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Natural resource volatility and financial development during Covid-19: Implications for economic recovery

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ABSTRACT

Demand for natural resources is constant, while the prices of natural resources increase day-by-day, which has a significant impact on financial development and economic activity. Thus, the study intends to test the association of natural resource volatility and financial development, in order to recommend policies for economic recovery. The study acquires and analyses data for the N11 economies. The findings reveal that natural resource volatility is linked to global economic growth and governmental governance in pre-pandemic era as well as during pandemic. Results exposed that natural resource volatility has a large detrimental impact on global economic growth and plays a prominent part in economic recovery. The findings are robust and reveal that natural gas, oil, and the quality of public administration all contribute to N11 financial development. The study suggests that policymakers address the challenges raised through the solutions discussed.

1. Introduction

There has been much discussion among academics and policymakers since the early 1990s about whether the presence of natural resources is beneficial to economic development and growth. Some argue that natural resource abundance is detrimental to an economy's health, since it slows growth relative to resources. Human capital, however, is a temporary component (Ainou et al., 2022; Thitinan and Chankoson Khunanan, 2022). Increases in institutional quality, and a broader range of products, are key factors in turning natural resource scarcity into resource plenty. There is empirical evidence showing that natural resources are beneficial to an economy, and the rent from natural resources is a driver of the economy with the potential to raise real per capita output or productivity. Thus, the value and profits from natural resources should not be disregarded. Natural resources are the most sought-after products because of their high demand and because they are essential to the functioning of commercial and agricultural industries (Bai et al., 2022; Li et al., 2022). The economy, industry, and agriculture all benefit from the overexploitation of natural resources because of the energy it produces. The increased carbon emissions from depleting natural resources is a major driver of environmental degradation. Nonetheless, using renewable energy sources to meet energy demands might significantly lessen ecological risk (Chien, 2022a; Han et al., 2022). Scholars and policymakers are more worried about the unpredictable behaviour of natural resource prices over time than about inconsistencies in the role of natural resources in development. Many events and crises, both economic and otherwise, have occurred throughout the previous three decades, causing widespread shifts in society across the globe, such as the European sovereign debt crisis, oil supply surplus, and recent Covid-19 pandemic, all of which have been blamed for global and regional financial difficulties (Anderson et al., 2020; Chien et al., 2022b). Is it plausible that a greater number of banks would improve the financial performance of small and medium-sized enterprises (SMEs). However, it is unclear whether the benefits change between times of normality and times of crisis. A long-term relationship with a bank may help a business withstand times of turmoil and keep contributing to the local economy, and SMEs are particularly vulnerable to this issue. However, few studies look at the spending and saving behaviours of micro-businesses, even though they are among the most resource-constrained and secretive of SMEs. Research shows that micro-businesses have more severe economic limits and a greater rejection rate for loans than larger SMEs. Indeed, numerous articles analyse the probability of default, the availability of bank lending and lending terms, and the credit limits of organizations, to show the major

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influence of financing and bank proximity on small businesses (Chien et al., 2022c; Lin, 2022). Several studies indicate that local banking has major benefits for socioeconomic activity and is increasingly important to the success of SMEs. International commerce also profoundly affects the extraction and conservation of natural resources. The Convention on International Trade in Endangered Species and the Convention on Biological Diversity are both bolstered by the General Agreement on Tariffs and Trade. In recognition of this influence, governments allow exceptions to treaty commitments for measures that "correspond to the preservation of extractable natural resources". Several ways exist to gauge the impact of trade. By altering relative prices, trade liberalization can be made to affect the incentives for exploitation (Chien, 2022d; Liu et al., 2022a). The demand for resource-intensive items or ecological processes may be affected by trade's effect on the labour market and wage levels. Natural resource administration organizations are affected by, and may affect, trade. Therefore, trading is a possible factor in the volatility of natural resources. The creation of new opportunities for employment and improvements in people's standard of living are two of the main ways technological progress boosts financial development (Dinh et al., 2022; Si et al., 2021). Surprisingly, both high- and low-income nations stand to gain from innovation. The prosperity of humanity in every sphere relies on the development of cutting-edge technology and ideas. Innovation is driven by human resources and affects both resource-poor and rich countries (Duong and Hai Thi Thanh, 2022; Liu et al., 2022b). The primary goal of technical innovation is to boost efficiency and enable businesses to meet the demands of global commerce. Increases in manufacturing need additional natural resources, leading to price and availability swings. Given the potential importance of international commerce and the technical progress in explaining price changes of natural resources, the research is motivated to include these factors alongside financial output. The findings from this research are useful for governments, administrators, and researchers tackling the problem of natural resource volatility (see Tables 2–5).

The interplay among natural resources, financial development, and economic recovery is critical to understanding the economic performance of N11 economies. This work is innovative and contributes threefold to the current literature. Firstly, the study reveals fresh insights into outlined constructs in the pandemic period and presents theoretical insights into N11 economies. This is less studied and is the first contribution of the research. Secondly, the research understands that public management quality has a significant impact on economic output. Many studies show that strong institutional quality positively impacts economic development and the availability of natural resources, but, as per author's knowledge, no previous research considers the importance of natural resource management quality in the context of volatility on global economic performance, which is another significance of this research. Finally, this research adds to practice by offering policy recommendations for economic recovery maximization through natural resource management and financial management.

The remaining part of study structured as follows: literature review which provides the synthesized review of preceding literature. Methodology, which is the next section of the study discusses about data techniques and constructs measurements. Next to methodology, results has been discussed and finally in last part of the study the conclusion has been drawn with implications.

1.1. Nexus between economic performance and innovation

Sustainability in developing economies requires a delicate balance between green funding, technological innovation, and environmental performance. Green technology's capacity to boost renewable energy production and consumption is one of its most visible advantages (Iram et al., 2020; Kamarudin et al., 2021; Chien et al., 2021). One way to increase ecological innovation and the possibility of producing more clean energy is to boost ecological preservation of green funding by attracting worldwide financial aid for clean energy R&D and REP. More green innovation means more green investment from businesses. The result is more international funding for environmental causes and better efficiency in those causes. Therefore, we insist that environmentally friendly developments are necessary for green finances and ecological effectiveness (Sadiq et al., 2023a; Huang et al., 2022; Mohsin et al., 2021).

Environmental efficiency, green finance, and new ideas are all interconnected. Firstly, increasing environmental productivity might inspire greener lifestyles in several ways. Secondly, ecologically friendly technology is connected with greater ecological efficacy. This pattern is likely to persist as long as green initiatives are planned for the long term. As public support for environmental causes grows, administrations increase their investment in research and development for renewable energy production. This suggests a link between green finance and ecologically sound practices, which drives green invention (Sadiq et al., 2023b; Anser et al., 2020; Lan et al., 2022). The financial industry finds the best available technologies and speeds up technological innovation by selecting technical projects with high chances of success (Kurniawan et al., 2022; Lin et al., 2022). The increased efficiency with which resources are used and new technologies are developed is directly attributable to the work of economic organizations, which enable consumers to save and invest money. Although we find that banking and stock market volatility are negative for financial development, overall, the financial sector has a positive effect, suggesting that the financial sector is an engine of economic activities.

1.2. Green finance and natural resources development

One school of thought holds that the renewable energy sector's endowment of natural resources has a crowding out effect on technological progress. The term 'crowding out' refers to a process that manifests itself in four ways. Firstly, removal industries are likely to crowd out manufacturing process in areas rich in natural resources, since the economy is based on exploiting these resources (Mostafa et al., 2015). Secondly, local economies may need more competence in renewable technologies (Moslehpour et al., 2022a; Zeng et al., 2020). Thirdly, mineral resource sites hinder technological improvements which boost resource and industrial efficiencies, since there are fewer resource constraints and less potential for gains in financial development. Finally, there are significant short-term benefits to extracting natural resources, which may be considered 'windfalls' in specific contexts. This means that regions abundant in natural resources are inclined to invest in sectors based on these resources, even if companies need less technological input to expand their economies. The financing of new ideas and economic expansion needs to improve. Data from previous global disasters is supplemented by new evidence.

Studies experimentally investigating the effect of pandemic on the volatility of mineral wealth demonstrate that the distribution of Covid-19 has a significant beneficial impact on the market liquidity of natural resources and oil stock prices. Even with pandemic, the demand and supply for these commodities significantly push natural resource prices up. Shocks to either demand or supply in a region may greatly influence market volatility. The number of people infected, the death rate, and news of falling oil prices all put upward pressure on the cost of essential resources (Mohsin et al., 2022; Moslehpour et al., 2022b). There is widespread agreement across the research on the importance of the crisis' connection to the unpredictability of natural capital. However, studies are yet to address one substantial contributor to the commercial success of countries and regions.

Developing countries are slowed in their economic development, which prevents them from receiving beneficial technical transfers that might speed up their financial development. Research addresses the role of finance in the economic development over a range of periods and circumstances. Despite some contradictory viewpoints Moslehpour et al. (2022c) and Poortinga et al. (2019) regarding the significance of green finance to financial systems, and the expectation that it has a bearing on economic growth in the long run, several studies, Bril et al. (2020) show that using "non-renewable energy causes uncontrolled ecological damage and diminishes organic assets, making it impossible to maintain a system, suggesting that using renewable energy could be the key to achieving sustainable financial development" (Nguyen et al., 2021; Waschull et al., 2022). Green bonds can only be used to fund low-carbon initiatives that lead to pollution reduction, conservation of natural resources or endangered species, or climate change mitigation. However, fossil fuels are still the most popular choice due to costs (Quynh et al., 2022; Sriyakul et al., 2022). Natural resource development involves widespread participation in clean energy and green technology projects, while spreading the risk among many stakeholders. Shareholders get liquidity and an exit strategy via the secondary market. Those focused on short-term investments are attracted to other financial instruments. Green bonds, which encourage expenditure in renewable energy and other ecologically beneficial technology, are worthy of support for several reasons (Chen et al., 2019; Phuoc et al., 2022).

The importance of innovation in power systems, digitalization, and finance, and their influence on attaining sustainability, are investigated. The benefits, drawbacks, possibilities, and threats to energy sustainability are analysed and quantified using an econometric method. We need to look at these concepts realistically, from the viewpoint of political institutions and strategies. Therefore, we consider how political actors in "China, Eurasia, Australasia, Africa, and Latin America" have dealt with energy sustainability before and during the Covid-19 pandemic period. This relationship is the product of the UN's Social Development Goals (SDGs) and the indicators used to measure progress toward them. This paper's pioneering function is comparing data from before and after the Covid-19 outbreak (Van Hoa et al., 2022).

2. Methodology

2.1. Theoretical background

Rising outputs and incomes are significant contributors to energy consumption trends (Gilbertson et al., 2012). Economic growth (GDP), financial development (FD), wind power generation, and green financing are used as control variables in the theoretical framework (Chandel et al., 2016). We use the following equation for the connection between environmentally responsible economic expansion and the responsible use of natural resources:

$$ln\ GDP_{it} = \mu_i + \alpha_1\ ln\ TNR_{it} + \theta_1\ ln\ NGR_{it} + \beta_1\ ln\ ORR_{it} + \beta_2\ ln\ FD_{it} + \varepsilon_{it} \tag{1}$$

This investigation is motivated by the findings of Renault et al. (2017), and focuses on the connection between crude oil price volatility for natural materials and economic efficiency. Because the N11 countries are still bearing the brunt of the Covid-19 pandemic's economic effects, and in light of their recent tendency to implement measures aimed at environmental conservation, the impacts of GDP, TNR, and GI on the N11 economies are studied over the period 1990 to 2020, including the Covid-19 outbreak. The methodology estimates how much income and quality of life increase energy consumption (Menegaki and Tugcu, 2017), and what mechanisms underlie the association among natural resources, sustainable growth objectives, and environmentally friendly financial expansion. The dynamic threshold model is used to explore the dynamics of the relationships. Finance can increase production in two ways, by enabling the distribution of resources to initiatives with the potential for large returns, and by stimulating capital accumulation and new technology growth. Thus, a thriving economy may see spiralling energy prices via a multiplier effect on output. This study constructs a dynamic threshold panel model for fully exploiting natural resources in the service of long-term, sustainable development objectives. It considers rising eco-friendly economies in the context of various economic growth levels.

2.2. Data sources

The study acquires data on the N11 countries from 1990 to 2020 (see Table 1). These countries are Indonesia, Iran, Nigeria, Mexico, Egypt, Bangladesh, Vietnam, Philippines, Pakistan, Turkey and South Korea. Data is acquired from the World Development Indicators (WDI) databank and world fact bank database/

2.3. Model

The study goals prompt us to develop two broad models. TNR, NGR, ORR, and FD all play a role in Model-1.

$$\text{B } GDP_t = f(TNR_t, NGR_t, ORR_t, \text{FD}_t) \tag{2}$$

Model-2 contains an interaction term between TNR and ORR:

$$GDP_t = f(TNR_t, NGR_t, OR_t, QPA_t, TNR * FD_t) \tag{3}$$

Estimation techniques are built from the following two generic models:

$$GDP_t = \beta_0 + \beta_1 TNR_t + \beta_2 NGR_t + \beta_3 OR_t + \beta_4 FD_t + \varepsilon_t \tag{4}$$

$$GDP_t = \beta_0 + \beta_1 TNR_t + \beta_2 NGR_t + \beta_3 OR_t + \beta_4 FD_t + \beta_5 TNR * QFD_t + \varepsilon_t \tag{5}$$

2.4. Estimation strategy

This research uses a variety of econometric methodologies to produce empirical estimates from econometric models. As stated, the research takes data from all over the world for all its variables, and therefore, they can be considered time-series variables. The normality test, means and standard deviation are used in the statistical analysis to summarize the data. The investigation employs time-series parameters, which may have a unit root problem. Consequently, the augmented Dickey-Fuller (ADF) and Dickey-Fuller generalized least square (DF-GLS) unit root tests are undertaken (Badri Ahmadi et al., 2017; Sadiq et al., 2022a). The latter is a more robust test which detrends the data series locally to more accurately define the expected properties. According to the findings, all the factors are stationary at the initial difference for economic recovery.

The Bayer-Hanck combination co-integration test is employed to verify the long-term connection between the research variables. This is chosen over individual tests because it produces more accurate estimates (Jermsittiparset, 2021; Mohsin et al., 2020). Using effective long-run estimators is made possible by the co-integration of variables. Thus, we use fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS), and canonical co-integrating regression (CCR) to analyse the data. FMOLS is descriptive, while DOLS is non-parametric. Hence these estimators are more efficient than the standard ordinary least squares (OLS) techniques, lacking leads and lags (Ojogiwa, 2021). Because the data does not include a mixed order of integration, these estimators effectively avoid the need for a vector autoregressive lag model for economic recovery. In addition, this work uses the regression coefficients estimator to check the data compared to the long-run regression methodologies previously discussed to get

Table 1
Constructs' Measurement details.

Variable Description	Unit	Data source
GDP Global economic performance	Constant 2010 US$	WDI
TNR Volatility of the natural resource	% Of GDP	WDI
NGR Natural gas rents	% Of GDP	WDI
ORR Oil rents	% Of GDP	WDI
FD Financial development	% Of GDP	WDI

Table 2
Slope heterogeneity and cross-sectional dependence.

Slope Heterogeneity Test	Statistics
Δ~	10.590***
Δ~Adjusted	13.777***
Cross-Section Dependence	
GDP	ORR
21.392**	7.71***
TNR	NGR
8.657***	12.782***
QPA	
0.960	

Table 3
Unit root testing.

Variables	Intercept and Trend	
	I(0)	I(1)
GDP	−1.849	−3.182***
ORR	−2.717	−4.132***
TNR	−3.027**	–
NGR	−3.167***	–
QPA	−4.868***	–

Table 4
Co-integration results (Westerlund, 2007)

Westerlund and Edgerton (2008) Statistics	
G_t	G_a
−4.488***	−11.975
P_t	P_a
−21.731***	−12.793***

Table 5
CS-ARDL.

Short Run			
Variable	Coefficient	Std. Error	Z-Statistic
ORR	0.097***	0.0068	7.96
TNR	0.079***	0.0079	7.48
NGR	0.065***	0.0052	4.07
GI	0.087***	0.0087	9.68
ECM(-1)	−0.96***	0.1376	−7.25
Long Run			
ORR	0.070***	0.0091	6.79
TNR	0.055***	0.0188	4.27
NGR	0.031***	0.0061	2.16
GI	0.091***	0.0104	5.65

robust findings.

2.4.1. Normality test and descriptive statistics

For the first step in our empirical estimate, we compute the descriptive statistics for each variable in the study. For each factor, the statistics include the measured and calculated values, the highest and lowest (range) values, the standard error value, and the measures of dispersion of the corresponding data. Each variable's normalcy is examined using the normalcy test introduced by Swanepoel et al. (2019). Slope and excess kurtosis are taken into account and are presumed to be zero. The null hypothesis of the regression analysis (Fornell and Larcker, 1981) assumes that the data is normal if these requirements are met. In other words, if the probabilities surpass 1%, 5%, or 10%, the hypothesis might be rejected, and the variables are not normally formed. The Jarque-Bera normalcy test estimations are computed using the equation:

$$JB = \frac{N}{6}\left(S^2 + 4^{-1}.(K-3)^2\right) \tag{6}$$

2.4.2. Stationarity test

The variable's unit root or serial correlation is examined once the descriptive and inferential statistics and regularity are verified (Hair Jr. et al., 2017). The ADF test takes into account serial correlation, making it an effective unit root test, and also computes a more sophisticated model than the classic Dickey-Fuller (DF) test. Using the continuity formula, the ADF unit root is found:

$$y_t = \gamma + \varphi t + \mu y_{t-1} + e_t \tag{7}$$

The OLS solution of the previous equation is:

$$\Delta y_t = (\mu - 1)y_{t-1} + \gamma + \theta t + e_t \tag{8}$$

The DF-GLS technique (Guo et al., 2017), which is a customized ADF unit root test, is used. This method is better than other unit root tests in terms of capability. An ADF unit root test is then done on the detrended dataset, to accurately identify the series' expected variables for economic recovery. This strategy removes the averages and time during the process from series close to the non-stationary domains. The DF-GLS estimates are obtained by solving the equation:

$$\overline{y}_t = y_t - \left(\frac{\overline{c}}{T}\right).y_{t-1} \tag{9}$$

A basic time series model is used to derive:

$$y_t = d_t + \mu_t \quad (10)$$

$$\mu_t = \rho\mu_{t-1} + \varepsilon_t \tag{11}$$

with a predictable part d_t and a probabilistic component μ_t. For example, $\rho = 1 - \frac{\overline{c}}{T}$.

2.4.3. Bayer-Hanck combined co-integration test

Analysing the information stationarity findings, shows that all the factors are stationary. A co-integration analysis is then performed by using the Bayer-Hanck combined co-integration test. Other Johansen co-integration procedures include the Treiblmaier and Sillaber (2021) co-integration tests. The Bayer-Hanck combined co-integration test is efficient, as it enables us to examine all the panel data procedures together. If these major mechanisms are used in isolation, the results may be unclear or inaccurate. To address this, the authors use a mixed co-integration technique, as well as Fisher F-statistics, a co-integration test combining the empirical results, to offer solid and definitive findings:

$$EG - J = -2[\ln(P_{EG}) + \ln(P_J)] \tag{12}$$

$$EG - J - Ba - Bo = -2[\ln(P_{EG}) + \ln(P_J) + \ln(P_{Ba}) + \ln(P_{Bo})] \tag{13}$$

2.4.4. Long-run estimation techniques

Once we have validated the co-integration relationship between the variables, we examine the unique effect on the global economic performance of each exogenous variable. The long-run estimation techniques FMOLS, DOLS, and CCR are used, which are all examples of modified ordinary least squares (MOLS). Non-parametric and parametric techniques are used by DOLS and FMOLS. These two estimators allow for autocorrelation problems and unobserved heterogeneity, therefore yielding accurate long-run estimates. Using DOLS, the macroeconomic variables' non-stationarity problem can be addressed. The FMOLS and DOLS estimations are:

$$\widehat{\varnothing} = \begin{bmatrix}\alpha\\ \beta\end{bmatrix} = \frac{1}{\sum_{t=2}^{T} Z_t Z_t'}\left(\sum_{t=2}^{T} Z_t y_t^{+} - T\begin{bmatrix}\widehat{\theta}_{12}^{+}\\ 0\end{bmatrix}\right) \tag{14}$$

$$y_t = X_t'\beta + D_{1t}'\gamma_1 + \sum_{j=-q}^{r}\Delta X_{t+j}\sigma + v_{1t} \tag{15}$$

CCR is a correlation coefficient technique for long-term forecasting. The CCR technique corrects the simple regression component, detecting lead and delay. CCR estimations are calculated using the formula:

$$y_t^* = \beta_{pq}^{'} z_{pqt}^* + \mu_{pqt}^* \tag{16}$$

A wide range of stakeholders can profit from the study outcomes in various ways. The pandemic has sparked worry among states and policymakers about natural resources markets, and prompted them to adopt prudent measures. The research results have policy implications for addressing natural resource unpredictability and economic recovery. By delaying investment due to unpredictability, entrepreneurs in financial assets and manufacturing industries may become less hesitant. As a result, economic and industrial activity may resume, and countries can get back on course, leading to a reduction in poverty and improved economic growth in most parts of the world.

3. Results and discussion

Academics and government officials have recently been concerned about natural resource instability. However, price volatility in natural resources, especially oil, has been a concern for decades (Sadiq et al., 2022b). On the other hand, natural resource volatility and financial efficiency have increased in frequency since the outbreak of the Covid-19 pandemic, when two problems relating to natural resources emerged simultaneously. The first was a worldwide financial slump, which harmed industrial and economic operations everywhere, and the second was a worldwide decline in oil prices. Natural resource price volatility has been exacerbated by the ongoing war (Sadiq et al., 2022c; Yumei et al., 2021).Because the current uncertainty, prompt policy insights are required to restore global financial efficiency and address volatility in natural resources. Recent research has established the link between natural resource product price volatility and financial efficiency, although issues remain.

This research investigates whether the volatility of natural resources and the quality of public management interact with the efficiency of economies throughout the world. The research is original and valuable. By giving an actual assessment of the connection between oil and natural gas rents and the worldwide economy, the research adds to previous literature.

It is true that public government has a significant impact on enhancing ecological quality. Nonetheless, its impact on the global economy remains untested. This research offers a complex data examination of the connections between government efficiency and the health of economies worldwide (Sadiq et al., 2022d). Also new to the literature, is the concept of public organizational quality's interplay with the availability of natural resources.

We first determine the normality and descriptive statistics of the data for the variables in question, before beginning the empirical estimates. The mean and median values of GDP, which in this context indicate worldwide financial efficiency, account for $60.3 and $48.8 trillion US, respectively. At the same time, the world economy's gross domestic product (GDP) has increased from a low of $46.8 trillion in 1990, when the time series began, to a high of $85.0 trillion in 2019, which is expected to be its peak (Tan et al., 2021). The wider the disparity between the values, the more extreme the departure from the mean. Therefore, $15.4 trillion US is the standard deviation value. Economies all around the world are actively seeking ways to expand their base of consumers and producers via the use of both natural and artificial means.

The global economic crisis of 2008 and the Covid-19 pandemic both found to have significant adverse effects on global financial development, as measured by a decline in GDP growth. The average and median levels of worldwide TNR are 2.381% and 2.047% of GDP, respectively, but the range of values is rising. As a percentage of GDP, the smallest TNR recorded worldwide is 0.909%, and the largest is 4.984%. Natural resource rent is increasingly essential to financial development. The figures show a TNR standard deviation of 1.076 (as a percentage of GDP), which is consistent with the previous observation that the disparity in the range values is rather substantial (Zhang et al., 2023). Both the skewness and kurtosis are quite close to their respective critical values of 0 and 3.

Four notable causal linkages are seen between the cost of commodities derived from natural resources and the outbreak of Covid-19. Firstly, the orientation of the arrows indicates a substantial relationship in February 2020. The leftward movement at that time show that the first positive instances of Covid-19 and the fluctuation in oil prices seem to be linked in both directions. Secondly, the time between August and November 2020 is identified as relevant for a causal connection. This time is especially significant since it marks the height of the Covid-19 epidemic. During this time, the arrows turn to the right and up, then afterward to the left and down. This shows that fluctuations in the number of Covid-19 positive cases are a major factor in the price swings of commodities derived from natural resources (Zhao et al., 2021). Thirdly, positive instances of Covid-19 had a substantial causal impact on oil prices in February 2021, as seen by the arrows' rightward and upward trajectory. Unfortunately, the scope of this causal connection is narrow. Lastly, there seems to be a direct link between oil prices and positive Covid-19 cases throughout June and July 2021. This influencing factor has a greater frequency, between 16 and 40. The arrows' rightward and upward movement shows a bidirectional causal relationship between the factors under discussion.

Although the number of Covid-19 positive cases is less, their impact is larger. The arrows pointing to the right show that this correlation is in phase, consistent with previous research by on N11 countries and globally (Furqan et al., 2021). The results show that natural resources became more unstable at the height of the Covid-19 pandemic. The pandemic and natural resources commodity prices show physical movement and a causal connection, because the N11 countries delayed production and industrial activity, contributing to the already high volatility in commodity pricing for natural resources. However, prior research reveals that the Covid-19 shock exhibits mean-reverting behaviour and is temporary, which is compatible with the empirical results that the causative impact only lasts for a short time. Using a unique movement panel auto-regressive distributed lag (ARDL) approach, we estimate the long-run elasticities of GDP, ORR, GI, and TNR. This information makes a causal connection between the dependent and explanatory variables.

The research uses the Granger panel causality heterogeneity test (Kraus et al., 2021), and Table 7 shows the predicted scores (see Table 6). The W-statistics show a correlation between the dependent and explanatory variables in both directions. In particular, a substantial unidirectional causal connection is shown between international commerce and TNR. This suggests that a shift in international trade policy might dramatically impact the volatility of natural resources. Any potential impact of a TNR policy shift on international commerce is discounted on the assumption that there is no feedback effect. However, there is a two-way relationship between the dependent variable and the other explanatory variables (GDP, TNR, GI). This demonstrates a feedback effect between the aforementioned explanatory factors and the volatility of natural resources. Therefore, it is inferred that there may be reciprocal effects between policy changes in explanatory factors and the

Table 6
Robustness test.

AMG			
Variable	Coefficient	Std. Error	Z-Statistic
ORR	0.081***	0.0273	2.47
TNR	0.279***	0.0535	5.16
NGR	0.045***	0.0073	2.57
GI	0.066***	0.0185	4.65
Constant	12.773***	0.2026	61.21

Table 7
Causality check.

Pairwise Dumitrescu Hurlin Panel Causality Tests			
Null Hypothesis:	W-Stat.	Zbar-Stat.	Prob.
ORR → GDP	2.37773***	6.38583	0.001
GDP → ORR	2.09773***	5.40747	0.001
TNR → GDP	3.16636***	4.66349	0.001
GDP → TNR	6.79774***	5.32289	0.001
NGR → GDP	3.01666***	1.06477	0.001
GDP → NGR	2.77374***	4.73774	0.001
GI → GDP	1.50172***	2.79618	0.001
GDP → GI	4.98630***	5.41795	0.001

volatility of natural resources. This study conclusions are corroborated by similar conclusions found by Yin et al. (2021), which show a causal relationship running in both directions between the volatility of natural resources and the performance of the economy. Recent years have seen a flurry of research and policymaking focused on the variables contributing to natural resource volatility. Therefore, this research looks at the roles of GDP growth, international commerce, energy infrastructure spending, and technology advancement. The findings indicate that the volatility of natural resources is significantly augmented by financial efficiency, international commerce, and technological innovation. In particular, economic activities that stimulate investment in products and services are causally linked to improvements in financial efficiency. The increased activities stimulate economic development and increase the use of fossil fuels, which causes rises and falls in the price of these fuels. Meanwhile, the economies and industries that benefit from oil exports provide greater energy resources. Volatility in natural resources happens when there is an increase in the supply of such resources. Research by Ma et al. (2022) corroborates the positive relationship between financial efficiency and volatility in natural resources. Therefore, our findings are consistent with these studies. As a result of rising worldwide demand, exporting economies are compelled to ramp up output to meet customer requirements and increase earnings. Because of technical progress, more products and services can be produced with fewer people. As a result, positive shifts in natural resource availability drive up demand. Empirical research by Todorov (2014) supports the statement that increased trade openness leads to price swings in natural resources. Enhancements in technical innovation and green technology dramatically disrupt natural resource demand and supply chains, leading to natural resource instability. The empirical results show that investing energy resources has a detrimental and unfavourable effect on the volatility of natural resources. The findings of this research align with those of Milenkovic et al. (2014), which argue that investing in energy resources, such as renewable energy, may significantly reduce natural resource volatility by reducing natural resource demand and use. This research sparks a new policy-level discussion on the variables influencing natural resource volatility, for which there is little evidence in the previous literature. Based on the empirical results, the paper makes policy recommendations to reduce natural resource volatility. It is essential to have a skilled and educated staff. Most research points to collaboration, empathy, and leadership as crucial soft skills.

Adaptability, social and collaborative problem-solving skills, a strong team spirit, an ability to communicate effectively, and a positive attitude are all capabilities (Zhao et al., 2022). It is essential for green economic recovery that service sectors, such as healthcare and financial services, have staff trained to manage challenges and keep up with constantly evolving customer expectations due to digitalization and soft skills. The evaluation of the impact of digitization on service quality and relationships between service providers and consumers remains a crucial and significant topic, even though it is essential to enabling improvement in service delivery procedures. Those businesses that need to establish themselves in the digital age should digitize their services as soon as possible. The methods used to achieve this goal incorporate technological elements and social, political, and organizational aspects (Daniali et al., 2021). This presents a severe challenge for organizations in the service sector. SMEs are a valuable resource for enacting wide-ranging changes in the service sector. The third line of inquiry is the financial challenges that small firms must overcome, including the role of financial intermediaries in N11 banking systems and the impact of specialization on loan availability. The results suggest that decentralizing the financial sector might help SMEs overcome funding constraints. While the city banking industry has less influence than joint-stock banking, the latter has a greater influence on loosening regulations than administration banks. An investigation of the Italian financial sector concludes that there has to be better lending technology available to SMEs, as owners of SMEs in the European Union have cash flow challenges that necessitate improved financing. According to Menzefricke et al. (2021), obtaining financing is a significant obstacle for start-ups and small businesses. In this predicament, borrowing costs play a significant role. Credit limitations have a detrimental effect on the resources of SMEs, and it is suggested that a high importance is placed on protecting jobs during external shocks and organizing actions to deal with disasters.

4. Conclusions and policy recommendations

The interplay among natural resources, financial development and economic recovery is critical to understanding the economic performance of N11 economies. This work is innovative and contributes threefold to the current literature. Firstly, the study reveals fresh insights into natural resource volatility, financial development and economic recovery in the Covid-19 period and presents theoretical insights into N11 economies. Volatility in the price of commodities derived from natural resources is a topic of intense interest among academics and policymakers. From an investor perspective, studying volatility is beneficial, and directly related to economic growth and development, especially in industrialized nations. The worldwide fear that followed the Covid-19 pandemic outbreak slowed and delayed many commercial and industrial activities, leading to unpredictability in the energy market. In this context, the present research examines the volatility of prices of natural resource commodities in the N11 countries, focusing on the years up to and including the Covid-19 pandemic.

The research employs the DOLS model to examine natural resource commodity price volatility. The results confirm the impact on both copper and crude oil. FMOLS is the only model that can distinguish between positive and negative shock asymmetry in crude oil prices. This suggests that a negative shock of the same size as a positive shock result in a higher level of volatility. The study does not find any evidence of a positive-negative shock imbalance in copper price movements. However, the variance of copper and crude oil prices is positively and statistically significantly correlated with historical volatilities, as shown by the FMOLS specification. Therefore, we conclude that the Covid-19 pandemic triggered uncertainty and volatility in commodity prices related to natural resources.

The Covid-19 pandemic has led to more volatility in the price of crude oil than in the price of copper. The findings are robust and compatible with previous literature. Natural resource commodity prices in the N11 countries are notoriously unstable, which has potentially negative consequences for the countries' finances. Interestingly, this volatility is at its maximum at the height of the Covid-19 pandemic. Therefore, this paper has practical strategy proposals that might address the uncertainty in pricing such resources.

This research provides managers and administrators with recommendations based on actual results that might help stabilize the volatile natural resources market in the face of future outbreaks. This research is essential because it offers evidence that the price volatility of commodities derived from natural resources increases during pandemics. Natural resource commodity price volatility may be mitigated via industrial channels, by enforcing stringent corrective measures such as controlling economic operations through standard operating procedures and assuring immunization for fast recovery from disease. Because of the reduced effects of the pandemic, commercial processes and financial activities can continue, increasing demand for natural resources such as petroleum, and bringing the market closer to a state of equilibrium of supply and demand, hence we may expect less volatility. Natural resource product price volatility is maximum during the Covid-19 epidemic, meaning that traditional price ceilings and price-fixing strategies are still practical. Industrialists can keep up with the demand and supply of natural resources, and investors can regain confidence due to the price stability strategy.

Natural resource protection necessitates state involvement in the market. Specifically, copper prices are observed to be less volatile than crude oil. Therefore, hedging crude oil for the N11 economies may have both immediate and long-term advantages.

The study results are significant, but there are several ways in which future researchers might improve upon the present work. For example, only crude oil and copper price fluctuations are examined in this research. Natural resources such as coal or natural gas or minerals such gold or platinum might be included in a more comprehensive empirical investigation that could expand the scope of this research. This research employs classic estimation methodologies, which have various downsides. Therefore, cutting-edge methods such as wavelets and Fourier transforms are suggested for future research. More research is needed to determine how fluctuations in natural resources affect economic, financial, and ecological metrics.

Author statement

Ching-Chi Hsu: Data Analysis, Writing - Original Draft, Investigation. Ka Yin Chau: Literature Review. Fengsheng Chien: Writing - Review & Editing, Supervision.

Data availability

Data will be made available on request.

References

Ainou, F.Z., Ali, M., Sadiq, M., 2022. Green energy security assessment in Morocco: green finance as a step toward sustainable energy transition. Environ. Sci. Pollut. Control Ser. https://doi.org/10.1007/s11356-022-19153-7.

Anderson, R., Bayer, P.E., Edwards, D., 2020. Climate change and the need for agricultural adaptation. Curr. Opin. Plant Biol. 56, 197–202.

Anser, M.K., Yousaf, Z., Hishan, S.S., Nassani, A.A., Sheikh, A.Z., Vo, X.V., Zaman, K., Qazi Abro, M.M., 2020. Dynamic linkages between transportation, waste management, and carbon pricing: evidence from the Arab World. J. Clean. Prod. https://doi.org/10.1016/j.jclepro.2020.122151.

Badri Ahmadi, H., Hashemi Petrudi, S.H., Wang, X., 2017. Integrating sustainability into supplier selection with analytical hierarchy process and improved grey relational analysis: a case of telecom industry. Int. J. Adv. Manuf. Technol. 90, 2413–2427. https://doi.org/10.1007/s00170-016-9518-z.

Bai, X., Wang, K.T., Tran, T.K., Sadiq, M., Trung, L.M., Khudoykulov, K., 2022. Measuring China's Green Economic Recovery and Energy Environment Sustainability: Econometric Analysis of Sustainable Development Goals. *Economic Analysis and Policy*. https://doi.org/10.1016/j.eap.2022.07.005.

Bril, A., Evseeva, S., Kalinina, O., Barykin, S., Vinogradova, E., 2020. Personnel changes and labor productivity in regulatory budget monitoring. IOP Conf. Ser. Mater. Sci. Eng. 940, 012105 https://doi.org/10.1088/1757-899X/940/1/012105.

Chandel, S.S., Shrivastva, R., Sharma, V., Ramasamy, P., 2016. Overview of the initiatives in renewable energy sector under the national action plan on climate change in India. Renew. Sustain. Energy Rev. https://doi.org/10.1016/j.rser.2015.10.057.

Chen, Z., Zhuang, X., Liu, J., 2019. A sustainability-Oriented enhanced indexation model with regime switching and cardinality constraint. Sustainability 11, 4055. https://doi.org/10.3390/su11154055.

Chien, F., 2022a. How renewable energy and non-renewable energy affect environmental excellence in N-11 economies? Renew. Energy. https://doi.org/10.1016/j.renene.2022.07.013.

Chien, F., Zhang, Y., Sharif, A., Sadiq, M., Hieu, M.V., 2022b. Does air pollution affect the tourism industry in the USA? Evidence from the quantile autoregressive distributed lagged approach. Tourism Econ. https://doi.org/10.1177/13548166221097021.

Chien, F., Chau, K.Y., Sadiq, M., Hsu, C.C., 2022c. The impact of economic and non-economic determinants on the natural resources commodity prices volatility in China. Resour. Pol. https://doi.org/10.1016/j.resourpol.2022.102863.

Chien, F., 2022d. The mediating role of energy efficiency on the relationship between sharing economy benefits and sustainable development goals (Case of China). J. Inno. Knowledge. https://doi.org/10.1016/j.jik.2022.100270.

Chien, F., Hsu, C.C., Sibghatullah, A., Hieu, V.M., Phan, T.T.H., Hoang Tien, N., 2021. The Role of Technological Innovation and Cleaner Energy towards the Environment in ASEAN Countries: Proposing a Policy for Sustainable Development Goals. Economic Research-Ekonomska Istraživanja. https://doi.org/10.1080/1331677X.2021.2016463.

Daniali, S.M., Barykin, S.E., Kapustina, I.V., Mohammadbeigi Khortabi, F., Sergeev, S.M., Kalinina, O.V., Mikhaylov, A., Veynberg, R., Zasova, L., Senjyu, T., 2021. Predicting volatility index according to technical index and economic indicators on the basis of deep learning algorithm. Sustainability 13, 14011. https://doi.org/10.3390/su132414011.

Dinh, H.P., Tran, K.N., Van Cao, T., Vo, L.T., Ngo, T.Q., 2022. Role of eco-financing in COP26 goals: empirical evidence from ASEAN countries. Cuad. Econ. 45 (128), 24–33.

Duong, K.D., Hai Thi Thanh, T., 2022. Association between post-Covid socio-economic development and energy-growth-environment nexus from developing economy. Int. J. Econ. Finance Stud. 14 (2), 247–270.

Fornell, C., Larcker, D.F., 1981. Structural equation models with unobservable variables and measurement error: algebra and statistics. J. Mark. Res. 18, 382. https://doi.org/10.2307/3150980.

Furqan, M.M., Verma, B.R., Cremer, P.C., Imazio, M., Klein, A.L., 2021. Pericardial diseases in COVID19: a contemporary review. Curr. Cardiol. Rep. 23, 1–10.

Gilbertson, J., Grimsley, M., Green, G., 2012. Psychosocial routes from housing investment to health: evidence from England's home energy efficiency scheme. Energy Pol. https://doi.org/10.1016/j.enpol.2012.01.053.

Guo, L. ling, Qu, Y., Tseng, M.L., 2017. The interaction effects of environmental regulation and technological innovation on regional green growth performance. J. Clean. Prod. 162, 894–902.

Hair Jr., J.F., Matthews, L.M., Matthews, R.L., Sarstedt, M., 2017. PLS-SEM or CB-SEM: updated guidelines on which method to use. Int. J. Multivar. Data Anal. 1, 107. https://doi.org/10.1504/ijmda.2017.10008574.

Han, Y., Tan, S., Zhu, C., Liu, Y., 2022. Research on the emission reduction effects of carbon trading mechanism on power industry: plant-level evidence from China. Int. J. Clim. Chang. Strateg. Manag. https://doi.org/10.1108/IJCCSM-06-2022-0074 ahead-of-p.

Huang, S.Z., Chien, F., Sadiq, M., 2022. A gateway towards a sustainable environment in emerging countries: the nexus between green energy and human Capital. Economic research-Ekonomska istraživanja 35 (1), 4159–4176.

Iram, R., Zhang, J., Erdogan, S., Abbas, Q., Mohsin, M., 2020. Economics of energy and environmental efficiency: evidence from OECD countries. Environ. Sci. Pollut. Res. https://doi.org/10.1007/s11356-019-07020-x.

Kamarudin, F., Anwar, N.A.M., Chien, F., Sadiq, M., 2021. Efficiency of microfinance institutions and economic freedom nexus: empirical evidence from four selected ASIAN countries. Transform. Bus. Econ. 20 (2b), 845–868.

Kraus, S., Schiavone, F., Pluzhnikova, A., Invernizzi, A.C., 2021. Digital transformation in healthcare: analyzing the current state-of-research. J. Bus. Res. 123, 557–567. https://doi.org/10.1016/j.jbusres.2020.10.030.

Kurniawan, K., Supriatna, J., Sapoheluwakan, J., Soesilo, T.E.B., Mariati, S., Gunarso, G., 2022. The analysis of forest and land fire and carbon and greenhouse gas emissions on the climate change in Indonesia. AgBioforum 24 (2), 1–11.

Lan, J., Khan, S.U., Sadiq, M., Chien, F., Baloch, Z.A., 2022. Evaluating energy poverty and its effects using multi-dimensional based DEA-like mathematical composite indicator approach: findings from Asia. Energy Pol. https://doi.org/10.1016/j.enpol.2022.112933.

Li, X., Wang, H., Yang, C., 2022. Driving mechanism of digital economy based on regulation algorithm for development of low-carbon industries. Sustain. Energy Technol. Assessments, 102909. https://doi.org/10.1016/j.seta.2022.102909.

Lin, H.-H., 2022. After the epidemic, is the smart traffic management system a key factor in creating a green leisure and tourism environment in the move towards sustainable urban development? Sustainability 14, 1–22. https://doi.org/10.3390/su14073762.

Lin, C.Y., Chau, K.Y., Tran, T.K., Sadiq, M., Van, L., Phan, T.T.H., 2022. Development of Renewable Energy Resources by Green Finance, Volatility and Risk: Empirical Evidence from China. Renewable Energy. https://doi.org/10.1016/j.renene.2022.10.086.

Liu, Z., Lan, J., Chien, F., Sadiq, M., Nawaz, M.A., 2022a. Role of tourism development in environmental degradation: a step towards emission reduction. J. Environ. Manag. https://doi.org/10.1016/j.jenvman.2021.114078.

Liu, L., Zhichao, Li, Fu, X., Liu, X., Li, Zehao, Zheng, W., 2022b. Impact of power on uneven development: evaluating built-up area changes in Chengdu based on NPP-VIIRS images (2015–2019). Land. https://doi.org/10.3390/land11040489.

Ma, Q., Mentel, G., Zhao, X., Salahodjaev, R., Kuldasheva, Z., 2022. Natural resources tax volatility and economic performance: evaluating the role of digital economy. Resour. Pol. 75, 102510 https://doi.org/10.1016/J.RESOURPOL.2021.102510.

Menegaki, A.N., Tugcu, C.T., 2017. Energy consumption and Sustainable Economic Welfare in G7 countries; A comparison with the conventional nexus. Renew. Sustain. Energy Rev. https://doi.org/10.1016/j.rser.2016.11.133.

Menzefricke, J.S., Wiederkehr, I., Koldewey, C., Dumitrescu, R., 2021. Socio-technical risk management in the age of digital transformation -identification and analysis of existing approaches. Procedia CIRP 100, 708–713. https://doi.org/10.1016/j.procir.2021.05.094.

Milenkovic, N., Vukmirovic, J., Bulajic, M., Radojicic, Z., 2014. A multivariate approach in measuring socio-economic development of MENA countries. Econ. Modell. 38, 604–608. https://doi.org/10.1016/j.econmod.2014.02.011.

Mohsin, M., Hanif, I., Taghizadeh-Hesary, F., Abbas, Q., Iqbal, W., 2021. Nexus between energy efficiency and electricity reforms: a DEA-Based way forward for clean power development. Energy Pol. https://doi.org/10.1016/j.enpol.2020.112052.

Mohsin, M., Taghizadeh-Hesary, F., Iqbal, N., Saydaliev, H.B., 2022. The role of technological progress and renewable energy deployment in Green Economic Growth. Renew. Energy. https://doi.org/10.1016/j.renene.2022.03.076.

Mohsin, M., Taghizadeh-Hesary, F., Panthamit, N., Anwar, S., Abbas, Q., Vo, X.V., 2020. Developing low carbon finance index: evidence from developed and developing economies. Finance Res. Lett. https://doi.org/10.1016/j.frl.2020.101520.

Moslehpour, M., Shalehah, A., Wong, W.K., Ismail, T., Altantsetseg, P., Tsevegjav, M., 2022a. Economic and tourism growth impact on the renewable energy production in Vietnam. Environ. Sci. Pollut. Control Ser. 29 (53), 81006–81020.

Moslehpour, M., Chau, K.Y., Tu, Y.T., Nguyen, K.L., Barry, M., Reddy, K.D., 2022b. Impact of corporate sustainable practices, government initiative, technology usage, and organizational culture on automobile industry sustainable performance. Environ. Sci. Pollut. Control Ser. 29 (55), 83907–83920.

Moslehpour, M., Chau, K.Y., Du, L., Qiu, R., Lin, C.Y., Batbayar, B., 2022c. Predictors of Green Purchase Intention toward Eco-Innovation and Green Products: Evidence from Taiwan. Economic Research-Ekonomska Istraživanja, pp. 1–22.

Mostafa, F., Dillon, T., Chang, E., 2015. Computational intelligence approach to capturing the implied volatility. In: IFIP Advances in Information and Communication Technology. Springer New York LLC, pp. 85–97. https://doi.org/10.1007/978-3-319-25261-2_8.

Nguyen, C.H., Ngo, Q.T., Pham, M.D., Nguyen, A.T., Huynh, N.C., 2021. Economic linkages, technology transfers, and firm heterogeneity: the case of manufacturing firms in the Southern Key Economic Zone of Vietnam. Cuad. Econ. 44 (124), 1–25.

Phuoc, V.H., Thuan, N.D., Vu, N.P.H., Tuyen, L.T., 2022. The impact of corporate social and environmental responsibilities and management characteristics on SMES' performance in Vietnam. Int. J. Econ. Finance Stud. 14 (2), 36–52.

Poortinga, W., Whitmarsh, L., Steg, L., Böhm, G., Fisher, S., 2019. Climate change perceptions and their individual-level determinants: a cross-European analysis. Global Environ. Change 55, 25–35.

Quynh, M.P., Van, M.H., Le-Dinh, T., Nguyen, T.T.H., 2022. The role of climate finance in achieving Cop26 goals: evidence from N-11 countries. Cuad. Econ. 45 (128), 1–12.

Renault, E., Sarisoy, C., Werker, B.J.M., 2017. Efficient estimation of integrated volatility and related processes. Econom. Theor. 33, 439–478.

Sadiq, M., Ou, J.P., Duong, K.D., Van, L., Ngo, T.Q., Bui, T.X., 2022a. The Influence of Economic Factors on the Sustainable Energy Consumption: Evidence from China. Economic Research-Ekonomska Istraživanja. https://doi.org/10.1080/1331677X.2022.2093244.

Sadiq, M., Lin, C.Y., Wang, K.T., Trung, L.M., Duong, K.D., Ngo, T.Q., 2022b. Commodity dynamism in the COVID-19 crisis: are gold, oil, and stock commodity prices, symmetrical? Resour. Pol. https://doi.org/10.1016/j.resourpol.2022.103033.

Sadiq, M., Ngo, T.Q., Pantamee, A.A., Khudoykulov, K., Thi Ngan, T., Tan, L.P., 2023a. The role of environmental social and governance in achieving sustainable development goals: evidence from ASEAN countries. Economic research-Ekonomska istraživanja 36 (1), 170–190.

Sadiq, M., Moslehpour, M., Qiu, R., Hieu, V.M., Duong, K.D., Ngo, T.Q., 2023b. Sharing economy benefits and sustainable development goals: empirical evidence from the transportation industry of Vietnam. J. Inno. Knowledge. https://doi.org/10.1016/j.jik.2022.100290.

Si, D.-K., Li, X.-L., Huang, S., 2021. Financial deregulation and operational risks of energy enterprise: the shock of liberalization of bank lending rate in China. Energy Econ. 93, 105047 https://doi.org/10.1016/j.eneco.2020.105047.

Sriyakul, T., Chienwattanasook, K., Chankoson, T., 2022. Does industrialization and renewable energy consumption determine economic growth? Empirical evidence from Asean Countries. Int. J. Econ. Finance Stud. 14, 264–279, 03.

Swanepoel, F., Retief, F., Bond, A., Pope, J., Morrison-Saunders, A., Houptfleisch, M., Fundingsland, M., 2019. Explanations for the quality of biodiversity inputs to environmental impact assessment (EIA) in areas with high biodiversity value. J. Environ. Assess. Pol. Manag. https://doi.org/10.1142/S1464333219500091.

Tan, L.P., Sadiq, M., Aldeehani, T.M., Ehsanullah, S., Mutira, P., Vu, H.M., 2021. How COVID-19 induced panic on stock price and green finance markets: global economic recovery nexus from volatility dynamics. Environ. Sci. Pollut. Control Ser. https://doi.org/10.1007/s11356-021-17774-y.

Thitinan, T.S., Chankoson Khunanan, S., 2022. Modelling the impact of e-government on corruption for the COVID-19 crisis. Int. J. Ebus. eGovernment Stud. 14 (3), 26–45.

Todorov, T.S., 2014. Evaluating project and program management as factor for socio-economic development within EU. Procedia - Soc. Behav. Sci. 119, 819–828. https://doi.org/10.1016/j.sbspro.2014.03.092.

Treiblmaier, H., Sillaber, C., 2021. The impact of blockchain on e-commerce: a framework for salient research topics. Electron. Commer. Res. Appl. 48, 101054 https://doi.org/10.1016/j.elerap.2021.101054.

Van Hoa, N., Van Hien, P., Tiep, N.C., Huong, N.T.X., Mai, T.T.H., Phuong, P.T.L., 2022. The role of financial inclusion, green investment and green credit on sustainable economic development: evidence from Vietnam. Cuad. Econ. 45 (127), 1–10.

Waschull, S., Bokhorst, J.A.C., Wortmann, J.C., Molleman, E., 2022. The redesign of blue- and white-collar work triggered by digitalization: collar matters. Comput. Ind. Eng. 165, 107910 https://doi.org/10.1016/j.cie.2021.107910.

Yin, C., Zhao, W., Cherubini, F., Pereira, P., 2021. Integrate ecosystem services into socio-economic development to enhance achievement of sustainable development goals in the post-pandemic era. Geogr. Sustain. 2, 68–73. https://doi.org/10.1016/j.geosus.2021.03.002.

Yumei, H., Iqbal, W., Nurunnabi, M., Abbas, M., Jingde, W., Chaudhry, I.S., 2021. Nexus between corporate social responsibility and firm's perceived performance: evidence from SME sector of developing economies. Environ. Sci. Pollut. Res. 28, 2132–2145. https://doi.org/10.1007/s11356-020-10415-w.

Zeng, B., Ma, X., Zhou, M., 2020. A new-structure grey Verhulst model for China's tight gas production forecasting. Appl. Soft Comput. 96, 106600.

Zhang, Y., Li, L., Sadiq, M., Chien, F., 2023. The Impact of Non-renewable Energy Production and Energy Usage on Carbon Emissions: Evidence from China. Energy & Environment. https://doi.org/10.1177/0958305X221150432.

Zhao, L., Zhang, Y., Sadiq, M., Hieu, V.M., Ngo, T.Q., 2021. Testing green fiscal policies for green investment, innovation and green productivity amid the COVID-19 era. Econ. Change Restruct. https://doi.org/10.1007/s10644-021-09367-z.

Zhao, L., Chau, K.Y., Tran, T.K., Sadiq, M., Xuyen, N.T.M., Phan, T.T.H., 2022. Enhancing green economic recovery through green bonds financing and energy efficiency investments. Econ. Anal. Pol. https://doi.org/10.1016/j.eap.2022.08.019.