Emerging Patterns and Behaviors in a Green Resilient Economy

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Emerging Patterns and Behaviors in a Green Resilient Economy

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Foreword

In a context of environmental challenges and the urgent need for sustainable development, *Emerging Patterns and Behaviors in a Green Resilient Economy* may represent a reference contribution to understanding this new economic and societal landscape, bringing together a series of in-depth analyses and discussions that together point the way to a future where economic growth is seamlessly aligned with environmental responsibility.

This edited volume explores the strategies and innovations that are shaping the global economy, focusing on the intersection of environmental sustainability and economic resilience. It comprehensively explores new business models, policy shifts, and technological advancements. The volume explores and presents a range of perspectives from different fields to illustrate the path to a more sustainable and resilient economic future. Policymakers, academics, and industry leaders who want to understand and contribute to developing a resilient green economy will find this text a vital resource.

With contributions from diverse experts, this book maps out a path toward a sustainable and robust economic future, making it an indispensable resource for policymakers, academics, and industry leaders. It begins with analyzing China's journey toward carbon neutrality, exploring the hurdles and successes that offer lessons for other economies. Further chapters delve into sustainable marketing strategies in tourism, the gender gap in entrepreneurship, and the nexus of CO_2 emissions with manufacturing growth, among other critical topics.

This book delves into the role of rural entrepreneurship, as discussed by Vesna Paraušić and Nataša Kljajić, and the intricate dynamics of scientific output in environmental science, as analyzed by Nikola Vasilić and the team. "China's Pursuit of Carbon Neutrality: Roadblocks and Greenlights" by Vasilii Erokhin and Tianming Gao sets the tone with an in-depth analysis of the world's largest emitter's journey toward carbon neutrality. It is a story of challenges and triumphs that offers valuable lessons for other economies. From China's journey toward carbon neutrality to the insightful examination of marketing strategies in historical tourism by Mahta Saremi and colleagues, this book traverses a broad spectrum of topics.

In "Marketing Strategies in Historical Tourism," authors like Mahta Saremi and Hassan Darabi explore the intersection of tourism, a significant economic

driver, with sustainability principles. This chapter is particularly relevant in preserving cultural heritage while fostering economic growth.

Addressing crucial aspects like gender gaps in entrepreneurship, corporate sustainability, and the intersection of CO_2 emissions with manufacturing growth, each chapter contributes unique perspectives and findings. This book also ventures into the critical discourse of gender and entrepreneurship. Gheorghe Dan Isbășoiu, Dana Volosevici, and Jean Vasile Andrei examine the gender gap in entrepreneurship, offering insights into developing competitive economies that are inclusive and diverse.

In addition to these, this book covers a broad spectrum of topics ranging from the LEADER approach in rural entrepreneurship, the relationship between CO_2 emissions and economic growth, to the development of smart cities, and the dynamics of scientific output in environmental science.

This book also includes in-depth discussions on corporate sustainability, offering operational frameworks for sustainable corporate practices, indicative of the evolving role of businesses in a greener economy. Covering a wide range of topics, including rural entrepreneurship, the relationship between CO_2 emissions and economic growth, and the development of smart cities, this book is a forward-looking collection that reflects and anticipates the future dynamics of green economies.

Cristina Gafu and her co-authors discuss women entrepreneurs' challenges, while Nikola Ćurčić and colleagues analyze personnel policies in Serbian organizations. Ljiljana Rajnović and Snežana Cico explore the possibilities for sustainable business operations in extraordinary external conditions.

Hiranya Dissanayake and colleagues present "Salience of Corporate Sustainability," a chapter that proposes operational frameworks for sustainable corporate practices. This chapter is a testament to the evolving role of businesses in leading the charge toward a greener economy.

Furthermore, chapters like the one on green energy paradigms by Răzvan Vasile and Adriana Grigorescu indicate the breadth and depth of this book's coverage. This forward-looking collection reflects the current state of green economies and anticipates future developments and challenges.

Each chapter presents unique perspectives and insights, contributing to a rich narrative that underscores the importance of inclusive, diverse, and competitive economies. Discussions range from rural entrepreneurship and scientific output in environmental science to the challenges women entrepreneurs and sustainable business operations face under extraordinary external conditions.

Emerging Patterns and Behaviors in a Green Resilient Economy serves as a call to action, inviting readers to engage with pioneering ideas and practices that are pivotal in steering societies toward a more sustainable and equitable future. It is a valuable resource for those in entrepreneurship, economics, environmental science, and sustainability studies, providing in-depth insights into the

emerging trends shaping contemporary economies. This book weaves together a narrative more significant than the sum of its parts, representing a mosaic of strategies, challenges, and innovations crucial for shaping the future of resilient green economies.

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Chapter 1

The Dynamic Interaction Between Scientific Output in Environmental Science and Energy and Carbon Dioxide Emissions in G7 Countries

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Abstract

Due to excessive carbon dioxide emissions, the world is facing environmental devastation. Energy and environmental innovations are considered to be critical tools in combating the growing CO_2 emissions. Developing these innovations requires extremely high investments in research and development processes, where knowledge is generated as one of the important outputs. This knowledge serves as a basis for innovation development and raising awareness among all relevant stakeholders about excessive environmental degradation. One of the significant sources of knowledge is scientific publications. Therefore, the aim of this research is to examine whether increased CO_2 emissions stimulate the scientific community to publish a greater number of papers, as well as whether the knowledge contained in these publications is utilized in reducing CO_2 emissions. The sample consists of G7 member countries. The time frame of the research is 1996–2019. The dynamic properties of the vector autoregression (VAR) models were summarized using impulse response function and variance decomposition forecast error. In most G7 countries, it has been determined that an increase in scientific production in environmental science and energy leads to a reduction in CO_2 emissions. On the other hand, increased CO_2 emissions affect higher scientific productivity in environmental science and energy only in Canada.

Emerging Patterns and Behaviors in a Green Resilient Economy, 1–30

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1. Introduction

Climate changes caused by irresponsible and environmentally unsustainable human behavior have devastating impacts on public welfare and population health (WHO, 2018). Starting from the 1880s, global average surface temperatures have increased by 1 °C because of the increase in greenhouse gas emissions (NASA, 2019). The consequence of this increase is significantly altered weather conditions (Difenbaugh, 2020; Đuričin et al., 2016). Droughts, heavy rainfall, and even in areas where such events were rare until recently are becoming more frequent. Further temperature rise and ocean acidification, as well as an increase in the average sea level globally, are almost inevitable (Petrović & Lobanov, 2020). Such forms of climate change lead to the spread of infectious diseases, reduction in available reserves of clean drinking water, and deterioration of air quality (Montgomery, 2017). Under such circumstances, the sustainability of the ecosystem is being questioned. Experts from relevant organizations estimate that 75% of all greenhouse gases are carbon dioxide (CO_2) emissions, which significantly contribute to the increase in global surface temperature (NASA, 2019). If prompt measures are not taken, it is predicted that with this pace, the global average surface temperature will reach a level of about 1.5 °C between 2030 and 2050 (Petrović & Lobanov, 2020). Therefore, to slow down the process of global warming, it is necessary to reduce CO_2 emissions. Various initiatives have been launched globally to find effective mechanisms for addressing the issue of excessive CO_2 emissions. Two of the most notable agreements are the Kyoto Protocol, established in 1997, and the Paris Agreement on climate change, adopted in 2015. The primary goal is to successfully mitigate global warming by ensuring that the temperature increase remains well below 2 °C (UNFCCC, 2015), through the promotion of energy efficiency principles worldwide. Also, in 2015, the United Nations General Assembly formulated the Sustainable Development Goals, which are projected to be achieved by 2030. Two out of the total 17 goals are clean energy and a less-polluted environment. The implemented measures have not yet yielded the desired results. CO_2 emissions have continued to rise, and in the meantime, a record increase rate of 2.7% was reached in 2018.

The main challenge for environmentalists, the scientific community, policymakers, and other stakeholders is to uncover the main drivers of CO_2 emissions and develop innovative solutions to mitigate them.

Many studies have been conducted to determine the causes of CO_2 emissions. Economic growth, energy consumption, international trade, population, and urbanization have been recognized as the primary factors contributing to the increase in CO_2 emissions (Acheampong, 2018; Apergis & Ozturk, 2015;

Cai et al., 2018; Dong et al., 2018; Mahmood et al., 2019; Sadorsky, 2014; Zhang et al., 2018). The desire of both advanced and developing economies is to achieve increased economic growth and long-term development to improve national well-being. However, this cannot be achieved without serious consequences for environmental quality, as economic growth is likely to be the leading driver of CO_2 emissions. Given that economic growth encompasses a wide range of structural changes and effects (Töbelmann & Wendler, 2020), the question is which is the dominant channel through which economic growth affects CO_2 emissions? With increased economic growth, there is a higher demand for output and a greater need to fulfill various human desires through energy-consuming activities. As economic activities expand, there is a corresponding need for a larger energy supply (Raghutla & Chittedi, 2021). The more energy is consumed, the more fossil fuels are needed to generate that amount of energy (Töbelmann & Wendler, 2020). It is estimated that fossil fuels accounted for 60% of worldwide CO_2 emissions, with coal accounting for 46%, oil for 33%, and natural gas for 20% (Alam et al., 2020). These data undoubtedly highlight fossil energy as the forefront contributor to environmental degradation.

After identifying the primary source of CO_2 emissions, it is now necessary to develop an appropriate mechanism for mitigating the negative effects of energy on the environment without compromising future economic progress.

The continuous growth of CO_2 emissions globally and the necessity to achieve the goals set in the 2030 Agenda for Sustainable Development place a demand on countries to make a change in the current trajectory of economic growth and development, which has predominantly been based on the use of fossil fuels. Analyzing the findings of the report "Mission Innovation Beyond 2020: Challenges and Opportunities," the International Institute for Sustainable Development emphasized the need for a greater focus on innovation, particularly in the field of energy, in order to fully achieve the goals of the 2030 Agenda (Beraha & Đuričin, 2022; Cheng et al., 2021). Energy innovations support the transformation of countries whose economies heavily rely on fossil fuel use into sustainable economies where priority is given to renewable energy sources. Renewable energy sources, such as biomass, sunlight, wind power, waves, hydro, and geothermal, result in lower CO_2 emissions (Chiu & Chang, 2009) compared to fossil fuels, which are widely recognized as the primary source of CO_2 emissions and global warming (Stern, 2007). Renewable energy production innovations, such as solar and wind energy, reduce energy consumption-related emissions. New types of biofuels or more efficient vehicles may reduce mobility-related emissions (Töbelmann & Wendler, 2020). The consumption of renewable energies is a real sustainable economic alternative that could limit the depletion of natural resources, reduce air pollution, ensure energy security, and finally create jobs (Mongo et al., 2021). Hence, the use of renewable sources of energy is considered one of the most important strategies to reduce CO_2 emissions (Gessinger, 1997). Successful implementation of such a strategy requires substantial investments in energy-related research and development activities (Alam et al., 2020) to create conditions for the development of new or the improvement of existing clean energy technologies. Even though increased research and development activities are likely to result in

new and improved clean energy technologies, experience has shown that governments have not been willing to increase funding for these purposes in the past few decades. Furthermore, the amount of funding for energy-related R&D has been declining since the 1980s in both developed and developing economies. In 2014, public energy-related R&D investment in the world was approximately 17 billion US dollars, which is even 3 billion dollars less than 40 years ago (Alam et al., 2020). A possible explanation for the negative trend in energy-related R&D investments is the insufficient awareness among policymakers about the benefits, as well as the consequences of limited investments in this field. Given the devastation that further uncontrolled increases in CO_2 emissions can have on people's livelihoods and the rate of global economic growth, it is imperative that all those responsible for developing and implementing environmental policies aimed at reducing and preventing environmental degradation collect and thoroughly analyze existing theoretical and empirical findings in the field of energy. Scientific publications on relevant topics in this field can be the most reliable source of knowledge for developing effective evidence-based policies (Đuričin et al., 2022). Furthermore, the theory of endogenous growth highlights that R&D sectors create technological innovation through the utilization of human capital and the stock of existing knowledge (Romer, 1986). Basically, scientific publications provide and disseminate knowledge that can inspire new innovative ideas or technological breakthroughs, which researchers and firms can utilize to develop new energy-friendly products, services, or processes that simultaneously stimulate economic growth.

In addition to energy innovation, it is important to highlight the significant role of environmental innovation in abating environmental degradation. Environmental innovations include novel or substantially enhanced products, manufacturing techniques, organizational strategies, or marketing approaches that foster environmental protection, enhance sustainability, and prevent or minimize adverse impacts on the environment (Aldieri et al., 2021). Environmental innovation encompasses a broader range of solutions beyond energy. The following six types of environmental innovations can be distinguished: reducing material costs per unit of output; reducing energy use per unit of output; reducing total production of CO_2; replacing materials with less hazardous or non-hazardous substitutes; reducing soil, water, noise, or air pollution; and recycling waste, water, or materials (Aldieri et al., 2021). These innovations synergistically collaborate with energy innovation to foster a more sustainable and environmentally friendly future.

Taking into consideration the importance of the topic, many studies have analyzed the impacts of energy and environmental innovations on CO_2 emissions. However, research is still limited and far from reaching a consensus (Mongo et al., 2021). Based on their findings, these studies can be divided into two categories. The first group of studies reports that energy or environmental-related innovations contribute reducing CO_2 emissions (Lee & Min (2015) in Japan; Churchill et al. (2019) and Khan et al. (2020) in G7; Álvarez-Herránz et al. (2017) and Dzator & Acheampong (2020) in Organisation for Economic Co-operation and Development (OECD) economies; Carrio'n-Flores & Innes (2010) and Dinda (2004) in United States; Shahbaz et al. (2018) in France; Du et al. (2019)

in high-income countries), while the second group didn't find any relationship (Garrone & Grilli (2010) in 13 advanced economies; Weina et al. (2016) and Herring & Sorrell (2009) in Italy; Wang et al. (2012) in China; Mensah et al. (2018) in Canada, Japan, United States, and United Kingdom). Also, the studies utilize various indicators for innovation, primarily relying on R&D expenditures and patents (Carrio'n-Flores & Innes, 2010; Churchill et al., 2019; Mensah et al., 2018) in the environmental and energy-related fields, while number of researchers (Huang et al., 2018; Wu et al., 2018) and, particularly, scientific publications (de Gouveia & Inglesi-Lot, 2021) in these areas are rarely used.

Given that the examination of the relationship between scientific publications and CO_2 emissions is not sufficiently covered in the existing literature, the aim of this study is to enrich the existing knowledge in this specific field. As can be seen in the previous paragraph, through a comprehensive search of various scientific publication databases, only one study addressing this issue has been identified. de Gouveia and Inglesi-Lotz (2021) conducted a comprehensive analysis of the causality between climate change-related research output and CO_2 emissions in developed and developing countries from 1996 to 2019. The results indicate the presence of bidirectional causality between research output and CO_2 emissions in developed countries, while there is a one-directional causality running from research output to CO_2 emissions in developing countries. When individually examining the world's leading economies (G7), only Germany and Italy exhibited a one-directional causality running from CO_2 emissions to research output. This research solely examined causality, which offers evidence regarding the presence and direction of causality. However, it does not provide information about dynamic behavior of variables or whether the impact is positive or negative. To overcome the given limitations, we will utilize impulse response and variance decomposition forecast error analysis. Additionally, the authors construct the research output indicator by aggregating publications from 13 climate-related scientific fields, which undoubtedly ensures extensive coverage. Nevertheless, this approach may lead to a loss of insight into the specificity and significance of each field in reducing CO_2 emissions. For this reason, and in line with the described state of the art in research, we have decided to use two indicators of scientific output: the number of publications in the field of energy and in the field of environmental science. For the research sample, an informal grouping of seven advanced world economies known as the G7 has been selected. These are among the most industrialized countries in the world with significant influence in shaping global policies (Ajmi et al., 2015). They have established ambitious targets for reducing CO_2 emissions and have placed R&D investments at the core of their energy and environmental policies. In accordance with the available data, the research covers the time frame of 1996–2019.

2. Materials and Methods

The main goal of this chapter is to investigate the dynamic interrelationship between scientific productivity in the field of energy and environmental sciences and CO_2 emission in the G7 group of countries. As indicators of scientific productivity in the fields of energy and environmental science, the number of scientific

publications was used. Environmental science encompasses scientific production in 11 subfields, while energy covers 5 subfields (Table 1.1). The required information on the number of scientific publications was retrieved from the Scopus-linked SCImago electronic database. On the other hand, the indicator of CO_2 emission is the total annual CO_2 emissions in kilotons. It covers emissions stemming from the burning of fossil fuels and the manufacture of cement. They include CO_2 produced during consumption of solid, liquid, and gas fuels and gas flaring. Data on CO_2 emission were obtained from the World Bank website. Limited by the availability of relevant data, the study covers a time frame from 1996 to 2019.

We begin our journey toward achieving the stated research aim by employing the VAR model. The VAR approach builds the model by expressing each endogenous variable in the system as a function of the lagged values of all endogenous variables within the system. This extends the univariate autoregressive model to a vector autoregressive model that consists of multiple time series variables. The general form of a VAR(m) model in terms of a mathematical expression follows:

$$y_t = \varphi_1 y_{t-1} + \ldots + \varphi_m y_{t-m} + ¥_1 x_t + \varepsilon_t \quad \text{(a)}$$

where y_t – endogenous column vector of order 2 × 1; x_t – exogenous column vector of order K × 1; m is the lag length for the endogenous variable; ε_t – error

Table 1.1. Scientific Subfields Included in the Analysis.

Fields	**Subfields**
Environmental science	Ecological modeling
	Ecology
	Environmental chemistry
	Environmental engineering
	Global and planetary change
	Health, toxicology, and mutagenesis
	Management, monitoring, policy, and law
	Nature and landscape conservation
	Pollution
	Waste management and disposal
	Water science and technology
Energy	Energy engineering and power technology
	Fuel technology
	Nuclear energy and engineering
	Renewable energy, sustainability, and the environment

Source: SCImago (n.d.).

column vector of order 2 × 1; $\varphi_1, \ldots, \varphi_m$ are 2 × 2 order matrices; and 2 × K order matrices ¥ are the coefficient matrices to be estimated. We estimated VAR models in levels rather than in first differences. A VAR estimation in levels is considered by many to be valid even if the underlying variables have unit roots (Ashley & Verbrugge, 2009; Gospodinov et al., 2013; Hamilton, 1994; Sims, 1980). Gospodinov et al. (2013) found that the level of specification of the VAR model is generally more robust than the vector error correction model (VECM) and VAR in differences in terms of impulse response estimation when the true data generation process is unknown. Their findings align with the results of Ashley and Verbrugge (2009) who demonstrated that overdifferencing of the model leads to inaccurate estimations of impulse response functions, including inadequate coverage of confidence intervals.

In the pursuit of measuring the dynamic interrelationship among variables, the VAR analysis frequently leads to the computation of impulse response function and forecast variance decomposition error.

The impulse response function explains how a variable reacts to a one standard deviation disturbance caused by another variable in the system over short- and long-time horizons, while keeping all other variables unchanged. We employed the cumulative impulse response function to showcase the accumulation of disturbance impact on our variables over time rather than focusing on the impact at a single moment. The impulse response function is based on a moving average representation of the VAR model in Equation (a). The Cholesky decomposition is used to orthogonalize the variance–covariance matrix in the VAR framework. In this way, the problem of contemporaneous correlation among the variables is mitigated (Swanson & Granger, 1997). The variables are ordered in a specific manner, introducing a deliberate framework that guides the calculation of impulse response function and forecast variance decomposition error as explained by Sims (1980). The order of variables is set as follows: [CO_2 Env] and [CO_2 Enrg].[1] To examine impulse response parameters, it is essential to compute confidence intervals. The confidence interval of the impulse response function is calculated by estimating the standard error of the estimated VAR parameters, as they form the basis for creating the impulse response matrix. Due to the small

[1]Placing CO_2 as the first variable in a model assumes that changes in CO_2 in the current period may directly influence scientific production in the fields of Env and Enrg in the same period. However, this ordering also implies that immediate or simultaneous changes in scientific productivity in the fields of Env and Enrg do not have a direct impact on CO_2 in the same period. In other words, when there are sudden economic shocks happening right now, those shocks are not assumed to immediately affect CO_2 at the same time. Instead, this ordering suggests that any impact from publications in the Env and Enrg scientific fields on CO_2 might take some time to show up or occur with a delay. To summarize, this ordering assumes that changes in CO_2 can affect publications in the Env and Enrg scientific fields right away, but changes in scientific productivity in the fields of Env and Enrg do not immediately affect CO_2; there may be a time lag or delay for publications in the Env and Enrg scientific fields effects to influence CO_2.

sample size, we cannot rely confidently on asymptotically based confidence interval as previous research has shown that it provides adequate coverage only in sufficiently large samples (Kilian & Kim, 2011). Instead, we opted for a bootstrap approach. Nevertheless, Kilian (1998) states that the standard bootstrap interval will perform poorly in small samples, because it doesn't explicitly account for the bias and skewness of the small-sample distribution of the impulse response estimator. To address this issue, a so-called two-stage bias-adjusted approach has been developed (Kilian, 1998). Accordingly, we will obtain the standard error distribution of the impulse response function through two-stage bias-adjusted bootstrap confidence intervals with 1,000 bootstrap replications and 500 double-bootstrap replications and use the 0.5th and 99.5th, 2.5th and 97.5th, and 5th and 95th percentiles of the distribution as the lower and upper bound limits of the confidence interval of the impulse response results.

The impulse response function indicates only the direction of the impact but not its magnitude. Hence, we utilize forecast variance decomposition error to estimate the proportion of the change in a variable that can be attributed to its own disturbances and the disturbances of other variables in the system. In case that a variable explains most of its own disturbance, then it does not allow variances of other variables to contribute to it being explained and is therefore said to be relatively exogenous (Sims, 1982). Variance decompositions and associated standard errors are calculated using 1,000 Monte Carlo simulations.

3. Results

Different criteria can assist in selecting the appropriate lag length for the VAR model. The results of the Akaike information criterion (AIC), Schwarz information criterion (SIC), and Hannan and Quinn information criterion (HQIC) are provided in Table 1.2. In some cases, these three information criteria choose different lag lengths. While choosing a small number of lags can generate an omitted-variables bias problem, introducing an excessive number reduces the sample size available for estimation and, hence, increases the standard errors (Puente-Ajovín & Sanso-Navarro, 2015). Bearing in mind that our sample is relatively small, the final decision is to rely on the Schwarz information criterion, as it selects the most parsimonious model in the case of finite small samples.

In this study, the VAR models are two-way variable systems with lag specifications determined in the previous step. In all models, the values of adjusted R^2 are quite high and slightly lower than those of unadjusted R^2.[2] Therefore, the explanatory power of all equations is robust.

To check for the statistical adequacy of the established VAR models, stability, heteroscedasticity, and serial correlation tests were performed (Table 1.3). This is particularly important because if the model is not statistically adequate, the reliability of the obtained results and the derived inferences based on them can be questioned. The Lagrange multiplier test shows that the residuals are independent

[2]The results of the estimated VAR models are available upon request.