Fintech, Financial Development, and Digitalization derive Environmentally Responsible Economic Recovery during and after the COVID-19 pandemic.

Abstract

Economic recovery has become a hot topic after the emergence of the COVID-19 pandemic, where financial, digital, and natural resources are important aspects to consider for economic revival. The study explores the impact of Fintech, Financial development, digitalization, and natural resource rents on economic recovery from 2019 to 2023 from the perspective of BRICS economies. With appropriate econometric models, the study observes that all the independent variables are the main drivers of economic recovery during and after the COVID-19 era. A bi-directional causal connectivity is observed between explanatory and outcome variables. The findings suggest that the BRICS economies should take preventive measures to avoidthe volatility of natural resources and actively promote Fintech, Financial development, and digitalised activities to achieve economic goals.

Keywords: Digitalization; Fintech; Financial Development; Economic Recovery; COVID-19 pandemic

1. Introduction

Environment sustainability, economic recovery, and performance are some of the most crucial challenges policymakers are coping with after the COVID-19 pandemic. While enough evidence is available on the role of natural resources in economic growth[1,2], the empirical literature yielded conflicting findings simultaneously. This is mainly due to the resource curse view suggesting that emerging countries with abundant natural resources may have lower economic growth rates than prosperous countries with limited natural resources[3,4]. Merely having a natural resource is insufficient; management is crucial for economic growth and sustainability.

Heavy reliance on natural resources such as oil and gas exposes economies to price and economic volatility, hindering economic recovery. By diversifying the real and financial sectors and investing in technology, countries can achieve sustainable economic growth and environmental sustainability goals. However, resource exploitation must be planned with sustainability in mind. Unsustainable practices could give rise to fragile ecosystems and biodiversity, jeopardizing long-term prosperity. Unsustainable resource use may improve economic growth at the expense of environmental, healthcare, and agriculture damage [5], impacting future economic growth and recovery. Sustainability and conservation of natural resources should be a deciding factor when formulating economic growth policies. Resources should be channelled towards economic diversification, green job creation, and improved social welfare. Policies to foster environmental sustainability, such as green businesses, green financing, and investment, are crucial for post-pandemic long-term economic recovery and growth.

Also, financial systems are crucial as developed financial markets and institutions have instruments and regulations that catalyze investments in environment-friendly projects[6,7]. Financial development increases investor confidence and participation, increasing production, employment, and economic growth[8,9]. Financial development may also improve environmental quality and sustainabilityif there is stakeholder interest in it[10]. Overlooking environmental sustainability in financial markets and institutions can make credit give rise to environmental degradation and unsustainable economic activities[11].

An important development in the financial industry has been the adoption of technologies such as Artificial Intelligence, Data Science, and Blockchain, giving rise to new business models such as Robo Advisors, Crowdfunding, E-Wallets, Digital Banks, etc. Collectively termed as Fintech, these businesses may improve financial inclusion and foster economic recovery and environmental sustainability. Several studies have highlighted the significant positive role of Fintech in addressing financing challenges in the green innovation sector, thereby contributing to environmental sustainability and economic performance[12,13]. Moreover, the dynamic impact of financial technology on sustainable growth has been a subject of research, emphasizing that fintech may promote green financing and contribute to sustainable growth, ultimately contributing to a greener economy[14]. These findings suggest that Fintech, through its digital nature, can contribute to environmental sustainability while also influencing economic performance.

This study examines the impact of natural resources use, fintech, digitalization, and financial development on environmental sustainability and economic growth within the BRICS context. The region's energy demand is quickly increasing due to industrialization, population growth, and urbanization. BRICS countries still have a long way to go in balancing economic aspirations with environmental protection. While the need for sustainable resource management in BRICS is increasingly recognized, significant challenges remain. This paper will contribute to the literature by comprehensively examining the impact of natural resource management, financial development, and Fintech in the specific context of BRICS. Secondly, we will study the challenges in the post-pandemic context in terms of economic recovery and environmental sustainability.

2. Literature Review

2.1 Natural resources, environmental sustainability, and economic performance

The relationship between natural resources, environmental sustainability, and economic performance has been a topic of significant interest and debate in the literature. The circular economy concept has emerged as a pivotal framework for promoting sustainable resource utilization and economic growth. Milios (2018) stressed the promise of the Circular Economy (CE) but emphasized the need for a nuanced understanding of its impact on various sustainability dimensions[15]. This aligns with Baars et al. (2021), who highlighted the rising importance of the CE concept amidst concerns about resource depletion and environmental pressures[16].

Umar et al. (2020) highlighted the critical link between economic resource use, economic growth, and CO2 emissions by saying that economic growth and natural resource use cause CO2 emissions in the long run, while financial development causes short-run CO2 emissions[17]. Usman et al. (2022) highlights the complex interactions between financial development, energy consumption, natural resources, and globalisation in Arctic countries,[18] exposing their significant role in triggering environmental pollution. Additionally. Muhammad et al. (2021) explored the impact of foreign direct investment, natural resources, renewable energy consumption, and economic growth on environmental degradation[19]. The study provided evidence from BRICS, developing, developed, and global countries, indicating that ore and metal resources cause environmental degradation. However, fuel resources and renewable energy consumption help to reduce the environmental degradation in BRICS. Surprisingly, urbanization, economic growth, and innovation had a long-term negative impact on emissions, conflicting with energy consumption, financial development, trade, foreign direct investment, and globalization generally increasing emissions[19].

Baydoun & Agha (2021)identified economic growth and energy consumption as detrimental to the environment, and globalisation exhibited a positive effect[11]. They call for green energy policies and further research to understand these complex relationships better. In the context of the pandemic, the volatility of mineral wealth is shown to have a substantial positive effect on the market liquidity of natural resources and oil stock prices, as pandemic-related disruptions contribute to increased demand and supply, leading to notable market price fluctuations in these commodities. Agarwal et al. (2022) pointed out that funding limitations and ineffective integration of Industry 4.0 technologies hinder sustainable supply chains[20]. They recommended exploring sustainable practices and4.0 technologies to overcome these limitations.

2.2.Financial Development, environmental sustainability, and economic performance

The impact of financial development on economic performance has been extensively studied, but the relationship between financial development on environmental sustainability is a relatively new area of research.Earlier studies such asLahiani (2020) investigated the asymmetric effect of financial development on CO2 emissions in China by controlling for the effects of economic growth and energy consumption[21]. They concluded that increased financial development contributes to lower CO2 emissions. Similarly, in another study, the dynamic linkages among CO2 emissions, green energy, green finance, and energy efficiency have been examined[22]. The results indicated that population growth and higher GDP could raise CO2 emissions without clean energy, but green bonds offer a potential solution to promote environmental sustainability. According toKhan et al. (2022),to reduce global CO2 emissions, there is a pressing need to increase green funding in renewable sources.[23]. Xu et al. (2022) analyzed the impact of financial development on environmental sustainability and found that when banks and other financial institutions show a preference for lending to eco-friendly borrowers, firms are encouraged to adopt greener practices[24]. Furthermore, Sadiq et. al (2023) found that an increase in the issuance of green finance, like green credit, green securities, green investment, and green loans, leads to an increase in the funds specifically for eco-friendly initiatives[25]. Financial development also promotes financial inclusion, incorporating unbanked populations into the formal economy and fostering broader economic participation and growth. Despite these dynamics, the relationship between financial development, environmental sustainability, and economic performance lacks extensive research, necessitating further attention and consideration in policy and decision-making.

2.3.Fintech, digitalization, environmental sustainability, and economic performance

The intersection of financial technology (Fintech) and digitalization with environmental sustainability and economic performance is a topic of growing interest among researchers. Several studies have examined the relationship between Fintech and sustainability, emphasizing Fintech's potential to foster green innovation and a green economy. For instance, Wang et al. (2022) reported that digital financial technology enables green economic growth through enterprise green[26]. Tang et al (2022) also suggested that Fintech significantly improves circular economy practices across green manufacturing, recycling, and remanufacturing, and green design[27]. Moreover, Ni et al. (2023) suggested that fintech fosters regional green innovation and interacts positively with environmental regulations. Green FinTech's impact extends beyond the financial system, influencing the entire economy, including fostering innovative sustainable businesses and startups, contributing to a broader green transition[28]. Moreover, Puschmann et al. (2020) examined the influence of FinTech finance on social-environmental performance incorporating economic, institutional, and social factors[29]. Their findings reveal a small yet statistically significant positive impact of FinTech finance on social-environmental performance. However, it is important to note that the relationship between Fintech, environmental sustainability, and economic performance is complex, as the severity and implementation of environmental regulation policies and technological advancement can influence the effectiveness of Fintech in promoting green innovation and economic growth.Digital transformation has brought about disruptions in the environmental sustainability domain, particularly in pollution control, waste management, sustainable production, and urban sustainability[30]. Overall, the literature suggests that Fintech can have a positive impact on environmental sustainability and economic performance, but more research is needed to fully understand the potential of Fintech in promoting sustainability.

Table 1: Constructs' Measurement details.

Variable Description	Abbreviations	Unit	Data source
Environmentally Responsible Economic Recovery	ERGDP	Constant 2010 US$	WDI
Natural Resource Rents	VNR	% Of GDP	WDI
Fintech	Fintech	% Of GDP	Statista.com
Financial Development	FD	% Of GDP	IMF
Digitalization	Digi	% Of GDP	IMF

3. Data Description and Methodology

BRICS economies are selected for analysis over the period from 2019 to 2023, the selected period also includes the era of the COVID-19 pandemic, and the pandemic has different implications on global economy[31]. To explore the impressions of natural resources, financial development, Fintech, and digitalization as driving forces for economic recovery, we develop the following function.

$$GDP_{it} = f(VNR_{it}, Fintech_{it}, FD_{it}, Digi_{it}) \quad (1)$$

The study presents the econometric expression of the above function in the following Equation:

$$\text{Ln } GDP_{it} = \beta_0 + \beta_1 \, lnVNR_{it} + \beta_2 \, LnFintech_{it} + \beta_3 \, LnFD_{it} + \beta_4 \, LnDigi_{it} + \varepsilon_{it} \quad (2)$$

In the modern era, natural resource volatility, financial technology, financial development, and digitalization contribute to economic development at the cost of climate quality, therefore we consider economic development (GDP) as environmentally responsible economic recovery (ERGDP) and re-present Equation 2 as:

$$\text{Ln ER}GDP_{it} = \beta_0 + \beta_1 \, lnVNR_{it} + \beta_2 \, LnFintech_{it} + \beta_3 \, LnFD_{it} + \beta_4 \, LnDigi_{it} + \varepsilon_{it} \quad (3)$$

Where all the abbreviations used in Equation 3 are discussed in Table 1. We use mean, standard deviation, and normality tests in descriptive analysis. To explore the unit root properties, we apply ADF (augmented dicky fuller) test and DFGLS (Dicky fuller generalised least square) test as suggested by Badri Ahmadi et al. (2017)[32]. The long-run connectedness among variables is investigated with the "Bayer-Hanck combination co-integration test", which produces accurate coefficients.Furthermore, we use FMOLS (fully modified ordinary least squares, which us descriptive in nature), DOLS (dynamic ordinary least squares, which is non-parametric in nature), and CCR (canonical co-integrating regression) test and all three tests are superior to simple OLS model.Furthermore, we use normality test of Swanepoel et al. (2019) where Kurtosis coefficients are used to uncover the excess kurtosis[33]. We use the Jarque-Bera test to account for the normality of variables used in the study, which is presented as:

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

After verifying the descriptive and inferential requirements[34], we examine the unit root properties of variables under study via ADF mode which is given as follows:

$$y_t = \gamma + \varphi t + \mu y_{t-1} + e_t \quad (5)$$

The OLS expression for the Equation 5 is given as:

$$\Delta \, y_t = (\mu - 1) y_{t-1} + \gamma + \theta t + e_t \quad (6)$$

We use the DF-GLS model which is a customized form of ADF and better capable to capture impact of independent variables on economic recovery[35], and can be calculated as:

$$\bar{y}_t = y_t - \left(\frac{\bar{c}}{T}\right) . \, y_{t-1} \quad (7)$$

We use the following expressions to derive a time series model for each country, with a probabilistic component μ_t and a predictable part d_t and presented via following Equations:

$$y_t = d_t + \mu_t \quad (8)$$

$$\mu_t = \rho\mu_{t-1} + \varepsilon_t \quad (9)$$

$$\rho = 1 - \frac{\bar{c}}{T^{\cdot}} \quad (10)$$

Bayer-Hanck combined co-integration test is used to perform cointegration analysis, the said test is more efficient as compared to other cointegrations models[36]commonly used for panel data.Moreover, for robustness purpose we mix the cointegration model with Fisher F-statistics to obtain more definitive outcomes:

$$EG - J = -2[ln(P_{EG}) + ln(P_J)] \quad (11)$$

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

After the confirmation of cointegrations, we uncover the long-run associations by using FMOLS, DOLS and CCR models (all ere the extensions of MOLS: modified ordinary least squares). These models reduce the problem of unobserved heterogeneity and the serial correlation. We present the FMOLS and DOLS estimators as:

$$\widehat{\varnothing} = \begin{bmatrix}\alpha \\ \hat{\beta}\end{bmatrix} = \frac{1}{\sum_{t=2}^{T} Z_t Z_t^{'}}\left(\sum_{t=2}^{T} Z_t y_t^{+} - T\begin{bmatrix}\hat{\theta}_{12}^{+} \\ 0\end{bmatrix}\right) \quad (13)$$

$$y_t = X_t^{'}\beta + D_{1t}^{'}\gamma_1 + \sum_{j=-q}^{r} \Delta X_{t+j}\sigma + v_{1t} \quad (14)$$

For long term forecasting, we use CCR technique that rectifies the OLS components i.e., delay and lead. Equation 15 presents the estimators of CCR in the following way:

$$y_t^{*} = \beta_{pq}^{'} + z_{pqr}^{*} + \mu_{pqt}^{*} \quad (15)$$

Table 2: Summary Statistics.

	ERGDP	Fintech	FD	NRR	Digi
Mean	4818.735	6.945671	0.322484	4.969883	491.3152
Std. Dev.	6290.694	4.739038	0.059362	4.529382	1184.532
Skewness	1.492457	0.867873	0.489565	1.600495	2.337233
Kurtosis	3.470925	4.011055	1.553274	4.793444	6.479878
Jarque-Bera	9.51***	8.77***	13.178***	14.37***	35.37***

Note: *** is the indication of significance at a 1 % level of the confidence interval.

Table 3: Heterogeneity of Slop parameters and CSD (cross-sectional dependency).

Slope Heterogeneity Test	Statistics
Δ~	15.084***
Δ~Adjusted	16.102***
Cross-Sectional Dependency	
ERGDP	18.364**
Fintech	06.294***
FD	07.413***
NRR	08.563***
Digi	10.552***

Note: *** is the indication of significance at 1% level of confidence interval, whereas ** shows the same for 5%.

4. Empirical Findings

The volatility of natural resources hasincreased during the COVID-19 pandemic. Such volatility results in a global decline in natural resource prices and financial-economic slumps in different economies around the globe[37].The current era requires restoration of economic growth; therefore, we establish a link between natural resource rents, Fintech, Financial development, Digitalization, and sustainable economic recovery through the current study. The mean value of environmentally responsible GDP is 4818 with a standard deviation of 6290, indicating the potential risk to BRICS economies due to COVID-19 (see also Tan et al., 2021). Fintech has a mean value of 6.94, whereas FD, NRR, and digitalization have 0.322, 4.96, and 491 mean values, respectively. The values of Skewness, kurtosis, and JB tests indicate a departure from the normality of the data series and suggest applying unit roots to account for the stationarity properties (see Table 2).Table 3 makes it clear that the variables have significant heterogeneity of slope parameters and confirms the existence of cross-sectional dependencies. Such findings support to apply the cointegration and causality test to explore the connected ness among variables.

Table 4: Coefficients of Unit root rest and Cointegration analysis.

Unit root testing		
Variables	Intercept and Trend	
	I(0)	I(1)
ERGDP	-0.478	-3.182***
Fintech	-3.937***	--
FD	-3.928***	--
NRR	-1.167	4.553***
Digi	-3.894***	--
Co-integration results (Westerlund, 2007)		
Gt	− 4.488**	
Ga	− 11.975***	
Pt	− 21.731***	
Pa	− 12.793***	

Note: *** is the indication of significance at a 1% level of confidence interval, whereas ** shows the same for 5%.

Table 4 represents coefficients for the unit root test and cointegration estimators. Table 4 reveals that ERGDP and NRR are non-stationary at a level while all other variables are stationary at first difference. However, when the first difference is taken, then both ERGDP and NRR become stationary at a 1% level of confidence. Table 4 also reveals the presence of significant cointegration associations among variables.

Table 5: CS-ARDL Coefficients.

Variable	Coefficient	Std. Error	Z-Statistic
		Short Run	
Fintech	0.085***	0.0057	8.97
FD	0.069***	0.0032	8.41
NRR	0.055***	0.0022	6.33
Digi	0.067***	0.0026	7.01
ECM(-1)	− 0.82***	0.1196	− 6.33
		Long Run	
Fintech	0.061***	0.0102	7.18
FD	0.046***	0.0089	5.09
NRR	0.058***	0.0042	3.23
Digi	0.073***	0.0093	4.77

Note: *** is the indication of significance at a 1% level of the confidence interval.

Table 5 exhibits the coefficients of the CS-ARDL model for both the short and long run. All the variables enhance the GDP in both the short and long runs, hence contributing to environmentally responsible economic recovery (ERGDP) because all the independent variables are directly related to climate quality. However, we find stronger and higher coefficients in short-run associations.

Table 6: Robustness test(AMG)

Variable	Coefficient	Std. Error	Z-Statistic
Constant	0.729***	0.1046	50.34
Fintech	0.294***	0.0184	3.20
FD	0.475***	0.0284	6.35
NRR	0.193***	0.0119	4.82
Digi	0.246***	0.0133	5.25

Note: *** is the indication of significance at 1% level of confidence interval.

The authors apply AMG test to explore the robustness of results obtained through CS-ARDL model and present the outcomes for robustness checks in Table 6. The robustness tests support the outcomes obtained through the application of CS-ARDL model. We observe Fintech brings 29.4% increase in economic recovery, while financial development enhances the economic recovery by 47.5%. Digitalization brings 24.6% rise in economic development in BRICS economies. Moreover, natural resource rents enhance the economic development by 19.3%. Overall, the robustness test supports the outcomes of the ARDL model.

To explore the causal elasticities (causal connection) between independent and dependent variables, we applythe Granger panel causality heterogeneity test recently proposed by 38 and present the results in Table 7. The bi-directional correlation between the independent and outcome variables is indicated with W statistics. We find strong causal connectivity between independent variables (Fintech, FD, NRR, Digi) and outcome variables in two ways. The findings are similar to the outcomes of a recent study by Yin et al. (2021), who observed a bi-directional causality between natural resource rents and economic performance[38]. Similarly, Ma et al. (2022) finds positive dual-directional associations between financial development and economic recovery[39]. The current outcomes are also in line with the findings of a study by Milenkovic et al. (2014), who argue that natural resource volatility can be reduced by focusing on renewable energy sources; thus, we may achieve high economic performance[40].

Table 7: Granger panel causality heterogeneity test outcomes

Null Hypothesis:	W-Stat.	Prob.	Zbar-Stat.
Fintech → ERGDP	3.73***	0.000	7.59
ERGDP → Fintech	3.19***	0.000	6.11
FD → ERGDP	2.45***	0.000	5.08
ERGDP → FD	5.38***	0.000	6.36
NRR → ERGDP	4.25***	0.000	6.29
ERGDP → NRR	3.12***	0.000	5.41
Digi → ERGDP	2.62***	0.000	5.39
ERGDP → Digi	3.02***	0.000	4.62

Note: *** is the indication of significance at 1% level of confidence interval.

5. Conclusions and policy recommendations

The connectedness of Fintech, Digitalization, Financial development and natural resource rents with economic recovery is crucial to understand in the recent era due to the emergence of COVID-19. For this purpose, we select BRICS economies to explore the proposed connectedness between variables. We contribute to literature by highlighting variables which derive the economic recovery and these variables have some direct impacts on climate quality, thus we name the outcome variable as environmentally responsible economic recovery and measure it with GDP growth. we find that all independent variables i.e., Fintech, FD, digitalization, and natural resource rents derive the economic recovery before, during, and after the COVID-19 period. We further observe a bi-directional causal connectivity between independent and dependent variables. The Governments of BRICS economies should enhance the financial development and digitalization to enhance the annual revenues which will contribute to economic development. Similarly, BRICS governments should promote Fintech through renewable energy sources behind the mining in Fintech. Utilization of renewable energy behind Fintech miningcan positively contribute to economic development and also enhance the climate quality. Moreover, the Governments of BRICS economies should control the corruption in natural resource rents to enhance their respective economic performance. The future research may use the model of current study in other country context. The future researchers should apply time series models to better capture the time varying phenomenon in connectedness of financial advancements (Fintech, Digitalization, FD) and economic recovery. The future research studies should compare different countries, regions and time periods. The future researchers may utilize the different market conditionsto uncover the connectedness explored in the current study under certain favorable and unfavorable market conditions.

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