



## EDITORIAL

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## Global energy transition: From the main determinants to economic challenges

Dynamic global energy transition has been accelerating for the last decade. Interestingly, the energy transition is multidimensional and concerns both the dimensions of technique/ technology and the economic, social, institutional, and legal spheres (Shuguang *et al.*, 2022; Tzeremes *et al.*, 2022; Ramzan *et al.*, 2022; Tzeremes *et al.*, 2022). The literature also points to the significant impact of the digitization of the global economy on accelerating energy transition processes (Shahbaz *et al.*, 2022; Yi *et al.*, 2022). It can be ex-

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pected that due to the currently observed "Artificial Intelligence Revolution," this factor may gain even higher importance.

From the normative perspective, it is commonly assumed that the energy transition should proceed according to the idea of the energy trilemma, which emphasizes three key aspects: ensuring energy security, fair access to energy, and environmental sustainability (Liu *et al.*, 2022). However, reaching this objective is one of the biggest challenges for highly developed societies; specifically, supporting this process is the greatest challenge for current science.

Energy security is about securing stable energy consumption for each economy while reducing the use of dirty energy and systematically expanding the resources of the renewable energy mix (Amigues *et al.*, 2015; Nasir *et al.*, 2022; Taghizadeh-Hesary *et al.*, 2022; Ainou *et al.*, 2023; Farid *et al.*, 2023). Fair access to energy at the microeconomic level is associated with the risk of energy poverty in households, which may significantly limit their functioning (Davidson *et al.*, 2021; Batool *et al.*, 2022; Fraser *et al.*, 2023). From the macroeconomic perspective, energy security is related to the principal of building high-security national energy system, which must be characterised with maximum resilience to geopolitical treats (Jonek-Kowalska, 2022).

In turn, the idea of environmental sustainability is not only related to eliminating the negative impact of energy transition processes on the environment, but also to obtaining positive effects of the transition, both in environmental and socio-economic aspects, defined as part of the implementation of the sustainable development goals set by the United Nations (Tzeremes *et al.*, 2022, Gao & Chen, 2023).

Therefore, the energy transition process which is understood in this way is crucial for all three basic dimensions of a sustainable economy (social, environmental, and economic dimensions) and for increasing economic resilience both at the micro and macroeconomic level as well (Skvarciany *et al.*, 2021; Matuszewska-Pierzynka, 2021; Richterová *et al.*, 2021; Stjepanovic *et al.*, 2022; Kowalska & Bieniek, 2022; Dvorskey *et al.*, 2023; Balcerzak *et al.*, 2023).

It should be emphasized that the currently progressing energy transition process results from many socio-economic phenomena, which have gained importance for the last 30–40 years. During this period, a whole set of changes occurred that enabled and positively influenced the systematic development of energy transition processes. The key determinant here is

the processes of globalization, which have been developing systematically and dynamically since the end of the 20th century (Li *et al.*, 2021; Ramzan *et al.*, 2022; Ahmed *et al.*, 2022). The increase in interdependence resulting from globalization has contributed to the dynamic development of markets and their significant unification in terms of functioning, interrelations, and institutional changes (Fałdziński *et al.*, 2016; Boateng *et al.*, 2022). In this context, the growing role of the financial market is often pointed out, whose instruments are used to finance the implementation of energy transition (Shuguang *et al.*, 2022; Ramzan, *et al.*, 2022; Al Mamun *et al.*, 2022; Lee & Lee, 2022; Zheng *et al.*, 2023).

Additionally, globalization processes have influenced the significant economic growth of world economies and increased their competitiveness and innovation. Significant social changes have occurred in most countries, influencing pro-environmental changes in consumption patterns (Cong Doanh *et al.*, 2021), including energy consumption. All the phenomena mentioned above have influenced the course of energy transition (Tzeremes *et al.*, 2022; Sun *et al.*, 2022; Mujtaba *et al.*, 2022; Adebayo *et al.*, 2022; Liu & Feng, 2023).

On the other hand, the currently observed retreat from that period of vigorous globalization and the time of growing protectionism opens a new chapter for the energy transition process, with the growing role of energy interdependence and energy security. The sudden change we have observed for the last two years confirms that these processes are directly or indirectly related to the changes in modern economies, societies and, obviously, politics, and are, therefore, difficult to control.

However, despite this change in attitude to unrestricted globalization, the measurable impact of the development of the international financial markets and the involvement of transnational policy in shaping the energy transition processes is emphasized (Shuguang *et al.*, 2022; Ramzan *et al.*, 2022; Al Mamun *et al.*, 2022; Lee & Lee, 2022). Some new financial instruments are constantly created as part of the functioning of financial markets. These processes tend to structure state policy; legal solutions and public finances should support investments in energy transition processes (Lindberg *et al.*, 2019; Shuguang *et al.*, 2022; Shahbaz *et al.*, 2022; Mahmood *et al.*, 2022; Liu & Feng, 2023; Lee *et al.*, 2023). This is extremely important because, on the one hand, access to financial market instruments and, on the other hand, access to modern infrastructure seem to be a necessary condition for the energy transition processes and enable, in the long term, the



unwavering development of modern technologies and the implementation of sustainable development goals. Therefore, it seems necessary for individual countries or international organizations to establish long-term energy strategies. From this last perspective, the mentioned determinants of energy transition are institutionally strengthened by the cooperation of countries at the international level and the creation of international legislation. In this case, the newly created institutions and legislation should ensure the socially fair nature of energy transition processes and, as far as possible, a positive impact on implementing sustainable development goals.

From this last perspective, the plans of international institutions are ambitious and assume that in the coming decades, the energy transition processes will positively impact changes in most countries' energy policies. In the case of analyzing the course of energy transition, it is assumed that it should be consistent with the sustainable development goals set out in the 2030 Agenda for Sustainable Development (Brodny & Tutak, 2023). International organizations point out that the energy transition related to implementing the Sustainable Development Goals will involve enormous economic effort, problems with society acceptance, reconstruction of markets, legislation, and institutions associated with investment expenditure that has yet to be recorded. From the European perspective, the ambitious plans of the European Commission, carrying out an energy transition based mainly on renewable energy sources, are aimed to lead to a situation where, by the end of 2050, we will have a decarbonized energy system.

Thus, as already mentioned, these factors force the implementation of substantial investment programs at the level of individual enterprises, entire economies, and even more blocs of countries. Achieving the indicated goals will not be possible without the active involvement of public funds, which in turn may force the need to change the recently widely accepted consensus regarding the foundations of the economic role of government, required or acceptable economic intervention of the state in a general sense, as well as the principles of a well-conducted fiscal policy in details (Balcerzak *et al.*, 2016; Balcerzak & Rogalska, 2016).

From the more technical market perspective, an essential aspect of the energy transition processes is the creation of the renewable energy sector and its dynamic and systematic development (Wang *et al.*, 2021; Agyekum *et al.*, 2021; Calvo & Valero, 2022). In the case of the renewable energy sector, the most significant expectations are related to environmental protec-



tion (Ibrahim *et al.*, 2022), socio-economic development (Gyimah *et al.*, 2022), and the implementation of sustainable development goals (Bei & Wang, 2023). The energy transition based mainly on using renewable energy sources allows for the reduction of pollutant emissions, which have contributed most to the degradation of the natural environment over recent decades (Shuguang *et al.*, 2022). Currently, electricity production, as well as the entire energy sector, is primarily based on the use of fossil fuels, the combustion of which is believed to be responsible for most greenhouse gas emissions. Therefore, the need to improve the energy production process is emphasized, where energy transition, including renewable energy sources, is expected to significantly reduce greenhouse gas emissions and pollutants in the coming decades. Finally, it is believed that it should translate into an improvement in the condition of the natural environment (Olabi & Abdelkareem, 2022). Due to availability, the most important for the renewable energy sector are solar energy, wind energy, and biomass (Olabi & Abdelkareem, 2022; Chang *et al.*, 2022; Chang *et al.*, 2022; Amjith & Bavanish, 2022).

However, it is essential that the renewable energy sector cannot be based on one energy source. Each country's energy system should be built on an energy mix based on a portfolio of renewable energy from various sources (Yana *et al.*, 2022; Bashir *et al.*, 2022). Additionally, the production of renewable energy to replace energy based on fossil fuels will require enormous challenges for societies in terms of technology, technical, infrastructure, and resilience of economies, which will, in turn, be associated with challenges related to legal regulations, sources of investment financing and social issues (Boot-Handford *et al.*, 2014; Abbasi *et al.*, 2022). There is still a technological problem of using the short-term oversupply of energy from renewable sources. The solution to this problem is undoubtedly the use of green hydrogen. The economically practical production of hydrogen from the oversupply of renewable energy and its storage, and then the conversion of hydrogen into energy, fuels, and valuable chemical compounds, is expected to become of the most significant importance in the energy transition processes shortly (Capurso *et al.*, 2021; Boot-Handford *et al.*, 2021; Lebrouhi *et al.*, 2022; Hermesmann & Muller, 2022; Qureshi *et al.*, 2022; Amin *et al.*, 2022).

Within this context, the last, but not most minor issue to consider — critical after 24 February 2022 (Fiszeder & Małeczka, 2022) — is the new role of nuclear energy, which can become the crucial factor in the actual decar-

bonization process of the economy, and at the same time it can determine the abilities of many countries to improve stability of the energy systems within the objective of building geopolitical energy security, and sufficient resilience of national economies (Jonek-Kowalska; 2022).

The interconnections between the challenges described above relating to fundamental technological, social, and systemic changes indicate the scale of dilemmas and economic problems faced by global society and the scientific community, where the characterized multidimensional issues must be treated as a critical research subject.

## References

- Abbasi, K. R., Shahbaz, M., Zhang, J. J., Irfan, M., & Alvarado, R. (2022). Analyze the environmental sustainability factors of China: The role of fossil fuel energy and renewable energy. *Renewable Energy*, 187, 390–402. doi: 10.1016/j.renene.2022.01.066
- Adebayo, T. S., Ullah, S., Kartal, M. T., Ali, K., Pata, U. K., Aga, M. (2022). Endorsing sustainable development in BRICS: The role of technological innovation, renewable energy consumption, and natural resources in limiting carbon emission. *Science of the Total Environment*, 859(1), 160181. doi: 10.1016/j.scitotenv.2022.160181.
- Agyekum, E. B., Amjad, F., Mohsin, M., Ansah, M. N. S. (2021). A bird's eye view of Ghana's renewable energy sector environment: A multi-criteria decision-making approach. *Utilities Policy*, 70, 101219. doi: 10.1016/j.jup.2021.101219.
- Ahmed, Z., Ahmad, M., Murshed, M., Shah, M. I., Mahmood, H., & Abbas, S. (2022). How do green energy technology investments, technological innovation, and trade globalization enhance green energy supply and stimulate environmental sustainability in the G7 countries? *Gondwana Research*, 112, 105–115. doi: 10.1016/j.gr.2022.09.014.
- Ainou, F. Z., Ali, M., Sadiq, M. (2023). Green energy security assessment in Morocco: green finance as a step toward sustainable energy transition. *Environmental Science and Pollution Research*, 30(22), 61411–61429. doi: 10.1007/s11356-022-19153-7.
- Al Mamun, M., Boubaker, S., & Nguyen, D. K. (2022). Green finance and decarbonization: Evidence from around the world. *Finance Research Letters*, 46, 102807. doi: 10.1016/j.frl.2022.102807.
- Amigues, J. P., Le Kama, A. A., & Moreaux, M. (2015). Equilibrium transitions from non-renewable energy to renewable energy under capacity constraints. *Journal of Economic Dynamics & Control*, 55, 89–112. doi: 10.1016/j.jedc.2015.04.001.



- Amin, M., Shah, H. H., Fareed, A. G., Khan, W. U., Chung, E. H. Y. Zia, A., Farooqi, Z. U. R. & Lee, C. H. Y. (2022). Hydrogen production through renewable and non-renewable energy processes and their impact on climate change. *International Journal of Hydrogen Energy*, 47(77), 33112–33134. doi: 10.1016/j.ijhydene.2022.07.172
- Amjith, L. R., & Bavanish, B. (2022). A review on biomass and wind as renewable energy for sustainable environment. *Chemosphere*, 293, 133579. doi: 10.1016/j.chemosphere.2022.133579.
- Balcerzak, A. P. & Rogalska, E. (2016). Non-Keynesian effects of fiscal consolidations in Central Europe in the Years 2000-2013. In M. H. Bilgin & H. Danis, (Eds.). *Entrepreneurship, business and economics - Vol. 2. Proceedings of the 15th Eurasia Business and Economics Society* (pp. 271–282). Springer International Publishing. doi: 10.1007/978-3-319-27573-4\_18.
- Balcerzak, A. P., Pietrzak, M. B., & Rogalska, E. (2016). Fiscal contractions in Eurozone in the years 1995-2012: Can non-Keynesian effects be helpful in future deleverage process?. In M. H. Bilgin, H. Danis, E. Demir, U. Can (Eds.). *Business challenges in the changing economic landscape - Vol. 1. Proceedings of the 14th Eurasia Business and Economics Society* (pp. 483–496). Springer International Publishing. doi: 10.1007/978-3-319-22596-8\_35.
- Balcerzak, A. P., MacGregor, R. K., MacGregor Pelikánová, R., Rogalska, E., & Szostek, D. (2023). The EU regulation of sustainable investment: The end of sustainability trade-offs? *Entrepreneurial Business and Economics Review*, 11(1), 199–212. doi: 10.15678/EBER.2023.110111.
- Bashir, M. F., Sadiq, M., Talbi, B., Shahzad, L., Bashir, M. A. (2022). An outlook on the development of renewable energy, policy measures to reshape the current energy mix, and how to achieve sustainable economic growth in the post COVID-19 era. *Environmental Science and Pollution Research*, 29(29), 43636–43647. doi: 10.1007/s11356-022-20010-w.
- Batool, K., Zhao, Z. Y., Atif, F., & Dilanchiev, A. (2022). Nexus between energy poverty and technological innovations: A pathway for addressing energy sustainability. *Frontiers in Environmental Science*, 10, 888080. doi: 10.3389/fenvs.2022.888080.
- Bei, J. L., & Wang, C. Y. (2023). Renewable energy resources and sustainable development goals: Evidence based on green finance, clean energy and environmentally friendly investment. *Resource Policy*, 80, 103194. doi: 10.1016/j.resourpol.2022.103194.
- Boateng, E., Asafo-Adjei, E., Gatsi, J. G., Gherghina, Ștefan C., & Simionescu, L. N. (2022). Multifrequency-based non-linear approach to analyzing implied volatility transmission across global financial markets. *Oeconomia Copernicana*, 13(3), 699–743. doi: 10.24136/oc.2022.021.



- Boot-Handford, M. E., Abanades, J. C., Anthony, E. J., Blunt, M. J., Brandani, S., Mac Dowell, N., Fernandez, J. R., Ferrari, M. C., Gross, R., Hallett, J. P. (2014). Carbon capture and storage update. *Energy & Environmental Science*, 7(1), 130–189. doi: 10.1039/c3ee42350f.
- Brodny, J., & Tutak, M. (2023). The level of implementing sustainable development goal "Industry, innovation and infrastructure" of Agenda 2030 in the European Union countries: Application of MCDM methods. *Oeconomia Copernicana*, 14(1), 47–102. doi: 10.24136/oc.2023.002.
- Calvo, G., & Valero, A. (2022). Strategic mineral resources: Availability and future estimations for the renewable energy sector. *Environmental Development*, 41, 100640. doi: 10.1016/j.envdev.2021.100640.
- Capurso, T., Stefanizzi, M., Torresi, M., & Camporeale, S. M. (2021). Perspective of the role of hydrogen in the 21st century energy transition. *Energy Conversion and Management*, 251, 114898. doi: 10.1016/j.enconman.2021.114898.
- Chang, L., Saydaliev, H. B., Meo, M. S., & Mohsin, M. (2022). How renewable energy matter for environmental sustainability: Evidence from top-10 wind energy consumer countries of European Union. *Sustainable Energy Grids & Networks*, 31, 100716. doi: 10.1016/j.segan.2022.100716.
- Cong Doanh, D., Gadomska-Lila, K., & Thi Loan, L. (2021). Antecedents of green purchase intention: A cross-cultural empirical evidence from Vietnam and Poland. *Oeconomia Copernicana*, 12(4), 935–971. doi: 10.24136/oc.2021.031.
- Darling, S. B., & You, F.Q. (2013). The case for organic photovoltaics. *RSC Advances*, 3(39), 17633–17648. doi: 10.1039/c3ra42989j.
- Davidson, N., Mariev, O., & Turkanova, S. (2021). Does income inequality matter for CO2 emissions in Russian regions?. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 16(3), 533–551. doi: 10.24136/eq.2021.019.
- Dvorský, J., Švihlíková, I., Kozubíková, Ludmila, Frajtova Michalíková, K., & Balcerzak, A. P. (2023). Effect of CSR implementation and crisis events in business on the financial management of SMEs. *Technological and Economic Development of Economy*, 29(5), 1496–1519. doi: 10.3846/tede.2023.19821.
- Fałdziński, M., Balcerzak, A. P., Meluzín, T., Pietrzak, M. B., & Zinecker, M. (2016). Cointegration of interdependencies among capital markets of chosen Visegrad countries and Germany. In A. Kocourek & M. Vavrousek (Eds.). *34th international conference mathematical methods in economics MME 2016 conference proceedings* (pp. 189–194). Liberec: Technical University of Liberec.
- Farid, S., Karim, S., Naeem, M. A., Nepal, R., & Jamasb, T. (2023). Co-movement between dirty and clean energy: A time-frequency perspective. *Energy Economics*, 119, 106565. doi: 10.1016/j.eneco.2023.106565.
- Fiszeder, P., & Małecka, M. (2022). Forecasting volatility during the outbreak of Russian invasion of Ukraine: Application to commodities, stock indices, currencies, and cryptocurrencies. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 17(4), 939–967. doi: 10.24136/eq.2022.032.





- Fraser, T., Chapman, A. J., & Shigetomi, Y. (2023). Leapfrogging or lagging? Drivers of social equity from renewable energy transitions globally. *Energy Research & Social Science*, 98, 103006. doi: 10.1016/j.erss.2023.103006.
- Gao, C. J., & Chen, H. X. (2023). Electricity from renewable energy resources: Sustainable energy transition and emissions for developed economies. *Utilities Policy*, 82, 101543. doi: 10.1016/j.jup.2023.101543.
- Gyimah, J., Yao, X. L., Tachega, M. A., Hayford, I. S., & Opoku-Mensah, E. (2022). Renewable energy consumption and economic growth: New evidence from Ghana. *Energy*, 248, 123559. doi: 10.1016/j.energy.2022.123559.
- Hermesmann, M., & Muller, T. E. (2022). Green, turquoise, blue, or grey? Environmentally friendly Hydrogen production in transforming energy systems. *Progress in Energy and Combustion Science*, 90, 100996. doi: 10.1016/j.pecs.2022.100996.
- Ibrahim, R. L., Ajide, K. B., Usman, M., & Kousar, R. (2022). Heterogeneous effects of renewable energy and structural change on environmental pollution in Africa: Do natural resources and environmental technologies reduce pressure on the environment? *Renewable Energy*, 200, 244–256. doi: 10.1016/j.renene.2022.09.134.
- Jonek-Kowalska, I. (2022). Assessing the energy security of European countries in the resource and economic context. *Oeconomia Copernicana*, 13(2), 301–334. doi: 10.24136/oc.2022.009.
- Khan, K., Su, C. W., Rehman, A. U., & Ullah, R. (2022). Is technological innovation a driver of renewable energy? *Technology in Society*, 70, 102044. doi: 10.1016/j.techsoc.2022.102044.
- Kowalska, A., & Bieniek, M. (2022). Meeting the European green deal objective of expanding organic farming. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 17(3), 607–633. doi: 10.24136/eq.2022.021.
- Lebrouhi, B. E., Djoupo, J. J., Lamrani, B., Benabdelaziz, K., & Kousksou, T. (2022). Global hydrogen development-A technological and geopolitical overview. *International Journal of Hydrogen Energy*, 47(11), 7016–7048. doi: 10.1016/j.ijhydene.2021.12.076.
- Lee, C. C., Wang, F. H., & Chang, Y. F. (2023). Does green finance promote renewable energy? Evidence from China. *Resource Policy*, 82, 103439. doi: 10.1016/j.resourpol.2023.103439.
- Lee, C. C., & Lee, C. C. (2022). How does green finance affect green total factor productivity? Evidence from China. *Energy Economics*, 107, 105863. doi: 10.1016/j.eneco.2022.105863.
- Li, Y. P., Ramzan, M., Li, X. C., Murshed, M., Awosusi, A. A., Ibrahim, S., & Adebayo, T. S. (2021). Determinants of carbon emissions in Argentina: The roles of renewable energy consumption and globalization. *Energy Reports*, 7, 4747–4760. doi: 10.1016/j.egy.2021.07.065.



- Lindberg, M. B., Markard, J., & Andersen, A. D. (2019). Policies, actors and sustainability transition pathways: A study of the EU's energy policy mix. *Research Policy*, 48(10), 103668. doi: 10.1016/j.respol.2018.09.003.
- Liu, H. Y., Khan, I., Zakari, A., & Alharthi, M. (2022). Roles of trilemma in the world energy sector and transition towards sustainable energy: A study of economic growth and the environment. *Energy Policy*, 170, 113238. doi: 10.1016/j.enpol.2022.113238.
- Liu, Y., & Feng, C. (2023). Promoting renewable energy through national energy legislation. *Energy Economics*, 118, 106504. doi: 10.1016/j.eneco.2023.106504.
- Mahmood, N., Zhao, Y. J., Lou, Q. Q., & Geng, J. Z. (2022). Role of environmental regulations and eco-innovation in energy structure transition for green growth: Evidence from OECD. *Technological Forecasting and Social Change*, 183, 121890. doi: 10.1016/j.techfore.2022.121890.
- Matuszewska-Pierzynka, A. (2021). Relationship between corporate sustainability performance and corporate financial performance: evidence from U.S. companies. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 16(4), 885–906. doi: 10.24136/eq.2021.033.
- Mujtaba, A., Jena, P. K., Bekun, F. V., & Sahu, P. K. (2022). Symmetric and asymmetric impact of economic growth, capital formation, renewable and non-renewable energy consumption on environment in OECD countries. *Renewable & Sustainable Energy Reviews*, 160, 112300. doi: 10.1016/j.rser.2022.112300.
- Nasir, M. H., Wen, J., Nassani, A. A., Haffar, M., Igharo, A. E., Musibau, H. O., & Waqas, M. (2022). Energy security and energy poverty in emerging economies: A step towards sustainable energy efficiency. *Frontiers in Energy Research*, 10, 834614. doi: 10.3389/fenrg.2022.834614.
- Nishiyama, H., Yamada, T., Nakabayashi, M., Maehara, Y., Yamaguchi, M., Kuro-miya, Y., Nagatsuma, Y., Tokudome, H., Akiyama, S., Watanabe, T., Narushima, R., Okunaka, S., Shibata, N., Takata, T., Hisatomi, T., & Domen, K. (2021). Photocatalytic solar hydrogen production from water on a 100-m<sup>2</sup> scale. *Nature*, 598(7880), 304–307. doi: 10.1038/s41586-021-03907-3.
- Olabi, A. G., & Abdelkareem, M. A. (2022). Renewable energy and climate change. *Renewable & Sustainable Energy Reviews*, 158, 112111. doi: 10.1016/j.rser.2022.112111.
- Qureshi, F., Yusuf, M., Kamyab, H., Vo, D. V. N., Chelliapan, S., Joo, S. W., & Vasseghian, Y. (2022). Latest eco-friendly avenues on hydrogen production towards a circular bioeconomy: Currents challenges, innovative insights, and future perspectives. *Renewable & Sustainable Energy Reviews*, 168, 112916. doi: 10.1016/j.rser.2022.112916.
- Ramzan, M., Razi, U., Quddoos, M. U., & Adebayo, T. S. (2022). Do green innovation and financial globalization contribute to the ecological sustainability and energy transition in the United Kingdom? Policy insights from a bootstrap rolling window approach. *Sustainable Development*, 31(1), 393–414. doi: 10.1002/sd.2399.

- Richterová, E., Richter, M., & Sojková, Z. (2021). Regional eco-efficiency of the agricultural sector in V4 regions, its dynamics in time and decomposition on the technological and pure technical eco-efficiency change. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 16(3), 553–576. doi: 10.24136/eq.2021.020.
- Shahbaz, M., Wang, J. D., Dong, K. Y., & Zhao, J. (2022). The impact of digital economy on energy transition across the globe: The mediating role of government governance. *Renewable & Sustainable Energy Reviews*, 166, 112620. doi: 10.1016/j.rser.2022.112620.
- Shuguang W., Luang, S., & Sajid, I. (2022). Green financing role on renewable energy dependence and energy transition in E7 economies. *Renewable Energy*, 200, 1561–1572. doi: 10.1016/j.renene.2022.10.067.
- Skvarciany, V., Lapinskaite, I., & Volskyte, G. (2021). Circular economy as assistance for sustainable development in OECD countries. *Oeconomia Copernicana*, 12(1), 11–34. doi: 10.24136/oc.2021.001.
- Stjepanovic, S., Tomic, D., & Skare, M. (2022). A new database on Green GDP; 1970–2019: A framework for assessing the green economy. *Oeconomia Copernicana*, 13(4), 949–975. doi: 10.24136/oc.2022.027.
- Sun, Y. P., Anwar, A., Razaq, A., Liang, X. P., & Siddique, M. (2022). Asymmetric role of renewable energy, green innovation, and globalization in deriving environmental sustainability: Evidence from top-10 polluted countries. *Renewable Energy*, 185, 280–290. doi: 10.1016/j.renene.2021.12.038.
- Taghizadeh-Hesary, F., Zakari, A., Yoshino, N., Khan, I. (2022). Leveraging on energy security to alleviate poverty in Asian economies. *Singapore Economic Review*, 68(04), 1063–1090. doi: 10.1142/S0217590822440015.
- Tzeremes, P., Dogan, E., & Alavijeh, N. K. (2022). Analyzing the nexus between energy transition, environment and ICT: A step towards COP26 targets. *Journal of Environmental Management*, 326, 116598. doi: 10.1016/j.jenvman.2022.116598.
- Tzeremes, P., Dogan, E., & Alavijeh, N. K. (2022). Analyzing the nexus between energy transition, environment and ICT: A step towards COP26 targets. *Journal of Environmental Management*, 326, 116598. doi: 10.1016/j.jenvman.2022.116598.
- Wang, J., Zhang, S. L., & Zhang, Q. J. (2021). The relationship of renewable energy consumption to financial development and economic growth in China. *Renewable Energy*, 170, 897–904. doi: 10.1016/j.renene.2021.02.038.
- Wang, Q., Dong, Z. Q., Li, R. R., Wang, L. L., (2021). Renewable energy and economic growth: New insight from country risks. *Energy*, 238(C), 122018. doi: 10.1016/j.energy.2021.122018.
- Yana, S., Nizar, M., Irhamni, & Mulyati, D. (2022). Biomass waste as a renewable energy in developing bio-based economies in Indonesia: A review. *Renewable & Sustainable Energy Reviews*, 160, 112268. doi: 10.1016/j.rser.2022.112268.



- Yi, M., Liu, Y. F., Sheng, M. S., & Wen, L. (2022). Effects of digital economy on carbon emission reduction: New evidence from China. *Energy Policy*, 171, 113271. doi: 10.1016/j.enpol.2022.113271.
- Zheng, M., Feng, G.-F., & Chang, C.-P. (2023). Is green finance capable of promoting renewable energy technology? Empirical investigation for 64 economies worldwide. *Oeconomia Copernicana*, 14(2), 483–510. doi: 10.24136/oc.2023.013.



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