Impact of Covid-19 on economic recovery: empirical analysis from China and global economies

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Abstract
This research aims to utilize quarterly global VAR data from April 1, 2020, to September 30, 2021, to assess the influence of the economic recovery of China following the COVID-19 outbreak on global economies. China is one of the first big economies globally to show indications of recovery following the COVID-19 pandemic. The nation’s economic growth has the biggest long-term influence on middle-income nations (0.17%) followed by low- and middle-income economies (0.16%) and high-income economies (0.16%) (0.15%). The chain reaction of China’s economic growth is most visible in high-income nations (0.11–0.45%), followed by middle-income countries (0.08–0.33%) and low-income countries (0.02–0.05%). Our findings show that the post-COVID-19 economic rebound in China will mostly benefit middle-income nations, with low- and middle-income countries following closely after. After COVID-19, the influence of the economic recovery of China is most visible in the rise of energy consumption in high-income nations, followed by middle-income economies. It is also worth noting that the influence of China’s economic expansion on low- and middle-income economies does not always imply a rise in energy consumption. Overall, China’s economic recovery has a significantly stronger influence on other countries’ economic development than other countries’ energy consumption has on other economies’ growth.

Keywords Economic recovery · Energy consumption · Gross value-added rate (GVAR) · China · Global
1 Introduction

COVID-19 first emerged in January 2020 and soon became a global pandemic that caused a devastating health crisis (World Health Organization 2020). The pandemic has affected over 37 million individuals and taken the lives of over 1.07 million people worldwide. In response to such a crisis, most governments resorted to measures like closing their international borders, restricting movement, and instituting quarantine (Wang and Su 2020; Wang and Zhang 2021). COVID-19 has significantly affected the economic development and energy consumption in almost every country, particularly industrial nations like France, Italy, and Spain. Furthermore, countries entirely excluded from the energy industry had cut their weekly energy consumption by an average of 25% in April, while other countries had minimized their daytime energy use by approximately 17–18%.

Additionally, the International Energy Agency (IEA) forecasted that the global energy consumption and oil demand would decline by almost 7% this year. However, as a critical nation initially affected by COVID-19, China was the first to contain the pandemic and avert the economic disaster. China estimates that its economy will recover from the global economic crisis in 2020 and that its growth will be 8.21% faster in 2021 than other countries (Wang and Luo 2022; Madueke et al. 2020). The country’s rapid economic recovery will thus influence and impose subsequent effects on other countries’ economic growth and energy consumption (Taghizadeh-Hesary and Yoshino 2019; Taghizadeh-Hesary and Yoshino 2020).

Growth and energy consumption are seen as pressing problems because they have many significant policy consequences (Guan and Li, 2020) (Song et al. 2020). Thus, the global financial system must operate correctly. Energy has played a critical role in various production and consumption activities. Economic development, on the other hand, will boost energy demand (Zhang et al. 2021; Hsu et al. 2021; Ehsanullah et al. 2021). International commerce has increased substantially because of the global economy’s growth (Aktar et al. 2021). According to the World Bank Index, worldwide goods exports, imports, and services increased from more than 38.53% in 1996 to 61.71% in 2014. Furthermore, globalization and national economic fluctuations gradually extend beyond its boundaries and can now be felt across the globe (Huang et al. 2020). Thus, its supranational impact cannot be disregarded in economics and energy consumption, particularly in significant economies such as China.

This paper mainly focuses on examining the effect of economic level recovery in China after the COVID-19 outbreak on other countries’ economic and energy consumption growth. This study evaluated the effect of China’s economic recovery on other countries’ economic growth and energy consumption. To visualize China’s impact, the chosen nations were classified into three income categories: China’s biggest trade partner, China’s second-largest trading partner, and China’s most diminutive trading partner. This paper addresses all literature gaps and offers policy implications for the post-COVID-19 situation for China and other global countries.
The remainder of the paper is structured as follows: Sect. 2 shows the relevant literature review, and Sect. 3 provides an overview of the methodology and data. Section 4 delves further into the empirical findings, while Sect. 5 examines the instability of China’s growth impact. Finally, Sect. 6 contains the conclusive remarks of the study.

2 Literature review

Research on the global economic crisis has recently shifted its focus to the economic implications of infectious illnesses and their connection with the share market, economic insecurity, and political risks. In this regard, most studies investigating the economic impact of infectious illnesses on China while monitoring the country’s oil and energy usage have contemplated that the COVID-19 pandemic will negatively impact China’s economy. Fortunately, renewable energy’s proportion of the total energy consumption is projected to grow for energy security. Furthermore, Mamun and Ullah (2020) had analyzed the link between COVID-19 and suicide cases in Pakistan using a novel approach and discovered that most suicides are strongly connected to rejection-related deterioration. Meanwhile, Khurshid and Khan (2021) looked at the effects of COVID-19 on Pakistan’s economic growth and energy consumption. Numerous studies have also examined the effects of power sector developments on energy consumption post-COVID-19 (Wang et al. 2021). According to (Kordej-De Villa and Slijepcevic 2019; Khosravi et al. 2019), when an infectious illness hits, the total energy demand will often decrease substantially as commercial and industrial activity is curtailed. Additionally, early energy poverty increases the energy usage of many families while everyday energy usage is significantly decreased.

China’s energy consumption and pollution control are expected to decrease immediately due to the reduced economic activity and mobility restrictions. Moreover, mandatory closure or isolation during the COVID-19 pandemic has substantially impacted the consumption of energy and greenhouse gas emissions (Aktar et al. 2021). Although many studies have examined the global economic and energy growth of COVID-19, the majority of them have concentrated on national and collective issues while being oblivious to the interrelationships. The global VAR (GVAR) model has been widely used in various fields to evaluate the connection between economies. For instance, Feldkircher and Korhonen (2014) had used the GVAR model to examine the effect of the world economy on China’s economy and its impact on the global economy. They discovered that China’s economic expansion has been beneficial to its trade partners. The GVAR was also used in the study by Gurara and Ncube (2013), who reported that the Eurozone and BRIC nations account for most of Africa’s global growth, as well as in the study by Bettendorf (2019), whose findings indicate that proliferation is more prevalent in EU member states. Therefore, it is safe to say that the GVAR has been extensively used in the research of global influence dissemination. It can be used to determine the degree of interconnectedness between economies.
impacted by global insider trading (Taghizadeh-Hesary and Taghizadeh-Hesary 2020; Taghizadeh-Hesary et al. 2021).

The main objective of this study is to determine the effects of the economic growth of China and other nations on energy consumption as a result of the COVID-19 pandemic. This is achieved by using the GVAR model to investigate China’s unexpected effect on other economies during COVID-19. This study aims to extend the literature in three ways. Firstly, the GVAR model accurately represents the economic recovery within and outside China. In contrast to prior research, multilateralism promotes international interdependence. Thus, this study hopes to understand better the worldwide relationship between economic growth and energy use. Secondly, this research analyses the growth and energy consumption curves of China from April 1, 2020, to September 30, 2021 that account for more than 90% of the global gross domestic product (GDP). Lastly, the findings of this research will aid in understanding the long-term effect of global growth and energy consumption on the economic recovery of China after the COVID-19 outbreak.

3 Data and methods

3.1 GVAR model

The GVAR model is a cutting-edge method of studying international interdependence (Bettendorf 2019) that can be implemented through two stages (Mwanyoka et al. 2019; Boshoff 2019). The first stage is for the foreign agent to predict the VECM for a certain country or region, while the second stage includes all nations’ models into the GVAR model using weights. In this study, each nation or area establishes the macroeconomic variables that were unique to itself. It was followed by the VECM model, which created the connections between economies that shared similar factors (Ozoike-Dennis et al. 2019; Hilbers et al. 2019). Furthermore, a country-specific autoregressive model was linked with the trade rights to represent the most dynamic global economy.

3.1.1 Model of population

The GVAR model pre-defines the $N+1$ nations as $n = 0, 1, 2, \ldots, N$, with the 0th nation being the reference country. Meanwhile, the $m = 1, 2, 3, \ldots, M$ trend is linked to each country’s domestic variable of $X_{nm}$, $w_m$ is the dominating unit, and the domestic variable $X_{NM}$ is related to the foreign variable of $X_{nm}$. The following is how the VARX$^*$ represents this improved VAR model:

$$X_{nm} = a_{n,0} + a_{n,1}t + \sum_{b=1}^{k_n} \phi_{n,b} X_{n,m-b} + \sum_{b=0}^{k_n} \gamma_{n,b} X_{n,m-b}^* + \sum_{b=0}^{k_n} \delta_{n,b} w_{m-b} + \epsilon_{n,m}$$

(1)
Among these, $\gamma_{n,b}$ is a $k_n \times k_n$ where the matrix represents the quantities associated with global variables. $\epsilon_{n,m}$ is a vector that reflects a country’s impact. The lag coefficient is represented by the $\phi_{n,b}$ matrix, which is a $k_n \times i_n$ the matrix that contains the coefficients associated with the global variables of $s_n$, $i_n$, and $s_n$ that denote the dominating domestic variables and global lag orders, respectively (Accastello et al. 2019; Molla et al. 2019; Pinto et al. 2019). Additionally, $X_{nm}$ is a country-specific foreign variable determined by the $w_{nj}$ with a fixed trade weight matrix. Concrete global variables reflect the dynamics of global economic factors and are believed to influence individual countries’ macro-economic type of variables.

$$\sum_{j=0}^{N} w_{nj} = 1, \quad w_{nj} = 0 \cdot w_{m}$$

(2)

Johansen’s approach is commonly used to look for co-integration connections when modeling the dominating variables. The basic model’s VAR ($i_w$) parameters are as follows:

$$w_{m} = \alpha_0 + \alpha_1 m + \sum_{b=1}^{i_w} \phi_{bp} w_{m-p} + \mu_{wm}$$

(3)

This equation can be rewritten as:

$$\Delta w_{m} = c - \beta_w \gamma_w' [w_{m-1} - k(m - 1)] + \sum_{j=1}^{i_w-1} \gamma_{wj} \Delta w_{m-j} + \mu_{wm}$$

(4)

where $\beta_w \gamma_w' = \sum_{p=1}^{i_w} \phi_{wp} \beta_{wp}$ and $\gamma_{wj}$ are vectors of $t_w \times r_w$, $r_w \cdot \tau_{wj} = -\left(\phi_{wp+1} + \phi_{wp+2} + \cdots + \phi_{wp+i_w}\right)$.\n
The (AIC) criterion chooses the length of hysteresis. Equation (3) must take the co-integration of the principal variables into account if $w_{m}$ includes stable first-order variables (Swanepoel et al. 2019; Mteki et al. 2019). If the variables in the GVAR model return the dominant variable with the cross-sectional mean, Eq. (3) can be improved by delaying the changes of other variables in the GVAR model

$$\tilde{X}_{wm} = \tilde{W}_w X_m\text{, where } X_m\text{ is a } k \times 1\text{ in the non-dominant variable rate model.}$$

$$k = \sum_{n=0}^{N} k_n \cdot \tilde{W}_w\text{ is a } t_\tilde{x} \times k\text{ the weight matrix: } t_\tilde{x}\text{ is the global cross-sectional weighted sum:}$$

$$w_{m} = \alpha_0 + \alpha_1 m + \sum_{b=1}^{i_w} \phi_{bp} w_{m-p} + \sum_{b=1}^{k_n} \gamma_{ip} \tilde{w}_{i,m-p} + \mu_{wm}$$

(5)

Assuming that the intersection vector $w_{m}$ and its product set means that there is no synthetic link in $\tilde{w}_{i,m-p}$, Eq. (4) can be expressed as:

$$\Delta w_{m} = -\beta_w \gamma_w' [w_{m-1} - k(m - 1)] + \sum_{b=1}^{i_w} \tau_{bp} \Delta w_{m-p} + \sum_{b=1}^{k_n} \theta_{ip} \Delta \tilde{w}_{i,m-p} + \mu_{wm} + c$$

(6)
The least-square technique is used to estimate $\theta_{ip}$. It is worth mentioning that in $\Delta \tilde{w}_{i,n}$, the same time value is not included in Eq. (6).

### 3.1.2 Generation of the global VAR (GVAR)

Several scholars (Sun et al. 2019; Tiep et al. 2021) have propounded the use of the GVAR model. For instance, Feldkircher et al. (2020) used the model to analyze the Eurozone’s monetary policy and examine the system-wide forecast density via numerous factors like individual countries’ GDP growth rates. In contrast to the Feld Kircher model, the present study had used the GVRTOOLSBOX, which forecasted the GVAR in a single dimension and built on the foundation of the national VAR model. It utilized the World Bank’s carbon dioxide emissions database supplemented by the EIA’s energy consumption database. These data were translated into a table to show the relationships between the local and foreign factors in terms of commerce, currency, and distance (Sun et al. 2020b; Baloch et al. 2020). This was then utilized in the research for massive foreign exchange transactions. Firstly, we defined the $(k_n + k^*_n) \times 1$ vector $Z_{n,m} = \left( X_{n,m}^*, X_{n,m}^u \right)$ and assumed that $i_n + s_n$. Equation (7) can thus be written as follows:

$$G_{n,0}Z_{n,m} = a_{n,0} + a_{n,1}t + \sum_{b=1}^{i_n} G_{n,b}Z_{n,m-b} + \sum_{b=0}^{k_n} D_{n,b}W_{n,m-b} + \varepsilon_{n,m}$$

(7)

where $G_{n,0} = (I_{k_n}, -\gamma_{n,0})G_{n,p} = (\phi_{n,p}, \gamma_{n,p}), p = 1 \ldots , i_n$ with addition, $G_{n,0}$ and $G_{n,p}$ are $k_n \times (k_n + k^*_n)$ matrices, ranking $(G_{n,0}) = k_n$.

Secondly, we applied the entire variable through a vector of $k \times 1$.

$$Y_m = \left( Y'_{0,m}, Y'_{1,m}, \ldots , Y'_{N,m} \right)'$$

where $k = \sum_{n=0}^{N} k_n$. The equation represents the total endogenic variables using the global model. After that, each country’s variables can be stated as:

$$Z_{n,m} = W_nY_m, n = 0, 1, 2, \ldots , N$$

(8)

where $W_n$ is a $k_n \times (k_n + k^*_n)$. The equation represents the constantly fixed matrix decided by the weight of a particular country, $W_n$, thus linking the country with the global countries. Third, additional equation number (8) into Eq. 7:

$$G_{n,0}W_nY_m = a_{n,0} + a_{n,1}t + \sum_{b=1}^{i_n} G_{n,b}W_nZ_{n,m-b} + \sum_{b=0}^{k_n} D_{n,b}W_{n,m-b} + \varepsilon_{n,m}$$

(9)

where $G_{n,0}W_n$ and $G_{n,b}W_n$ are $k_n \times k$ matrix. Combining the following equations had yielded a “global” solution where a complete GVAR model can be built by combining, thus forming Eq. (10).

$$G_{0}Y_n = a_0 + a_1t + \sum_{p=1}^{i} G_{p}Y_{m-p} + \sum_{p=0}^{k} D_{p}W_{m-b} + \varepsilon_n$$

(10)

Both appeared on the right side of Eq. (9), and:
where $H_0$ represents the full-rank $k \times k$ dimensional matrix.

\[
H_0 X_m = h_0 + h_1 m + \sum_{p=1}^i H_b X_{m-p} + \vartheta_n
\]

Finally, $H_0$ represents the full-rank $k \times k$ dimensional matrix.

\[
X_m = h_0 H_0^{-1} + h_1 m H_0^{-1} + H_0^{-1} \sum_{p=1}^i H_b X_{m-p} + H_0^{-1} \vartheta_n
\]

$H_0^{-1}$ is a lower constant triangular matrix, which shows the causality of the dominant variable $WN$. Equation (10) can be used to determine the future value of $XN$ to be solved recursively from Eqs. (11)–(12).

### 3.2 VAR (GVAR) the global dataset

In this research, the GVAR model was applied to the quarterly data from April 1, 2020, to September 30, 2021. A benefit of the GVAR model is that it integrates different economies within the same sector. The Eurozone (Austria, Belgium, Finland, France, Germany, Italy, Netherlands, and Spain) was merged into a single area under this concept. The World Bank (2020) classifies the nations mentioned above into three income groups. The data were set above the table volatility and processed logarithmically by taking sample differences at other national levels into account. Table 2 contains further detailed descriptions and sources of the variables (Chandio et al. 2020; Sun et al. 2020a). The GVAR model illustrates how the transmission lines from many nations are linked. As a result, all variables have been classified into three categories (Agyekum et al. 2021; Zhang et al. 2021). Furthermore, $X_{nm}^\prime X_{nm}$ is a domestic macroeconomic indicator formed by
macroeconomic variables that were decided by the present and delayed values of the $X_{nm} \cdot X_{nm} = (GDP_{nm}, EP_{nm}, CE_{nm}, ENC_{nm}, ENS_{nm})'$. National variables were then used to weight the local variables. In this regard, the countries P had formed the formula $Y_{nm} = \sum_{n=1}^{N} w_{n,p} Y_{n,p,m}$, where $w_{n,p}$ (WNP stands for gross weight and $Y_{n,p,m}$ represents the number of regions). Additionally, the external variables $X^*_{nm} \cdot X^*_{nm}$ correlates to $X_{nm}$ in the commercially accessible weight chart (Alemzero et al. 2020a, b; Sun et al. 2020a). The trade weighting table was created using other nations’ import and export trade statistics. This demonstrates the economic connection that contributes to the integration of many countries.

$$X^*_{nm} = \sum_{j=0}^{N} w_{nj} X_{jm}$$  \hspace{1cm} (13)

The trade weight table $w_{nj}$ obtained partners and multiplied the nation $j$ by $n$. The burden of commerce is critical for a country’s ability to deal with external shocks transmitted through trade channels (Li et al. 2021; Chien et al. 2021; Iqbal et al. 2021). Thus, country n’s present impact will affect country j. The mismatched matrix model presupposes that $X^*_{nm}$ has a low excretion state, which is consistent with,

$$X^*_{nm} = \left( GDP^*_{nm}, EP^*_{nm}, CE^*_{nm}, ENC^*_{nm}, ENS^*_{nm} \right)$$  \hspace{1cm} (14)

where $GDP^*_{nm} = \sum_{j=0}^{N} w_{nj} GDP_{nm}$, $EP^*_{nm} = \sum_{j=0}^{N} w_{nj} EP_{nm}$, $CE^*_{nm} = \sum_{j=0}^{N} w_{nj} CE_{nm}$

$$ENC^*_{nm} = \sum_{j=0}^{N} w_{nj} ENC_{nm}, \quad ENS^*_{nm} = \sum_{j=0}^{N} w_{nj} ENS_{nm}$$  \hspace{1cm} (15)

A variable that has a global impact. Global influences affect all national characteristics. In this regard, changes in the price of crude oil, i.e., external shocks, have a significant effect on all nations. We utilized the Bloomberg Brent crude oil prices in this research since it represents worldwide variables. The data in Table 1 are described in full, including a summary of statistics, variable descriptions, and data sources. Meanwhile, the reciprocal connection between the most relevant factors and the inverse link between logistics performance and economic development are shown in Table 2, with the parentheses denoting probability values (Iqbal et al. 2021; Zhang et al. 2021).

4 Estimation results

4.1 Estimation of China’s economic growth

Tables 1 and 2 estimate China’s economic growth, elements, and fundamental analysis using econometric estimates. The region-specific temporal effects include estimated supply chain logistics inputs and outputs. Finally, Table 1 summarizes (Cameron and Trivedi 1992) the information matrix, heterozygous
anomaly tree, and strange kurtosis decomposition tests. Both equal variances and aberrant asymmetry/kurtosis were rejected as these mistakes show that the constant variance is improper. We calculated the statistical significance of individual coefficient values using significant standard errors to account for the variability. Quantitative regression was used to re-evaluate the underlying model in the presence of anomalies.

Additionally, concurrent economic development and supply network logistical performance is possible, which might influence the supply chain performance. Additionally, the justifications in Table 3 stem from a quantitative regression designed to evaluate if the influence of logistic performance depends on the underlying growth rate. The results are presented in the following section.

| Variables     | (1)          | (2)          | (3)          |
|---------------|--------------|--------------|--------------|
| SClogistics   | 0.010**      | -0.004       |              |
| Energy consump| 0.003        | -0.003       |              |
| CO$_2$ emissions | 0.011***      | -0.004       |              |
| GDP($t-1$)    | -0.009***    | -0.009***    | -0.009***    |
| Financial aid | 0.018***     | 0.018***     | 0.018***     |
| Tax cut       | 0.271***     | 0.273***     | 0.268***     |
| Subsidy       | 0.010**      | 0.011***     | 0.010**      |
| Insurance     | 0.005        | 0.004        | 0.005        |
| Elasticity    |              |              |              |
| Logistics measure | 1.439**      | 0.471        | 1.760**      |
|                | -0.672       | (0.489)      | -0.695       |
| Cameron and Trivedi’s IM-test |              |              |              |
| Heteroskedasticity | [0.000]     | [0.000]      | [0.000]      |
| Skewness      | [0.089]      | [0.087]      | [0.095]      |
| Kurtosis      | [0.140]      | [0.132]      | [0.146]      |
| Total         | [0.000]      | [0.000]      | [0.000]      |
| Observations  | 522          | 522          | 522          |
| $R$-squared   | 0.231        | 0.26         | 0.26         |

Author calculation
4.2 China’s economic growth is not limited to nations

The economic impact of China’s growth is examined in-depth in this section, where the financial and energy indices are GDP and energy consumption, respectively. The GVAR model simulates the effects of specified variables and generates responses to the GDP and energy expenditure. The three main variables that affect China’s GDP and potential changes in energy consumption are the exchange rate, energy consumption structure, and carbon dioxide emissions. According to the global banking standards, nations can be classified into three categories: high-income (HI), middle-income (UMI), and low-income (LMI). Therefore, this section is split into three sections. In 2014, we selected the top ten accounts in China using the AIOD (Global Entry Cost Database) transaction weight table (WIOD, 2016). The first ten accounts in this research are primary accounts, whereas the remaining accounts are secondary.

Moreover, the widespread instinct response function (GIRF) developed by Koop et al. (1996) was utilized in this research, which corresponds to the rise in the VAR models (Pesaran and Shin 1998). GIRF may be used to assist in the detection of structural vibrations in GVAR models. It offers advice based on an average beginning estimate and a 90% relative confidence interval based on 100 iterations of GIRF computations. Additionally, it makes horizontal axis predictions, resulting in up to 40 branches. Before the assessment, we performed the required statistical tests, including a GVAR model routing unit test, an integration test, and an external test (Yumei et al. 2021; Abbas et al. 2022; Huang et al. 2022).

| Variable          | (1)     | (2)     | (3)     |
|-------------------|---------|---------|---------|
| SClogistics       | 0.024*  | 0.021*  | -0.013*** |
| Energy consumption|         |         |         |
| CO2 emissions     | 0.017***| 0.017***| 0.016*** |
| Financial aid     | 0.260***| 0.261***| 0.253*** |
| Tax cut           | 0.006   | 0.006   | 0.006   |
| Subsidy           | 0.007*  | 0.007*  | 0.008*  |
| Insurance         | 0.214   | 0.19    | 0.205   |
| R-squared         | 1.517   | 2.817*  | 1.154   |
| Endogeneity test  | 29.18   | 24.01   | 11.45   |
| Under identification test | 33.41*** | 30.83*** | 17.33*** |
| Over identification test | 0.125 [0.731] | 0.018 [0.897] | 0.221 [0.639] |

Author calculation

Additional information on the variables may be found in Table 1. Each model is subjected to an OLS control to account for peripheral and temporal effects. Although a fixed term is included, it is omitted. Standard errors with large magnitudes are enclosed in parentheses, whereas probability values are enclosed in parentheses. The delta technique was used to calculate the typical elasticity errors. The asterisks denote the following degrees of significance: **p<0.05; ***p<0.01
Table 3 Quantile regression of the impact of supply chain performance in countries with various growth rates

| Variable                  | Financial aid | Tax cut | Supply chain output performance |
|---------------------------|---------------|---------|---------------------------------|
|                           | −5.1          | −5.2    | −5.3                            | −5.4          | −5.5    | −5.6                     | −5.7          | −5.8    | −5.9     |
| Quantile                  | Q25           | Q50     | Q75                             | Q25           | Q50     | Q75                      | Q25           | Q50     | Q75      |
| SClogistics               | 0.018***      | 0.003 (0.004) | −0.005 (0.005) | 0.012***      | −0.001 (0.004) | −0.006 (0.004) | 0.017***      | 0.003 (0.004) | 0.002 (0.005) |
| Energy consumption        |               |         |                                 |               |         |                          |               |         |           |
| CO₂ emissions             |               |         |                                 |               |         |                          |               |         |           |
| Financial aid             | −0.017**      | −0.09*** | −0.09**                         | −0.020***     | −0.010*** | −0.007*                   | −0.020***     | −0.0098*** | −0.008*** |
|                           | (0.004)       | (−0.004) | (−0.004)                        | (−0.003)      | (−0.004) | (−0.004)                 | (−0.005)      | (−0.005) | (−0.006) |
| Tax cut                   | 0.019***      | 0.020*** | 0.020***                        | 0.019***      | 0.020*** | 0.020***                 | 0.19***       | 0.015*** | 0.0189*** |
|                           | (−0.007)      | (−0.004) | (−0.01)                         | (−0.007)      | (−0.006) | (−0.006)                | (−0.01)       | (−0.005) | (−0.006) |
| Subsidy                   | 0.290***      | 0.190*** | 0.129                           | 0.270***      | 0.189*** | 0.14 (−0.089)            | 0.269***      | 0.200*** | 0.106 (−0.079) |
|                           | (−0.01)       | (−0.079) | (−0.079)                        | (−0.089)      | (−0.069) | (−0.069)                | (−0.099)      | (−0.079) | (−0.079) |
| Insurance                 | 0.020***      | 0.009*** | 0.010***                        | 0.009***      | 0.009*** | 0.010***                 | 0.020***      | 0.010*** | 0.006 (−0.005) |
|                           | (−0.01)       | (−0.006) | (−0.005)                        | (−0.006)      | (−0.005) | (−0.004)                | (−0.007)      | (−0.005) | (−0.005) |
|                           | 0.002         | 0.0099   | 0.00099                         | 0.003         | 0.0009   | 0.003                    | 0.002         | 0.002   | 0.005 (−0.005) |
|                           | (−0.005)      | (−0.004) | (−0.004)                        | (−0.003)      | (−0.005) | (−0.005)                | (−0.005)      | (−0.005) | (−0.005) |
| $H_0$:Q25 = Q50 = Q75     | 7.89***       | [0.000]  |                                 | 10.20***      | [0.000]  |                          | 4.89***       | [0.009] |
| (logistics measure)       |               |         |                                 |               |         |                          |               |         |           |
| Pseudo R-squared          | 0.145         | 0.163   | 0.178                           | 0.134         | 0.163   | 0.181                    | 0.145         | 0.163   | 0.177    |

Additional information on the variables may be found in Table 1. Each model is subjected to a quantitative regression control to account for peripheral and temporal effects. Although a fixed term is included, it is omitted. Typical bootstrap mistakes (100 duplicates) are listed in brackets. Q25 denotes the twenty-fifth percentile, Q50 denotes the fifty-fifth (middle) percentile, and Q75 denotes the seventy-fifth percentile. The asterisks indicate the following degrees of significance: **p<0.05; ***p<0.01; *p<0.1. Author’s calculation
4.2.1 The two nations’ major trade partners

A total of 14 economies were rated as the world’s best in this research. India’s seven main trade partners are the USA, European Union, Japan, South Korea, UK, Australia, and Canada. The currency GIRF of the Second Bureau’s main trade partners owes to the impact of China’s economic factors (the influence of the standard error toward the positive error). China’s three largest trade partners are the USA, European Union, and Japan, placed first, second, and fourth, respectively, with 0.32%, 0.53%, and 0.54%. Meanwhile, the nations’ relative power consumptions are 0.07%, 0.15%, and 0.28%, with Japan recording the most rapid reaction. After 1/4 of zero, the GDP value decreases while the energy consumption value increases. The second is a long-term reaction to China’s economic growth’s spillover consequences. Since the fourth quarter, the US’ reaction (0.12%) has been greater than European Union’s (0.02%). Japan’s positive reaction had increased to 0.27% in the ninth quarter while the USA and European Union remained relatively stable. Additionally, the response prices of each country originally rose in reaction to its energy responses. However, it has been gradually decreasing since the ninth quarter. In this regard, the USA, European Union, and Japan responded at 0.41%, 0.75%, and 0.72%, respectively.

It was South Korea’s fourth and seventh-largest trade partner in 2014, followed by the UK, Australia, Canada, and China. South Korea (0.57%) and Australia (0.19%) have the smallest direct reaction to GDP outflows. Except for Australia, the other nations’ immediate energy reaction to the loss is Minimum (0.24%). South Korea’s reaction value has now stabilized between 0.16 and 0.48% based on the long-term effect response of the GDP, while the UK had the greatest drop at 0.35%, which is almost zero. In other words, this favorable reaction of four-fourths of the time after the impact seems to be an unnoticed characteristic. Canada saw the lowest decrease ranging between 0.28% and 0.15%. Table 4 shows the panel data regression analysis.

Past literature has denoted that Chile, New Zealand, Norway, Saudi Arabia, Singapore, Sweden, and Switzerland are not part of the IN nations’ most significant trade partners. Economic and energy GIRF have a beneficial effect on China’s economic factors. By and large, China’s favorable effect on GDP has benefited most WTD trade partners. Additionally, the effect of losses in different nations steadied after the shock. Saudi Arabia’s value had increased to 0.14% before the second quarter due to the GDP’s immediate response showing a decreasing tendency in their first reaction. The results showed that Chile had a direct impact of 0.94%, Sweden with 0.83%, Singapore with 0.79%, Norway with 0.67%, Switzerland with 0.55%, and New Zealand with 0.2%.

Meanwhile, both Norway and Sweden had recorded direct energy response rates of 0.26% and 0.78% to the effect of China’s economic development. Mini was the first response from other nations. Saudi Arabia’s long-term recognition had increased by 0.5% in the second quarter due to China’s economic development. At the same time, Chile, New Zealand, Norway, Singapore, Sweden, and Elba were struck by a long-term responsibility for the first time in 12 years. Relevant prices in New Zealand, Norway, and Switzerland have been close to nil since the fourth quarter. This implies that the economic growth in New Zealand, Norway, Switzerland, and China is not proportional to GDP over time, which is in contrast to
Furthermore, the long-term GDP response rates in Chile, Sweden, and Singapore remained unchanged at 0.23%, 0.33%, and 0.29%, respectively. At the same time, New Zealand, Sweden, Switzerland, and Saudi Arabia contributed positively to China’s economic growth recovery.

### 4.3 Spillover of China’s economic growth onto UMI member states

#### 4.3.1 The primary trading partners of UMI

Brazil and Indonesia are significant trading partners for UMI. The dynamic response curves of UMI’s major trading partners positively affect China’s economy. China’s economic development frequently has a differential effect on the two countries. The following summarizes UMI’s primary business partners’ short- and long-term responses. It was found that Brazil and Indonesia have recorded statistically significant immediate responses of 0.34% and 0.14% and quarterly GDP data with a value of 0.

On the other hand, the critical nature of rapid energy response remains unknown. Indonesia’s GDP increased by 0.55% in the first quarter. Additionally, the two countries’ energy response prices increased from 0 to 2 in this quarter. Second, Indonesia’s GDP price and energy responses have been significant and positive in the long run while maintaining 0.28% and 0.24% growth rates since the fourth quarter.
Whereas Brazil’s long-term reaction to GDP is Mini, with only a somewhat positive response, the country’s energy response over the long term is 0.61%.

### 4.3.2 Non-major trading partners

Tables 5 and 6 illustrate the GIRF’s beneficial effect on China’s economic indicators and UMI’s small trading partners. In general, the GIRF curve fluctuates smoothly, indicating that it has a long-term effect on China’s economic growth. The initiative established China’s quick reaction to economic development impacts in the first instance. It turns out that all UMI small trade partners’ first reaction is critical. These nations’ GDP figures are all positive, ranging from 0.26 to 1.76% in period 0. As a result, the curve exhibits a declining tendency. However, Mini is the initial energy response in the
majority of nations. Following that, we examined the long-term reaction to loss. It was found that Argentina, Mexico, Peru, and Thailand all reacted positively to GDP with 0.39%, 0.27%, 0.34%, and 0.32%, respectively. Moreover, Malaysia and South Africa have more severe replies with 0.11% and 0.09% GDP responses, while Turkey recorded a GDP response rate of 0.35% over the long run. This posits that all nations had a positive and substantial long-term energy response ranging from 0.11 to 0.44%, except Turkey (0.17%).

4.4 The influence of China’s economic development on low- and middle-income nations

4.4.1 The LMI nations’ primary trade partner

This research had focused on the LMI nations of India and the Philippines. India is one of China’s most significant trade partners in LMI nations. Results illustrate the GIRF of China’s positive economic factors and its impact on LMI nations. How India responded to this process has directly impacted China’s economic development. The first quarter GDP reaction cost is 0.61%, which is the stage at which India’s GDP would be most negatively impacted.

The energy is returned at branch 0, and the value of the load is irrelevant. Following that, GDP prices and the energy response will continue to fall. China’s economic development has slowed India’s economic growth and energy consumption, owing to China’s competitiveness in the India–China bilateral trade market.

4.4.2 LMI nations’ small trading partners

There are no significant trade partners for the Philippines in LMI nations. In general, the Philippines has responded positively to China’s economic development. China’s GDP and energy sectors directly respond to the growing impact of Zone 0 at 0.25% and 0%, respectively. Since then, the Philippines’ first-quarter GDP and energy costs rose by 0.53% and 0.29%, while the long-term GDP and energy response prices have steadied.

5 Discussion and analysis

The preceding section discussed how the GVAR model forecasts the dynamic economic and energy responses of the 24 EU member states and regions (including 8) to China’s GDP growth. We examined in-depth the effect of success on other nations, an overview and diversification of China’s growth impact. It offers an in-depth analysis of the effect. The nation after the corona’s outbreak on the 19th.
5.1 Overview of other nations’ economic effect

This part stresses dynamic reactions and provides a complete picture of China’s economic growth effects to contrast the harm caused to China’s economic growth by other nations. Results depict the 24 EU member states and regions (including eight nations) following China’s beneficial impact on GDP. A curve may be split into two sections using the variations in a reaction where the fourth and sixth act as clues, and the curves that surround them provide a wealth of information. It was found that countries with a response rate of more than 80%, particularly in the 0 months ending in the sixth quarter, had the greatest response rate. This implies that as China’s economy develops, other nations will suffer more acutely. The effect of the loss progressively waned as the divergence proceeded and some modifications occurred. In sum, the benefit to China’s economic development is temporary. Since the sixth quarter, more than 85% of nations’ long-term reaction has been much less than their initial response. At the lowest threshold, the long-term reaction stays constant. The economic effect of renminbi distribution on nations participating in the “region and road” has benefitted more than 90% of countries. China’s economic development is influenced by two distinct steps: quick reaction and long-term response. The most significant response happened instantaneously, where the response will resume shortly after Sect. 63. Meanwhile, the 34th Battalion’s long-term reaction was much poorer than its acute response.

5.1.1 Overview of energy’s effect on other nations

Following the 24 EU member states and regions (including eight nations). Energy consumption also shows comparable dynamic features due to the effect on China’s GDP. In general, the curve exhibits a steady rise and decrease. This is comparable to the effect of the US EPU on other economies’ output, which increased for the first time in a few months before falling for the first time in a few months (Trung, 2019). Over 90% of the national energy response curve increased in the first quarter of this year. The process’s maximum response value will reach the second quarter. Almost all nations reported a decrease in response rates during the February–June quarter. After all, the curve was steady for six to forty quarters and reached a relatively low position. This implies that China’s economic development will benefit energy consumption in most nations. The good news is that it reached a high in the second quarter. However, in the long term, China’s economic development will benefit energy consumption in most nations. Previous research has established a regional link between GDP and renewable energy utilization. While this connection exists solely in the EU’s 26 member states, the reverse is valid in the USA. Furthermore, China’s economy has a minor short-term influence on this process. By combining immediate and long-term outcomes, the positive reaction value of the results is increased.
5.2 The effect of China’s economic development’s loss and diversity

The Election Bureau’s study of GIRF classifies respondents into three income categories. This number is used to calculate the economic effect of China’s growth, where any number that exceeds 0 indicates a positive outcome while others are considered negative unless otherwise specified. The findings indicate that China’s economic development has a positive and sustained effect. However, it raises the question of whether the impact is universal. To address this issue, we shall describe the variations in China’s economic development as a function of income levels in this section. Results illustrate the economic and energy GIRF curves for the three income levels. A country’s average response value is calculated for each income level.

5.2.1 Heterogeneousness of spillover impacts on the economic growth of other economies

Other economies with a bad rating often responded differently to China’s economic shock. In the first quarter, the average response rate for HI and UMI nations was 0.51%, showing that HI and UMI economies did better than LMI countries considering China’s economic expansion. There is evidence that the long-term reaction to LMI loss grows progressively over time, but the long-term response to HI and UMI declines gradually. The average response rate for LMI and UMI nations during the last 30 quarters was 0.16% and 0.17%, respectively, the second-lowest response rate (0.15%). These findings suggest that China’s long-term response to the development of LMI and UMI is stronger than its response to the growth of HI. Finally, the researchers discovered that China’s economic expansion is evident in the income disparity between the country and other nations. Due to their rapid reaction times, HI and UMI nations have a greater loss effect than LMI countries. Low- and middle-income nations are less vulnerable to the economic turmoil that fueled China’s expansion. However, the results of LMI nations are more intuitive than those of HI and UMI countries based on long-term reactions. This demonstrates that HI and UMI nations have benefited LMI countries over time. This has unsurprising consequences. The influence of the US’ Universal Periodic Review varies across each nation. Developing and developing countries are more vulnerable than developed and developed ones. It is believed that Asian emerging economies are more susceptible to shocks than the US PEU as the US economy and commerce are quite strong in the area (Trung, 2019).

5.2.2 Heterogeneousness spillover impacts on other economies’ energy

The energy consumption of countries with varying income levels varies significantly due to China’s economic development. This has something to do with the effect’s product where the transaction’s outcome should be anticipated. Furthermore, the extent to which it exerts influence will impact the rigidity of the labor market, the industrial structure, and the host country’s integration into the global value chain. The developed and developing worlds frequently influence national distinctions.
The following is the order of energy consumption and price over 40 quarters. HI (0.11–0.45%) > UMI (0.08–0.33%) > LMI (0.02–0.05%). Throughout China’s economic development, this graph depicts the impact of income on energy consumption. Furthermore, the inefficiency of energy use increases as one becomes wealthier, suggesting that the most favorable indicator of economic development in China is energy consumption.

6 Conclusion and policy implications

COVID-19 preventive and control efforts will exacerbate the global economic downturn in 2020 and the world’s energy issues. The study uses the VAR data from April 1, 2020, to September 30, 2021, to conduct an empirical analysis. China became the first major economy to recover from COVID-19 via prompt and effective governance. To evaluate the effect of China’s economic recovery, this research investigates the impact of China’s GDP growth on other countries’ economic and energy systems. The GVAR model, which is interdependent and may be used to investigate the worldwide effect of economic fundamentals, was utilized as the empirical approach in this research. To properly evaluate the economic recovery in China.

Firstly, dynamic research on China’s growth effect demonstrates that China’s economic recovery impacts a wide range of nations. Numerous nations have benefited from the Chinese economy’s positive economic and energy impacts. In terms of economic reaction, it is discovered that China’s enormous economic size has a significant effect on the global economy’s recovery. The GDP of China’s impacted nations was initially high but has been steadily decreasing regardless of income level. After about 1/6, the feeble reaction stays steady for an extended period. In 34 quarters, these long-term GDP responses are anticipated to persist. In terms of energy consumption, China’s economic development has benefited more than 80% of the country’s energy use. Ultimately, electricity usage will rise positively in the long term.

Second, since the assessment is heterogeneous, the effect of China’s economic recovery will vary according to income level. Economic response volatility manifests itself in two ways. The first determining element is reaction time. The average instantaneous reaction of HI and UMI nations was more significant (0.51% and 0.66%, respectively) than LMI countries (0.43%). This demonstrates that HI and UMI have a more beneficial effect on China’s economic recovery than LMI. In other words, LMI is slower than HI, whereas China is squeezing UMI. Another criterion is the mode of delivery. The average long-term reaction of HI and UMI (0.15% and 0.17%, respectively) is lower than that of LMI (0.16%). On the other hand, the excellent effect of China’s economy over the last year may have been transmitted to the UMI of technology and technology nations.

China’s economic growth variations are predictable in short- and long-term energy responses. Staff nations (0.11–0.45%) have a greater response rate than UMI countries (0.08–0.33%), while LMI countries have the lowest response rates (0.02–0.05%). This implies that the level of sales correlates to the level of value. Our study demonstrates that since the onset of COVID-19, China has been instrumental in reviving the world economy. International commerce and collaboration must
address the economic and energy challenges created by the COVID-19 pandemic. China’s manufacturing capacity will be bolstered, particularly in light of global economic and energy problems.

Additionally, global and national decision-makers must collaborate to manage and react to global significance. In several nations, GVAR models are capable of forecasting economic changes. However, this research examines China’s effect on other nations’ economic development and energy consumption after the COVID-19 pandemic because of a data shortage. After the peak phase, the control measures that certain governments should implement will influence the growth of the local economy and energy use. Nevertheless, our model is indeterminate and updated data on COVID-19 infection may be utilized to address this problem.

Declarations

Conflict of interest We have no conflict of interest.

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