic created comprehensive structure through identifying social, economic, ecologic, technical and institutional barriers in the process of low carbon transition. This analysis further highlights that Paris Agreement was followed by the sharp increase in the number of scientific publications. Moreover, in the article published in the Journal of Innovation and Knowledge, it was highlighted that low-carbon energy transition decelerates the process of financial and political barriers. Thus, the high initial investment cost, shortage of financial rewards, scarcity of natural resources and subsidies for fossil fuels are the main barriers for low-carbon energy transition. (Saraji and Streimikiene, 2024).

In recent years around the sustainable development conception principles of ESG become a key criterion of global flows of finance and investment. Mainly against the backdrop of necessity to decrease carbon emissions and moderate the bad results of climate change, ESG principles are regarded as a crucial factor to accelerate the low carbon energy transition. ESG rankings evaluate the ecological efficiency, social responsibility and the level of clearness in governance and can be reliable signal for investors (Lu and Li, 2024). Large amount of financial resource is demanded during the procedure of structural change to low carbon energy, because the enforcement of sustainable energy technologies, increasing the efficiency of energy and developing innovative solutions require significant amount of capital and comprehensive strategies (Cenci and Tang, 2024). Empirical researches highlight that the companies with ESG ratings, on average, 2.1% higher volume of low-carbon investments compared to others (Lu and Li, 2024). But, low-carbon energy transition not only focused on the direction of investment, but also requires diversified approach. Because during the process of reducing emissions, enterprises face up to different risks, including volatility of carbon prices and technological uncertainty. For this reason, by allocating diversified investments across different environmental initiatives, companies are able to shape enduring and resilient low-carbon approaches in accordance with ESG standards (Cenci and, 2024). Therefore, ESG principles and diversified low carbon investments are connected to each other, and they are regarded as the main basics of sustainable development as well as reaching climate related goals.

It is clear that previous studies tend to employ ESG and low-carbon energy variables. Some of them deals with the reverse effect whereas others apply various energy variables. However, it should be noted that low-carbon energy risk score is not investigated which might be affected by ESG and its sub-dimensions. Although this relation can be theoretically supported, it is still remaining as a gap. Therefore, this investigation analyses the impact of ESG and its subdimensions on the low-carbon energy risk, running Method of Moments Quantile Regression for the empirical estimations.

2. LITERATURE REVIEW

2.1. The Impact of ESG on Low-carbon Energy Transition

In literature, analyzing ESG and low-carbon energy transition with other factors is gaining interest. More specifically, Peng et al. (2024) examine the carbon reduction measures' effect on the ESG performance of companies which produce energy. Empirical results analyzed and economic studies connected with environment and allow for a relation for energy enterprises to encourage ESG practices and the low-carbon transition, assisting to alleviate the carbon neutrality process.

Especially, Tu et al. (2025) study the effect of energy transition measures on corporate Environmental, Social, and Governance performance by leveraging a quasi-natural test on the basis of the New Energy Demonstration City policy. The outcomes of the research illustrate that the disputes that energy transition policies pose to corporate sustainability and underscore the necessity for politicians to project measures that moderate these troubles while promoting environmental goals. Specially, Kuziboev et al. (2025) analysed how the environmental factor of the Environmental, Social, Governance index led to the energy resources diversification in 36 developed countries between 2000 and 2018. The results highlight considerable modifications, indicating that environmental performance of ESG positively effects energy source diversification around all quantiles from 10% to 90%.

He et al. (2025) studies the outward features of hydrogen energy industry market consumption, regulating the countries policy and enterprises behaviour. Their empiric research also illustrates that the main impel position of technological innovations and the performance of corporate social responsibility in companies perform an increase. Abakah et al. (2024) examine the connection between monetary policy uncertainty and the Environmental, Social, and Governance performance of energy companies. Their crucial results show that there is a continuous indirect correlation between uncertainty and ESG performance in the energy field. Díaz et al. (2024) judges monthly quartile portfolios of ESG-labelled enterprises raised based on their Prospect Theory Value and ESG scores in the tightly checked energy sector. This strategy demonstrates interchangeable to a completely diversified world market index and conformably performs out a world energy index. Fu et al. (2024) evaluates the initially in the literature on Environmental, Social, and Governance investments and renewable markets of energy so as to engage a time-frequency-quantile framework, investigating the correlations among energy commodities (such as oil, coal, and coke), renewable energy equities, and funds of ESG in China. Their basic results highlight that, in the short run, energy equities which are clean are substantial to net contributors, whereas commodity markets mainly behave as recipients.

Lin et al. (2024) examines the asymmetric spillover network relation of uncertainty of policy, the fossil fuel energy market, and international ESG investments with the help of a time-frequency domain test. Their results highlight that when the economy runs undisturbedly, the natural gas market risks have negative spillover impacts on emerging ESG investment of economies. Lu and Li (2024) examined the impact of environmental, social, and governance on low-carbon investment. Their study gives consequences for encouraging low-carbon funds and promoting ESG rankings for clean energy enterprises. More definitely, Wu and Qin (2024) analyses the asymmetric dynamic instability spillovers around new energy, environmental, social and governance, green investment and carbon markets in China, by improving an asymmetric dynamic imbalance connection method. The outcomes indicate that the determination of asymmetric instability shock transference between new energy and ESG stock markets is approximately 40 days. Puttachai et al. (2022) analyse the environmental, social, and governance factors and supposed to have played roles driving the transitions to energy in three dominant countries such as, Sweden, Switzerland, and Norway and three developing countries India, South Africa, and Cambodia during a two century period. Their empirical outcomes indicate the presence of the nonlinear effects of a number of variables - Environmental, Social, and Governance.

Literature review provided above shows that there is no any unique research which examine the effect of ESG and its sub-dimensions on low-carbon energy risk score. Therefore, the current work addresses this limitation.

3. DATA, THEORETICAL BACKGROUND AND METHODOLOGY

3.1. Data and Theoretical Background

The study employs the data of 148 nations spanning the time from 2000 to 2023 on annual basis in order to explore the reveal the influence of Environmental, Social and Governance (ESG) factors on low-carbon energy transition. The explained variable is low-carbon energy risk score. The main non-dependent variable is ESG global metrics, and dimensions such as ESG environmental score, ESG social score, as well as ESG governance score. The control variables are economic development, financial development, globalization and interaction of technological development with ESG indices. The explanation and source of the indicators are given in Tables 1 and 2 contains correlation matrix.

The theoretically, the effect of ESG on low-carbon energy risk is also affected by other factors. Control variables are selected on the basis of their integration with ESG, thus influencing low carbon energy transition. In particular, economic development usually supports low carbon energy transition, but this is not a direct impact: It is implemented by some factors such as investments, political-institutional support, technical development and threshold (Gao et al., 2023). Economic development creates more financial resources and investment opportunities for countries and businesses. Research show that during the periods on high economic growth investments on renewable energy also rise in OECD and other country groups (Ibrahiem et al., 2024). Along with economic development technologies also increase rapidly and energy efficiency rises – as a result the amount of energy consumed per unit of production (energy intensity) decreases. Empirical analyses indicate that an increase in per capita income can reduce energy intensity significantly and thereby accelerate the process of low carbon energy transition. For instance, panel threshold analyses conducted by Zhou and Ma show that 1% increase in GDP per capita decreases energy intensity by 0.6-0.8% (Zhou et al., 2021). Several researches highlight that the implication of economic growth on low carbon energy transition is nonlinear: when economic growth is at a low level or investing process is insufficient, the growth in economy does not promote low carbon energy transition or stimulates it at weak level,

Table 1: The definition and source of the variables

Variable	Abbreviation	Definition	Source
Low-carbon energy risk	LCE	Low-carbon energy risk score, ranging between 0 and 100	Refinitive
ESG	ESG	ESG global score	Refinitive
ESG environmental dimension	ESGE	ESG environmental score	Refinitive
ESG social dimension	ESGS	ESG social score	Refinitive
ESG governance dimension	ESGG	ESG governance score	Refinitive
Economic development	ED	GDP per capita (current US$)	World Development Indicators
Financial development	FD	Domestic credit to private sector by banks (% of GDP)	World Development indicators
Globalization	GLB	KOF globalization index	KOF Swiss economic institute
Technological development	TD	Domestic credit to private sector by banks (% of GDP)	World development indicators

The variables, LCE, ESG, ESGE, ESGS, ESGG, ECDEV, TD and GLB are transformed into natural logarithm. FD cannot be transformed into natural logarithm since it is already given in percentage

Table 2: Correlation matrix

	LOGLCE	LOGESG	LOGESGE	LOGESGS	LOGESGG	LOGED	FD	LOGGLB	LOGTD
LOGLCE	1.000								
LOGESG	−0.287	1.000							
LOGESGE	−0.286	0.941	1.000						
LOGESGS	−0.307	0.967	0.935	1.000					
LOGESGG	−0.264	0.967	0.900	0.915	1.000				
LOGED	−0.278	0.812	0.778	0.817	0.799	1.000			
FD	−0.122	0.511	0.481	0.509	0.515	0.671	1.000		
LOGGLB	−0.072	0.750	0.698	0.745	0.756	0.828	0.652	1.000	
LOGTD	0.022	0.481	0.445	0.481	0.489	0.558	0.532	0.731	1.000

however after a significant income and investment threshold, growth facilitates low carbon energy transition considerably. For this reason, it is necessary to take into account the interactions of "growth*investment" or "growth*government policy" (Chang et al., 2025). The effect of economic growth on low carbon energy transition also differs socially: investments created by economic growth and can increase job opportunities and income prospects widely – and this increases the support for low carbon energy transition in turn. Studies conducted by show that distributive mechanisms such as compensation and retraining programs are not considered in the designing process policy of low carbon energy transition, the benefit from economic growth is distributed differently (Gao et al., 2023).

Additionally, developed financial system (banks, capital markets, "green bonds" private investment funds) expands the opportunities to finance the renewable energy projects. Researches highlight that when the depths of financial markets and the volume of green bonds increase, low carbon energy transition process accelerates. For example, the development of green bonds market helped to improve the share of renewable energy in China (Zhang et al., 2024). Rohan Best indicates that deployment of financial capital directly impacts on the speed of energy transition. If financial resources flow into energy technologies, low carbon energy transition speeds up. But if the financial resources are directed to coal and gas projects this process slows down. Therefore, the efficiency of financial system and management of capital flows plays important role in the process of low carbon energy transition (Best et al., 2017).

Moreover, globalization also supports the low carbon energy transition by technologic transfers and investments. International trade, foreign direct investments and financial globalization accelerates the process through importing renewable energy technologies, attracting new investment and technological experience exchange (Zhang et al., 2024). Financial globalization and depth of markets increases the consumption of renewables. Studies indicate that financial globalization, energy efficiency and ecological innovations supports the consumption of renewable energy products but this impact directly depends on institutional potential and policy of countries (Abdul et al., 2022). Globalization does not always generate a positive impact – it may increase the amount of fossil fuels in certain contexts. Trade liberalization and integration to global markets, in some cases, may give a way to fossil fuel export, thereby it undermines the progress of low carbon energy transition (Guo et al., 2023).

Hence, overall effect of economic growth, financial development and globalization to the low carbon energy transition are contingent upon the economic structure and political choices of the countries.

3.2. Methodology

We apply MMQR as a robust estimator in order to estimate the relevance of the descriptive indicators among diverse low-carbon energy risk quantiles. With this objective, the Method of Moments Quantile Regression (MMQR) equation can be prescribed below (Machado and Silva 2019):

$$LOGLCE_{it} = \alpha_i + X'_{it}\beta + (\delta_i + Z'_{it}\gamma)U_{it} \quad (1)$$

β stands for the vector that includes the coefficients of the metrics. α_i stands for the distinct static effect, whereas δ_i stands for the quantile-specific static influence for country i. Zit stands set identifiable alterations' vector of the descriptive indicators that fulfill the expectation $P\{\delta_i + Z'_{it}\gamma > 0\} = 1$. U_{it} is a stochastic variable that is indetectable and is not mutually related with descriptive variables. It has been regularized to encounter these conditions below:

The value expected of U_{it} is zero, $E(U_{it}) = 0$, whereas the expected absolute value of U_{it} is identical to one $E(|U_{it}|) = 1$. The attributes of equation-1, i.e. α_i^t, β', δ^t, γ' and $q(\tau)'$, are evaluated on the basis of the first moment conditions, accounting for the exogeneity of the explanatory variables. The strategy described by Machado and Silva is followed by this evaluation method (2019). Therefore, the conditional quantile demonstration of this model is exactly described as followed:

$$Q_{LOGLCE_{it}}\left(\tau \mid X_{it}\right) = \left(\alpha_i + \delta_i q(\tau)\right) + X'_{it}\beta + Z'_{it}\gamma\, q(\tau) \quad (2)$$

This evaluates the quantile of conditional distribution the response variable ($LOGLCE_{it}$) related to the covariates as well as it takes into account a panel of individuals analyzed during numerous periods of time. The quantile-τ fixed influence on individual *i*, or the distributional impact on τ, is demonstrated via parameter which is scalar $i(\tau) \equiv (\alpha_i + \delta_i q(\tau))$ in parenthesis. Hansen (1982) formulated the one-step GMM estimator (1982) to evaluate the highlighted model[1] above.

4. EMPIRICAL ESTIMATIONS

The empirical estimations are run by MMQR method. Table 3 contains the outcomes which show the impact of ESG on low-carbon energy risk. They reveal that an increase of ESG negatively and significantly impacts on low-carbon energy risk across all the quantiles, 10-90%. This result is similar to the ones by Lu and Li (2024) who also find that ESG can promote low-carbon investment. They studied the correlation between ESG, and low carbon energy grounded in CSMAR and WIND databases, the example of companies using sustainable energy between 2012 and 2021. The research driven by Lu and Li (2024) proved that ESG rating promotes increase in LCI by 2.1% which is identical to this research. Moreover, ESG ranking lead to expansion in LCI facilitates financial constraints, government subsidies and diminishing inner regulating risks (Lu and Li, 2024). Additionally, another similar result recorded by Jian and Wenhua (2023) who studied ESG performance and carbon emissions intensity of Chinese manufacturing companies from 2010 to 2020 and found that improvement of ESG has constructive effect on decreasing carbon emissions, that is 1unit increase in ESG reduces carbon energy intensity by 2.9%. Even when control variables such as management, firm size and profitability are added to the model, the result does not change (Jian and Wenhua, 2023).

1 Address to Machado and Silva (2019) so as to get more information on estimation steps of the model.

Table 3: MMQR estimations for the impact of ESG on low-carbon energy risk

Dependent variable: LOGLCE					
Variables	Quantiles				
	10%	25%	50%	75%	90%
LOGESG	−0.187***	−0.191***	−0.198***	−0.205***	−0.210***
LOGED	0.045	0.006	−0.053**	−0.110***	−0.151***
FD	−0.001	−0.001**	−0.002***	−0.003***	−0.003***
LOGGLB	−0.244	−0.266**	−0.300***	−0.332***	−0.356***
LOGTD*LOGESG	0.023***	0.029***	0.038***	0.046***	0.052***
Constant	3.595***	4.014***	4.653***	5.273***	5.713***

***, ** and *denote statistical significance at 1%, 5% and 10% levels, respectively

Table 4: MMQR estimations for the impact of ESG environmental dimension on low-carbon energy risk

Dependent variable: LOGLCE					
Variables	Quantiles				
	10%	25%	50%	75%	90%
LOGESGE	−0.127***	−0.141***	−0.160***	−0.180***	−0.194***
LOGED	0.040	−0.000	−0.058**	−0.117***	−0.158***
FD	−0.001	−0.001**	−0.002***	−0.003***	−0.003***
LOGGLB	−0.258	−0.281**	−0.313***	−0.346***	−0.369***
LOGTD*LOGESG	0.023***	0.029***	0.038***	0.047***	0.054***
Constant	3.477***	3.940***	4.601***	5.267***	5.724***

***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively

Table 5: MMQR estimations for the impact of ESG social dimension on low-carbon energy risk

Dependent variable: LOGLCE					
Variables	Quantiles				
	10%	25%	50%	75%	90%
LOGESGS	−0.226***	−0.225***	−0.224***	−0.224***	−0.223***
LOGED	0.046*	0.007	−0.052**	−0.111***	−0.152***
FD	−0.001	−0.001**	−0.002***	−0.003***	−0.003***
LOGGLB	−0.142	−0.177	−0.230**	−0.283**	−0.319**
LOGTD*LOGESG	0.022***	0.028***	0.037***	0.046***	0.052***
Constant	3.337***	3.785***	4.479***	5.156***	5.628***

***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively

Table 6: MMQR estimations for the impact of ESG governance dimension on low-carbon energy risk

Dependent variable: LOGLCE					
Variables	Quantiles				
	10%	25%	50%	75%	90%
LOGESGG	−0.197***	−0.199***	−0.203***	−0.206***	−0.208***
LOGED	0.049*	0.009	−0.048*	−0.107***	−0.146***
FD	−0.001	−0.001**	−0.002***	−0.003***	−0.003***
LOGGLB	−0.302*	−0.313**	−0.328***	−0.344***	−0.355***
LOGTD*LOGESG	0.023***	0.029***	0.037***	0.045***	0.051***
Constant	3.839***	4.218***	4.765***	5.318***	5.683***

***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively

Moreover, economic development has a negative influence on low-carbon energy insecurity at the quantiles from 50% to 90%. Irfan analysed the connection between economic development and low carbon energy strategies by the research driven by the data from 1997 to 2017 of 28 developed and 34 developing countries using ARDL and Granger causality tests indicates that in developed countries economic growth and energy efficiency are unidirectional, that is, in the long run 1% economic development improves energy efficiency by 0.37%. In developing countries bidirectional causality is observed and they stimulate each other. In the short run, energy efficiency increases economic development by 0.15% and economic development increases energy efficiency by 0.22% (Irfan, 2021).

Furthermore, financial development negatively impacts on low-carbon energy risk at the quantiles of 25-90%. This result is similar to the research driven by Latif et al., (2022) who analysed panel data from 2010 to 2021. The main variables of the study are carbon emission, energy efficiency and financial development. The research proved that financial development positively stimulates energy efficiency through the expansion of financial institutions and services, this effect is statistically significant in both the long and short run.And again, increasing efficiency of energy reduces carbon dioxide releases (Latif et al., 2022).

Regarding the globalization, it has also an adverse effect on low-carbon energy risk over the quantiles anayzed from 25% to 90%. A similar result was found in a study conducted by Hu and Tu in China, enterprises from 2011 to 2021. It is found that as the level of globalization increase, the ESG indicators improve and this positive effect is also observed in the environmental, social and governance components. The promoting effect of ESG rankings is more pronounced for large companies which are mainly state-owned. The main is that if globalization increase by 1%, the overall ESG score increases by about 0.05-0.07 points. Globalization encourage the countries to adapt to international ESG standards and improve environmental safety (Hu et al., 2023).

Lastly, the interaction of technological development has a supportive effect on low-carbon energy risk. Jin and Duan investigate the dependence among energy consumption and technological improvement on the basis of a panel data model and regional-level data from China during the period between 1995 and 2012. Contrary to former research, it studies both the short and long-run symmetrical correlation between technology development and energy consuming. The outcomes indicate that in the short run, technology innovations connected with an improvement in energy utilization, as there is no considerable effect on technological innovations and energy consumption. In the long run, however, consumption of energy is favourably and associated with technology innovations mutually. The results of the research highlight that modernization and diversification in technological sector does not straightforwardly lead to a decrease in energy consuming, it helps to achieve sustainable development by increasing efficiency of energy and well-organized energy mechanisms for developing nations (Jin et al., 2018).

The empirical estimations are further done with the application of sub-indices of ESG. More specifically, three pillars of ESG such as ESG environmental dimension (Table 4), ESG social dimension (Table 5) and ESG governance dimension (Table 6) are employed to check their impact on low-carbon energy risk. In this way, the robustness tests are run. According to the results, ESG environmental dimension, ESG social dimension and ESG governance dimensions have negative and considerable influence on low-carbon energy risk at the all quantiles, 10-90%. These outcomes are in line with the ones given in Table 3, and theoretical one as well.

5. CONCLUSION, POLICY IMPLICATIONS AND FUTURE RESEARCH

5.1. Conclusion

Although the necessity to enlarge low carbon energy transition is growing globally, how quickly and efficiently countries can adapt to this process directly depends on such factors as the level of ESG (environmental, social and corporate management) practices.

Which components of ESG (E, S or G) play a crucial role in improving the share of low carbon energy? Does the improvement of ESG directly accelerate the LCET process or does it affect only through indirect channels such as financial flows, innovation levels? How different is this impact in different countries? Hence, the problem was the need to prove the real impact of ESG practices on the transition to low carbon energy through specific economic models and reveal their mechanism.

In this research, the impact of ESG on low carbon energy transition is studied based on the meta data of 148 countries from 2000 to 2023. Panel data-driven and analyzed show that improved ESG performance is significantly connected with increased share of low carbon energy, increased energy efficiency. The results revealed several key mechanisms of ESG affecting the transition to low carbon energy. ESG is employed as the main independent variable and the dependent variables are economic development, financial development as well as globalization. Empirical evaluations are carried out on the basis of MMQR method. The study analyses the data of 23-year period and proves that the development of ESG reduces the low carbon energy risk by 10-90% according to the econometric models used. Moreover, it is also proved that the sub-dimensions (environmental, social and governance) and dependent variables also affects negatively to low carbon energy risk.

In conclusion, it can be said that the increase in ESG will accelerate the low carbon energy transition process, because it is an indicator that includes all environmental, social and governance factors. The countries that follow ESG rules expand the opportunities to finance the projects related to sustainable development, attract investments for green technologies and facilitates the low carbon energy transition process. From a political point of view, States should combine carbon pricing mechanisms with ESG factors and regulatory measures that encourage green bonds to alleviate energy decarbonization. In general, the study confirms that ESG practices are not just a means of image strengthening, but a real driving force of sustainable energy transformation. Strengthening ESG mechanisms at the corporate and institutional levels is an important condition for achieving long-term climate goals and ensuring a sustainable, low-carbon economic future.

5.2. Policy Implications

In order to enhance low carbon energy transition, countries should develop an integrated set of policies including regulatory, financial, infrastructure social and governance factors after which ESG principles also creates conditions to attract investments, improve transparency and ensure just transition. The transition to low carbon energy ought to be accelerated by the legal measures such as national low-carbon strategies and clearly defined emission reduction plans. Additionally, the process need to be facilitated by introducing carbon taxes, reducing subsidies for fossil fuels and promoting green energy projects. As well as, favourable conditions for low carbon energy transition should also be created through preferential loans for green projects, grants and financing low carbon plans based on public-private partnership. By improving renewable energy networks and energy efficient systems countries should create conditions to low carbon energy transition and also there is necessity in conducting strict energy saving standards and constantly monitoring the work process in buildings, transports and industry. In addition to these measures above, governments should also establish the international cooperation with other countries which support low carbon energy and green technologies in the areas of retraining and exchanging the personnel and attracting green bonds on a global scale.

5.3. Future Research

Although the paper deals with the novel relation between ESG and low-carbon energy risk, there are some limitations. More specifically, the empirical estimations do not apply the sub-sample analysis, dividing the dataset by the continents and income level. However, this limitation does not diminish the scientific value of the research and can be done in the future works.

REFERENCES

Abakah, E.J.A., Tiwari, A.K., Abdullah, M., Ji, Q., Sulong, Z. (2024), Monetary policy uncertainty and ESG performance across energy firms. Energy Economics, 136, 107699.

Abdul, M., Mahmood, A., Faisal, R.M., Kaleem, K.M., József, P., Judit O. (2022), The dynamic impact of financial globalization, environmental innovations and energy productivity on renewable energy consumption: Evidence from advanced panel techniques. Frontiers in Environmental Science, 10, 894857.

Ahmad, H., Yaqub, M., Lee, S.H. (2024), Environmental-, social-, and governance-related factors for business investment and sustainability: A scientometric review of global trends. Environment Development and Sustainability, 26, 2965-2987.

Bel-Oms, I. (2025), Determinants and consequences of environmental, social and governance controversies. Corporate Social Responsibility and Environmental Management, 32, 3071.

Best, R. (2017), Switching towards coal or renewable energy? The effects of financial capital on energy transitions. Energy Economics, 63, 75-83.

Cenci, S., Tang, S. (2024), Addressing companies' low-carbon transition challenges requires diversified investments in environmental initiatives. Climatic Change, 177, 161.

Chang, Q., Fan, X., Zou, S. (2025), Threshold effects of renewable energy investment on the energy efficiency-fossil fuel consumption nexus: Evidence from 71 Countries. Energies, 18(8), 2078.

Díaz, A., Esparcia, C., Alonso, D., Alonso, M. (2024), Portfolio management of ESG-labeled energy companies based on PTV and ESG factors. Energy Economics, 134, 107545.

Friede, G., Busch, T., Bassen, A. (2015), ESG and financial performance: Aggregated evidence from more than 2000 empirical studies. Journal of Sustainable Finance and Investment, 5(4), 210-233.

Fu, Y., Qi, H., Chen, Y., Wang, Y. (2024), Short-term impacts vs. Long-term contributions: The role of clean energy and ESG investments in China. Renewable Energy, 233, 121131.

Gao, Sh., Zhou, P., Zhan, H. (2023), Does energy transition help narrow the Urban-rural income gap? Evidence from China Energy Policy, 182, 113759.

Guo, X., Meng, X., Luan, Q., Wang, Y. (2023), Trade openness, globalization, and natural resources management: The moderating role of economic complexity in newly industrialized countries, Resources Policy, 85, 103757.

Hansen, L. P. (1982), Large sample properties of generalized method of moments estimators. Econometrica, 50(4), 1029-1054.

He, M., Zhang, W., Du, X., Zhang, Y., Cui, X., Huang, J., Chen, X., Gao, H. (2025), A study on accelerate the hydrogen energy industry adjustment and regain investment confidence. Renewable Energy, 245, 122768.

Hu, H., Tu, Z., Chen, A., Huang, J. (2023), Enterprises and globalization and ESG performance. Finance Research Letters, 58, 104653.

Ibrahiem, D.M., Houssam, N., Esily, R.R., Sethi, N., Fouad, H. (2024), Modelling energy trilemma and economic growth on renewables in N11 economies: Do economic complexity matter? Heliyon, 10, e36937.

IEA. (2024), World Energy Investment 2024: Overview and Key Findings. Available from: https://www.iea.org/reports/world/energy/investment/2024/overview/and/key/findings

Irfan, M. (2021), Low-carbon energy strategies and economic growth in developed and developing economies: The case of energy efficiency and energy diversity. Environmental Science and Pollution Research, 28, 54608-54620.

Jian, Y., Wenhua, X. (2023), Carbon reduction effect of ESG: Empirical evidence from listed manufacturing companies in China. Frontiers in Ecology and Evolution, 11, 1311777.

Jin, L., Duan, K., Tang, X. (2018), What is the relationship between technological innovation and energy consumption? Empirical analysis based on provincial panel data from China. Sustainability, 10(1), 145.

Kuziboev, B., Ozturk, I., Kalandarov, F., Samandarov, O., Bekjanov, D., Makhmudov, S. (2025), Promoting energy sources diversification through ESG performance, Energy, 324, 136009.

Latif, Y., Shunqi, G., Fareed, Z., Ali, S., Bashir, A. (2022), Do financial development and energy efficiency ensure green environment? Evidence from R.C.E.P. economies. Economic Research Ekonomska Istraživanja, 36(1), 2066555.

Lin, L., Jiang, Y., Zhou, Z. (2024), Asymmetric spillover and network connectedness of policy uncertainty, fossil fuel energy, and global ESG investment. Applied Energy, 368, 123432.

Lu, J., Li, H. (2024), The impact of ESG ratings on low carbon investment: Evidence from renewable energy companies. Renewable Energy, 223, 119984.

Machado, J.A., Silva, J.S. (2019), Quantiles via moments. Journal of Econometrics, 213(1), 145-173.

Puttachai, W., Phadkantha, R., Yamaka, W. (2022), The threshold effects of ESG performance on the energy transitions: A country-level data. Energy Reports, 8(Suppl 16), 234-241.

Peng, Sh., Liu, Ch., Wang, Z., Ye, Z., Sun, X., Tan, Z. (2024), The impact of the carbon reduction policy effectiveness on energy companies' ESG performance, International Review of Financial Analysis, 96, 103720.

Saraji, M.K., Streimikiene, D. (2023), Challenges to the low carbon energy transition: A systematic literature review and research Agenda. Energy Strategy Reviews, 49, 101163.

Saraji, M.K., Streimikiene, D. (2024), An analysis of challenges to the low-carbon energy transition toward sustainable energy development using an IFCM-TOPSIS approach: A case study. Journal of Innovation and Knowledge, 9, 100496.

Tu, Z., Cao, Y., Ma, G., Goh, M., Wang, Y. (2025), Research on the impact of energy transition policies on corporate ESG performance. Journal of Environmental Management, 392, 126702.

Wu, R., Qin, Z. (2024), Asymmetric volatility spillovers among new energy, ESG, green bond and carbon markets. Energy, 292, 130504.

Xue, R., Wang, H., Yang, Y., Linnenluecke, M.K., Jin, K., Cai, C.W. (2023), The adverse impact of corporate ESG controversies on sustainable investment. Journal of Cleaner Production, 427, 139237.

Zhang, J., Li, Z., Ali, A., Wang, J. (2023), Does globalization matter in the relationship between renewable energy consumption and economic growth, evidence from Asian emerging economies. PLoS One, 18, e0289720.

Zhang, Y., Xu, T., Wu, S. (2024), The promoting effect of green bonds on reducing carbon emission intensity through energy structure transition. Sustainability, 16(21), 9318.

Zhou, J., Ma, Z., Wei, T., Li, C. (2021), Threshold effect of economic growth on energy intensity-evidence from 21 developed countries. Energies, 14, 4199.