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Role of banking sector in green economic growth: empirical evidence from South Asian economies

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Abstract
The COVID-19 pandemic has slowed progress to the achievement of net-zero and sustainability goals. In particular, emerging economies may benefit greatly from the cooperation of banking institutions in promoting green recovery. This study focusses on banking institutions in South Asian countries that boost the intermediary financial spread, according to a thorough sample of banks from 2011 to 2021. The analysis employs the data envelopment analysis method, and the results are robust. In addition to these characteristics, we also consider aspects such as urbanisation, industrialisation, and population expansion. Banks may play a significant role in facilitating the realisation of environmental targets because of the clear advantages of the results, which provide comfort for green recovery. As green financing may lead to more efficient and robust financial systems, the results provide strong evidence for policymakers, financial institutions, and the financial sector.

Keywords Banking sector · Green finance · Green economic recovery · Urbanisation · COVID-19 · Financial sector

1 Introduction

The urgency of dealing with the consequences of global warming and climate change, such as ecological deterioration and rising sea levels, has increased dramatically over the last several decades. Human activity, such as the excessive use of electricity in industry, construction, and transport, has contributed to a steadily rising concentration of carbon dioxide (CO2) in the Earth's atmosphere, one of the primary drivers of climate change. Authorities worldwide are working on plans to reduce CO2 emissions in response to the widespread damage and social discontent that global warming has wrought (Si et al. 2021). Among the world's poorest countries

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are also some of the least urbanised, as their economies are only their infancies. Consequently, future financial development in these nations may increase their carbon emissions (Huang and Liu 2021). As the most populous developing part of the world, South Asia is experiencing unprecedented economic growth and urbanisation (Liu et al. 2022a, b). South Asia's urbanisation rate is projected to reach 75% by 2070, increasing significantly from 49.7 percentage points in 2010 to 61.58% in 2019. Owing to urbanisation, major ecological problems have surfaced, most notably the consequences of CO2 emissions. Rapid urbanisation and low CO2 emissions have been challenging to many countries and regions, including South Asia.

The rapid spread of the fatal coronavirus disease 2019 (COVID-19) in 2020 caused widespread disruption to companies and the daily lives of hundreds of millions of people, sending the global economy into a tailspin. Some researchers have drawn parallels between the financial impacts of the COVID-19 pandemic and the Global Financial Crisis of 2006–2008, while others have drawn parallels to the Great Depression of the 1930s in the USA. Academics in finance and economics reacted swiftly to the pressing need to study the consequences of pandemics (Liu et al. 2022a, b). A 'black swan' event, such as COVID-19, is an unprecedented situation, for which the risk assessment methods presently in use are inadequate (Lin 2022). Nevertheless, it is impossible to forecast the extent of the economic ramifications of the COVID-19 crisis. To that end, this study summarises the seminal research on the international spread of crisis shocks and the mechanisms at play therein.

Although there is a wealth of information to draw from, numerous aspects of the COVID-19 dissemination warrant fresh considerations of the contagion phenomenon and the creation of innovative approaches for evaluating this unexpected and complicated occurrence. Different effects on petroleum and petroleum-producing countries are shown in the input display (Qiao et al. 2022). An increase in oil prices has a more noticeable effect on oil producers than on oil importers, as oil-exporting nations would have welcomed a price boost. According to the data, oil price fluctuations take numerous shapes and have varying consequences for nations. Many studies have investigated the many sources of unpredictability in the cost and output of raw materials (Li et al. 2022). However, other studies have examined the domino effect of oil price volatility on the rest of the economy, finding the same depressing result. Zhang et al. (2021a) investigate how the movement of money affects oil prices. As reported, rising oil price volatility harms stock markets in South Asian countries. Oil price volatility is tied to economic actions and the currency market. However, little attention has been paid to the connection between oil prices and economic and political instability. The economic acceleration model suggests that a shock to financial markets may have repercussions for the real economy. As the degree of economic volatility increases, companies move away from low-risk ventures, which raises the cost of borrowing and the possibility of failure (Mohsin et al. 2020a, 2020b). Any significant change in oil prices may lead to an increase in the rate, as suggested. Even amid the pandemic, climate concerns persist, and mitigating ecological damage is more critical than ever (Wang et al. 2019). Greenhouse gas emissions are responsible for most environmental concerns, mainly from burning fossil fuels and other non-renewable energy sources. In addition to posing social and financial dangers, the health problems caused by these emissions have been well documented. Greater sovereign risk, slower financial growth, and higher cost of debt are all possible outcomes (Asbahi et al. 2019). To make the changes necessary to achieve the sustainability and net-zero impact, vast sums of money are required. According to Ikram et al. (2019) analysis, there is a vast chasm between the supply and demand for environmentally friendly investments. This gulf is expected to widen in the wake of the COVID-19 pandemic, hence necessitating the conceptualisation of novel forms of mediation. When resources (either of the lender or borrower) are limited, the job becomes much more difficult (Mohsin et al. 2020).

In developing nations, this issue is more difficult because banking revenues are based on a few massive corporations, many of which are also major emitters. In addition, banks are the primary source of funding for businesses (Iqbal et al. 2022). In principle, green recovery requires banks to lend money to people who are concerned about the environment. However, incentives are needed to keep them doing this throughout the medium to long term. Motivating banks to include sustainability objectives in lending criteria requires the investigation of specific advantages for the banking industry. Financial institutions will be more willing to back the environmentally friendly economic revival (Agyekum et al. 2021). This means that businesses may have access to financing without interruption. As researchers, it is essential to address the dearth of data on how thriving banks in developing economies maintain sustainable loan portfolios.

Increases in green exposure will boost the intermediary financial spread, according to a thorough sample of banks from 2011 to 2021. The analysis employs the data envelopment analysis (DEA) method, and the results are robust. Consequently, banks' default risk decreases when they consider environmental issues when granting loans. To this end, we examine the influence of sustainability lending practices on financial service spreads and default probability. Banks are more likely to prioritise green financing if there is a strong correlation between green lending and profitability. Likewise, a negative correlation between sustainability lending and default probability may operate as a risk mitigator and promote the financial stability criteria as a risk mitigation measure. Our findings are optimistic from the standpoint of green recovery, as banks gain from increased funding for corporate sustainability divisions. The most effective green finance methods are used, including the COVID-19 approach to green financing, market-based approach, natural resource utilisation approach, banking-based approach, and government assistance approach. Each green financing category affects the economic features of security price fluctuations. Emotion and political sympathies are other aspects that contribute to the power of green financing and its influence on security prices, thereby making it difficult to map.

The next section of this paper presents a literature review and hypothesis development. Section 3 focusses on the methodology and data. The results and discussion are presented in Sect. 4. Section 5 presents the conclusion and policy implications.

2 Literature review

The purpose of this study is to discuss the link between oil prices, COVID-19, global renewable energy technology, and carbon emissions.

2.1 Oil price and carbon emission

Two possible impacts of oil price on carbon emissions have been reported in the empirical literature: a positive (negative) effect that shows how oil price increases (decreases) carbon emissions.

Iqbal et al. (2019) used the environmental Kuznets curve paradigm to examine Spain's carbon emission and oil price dynamics. The DEA was used, and data from 1874 to 2011 were included in the analysis. Insights from the study show that the cost of oil considerably impacts emissions levels. More precisely, a rise of only 1% in the actual oil price may cut emissions by approximately 0.4 percentage points. According to Shah et al. (2019), oil price shocks may have two impacts on ecological quality: the influence on energy usage and manufacturing, and the impact on the macroeconomy. Liu et al. (2022c) and Zhang et al. (2021b) modelled the effects of varying oil prices on India's carbon emission development rate using were shown to have a positive net effect on the rising rate of carbon emissions and a lasting influence on these emissions.

Oil prices and CO2 emissions were related using data from 23 African nations. The countries on the panel were separated from those that exported oil (Xia et al. 2020). The findings showed that oil prices had a positive and substantial effect on carbon emissions in the long and short run. The impact was more significant in the case of non-oil-exporting countries than it was for exporting countries or the entire African sample. Pakistan is a South Asian nation. Hence, Mohsin et al. (2022) investigated how factors such as oil prices, foreign direct investment, and economic development might influence the country's carbon emissions. They used symmetric and asymmetric DEA techniques on data spanning approximately 45 years. Using symmetric DEA, it is shown that although oil prices have a favourable short-term effect on carbon emissions, their long-term effects are adverse. Nonlinear DEA showed that increases in oil prices reduced CO2 emissions, while drops in oil prices increased carbon emissions. However, negative oil price shocks greatly affected carbon emissions, whereas positive oil price shocks had no short-term effects on CO2 emissions (Ullah et al. 2020).

To determine the relationship between oil prices, fossil fuel usage, renewable energy use, and carbon emissions in Turkey, Umair and Dilanchiev (2022) used several co-integrations. Adopting the three other estimators, we find that oil price has a substantial adverse effect on CO2 emissions in the long term, contrary to the DEA findings. Notably, the DEA analysis also showed that rising oil prices in Turkey were detrimental to CO2 emission levels.

2.2 COVID-19 and carbon emission

The second body of research considers how the COVID-19 pandemic may affect greenhouse gas emissions. However, only a few studies have investigated this issue. For instance, Wu et al. (2022) assess the impact of the COVID-19 pandemic on global carbon emissions. To verify the association between the COVID-19 pandemic and carbon emission, they use wavelet coherence, continuous wavelet coherence, and partial and multiple wavelet coherence. The results showed that the COVID-19 pandemic had the most significant impact on lowering atmospheric CO2.

Using daily data, Xiuzhen et al. (2022) examined the impact of the COVID-19 pandemic on energy use and carbon emissions across 16 European nations. Using an instrumental variable methodology, the authors showed that peak power consumption during the COVID-19 pandemic fell by 20 percentage points per hour, with certain economies experiencing declines of 30 percentage points or more. They also calculated a 34% decrease in hourly emissions. In addition, they anticipated a reduction of 18.4% in the power industry emissions by 2020. Wahid et al. (2020) published a groundbreaking work that predicted a worldwide decrease in CO2 emissions due to the COVID-19 lockout and state efforts, leading to an enormous demand for energy. The COVID-19 containment resulted in a 17% decrease in CO2 emissions in April 2019 compared to April 2019. However, on average, each country saw a 27% decrease in their daily total nations, which might explain the more considerable reductions seen at the national level compared to the global level. However, they cautioned that these shifts were only transient, as they did not represent the underlying shifts in the economic, energy, and transportation systems. According to another study, Kalli and Griffin (2015) found that, compared to the first half of 2018, worldwide CO2 emissions dropped by 7.7% in the first half of 2019. However, they also noted that the recovery of economies and how people behaved would significantly impact how CO2 levels fluctuated in the long run. An increase in emissions was observed in China in early May, despite the country's successful containment of COVID-19 instances earlier than most others. Almost everywhere else, data from June indicated an increase in emissions, as strict regulations were eased. Additional research by Emrouznejad and Yang (2018) established a correlation between COVID-19 and measures of CO2 emissions and corporate output in the USA. The authors used the DEA method to show that the number of fatalities and confirmed COVID-19 cases had a substantial negative impact on CO2 emission and corporate productivity.

2.3 Green energy innovation and carbon emission

Research has been conducted on how new forms of sustainable energy affect carbon footprint. Although there is research on the connection between green energy innovation and ecological quality, such studies are relatively scarce. For instance, (Li and Umair 2023) investigated the impact of green patent volume on CO2 emissions and emission effectiveness in Italian regions. Although green technology contributed to increased ecological efficiency, their IPAT/STIRPAT analysis could not confirm a causal relationship between green technology and lower CO2 emissions (Liu et al. 2023), a landmark study that examined the impact of fossil fuel technological development and carbon-free energy innovation on CO2 emissions in different regions throughout China. The results of the first-differenced generalised method of moments test for the correlation between carbon emissions and fossil fuel energy technologies are inconclusive. Nonetheless, research has shown that renewable energy technologies significantly and negatively impact CO2 reduction.

The impact of green technological innovation on total carbon factor efficiency across nations of varying socio-economic levels was investigated by Fang et al. (2022). Green technological innovation was shown to increase overall carbon productivity in high-income countries, but this benefit was not seen in low-income nations. Using data from individual provinces in China, Pan et al. (2023) sought to determine the impact of advances in renewable energy technology on global warming. Renewable energy technology advancement lowers carbon emissions, as shown by the linear regression, but renewable energy generation does not exhibit any meaningful results. In contrast, the structure of energy usage in the Chinese economy is dominated by coal, which may impede renewable technology development.

3 Methodology and data

3.1 Theoretical background

Charles, Cooper, and Rhodes expanded and experimentally implemented the strategy given by Glasbergen (1992). They put out a theory known as DEA. In scholarly works, this is known as the CCR model. The authors introduced the term ‘decision-making units’ (DMUs) to underline how interested they were in gauging the effectiveness of non-profit organisations. Notably, DEA aids in locating effective DMUs and building an effective output gap. The overall performance of each DMU relative to other DMUs of a similar type in the sample is measured using DEA models. Therefore, it is feasible to establish two clusters by using DEA to evaluate the performance of a single group of firms: companies that make up a productive frontier and ineffective businesses that are located below the frontier. The theory that increasing volatility dynamics would increase banking stability and improve green economic growth is the foundation of the hypothesis explaining the relationship. Banking stability significantly impacts the link between green economic growth because it affects the costs of other products and sustainability studied by (Zhang and Dilanchiev 2022). The inflation and economic intermediation volatility are determined by adding the usage price indicator and bank loans to the DEA model. We build a six-variable DEA model by considering the following:

$$Ay_t = \beta_0 + \sum_{i=1}^{p} \beta_i y_{t-i} + v_t \tag{1}$$

The empirical framework is presented as follows. First, the directional spillover approach is used to assess the degree of green economic growth at the national level. Determining the dominance of one nation over another on the dimensional spillover impact throughout the pandemic period, indicated by the rigorousness rating, is the crucial goal. Second, causality networks are built using Granger causality estimations to assess the magnitude of the economic effects of the pandemic on banking stability and volatility dynamics on green economic growth (Wu et al. 2022). Based on a simple assumption, we determine whether financial institutions can assist in green recovery. If going green rewards performance, these middlemen will assist. In contrast, engagement will be spontaneous if there are no specific advantages. Accordingly, we examine two aspects of bank profitability. The first relates to profitability, while the second entails risk exposure. Numerous studies, including Koopmann (1951), claim that the profitability ratio and risk exposure of banks affect their business. Following these claims, we use banking spread as the risk measurement and default chance as the profitability indicator.

3.2 DEA model

We consider various volatility dynamics in the reactions to both regular and extraordinary occurrences. Thus, the unobserved news process that controls the time series returns is maintained via the DEA model for returns. Time series often vary because of news events and investors' anticipation of these occurrences. This study uses the conditional variance of returns model proposed by Chang et al. (2023) that considers the effects of different forms of news. It is assumed that the latent process consists of two distinct components: typical and extraordinary occurrences. We use the influence of these news innovations common and unusual on return volatility for identification (Eq. (2)). Remarkably, the return innovation component is assumed to represent the effects of unobservable routine innovations. The variance of yields undergoes smoothly developing modifications owing to this process component, and the reduced-form DEA model may be developed based on the assumption that A is reversible as follows:

$$y_t = A^{-1}\beta_0 + \sum_{i=1}^{p} A^{-1}\beta_i y_{t-i} + A^{-1}v_t = C_0 + \sum_{i=1}^{p} C_i y_{t-i} + \varepsilon_t \tag{2}$$

$$\mathrm{IC} = \sum_{j}^{C_{\mathrm{iverr}}} \left(\mathrm{Loss}_j + G_i\right) = \sum_{j}^{i} C_{\min}\left(\frac{\omega_j^*}{V^2} + G_j\right), j \tag{3}$$

$$\mathrm{HC} = \sum_{j}^{i} C_h\left(G_j - E\left[D_j\right]\right), j = \{p, o\} \tag{4}$$

$$\mathrm{SC} = \sum_{j}^{i} C_x\left(E\left[D_j\right] - G_j\right), j = \{p, o\} \tag{5}$$

$$U^{\mathrm{mat}} = h\ln\left(\sum_{j}^{i}\left(\frac{L}{P_j} - G_j^{\min} + \theta\right)\right), j = \{p, o\} \tag{6}$$

The parameters are unstable. It is difficult to determine everything that affects renewable energy sources. Previous studies have demonstrated that increasing the number of factors leads to an inability to portray their dynamic interactions.

$$\begin{aligned}\prod\left(P_j, G_j, L\right) &= \mathrm{TR} - \mathrm{IC} - \mathrm{HC} - \mathrm{SC} - \mathrm{IP} \\ &= \sum_{j}^{i} P_j y^* E\left[D_j\right] - \sum_{j}^{i} C_{\mathrm{im}=x}\left(\mathrm{LL}_j + G_j\right) \\ &- \sum_{j}^{i} \sum_{j}^{C_x} \left(E\left[D_j\right] - G_j\right)^+ - +\lambda\left(U^{\mathrm{mit}} - I_e gL\right) - r(1-\lambda)L \end{aligned} \tag{7}$$

A scholar must decide to determine where the elements are also most important.

$$G^*_{\mathrm{ji}} = \left[15\sqrt{2}\gamma C_h\left(M_j^{\mathrm{mam}}\right)^4 P_j V^2 + \cdots + \left(3\sqrt{2}C_h V^2 + 3\sqrt{2}C_x V^2 - 3\sqrt{2}P_j V^2\right)\#1^5, i\right] j = \{p, o\},\ i = [1, 5] \tag{8}$$

The stability of the variables must be checked using the Copenhagen test. These equations' extended Kalman model uses ordinary least squares (OLS) analysis. Equation (9) illustrates the OLS methodology (1).

$$Y_t = \alpha_0 + \alpha_1 X_t + \alpha_2 Z_t + u_t \tag{9}$$

If all the matrix members in Eq. (10) are identical to one, then Eq. (11) implements the non-stationary process.

$$\mathrm{ME}\ :\ Y_t = \beta + \beta_{1t} X_t + \beta_{2t} Z_t + u_t\,\mathrm{TE}\ :\ \beta_{it} = \emptyset_i\,\beta_{\mathrm{it}-1} + v_{it} \tag{10}$$

Assuming that the state formula calls for randomised walking, it is reasonable to assume that this is an atypical circumstance. Changes in governance are examples of green financing (nit).

$$\mathrm{DLI}\ :\ Y_t = \beta + \beta_1 X_t + \beta_{2t} Z_t + u_t\,\mathrm{TE}\ :\ \beta_{2t} = \emptyset\beta_{2t-1} + v_t \tag{11}$$

According to Eq. (12), when describing the governing equations, acceptable model fit criteria govern the form of the state equation.

$$\begin{gathered}\mathrm{WDLI}_t = \beta + \beta_1\,\mathrm{CAR}_t + \beta_2\,\mathrm{HHI} + \beta_{3t}\,\mathrm{GL} + \beta_{4t}\,\mathrm{GDP}_t + \beta_{5t}\,\mathrm{MS} + u_t \\ \beta_{\mathrm{it}} = \beta_{\mathrm{it}-2} + v_{\mathrm{it}-1} + v_{\mathrm{it}} \end{gathered} \tag{12}$$

This model developed by Shen et al. (2022) has proved to be an invaluable tool in economic policy research. Consequently, Zhou et al. (2008) reveal that there is no loss of data during differencing. Using factors in levels independent of the outcomes of co-integration tests leads to consistent estimates, including those in this study.

$$\beta_{\mathrm{it}} = \beta_{i0} + \sum_{h=0}^{n} v_{\mathrm{it}-k} \tag{13}$$

This study focusses on the impact of South Asian economies. Researchers can determine time-varying variables using the Kalman filter and vector autoregression techniques. As with other regression models, this approach is divided into time-varying and fixed variables.

$$y_t = \sum_{i=1}^{p} A_i y_{t-i} + \sum B_J X_{t-j} + \varepsilon_t, \ t = 1, 2, \ldots, n \tag{14}$$

For the moving coefficient, according to Chang et al. (2022e, 2022a, 2022b, 2022c, 2022d), the Kalman filter approach is presented for unstable models. First, the Hansen test must be used to verify the robustness of the variables. Table 1 presents the definitions and data sources of our variables.

3.3 Data

Each South Asian commercial bank is considered part of our sample. Members of South Asian countries are fast-growing emerging economies that have historically relied on high-emitting businesses for their economic development. Statistics on credit exposure can be used to separate these categories. This is a critical requirement. The corporate activity database and, if not, the financial results of banking institutions are used to gather these data. The sample period is from February 2011 to September 2021, and Table 2 presents the sample description. As a precaution against any biases introduced by the international economic meltdown, we begin our study period in 2011. In addition to annual financial reports, we use Datastream and other items of information from local stock exchanges and central banks, as well as other sources of information. Across 42 quarters, we have a panel ranging from 68 to 92 banks in our final sample.

4 Results and discussion

Additionally, new financial models are being introduced into the market based on big data, block chains, mobile commerce, digital twins, and the Internet of Things (Chang et al. 2022e) to demonstrate the value of green financing in the fight against climate change by using sustainable projects, renewable energy, and carbon credits.

Table 1 Definitions and data sources of variables

	Description	Data source	Transformation
GL	Green lending to the portfolio ratio	Bankscope database	Logarithm
GDP per capita (ppp)	Gross domestic product (GDP) at purchasing power parity Per capita (international dollar)	Bankscope database	Logarithm
TA	Trade openness	Bankscope database	Logarithm
HHI	Herfindahl index	Bankscope database	
MS	Money supply	Bankscope database	
DLI	Default likelihood	Bankscope database	Logarithm

Table 2 Sample description

Country	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Pakistan	4	6	6	8	6	6	7	9	6	8	8
India	7	9	11	17	8	8	7	13	12	10	12
Sri Lanka	5	7	6	7	8	7	8	8	7	6	8
Nepal	14	12	17	16	12	14	12	16	17	15	17
Bhutan	19	21	18	22	21	21	17	23	23	23	23
Bangladesh	14	17	19	19	21	19	19	21	23	21	21
Afghanistan	11	15	16	13	19	17	16	17	19	18	17
Total	70	70	92	92	93	92	92	86	89	92	93

Green financing is used in the construction sector to improve budgets and maintain green designs, buildings, and facilities in the long run. Financial organisations are not obligated to alter their capital distribution approach in a green finance plan that aids green industries. Thus, they need more guidance regarding green investing. The economic sector needs to help transition to a carbon–neutral economy by removing barriers to entry for eco-friendly enterprises (Table 3).

In the first stage, we look at the primary catalyst of the spread of the disease or the characteristics associated with the first trigger event. The term 'black swan' is commonly used in the economic sector to refer to unlikely events that have far-reaching consequences for the economy and markets. These shocks alter people's expectations and views of risk, thereby preventing analysts from accurately predicting the course of a crisis using conventional methods. For instance, the spread of the COVID-19 outbreak led to unprecedented levels of social isolation and state limitations, making this event economic, as Wang (2018) declares that an event may exhibit the following three features: because nothing like it has ever happened

Table 3 Fixed effect regressions for banking spreads

Variables	Coefficient	Standard error	t stats
Constant	0.08431	0.13339	0.63151
GL	0.03921	0.01090	2.57019***
ϑ	0.03111	0.01529	3.04390**
Liquidity	−0.02031	0.00929	−3.18078**
Log TA	0.01431	0.00688	3.05580**
gGDP	0.11870	0.05608	3.11543**
HHI	0.39451	0.13102	2.01079***
MS	−0.03641	0.04031	−0.90331
No of Obs	1729		
Adjusted R2	0.7170		
Country FE	YES		
Year FE	YES		

*** represents significance at 1%, ** at 5%, and * at 10%

before, it stands out; it has far-reaching consequences; and despite its impact, our propensity for retroactive explanations makes it eventually explainable and predictable. The Global Financial Crisis of 2008–2018, the worst financial shock on a global scale since the Great Depression, has often been compared to a roller coaster (Avom et al. 2020), the collapse of the Asian stock market in 2015, and a change in state strategy. Chang et al. (2022b) examined the reaction (and subsequent recovery) of 15 stock indices, 4 bond benchmark indices, 9 precious metals, and 3 major cryptocurrencies to determine whether or not the events surrounding the COVID-19 situation constituted a market-wide 'crash' (Dafermos and Nikolaidi 2019). The findings showed that the effect of the COVID-19 outbreak was unevenly felt across markets and different asset classes, as presented in Table 5. This crisis will be the first in the history of these instruments and exceptional, making the black swan metaphor all the more applicable to conventional economic industries and their response to the COVID-19 outbreak. The authors (Sun et al. 2019) are only two of many who have explored the likelihood and foreseeability of the black swan scenario in the literature. The benefits of green finance include, but are not limited to, more favourable lending terms for long-term projects; the creation of innovative, economical products; and the growth of the market via the increased visibility and understanding of the value of eco-friendly practices (China 2011). Among the many benefits of investing in green bonds is the availability of long-term capital to refinance existing green buildings.

An investigation examining the impact of the COVID-19 outbreak on the share market (Ning et al. 2022) indicated that investor yields decreased as the number of confirmed cases increased. When the growing number of fatalities is contrasted with the rising number of confirmed cases, concerns are compounded. Based on CAR, GDP, and MS, notable market reactions also occurred after the first week of verified cases, around Days 40 and 60, following the first reports of confirmed cases. The results reported by Nižetić et al. (2019) showed that in the aggregate, the stock market reacted quickly but, continuing ahead, changed over time depending on the stage of the pandemic. According to Wen et al. (2021) findings, global financial markets have collapsed, particularly in the latter phases of the pandemic's spread, even when the certain products considered suffer. This is even though the original outbreak site in Asia has stabilised. Examining the predicted stochastic volatility over time reveals that shock volatility follows a predictable pattern, as shown in Table 4. After almost a zero variance in the structural shocks through 2017, 2019 recorded the highest oil supply levels and financial intermediation volatilities. These levels were sustained during the COVID-19 pandemic crisis and until the end of the year.

There has been a striking similarity between the volatility of the two variables since the fracking revolution. One possible explanation is the industry's increasing reliance on debt. The debt levels for publicly traded oil companies increased by more than a factor of three between 2006 and 2014. Since the steep drop in oil prices in 2013 and the beginning of 2014, oil producers' financial viability has worsened dramatically. Regarding CAR, GDP, and MS, the proportion of Asian consumer loans tied to the oil and gas sector increased from 0.6 percentage points in the second quarter of 2013 to 10.4 percentage points in the third quarter of 2017. As a direct consequence of the sharp reduction in the quality of their loans, banks saw a decline

Table 4 Fixed effect for banking spreads—big banks

Variables	Coefficient	Standard error	t stats
Constant	−0.08490	0.081771	−1.037490
GL	0.022321	0.010791	3.06661**
ϑ	0.0340290	0.017169	1.98170**
Liquidity	−0.713388	0.813308	−0.877291
gGDP	0.023760	0.011141	3.133069**
HHI	0.0187690	0.005477	4.42361***
MS	0.005499	0.00478	1.13749
No of Obs	1729		
Adjusted R2	0.68971		
Country FE	YES		
Year FE	YES		

***represents significance at 1%, ** at 5%, and * at 10%

Table 5 Robustness analysis

Variables	Coefficient	Standard error	t stats
Constant	0.081710	0.261390	0.312388
GL	−0.098770	0.031190	−4.163290***
ϑ	−0.036580	0.009159	−3.991666***
Liquidity	−0.057432	0.028071	−2.050078**
gGDP	−0.061390	0.030866	−1.994221**
HHI	0.052310	0.085719	0.611577
MS	0.023049	0.255432	0.090171
No of Obs	1729		
Adjusted R2	0.719531		
Country FE	YES		
Year FE	YES		

in their stock prices and market capitalisation. Therefore, banks began deleveraging by reducing risk-taking and tightening lending rules, as shown in Table 4. Since the shale boom, Asian oil investment has been more vulnerable to shocks in oil supply, aggregate demand. Both overall investment and investment in sectors other than oil react similarly to changes in demand.

Stochastic volatility is shared by foreign and domestic demand, as well as inflation. Regarding trend behaviours and cyclical ups and downs, the three stochastic volatilities have a typical time-evolutionary pattern marked by three defining dates. The 2019 COVID-19 outbreak will be far more unpredictable than the 2007 subprime crisis or 2013 oil price collapse. The Federal Reserve's changing responses to and expectations of inflation might be to blame for this. Dhakouani et al. (2019) argued for further monetary policy relaxation after the oil price drop and pointed to sluggish global demand for oil as a contributing cause. The Federal Reserve, for its part, saw the shock as normal, the kind of thing that would lead to increased actual output in reaction to lower prices. The Federal Reserve forecasted that the oil industry would be severely hurt by this shock, but the South Asian economy would rise, urging significant caution when forecasting future inflation. Furthermore, as previously highlighted in this study, the private sector's firmly established confidence in low inflation credibility. This did not trigger a quick response from the Federal Reserve, despite expectations that a drop in oil prices would reduce headline inflation. For inflation, the Federal Reserve expects that a rate of increase that is more responsive to aggregate and residential demands is accurate, as indicated by the consistency with which the stochastic volatility has changed over time.

There is no statistically significant correlation between the financial situation index and the positive and negative spillovers for any quantile. However, understanding the financial index displays a strong causal link between midrange quantiles and the understanding of the financial index. We find that causation in the mean and variance is unbalanced and susceptible to the distributions and South Asian regions. There has been an increase in renewable power generation owing to an increase in oil prices due to increased energy growth in developing nations. With rising energy costs, investments in the renewables industry have increased, hence enhancing South Asia's capacity to generate renewable energy power. There were no significant fluctuations in GDP nor private energy development.

However, this might be attributed to the rise in global energy costs between 2006 and 2008, as indicated by volatility. One may claim that green financing grows because of shocks and crises, as shown in Table 5. The green finance movement gained traction in meeting environmental concerns while also advancing economic growth. Most nations enacted lockdowns and immigration restrictions during the early stages of the COVID-19 epidemic. When company activity is severely restricted, equity and debt markets react negatively, which may have resulted in a change in market credit spreads. This disaster was not different from the previous ones, in which volatility increased. Consequently, the market's response was negative.

The pandemic has had varying effects on different businesses. High-leverage corporations were hurt more than those with superior brand awareness, extensive cash holdings, larger economy ratios, and excellent corporate responsibility rankings. Cross-market integration diminishes the effectiveness of hedging and exacerbates the consequences of a financial crisis (Seghier et al. 2020), which shows that hedging is less effective when markets are integrated. Timely government involvement and aid may mitigate some of the negative consequences of market responses. During the financial crisis, stockholders' attitudes and social media also affected stocks, and it was found that significantly altered investor behaviours could also have contributed to stock market reactions. Increased trade levels and higher search engine volumes might be attributed to investor fear and could be an effective prediction tool. Accordingly, investors prioritise strong governance and choose companies with better ESG ratings, such as sustainable energy companies (Alemzero et al. 2020). In the early stages of the outbreak, world markets were mostly negative, although there was substantial asymmetry in many regions of the globe. Some of the many moderator variables, such as state interference, mortality rate, and the growth of market trust and freedom, have influenced the amount of negative returns, revealing that

Asian markets have been more robust since volatility-faded use currency rates, oil prices, and COVID-19 infections to determine that Asian equity markets have been hit more than other markets.

Chang et al. (2022c) found that increasing medical risks negatively influenced investment returns and price volatility. They also found that developing markets had a more significant impact on the stock market than mature markets. Data from the USA and Canada were used by to establish an asymmetrical relationship between stock market movements and the reduction in COVID-19 cases. Asian countries are heavily dependent on oil prices, which makes them vulnerable to market fluctuations. The COVID crisis saw Brent crude oil fall from US$ 62 a barrel to below US$ 26. The reduction in oil prices did not impact Asian nations' revenues, and they focussed on diversifying their income streams. According to Chang et al. (2022a), lockdown limits caused the markets to go through well over and under the response periods connected to the data. Since the crisis in 2003, the degree of volatility in oil-related demand has grown, reaching a high level. After the subprime crisis in 2007, volatility fell dramatically, hitting a nadir with the oil price crash of 2015.

Some indications that the covariance architecture of volatility has changed and the dynamics of the parameters throughout the key essential found dates have been shown above. Belussi et al. (2019) claim that considering volatility over time helps identify frame volatility within an appropriate range of innovation sizes. As the results of our empirical method are highly dependent on the passage of time, using a time-invariant DEA identification strategy would provide inaccurate estimations.

5 Conclusion and policy implication

One school of thinking holds that the natural resource product industries are better capable of generating a widespread economic impact. Increases in green exposure will boost the intermediary financial spread, according to a thorough sample of banks from 2011 to 2021 in South Asian economies. The analysis employed the DEA method, and the results were robust. Consequently, banks' default risk decreased when they considered environmental issues when granting loans. There needs to be more transparency between the resource sector and the economy. Experts are actively investigating the links between oil prices and socio-economic activity because of their apparent association. This groundbreaking study examines how oil volatility affected other socio-economic activities after the 2008 economic crisis and the onset of the COVID-19 outbreak. The COVID-19 outbreak has had a significant monetary impact. The oil market is one of the areas that has experienced the most blows. Oil market volatility presents additional hurdles for governments and enterprises worldwide, especially in the Asian region. The tight connection between oil and other financial markets means that the spillover of oil shocks to other markets is expected to be more prolonged during the COVID-19 outbreak. Since then, extreme volatility has been observed in other markets. The COVID-19 pandemic has considerably affected the volatility and returns of the oil market. Although the CAR crude oil price reflects the equilibrium between domestic buyers and sellers, the London petroleum price is utilised as a benchmark in Asian countries.

Therefore, it is necessary to analyse the spillover dynamics between oil price shocks and macroeconomic activity over many periods. This study used a vector DEA model to investigate whether oil prices and GDP are time- and frequency-dependent. This approach also explores the link between oil prices and global economic activity. To gain insights into the time–frequency fluctuations of the variables, DEA is used. In the context of the global financial crisis, there is a robust connection between (GDP and MS); a shock in oil prices has long-term consequences for commercial development; in the short run, there is a pre-emptive causal relationship between oil and gas prices and economic expansion; any policy to approach the price of crude oil has a strong impact on economic activities; and any policy to approach the price of crude oil strongly affects financial activities.

This study aims to better inform authorities about the causes of oil price fluctuations. The policy implications suggest that state intervention cushions the blow of the recent drop in oil prices. Administrations may lift restrictions to aid the oil market and get economies moving again. Natural disasters are another risk that countries must be ready to face. It is important to note the long-term impact of the COVID-19 pandemic on oil prices seen in this study. The oil industry will return to normal after COVID-19 has been eradicated.

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Declarations

Conflict of interest The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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