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Editorial

Modeling Energy–Environment–Economy Interrelations

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1. Introduction

Energy has become a significant research issue across many disciplines under different methodological approaches, indicating the importance of theoretical and practical implications to structure and implement robust decision-making processes at a global level. This scientific importance stems from its contribution to various economic activities (e.g., production lines and industry, electricity generation, transportation) and for households and respectable living. Energy plays a determining role in keeping the natural environment safe and clean, accommodating all living and non-living things, and maintaining quality issues and decent well-being.

Such matters require an advanced way of structuring scientific arguments to tackle issues related to energy production, distribution, and consumption to prevent or limit environmental degradation (e.g., air pollution) and create ecological improvements with a long-term perspective. Halkos & Paizanos [1] explored the links between environmental quality and macroeconomic variables to concretely inform effective policies, such as fiscal policies on CO_2 emissions. These fundamental research issues meet the global need to effectively and efficiently confront climate change and crisis and bring sustainability closer to our current reality. Kostakis & Arauzo-Carod [2] claim that increased consumption rates in wealthy countries have created economic growth patterns with little concern regarding environmental quality issues.

2. Modeling Issues

Economies exploit many resources (e.g., financial, human, and technical) to increase global competitiveness. In this growth endeavor, overexploitation and over consumption of natural resources generate environmental problems, such as resource depletion and degradation (inter alia: Ekonomou & Menegaki [3]).

The multifaceted character of energy allows for matching scientific approaches toward the common goals of replacing fossil fuels with renewables and exploiting clean energy types to experience sustainable economic growth. Interestingly, policy formulation and strategy implementation regarding energy and environmental issues appear to be challenging and demanding research fields that must process high-value research efforts, collaborating with various scientific viewpoints.

The new climate conditions and extreme weather conditions experienced in many regions intensify the efforts to generate impactful research findings and outputs. Consequently, mitigation and adaptation measures as an integrated part of strategic climate resilience planning should be implemented to confront severe weather conditions and minimize the severity of negative impacts. In turn, the latest technological advancements and energy efficiency issues provide a basis for decision-makers to make applicable, tangible, and measurable efforts to support sustainable practices within socio-economic systems. Supportively, Ruchała et al. [4] researched the possibility of energy recovery from airflow around an SUV-class car based on wind tunnel testing. The study claims that technological progress has been made to minimize device energy consumption and increase energy

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efficiency from freely available sources. The authors state that Energy Harvesting (EH) is a dependable way to increase vehicle energy.

Energy-related concerns, issues, and topics are at the top of the regional, national, and international agendas, prioritizing relevant policy schemes, financial instruments, technology, and environmental awareness across populations. Indicatively, global and international initiatives such as the Paris Agreement, the Conference of the Parties (COP) series, the European Green Deal, and European-Funded programs (e.g., HORIZON, INTERREG, LIFE to name but a few) stress the importance of preserving the environment in front of the climate crisis and relevant risks. To exemplify this, the aforementioned global initiatives have proposed similar green energy pathways towards carbon neutrality that can be achieved through the improvement of overall productivity that are apparently based on renewable energy sources, as noted by Halkos and Aslanidis [5].

A central part of these approaches is dedicated to energy efficiency and renewable energy production and consumption to increase energy efficiency patterns and generate relevant socio-ecological benefits. However, consumer attitudes and individual practices significantly contribute to performing pro-environmental behavior and in becoming more sustainability-focused. Considering the above issues, derived implications and interactions are expected to enhance responsible consumptive behavior by establishing a sustainable business and individual culture with a long-term perspective. Stimulatingly, Stanisławska [6] comprehensively examined households' attitudes towards renewable energy source investments in the lower Silesian voivodeship. The author concluded that financial accessibility and perceived profitability were pivotal drivers for RES investment, whereas policy interventions should seriously consider these factors to reinforce green energy adoption, particularly for low-income households.

Current reality has shown that uncontrolled and unregulated economic activities adversely affect all sustainability dimensions: the economy, environment, and society. In this framework, one particular point that deserves scientific attention is ecosystem services and energy-related issues. Ecosystem services are the benefits people obtain from ecosystems [7]. The level of functioning of ecosystem services, namely provisioning, supporting, regulating, and cultural, should become the primary priority when developing economic plans that use the natural environment to expand. As an activity that threatens the good ecological status of provisioning services, energy is a crucial component in this category, creating dysfunction in the benefits humans receive from the environment. Consequently, there is an imperative need to protect the smooth provisioning flows from nature to the economy and society.

To address these issues, researchers have processed thorough analyses based on detailed and informed methodological approaches to test how the economy interrelates with environmental quality and the role of energy in performing eco-friendly practices. They investigate causal linkages and integration relationships to conclude whether economic expansion impacts environmental quality or whether energy conservation measures are required in the presence of economic growth. In academia, these approaches are grounded in four hypotheses: Growth, Conservation, Feedback, and Neutrality. These hypotheses test whether uni-directional, bi-directional, or no relationships exist between tested variables that reflect energy or environmental processes and economic growth for a country or a group of countries.

Practically, these research efforts are grouped into various 'nexus discussions', indicatively, an energy growth nexus discussion and an environmental growth nexus discussion, based on the variables used. Also, the environmental kuznets curve (EKC) hypothesis has been widely examined to test if economic growth stops degrading the environment after a specific or turning point in the so-called inverted U-shaped curve. For instance, Halkos & Ekonomou [8] investigated if spending on business and leisure tourism leads to lower environmental degradation. They processed a panel data analysis for the euro zone economic space. The research results confirmed the tourism-induced EKC hypothesis for both tested tourism segments.

Moreover, Ekonomou & Halkos [9] thoroughly explored the impact of economic growth on the environment. In their integrative review, the authors extensively discussed all contemporary research efforts bridging two strands of the empirical literature in environmental economics: developments in energy growth nexus discussion and the environmental Kuznets curve.

Considering the above approaches, the researchers processed causality tests to communicate justified arguments at the interface of the economy and energy and environmental proxies. The research findings of these attempts created different results, and various assumptions and hypotheses have been confirmed after being empirically tested. These variations are expected since authors have used different econometric approaches and methodologies to process different sets of variables for other countries or groups of countries of interest. For instance, the research results differ based on whether authors have implemented time series, panel, or cross-section analyses.

In addition, the time range or slots of the analysis constitute a factor that different results rely on. What is important is that these research findings add to the relevant literature from various points of view and synthesize a concrete and solid body of knowledge with meaningful and interpretable inputs and insight available to every interested party for legal and ethical use. A crucial contribution of research in the field is the motives and opportunities to enrich existing knowledge and proceed with further research analyses that will yield new research findings based on contemporary data and processes. Then, this new scientific material will enhance the efforts to shed light on impacts and influences, consequences and results on the socio-ecological and economic systems at the interface of energy production and use and environmental degradation levels.

Understandingly, the economic system encompasses many sectors with an 'individual' ecological footprint when developing expansion or investment plans and using energy or exploiting natural resources. Consequently, an essential strand in the literature concerns the heterogenous nature of many sectors (e.g., the tourism sector, car industry, agrifood) to define impacts and causalities between economic growth and the environment or energy consumption (e.g., primary or final). This research approach helps determine where the contribution of each high-leverage economic sector lies and enriches existing knowledge in the context of environmental or ecological economics. As a direct connection, results can be linked with other disciplines and provide a systemic view of the phenomena under investigation.

Perceiving such a research need, Mainar-Toledo et al. [10] discussed a multi-criteria approach to evaluate wine production, focused on the three sustainability pillars: environmental, economic, and social. The research results support identifying the strengths and weaknesses regarding the sustainability performance of their production for both the vineyard and winery. Furthermore, their approach highlights the significance of required actions to increase the company's sustainability. Additionally, Rodrigues et al. [11] studied the viability of adopting battery electric vehicles in rapid bus transit in Brazil using the AHP method. The results showed that the initial acquisition costs could be a barrier, but in the long run, cities adopting battery buses in their BRT systems can benefit from reduced gas emissions and longer lifetimes of electric bus components.

Notably, Tucki et al. [12] analyzed the influence of the spark plug on exhaust gas composition. They examined specific car models in their research. The vehicles were powered by petrol and LPG, and CO, HC, CO_2, and O_2 emissions were analyzed. Then, the test results were compared with the applicable exhaust gas emission standards. Both in the case of E5 95 petrol and LPG gas, lower exhaust gas emissions were observed when iridium spark plugs were used. Al Mestneer & Bollino [13] elaborated on long-term forecasting models for oil demand emerging from the petrochemical sectors globally. This research effort helps policymakers identify demand patterns and make decisions on crucial economic diversification, economic planning, and environmental sustainability issues. Interestingly, Krysa et al. [14] focused on identifying a methodology for projecting operating costs in a surface mine or quarry. Their

research purpose was to determine the optimal configuration of mining equipment to extract low-grade secondary deposits, considering volatile energy prices.

3. Conclusions

Research studies provide empirical results for making projections and forecasting future situations. In this perspective, test results inform decision-making processes regarding energy generation rates, consumer and household needs, and use patterns. Moreover, they underscore the importance of replacing fossil fuels with renewables and implementing environmentally friendly practices to drastically limit devastating air emissions and other pollution factors negatively affecting environmental quality. Notably, great importance should be placed on the role of technology in the interaction between energy and the economic system to increase efficiency levels without impacting businesses' goals and objectives. These issues demand continuous improvement processes and benchmarking approaches to set targets, define relevant gaps, and take corrective action to establish a protective rather than a reactive atmosphere concerning all interested parties and key stakeholders in the energy–environment–economy interface.

Conflicts of Interest: The author declares no conflicts of interest.

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