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How has FinTech become a solution for minerals management?

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ABSTRACT

Effectively managing natural resources is crucial for ensuring sustainable economic development, a topic that has been widely debated in recent decades. While numerous discussions have focused on the use of technology to optimize the utilization of natural resources, the previous studies have yet to delve into the role of financial technology (FinTech) in minerals management and energy transition concerning the resource curse/blessing hypothesis. To address this research objective, this study valuably adds to the empirical literature by investigating the role of FinTech and energy transition in economic growth to manage minerals. To accomplish this goal, panel data of the top 10 resource-rich economies that range from 1990 to 2022 based on novel panel estimations such as Cross-sectional autoregressive distributive lag (CS-ARDL) and panel Granger non-causality (Juodis et al., 2021) is taken. The outcomes of the study discovered that FinTech is positively influencing GDP in both the long- and short-run. The robust outcomes further reveal that minerals management (coal, oil, minerals, and forests) becomes a part of enriching GDP to confirm the resources blessing theory. The study analysis sets down the practical implications of formulating sustainable economic development policies for stakeholders.

1. Introduction

Sustainable development has gained increased focus from academics, policymakers, and industry representatives. Achieving sustainable development in the digital age predominantly relies on energy transition and sustainable economic growth (Hosan et al., 2022; Rehman et al., 2023a). It is crucial, however, to ensure that the pursuit of sustainable economic growth does not compromise the well-being of future generations. This underscores the importance of aligning economic progress with environmental sustainability. The imperative of sustainable development is recognized globally across all economies (Hung, 2023).

In recent times, financial technologies (FinTech) have gained widespread global prominence. As *"Pulse of FinTech,"* global investment in FinTech[1] has consistently exceeded $100 billion annually over the past years, reaching $220 billion in 2021 and 2022. It acts a constructive role in reducing transaction costs, facilitating the exchange of information,[2] broadening avenues for financing, and effectively managing financial risks. Scholars widely acknowledge the opportunities presented by the FinTech revolution in reshaping the banking system (Zheng et al., 2023). Rapid technology innovation and finance have transformed the landscape of mineral consumption, efficiency, and management. Consequently, FinTech, which involves leveraging innovation and technology to provide financial products and services more conveniently, efficiently, and accessibly, has emerged as a key technological advancement.[3] Recent technological progress related to internet accessibility and mobile phones has facilitated enhancements in the delivery and cost of financial services, particularly at the consumer and retail levels (Ernst and Young, 2017). As a result, personalized and specially tailored financial products have become accessible in convenient and low-cost ways. The utilization of technological innovations in the financial domain has the potential to stimulate economic activities, generating earnings from financial cost-effective activities for marginalized groups such as the poor, farmers, women, underserved and elderly customers (Daud, 2023).

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[1] FinTech has transformed the financial landscape, rendering it intelligent, digitized and information-driven.

[2] Traditional financial institutions and startups alike have adopted various FinTech business models, encompassing payment, lending, crowdfunding, capital markets, and insurance (Lee and Shin, 2018).

[3] This entails the integration of cloud computing, mobile, artificial intelligence, applications, and blockchain to enhance conventional financial systems. Notable aspects of FinTech encompass personal insurance and regulatory technologies, finance and wealth management, payments and transfers, financial inclusion, and risk assessments.

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Table 1
Summary statistics.

Variables	N	Mean	SD	Min	1st Quartile	Median	3rd Quartile	Max	Skewness	Kurtosis
GDP	330	4.027	0.655	2.723	3.580	4.128	4.632	4.810	−0.532	1.961
FD	330	0.806	0.764	0.011	0.213	0.500	1.424	3.122	0.981	2.918
TECH	330	1.158	0.784	0.035	0.534	1.031	1.711	3.423	0.586	2.551
FTECH	330	0.557	0.236	0.148	0.382	0.509	0.760	0.974	0.170	1.872
ET	330	72.620	18.884	25.547	73.508	80.253	84.508	88.378	−1.544	3.835
URB	330	0.240	0.277	0.000	0.039	0.130	0.309	0.985	1.274	3.365
COAL	330	0.364	0.601	0.000	0.006	0.137	0.472	4.953	3.222	17.629
OIL	330	8.491	11.701	0.008	0.703	1.664	14.473	54.086	1.644	5.210
MIN	330	0.629	1.032	0.000	0.078	0.279	0.770	10.466	4.406	32.038
FOR	330	0.219	0.243	0.000	0.045	0.129	0.314	1.090	1.440	4.416

Notes: N shows no. of observations while SD represents standard deviation.

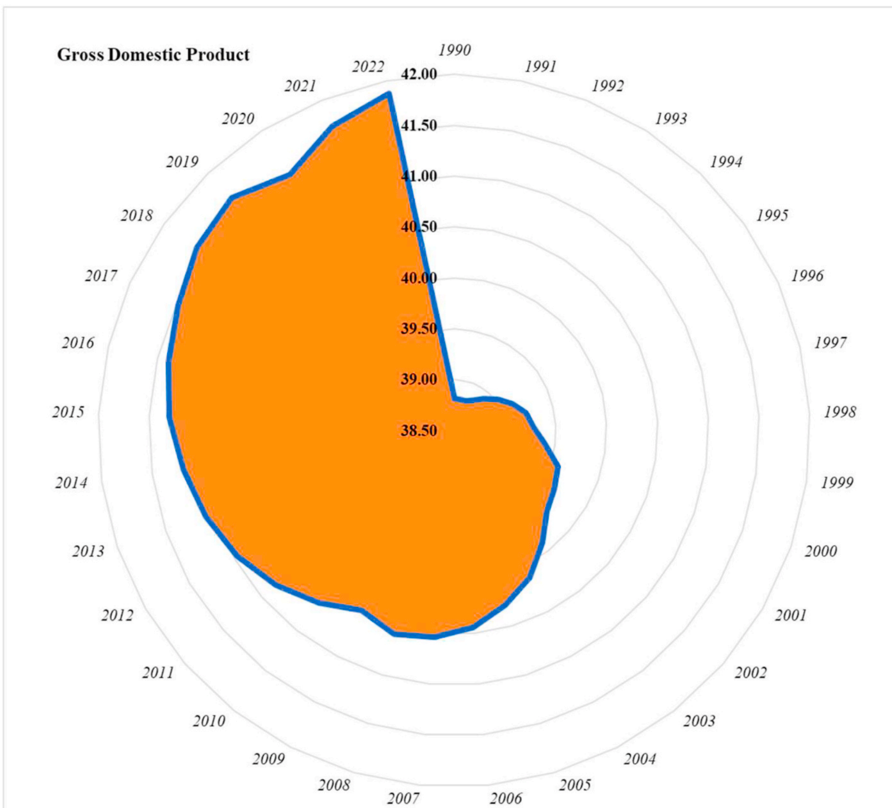

Fig. 1. Radar plot for GDP for resources-rich countries over the period 1990–2022.

Table 2
Findings of the CSD test.

Variables	Model 1		Model 2		Model 3		Model 4	
	Breusch-Pagan LM	Pesaran CD	Breusch-Pagan LM	Pesaran CD	Breusch-Pagan LM	Pesaran CD	Breusch-Pagan LM	Pesaran CD
GDP	412.517***	1.019	417.646***	0.641	388.463***	0.450	482.031***	5.039***
FD	664.986***	−1.415	644.727***	−1.379	613.203***	−1.167	723.364***	−0.113
TECH	359.002***	−3.268***	357.790***	−3.227***	284.938***	−3.249***	387.988***	−1.108
FTECH	591.488***	4.724***	595.157***	4.909***	594.332***	4.727***	480.071***	5.199***
ET	328.225***	−2.356**	331.388***	−2.426**	335.286***	−2.350**	302.733***	9.870***
URB	262.148***	6.973***	264.936***	7.117***	251.358***	6.028***	386.900***	13.586***
COAL	343.876***	11.555***	351.599***	8.619***	321.016***	7.544***	309.713***	7.516***
OIL			243.787***	7.712***	259.768***	8.049***	314.598***	6.332***
MIN					197.223***	7.341***	160.103***	5.329***
FOR							348.504***	4.191***

Notes: ** and *** denote the significance at 5% level and 1% level, respectively.

Table 3
Findings of the slope heterogeneity test.

Statistics	Model 1		Model 2		Model 3		Model 4	
	T-value	Prob.	T-value	Prob.	T-value	Prob.	T-value	Prob.
Tilde (Delta)	7.549***	0.000	7.540***	0.000	6.924***	0.000	6.457***	0.000
Adjusted tilde (Delta)	8.904***	0.000	9.093***	0.000	8.547***	0.000	8.167***	0.000

Notes: *** denotes the significant level at 1%.

In a recent investigation conducted by Tok and Heng (2022), the adoption of financial technology has proven effective in reducing the digital accessibility divide among rural and socioeconomically diverse groups, with the exception of the gender gap. Nonetheless, the integration of social norms and sociocultural factors to complement technological advancements in banking services products presents a persistent challenge (Tok and Heng, 2022). Despite this challenge, Khera et al. (2022) found that increased gender diversity correlates with enhanced performance in FinTech companies. Looking ahead, central banks have initiated several pilot initiatives on Central Bank Digital Currencies (CBDCs) to explore the strategy, consequences, and implementation of CBDC in potentially enhancing efficiency, introducing new services, and addressing wealth disparities between rich and poor groups, notwithstanding reputational and cybersecurity risks (Daud, 2023; Rehman et al., 2023b).

Natural resources serve as the material foundation for economic and societal development.[4] Nonetheless, ensuring sustainability in the use of mineral resources becomes crucial to maintaining balance in the world's ecosystem. Simultaneously, policymakers have focused on the management of natural resources. Enhancing the efficiency of natural resource[5] utilization can be achieved through the adoption of eco-innovation technologies (Diaz-Rainey and Ashton, 2015). Financial development retains promising natural resources management and its implications (Khan et al., 2022). While past studies have underscored the value of financial development in relation to natural resource rents (Tan et al., 2023). Consequently, it is crucial to investigate the role of FinTech advancement in the management of mineral resources.

Natural resources are pivotal for the economy, particularly in the perspective of developing nations. These countries prioritize the optimal consumption of natural resources to enhance their economic growth (Ahmad et al., 2020). Additionally, it is asserted that natural resources serve as the foundational materials upon which all living organisms rely,[6] acting as the primary driving force for contemporary production. In the economic context, natural resources can contribute to promoting economic development. As large quantities of natural resources are consumed in the pursuit of GDP and social development, a positive connection between resource consumption and economic growth is termed a "resource blessing." Conversely, if there is an inverse association between growth and resources, it is referred to as a "resource curse" (Van der Ploeg, 2011; Yasmeen et al., 2021). Among the countries abundant in resources, the top 10 nations are rich in oil, gas, coal, minerals, and other rare metals. These economies, over the past three decades, have demonstrated a varied pattern in terms of natural resource rents (NRR) as a percentage of gross domestic product (GDP).

The present investigation seeks to examine the evolving factors influencing sustainable economic growth, intending to make various potential contributions to the field from multiple perspectives. *First,* this study probes the impact of a significant obstacle in infrastructure—financial technology—on the promotion of economic development. I build upon current literature that underscores the potential combination of finance and technology to overcome hurdles in the development system. For instance, Daud (2023) suggested that, despite noticeable variations at the country level, encompassing differences in regulation, culture, infrastructure, financial literacy, and technology play a crucial role in advancing economic growth. This research delves into the connection between financial development and technology within a macroeconomic framework, drawing on the principles of resource blessing theory. *Second,* the emphasis is placed on supportive relationships, such as the presence of a FinTech that facilitates mineral management to escalate inclusive economic growth. Moreover, by utilizing resource-rich countries' data, this study aims to pinpoint the pivotal role financial technology plays in augmenting economic growth.

Third, the dynamic impact of financial development, FinTech, energy transition and minerals management (coal, oil, minerals, and forests) are inspected using the cross-sectional autoregressive distributive lag (CS-ARDL) statistical approach to estimate the short- and long-run impact of explanatory variables. This sophisticated methodology is effective in addressing endogeneity, cross-section dependence (CSD), non-stationarity concerns and heterogeneous slope coefficients within the series (Irfan et al., 2023). In addition to the dynamic technique, a novel panel Granger Non-causality technique, introduced by Juodis et al. (2021), is employed to investigate the bidirectional relationship among the study variables, ensuring robustness. This method is adept at capturing causality in both panels, whether they involve heterogeneous or homogeneous records, and it can effectively address endogeneity matters by considering multiple variables. *Last*, to the best of my knowledge, this is the first study to capture the dynamic connection of financial development, technology, FinTech, energy transition, urbanization, and minerals management (coal, oil, minerals, and forests) with economic growth in natural resources abundance countries considering the resources blessing/curse theories. The purpose of this unique research is to draw potential policy recommendations for the stakeholders of the pertinent countries to consider while making decisions. Following these research contributions, the current analysis works on the following questions.

- *Can FinTech contribute positively to economic development in economies abundant in resources?*
- *Is there any role of minerals management in boosting sustainable economic growth to meet the current climate challenges?*
- *How does FinTech convert the curse into a blessing in resource-rich countries?*

The remainder of this research is ordered as follows: Section 2 examines and presents pertinent literature on FinTech, minerals management and GDP. Section 3 outlines the data and methodology applied in this article. Section 4 illustrates the empirical evaluation of the impacts of FinTech and minerals management on economic growth in resource-rich nations. Lastly, Section 5 specifies the conclusion along with essential policy implications.

[4] The combination of a growing population and rapid industrialization has led to an increasing demand for natural resources, necessitating their extensive utilization.

[5] Emphasizing the role of the financial services in supporting economic development and prosperity, it plays a vital role in mobilizing resources to initiate economic opportunities (Ullah et al., 2022).

[6] The survival of humanity is deemed impossible without minerals resources, including gas, oil, coal, minerals, soil, water, forests, and others (Haseeb et al., 2021).

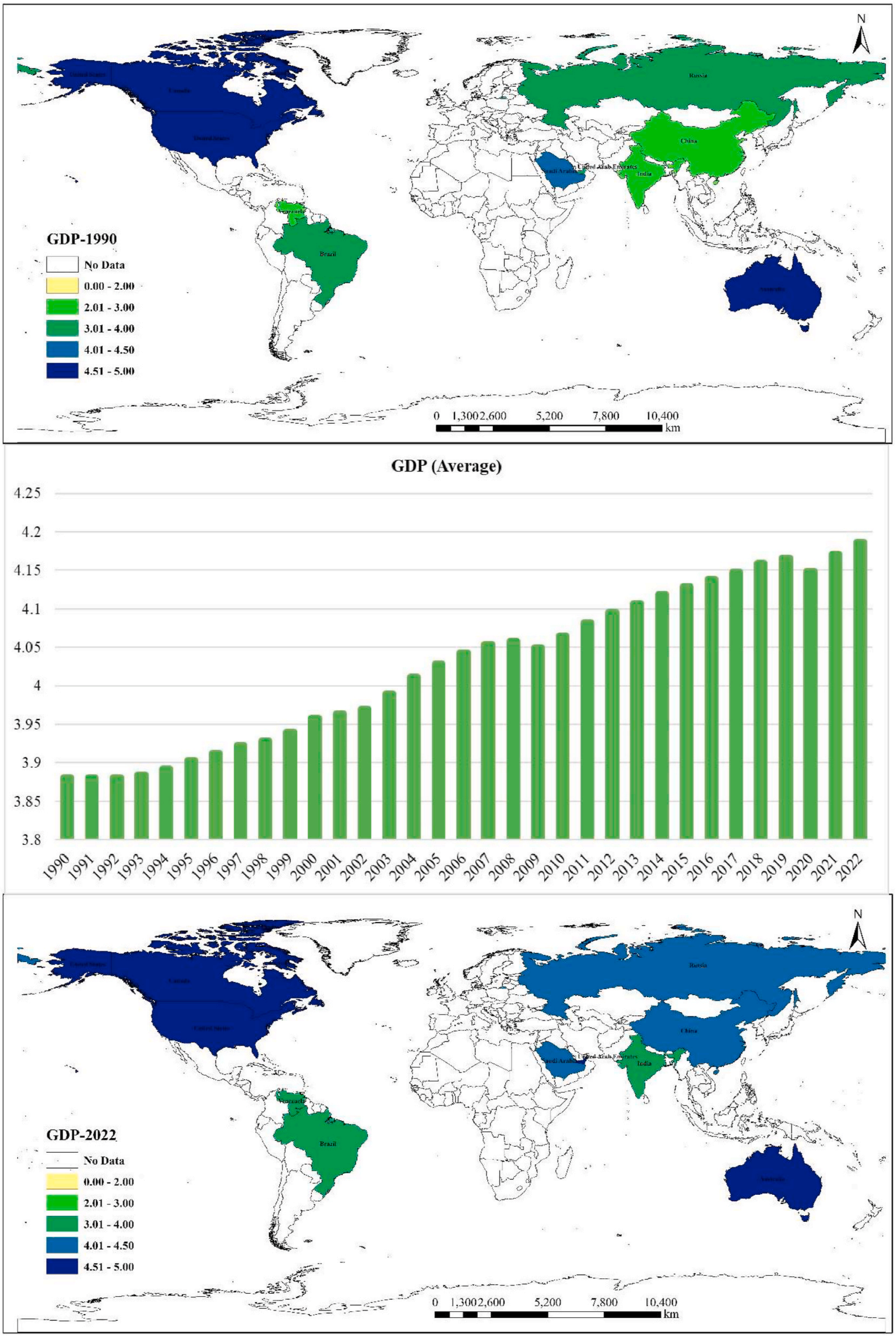

Fig. 2a. Distributions of GDP in resource-rich countries in 1990 and 2022, whereas no data is available for countries outside the sample.

2. Literature review and theoretical framework

2.1. Literature review

According to the Solow model, advancements in technology are the sole explanation for the improvement in living standards. Recent growth models, such as those also highlighted by Mentsiev et al. (2020), emphasize technical progress as a pivotal factor in economic growth. Opposite to the Solow growth model, which treats technological innovation as exogenous, a novel growth model that views technological innovation as endogenous has emerged. Moreover, it is asserted that the pace of modern technological advancements not only influences

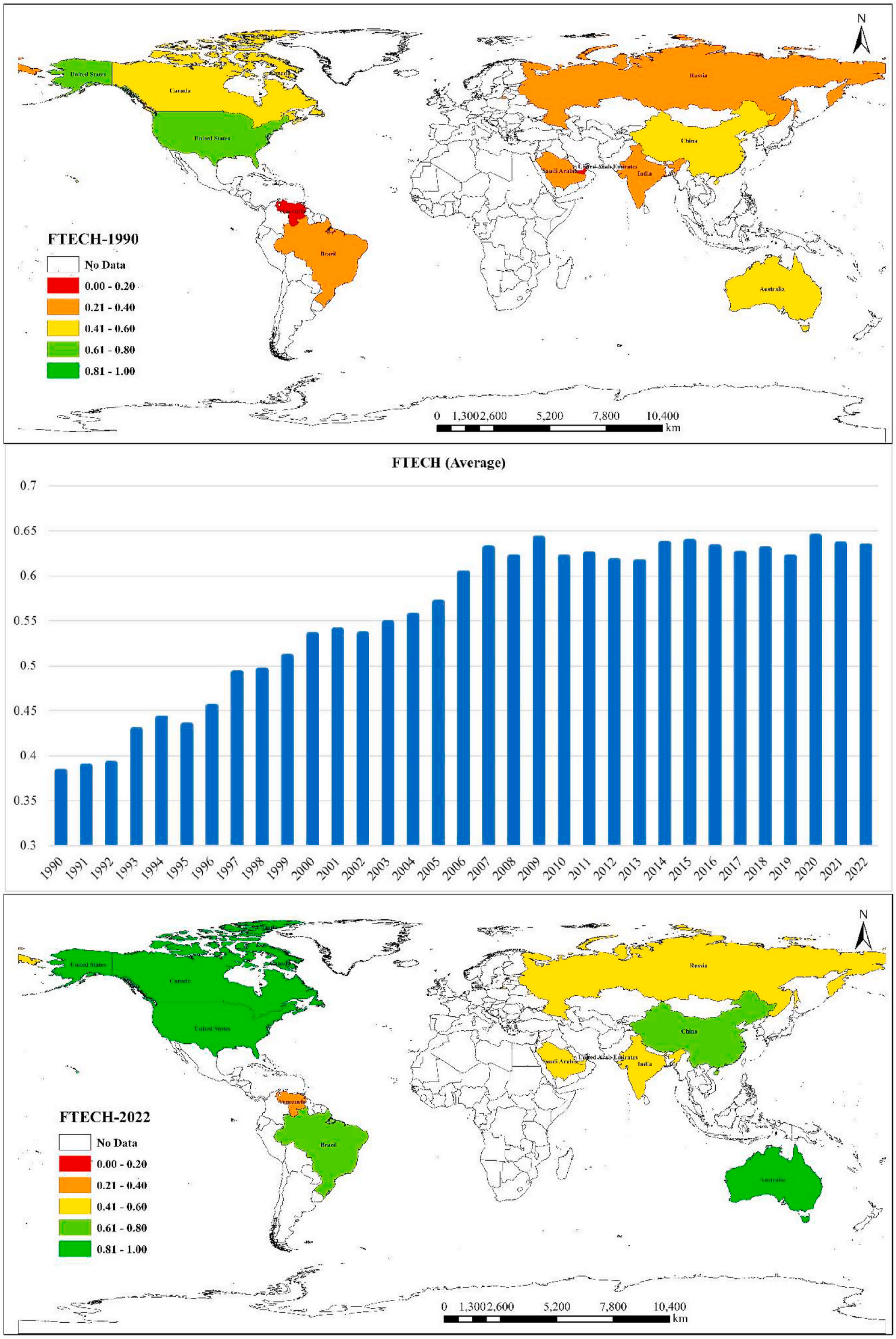

Fig. 2b. Distributions of FTECH in resource-rich countries in 1990 and 2022, whereas no data is available for countries outside the sample.

Table 4
Findings of the non-stationary test.

Variables	IPS		ADF		CIPS		CADF	
	I(0)	I(I)	I(0)	I(I)	I(0)	I(I)	I(0)	I(I)
GDP	0.411	−6.580***	0.465	−7.192***	−1.629	−3.630***	−2.654***	−3.413***
	(0.660)	*(0.000)*	*(0.679)*	*(0.000)*			*(0.004)*	*(0.000)*
FD	0.287	−8.200***	0.240	−8.975***	−1.724	−5.534***	0.529	−6.137***
	(0.613)	*(0.000)*	*(0.595)*	*(0.000)*			*(0.701)*	*(0.000)*
TECH	0.844	−10.433***	0.733	−11.188***	−2.307*	−5.923***	−0.286	−8.110***
	(0.801)	*(0.000)*	*(0.768)*	*(0.000)*			(0.387)	*(0.000)*
FTECH	−1.975**	−9.419***	−2.072**	−10.154***	−2.152	−5.384***	−1.269	−8.117***
	(0.024)	*(0.000)*	*(0.019)*	*(0.000)*			*(0.102)*	*(0.000)*
ET	1.145	−18.108***	0.762	−1.980**	−3.586***	−1.579	−5.478***	0.362
	(0.874)	*(0.000)*	*(0.777)*	*(0.024)*			*(0.000)*	*(0.641)*
URB	0.445	−9.160***	0.449	−9.732***	−1.860	−4.950***	0.400	−7.298***
	(0.672)	*(0.000)*	*(0.673)*	*(0.000)*			*(0.655)*	*(0.000)*
COAL	−2.343**	−16.506***	−1.507*	−14.328***	−1.539	−3.706***	1.174	−5.104***
	(0.010)	*(0.000)*	*(0.066)*	*(0.000)*			*(0.880)*	*(0.000)*
OIL	−2.381***	−13.822***	−2.572***	−14.502***	−2.865***	−5.838***	−0.775	−8.414***
	(0.009)	*(0.000)*	*(0.005)*	*(0.000)*			*(0.219)*	*(0.000)*
MIN	−1.082	−11.739***	−1.142	−12.487***	−2.213*	−5.757***	1.860	−6.520***
	(0.140)	*(0.000)*	*(0.127)*	*(0.000)*			*(0.969)*	*(0.000)*
FOR	−1.725**	−10.489***	−1.841**	−11.232***	−2.754***	−5.331***	−2.578***	−6.219***
	(0.042)	*(0.000)*	*(0.033)*	*(0.000)*			*(0.005)*	*(0.000)*

Notes: * and ** refer to the significance at a 10% level and 5% level, respectively, whereas *** claims at a 1% significance level. In parathesis, p-values are shown.

Table 5
Findings of the first generation cointegration test.

Estimates	Model 1		Model 2		Model 3		Model 4	
	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
Pedroni Co-integration Test								
Phillips-Perron t	2.470***	0.007	3.229***	0.001	−2.533***	0.006	−6.322***	0.000
Phillips-Perron t (Modified)	2.788***	0.003	3.725***	0.000	3.608***	0.000	3.649***	0.000
Dickey-Fuller t (Augmented)	0.837	0.201	1.421*	0.078	−0.115	0.454	−0.300	0.382
Westerlund Co-integration Test								
Ratio (variance)	1.838**	0.033	0.553	0.290	4.429***	0.000	2.272**	0.012
Kao Co-integration Test								
Dickey-Fuller t	1.364*	0.086	1.953**	0.025	1.659**	0.049	1.297*	0.097
Dickey-Fuller t (Modified)	1.644*	0.050	1.765**	0.039	0.630	0.265	−1.652**	0.049
Dickey-Fuller t (Augmented)	0.668	0.252	−0.127	0.450	−0.081	0.468	−0.553	0.290
Unadjusted Dickey-Fuller t	2.060**	0.020	1.474*	0.070	1.974**	0.024	1.288*	0.099
Unadjusted Dickey-Fuller t (Modified)	2.134**	0.016	1.903**	0.029	1.872**	0.031	0.327	0.372

Notes: * and ** denote significance at the 10% and 5% levels, respectively, while *** signifies significance at the 1% level.

economic development and expansion but also has repercussions on outcomes. Over the past three decades, with the significant global advancement of technology, scholars and economists have focused on analyzing the impact of digitalization on outcomes (Aleksandrova et al., 2022). In alignment with the literature on technology, it is acknowledged that technology[7] plays a crucial role in promoting economic development in both advanced and emerging nations (Fareed et al., 2022). Developed countries tend to derive greater economic benefits from investments in technological innovation compared to emerging nations. Notably, in OECD countries, the use of the Internet is associated with promoting trade openness and financial development (Habibi and Zabardast, 2020; Hung, 2023).

In recent times, the financial sector has experienced a profound integration of advanced digital technologies, offering technical support and opening avenues for innovation (Muhammad et al., 2022) in financial supply-side reform. This intersection of the financial and digital industries has given rise to the rapid development of FinTech. FinTech,[8] as defined by Molla and Biru (2023) and Yang and Wang (2022), involves the communication technologies and utilization of modern information to create innovative financial solutions. The global impact of the COVID-19 pandemic has further enhanced the widespread adoption of FinTech services like online transfers and mobile payments. Importantly, the benefits derived from FinTech are not contingent on physical business outlets (Fan et al., 2023).

Hence, FinTech has the potential to reach rural and remote areas where conventional financial infrastructure may still be underdeveloped. In such regions, individuals can conduct various financial transactions, including payments and remittances, through computers or mobile phones. Consequently, FinTech opens avenues for people to access financial services (Yang and Zhang, 2022). Additionally, individuals lacking substantial collateral can secure financing through FinTech platforms.[9] Moreover,

[7] The progression of technology contributes to economic growth by meeting the demand for digital products, computers, and software while simultaneously enhancing investment and productivity in high-tech industries. The declining relative pricing of high-tech tools in affluent countries may outpace that of underdeveloped countries due to the potential for learning economies from increased investment in high-tech sectors.

[8] Its applications span a range of financial services, including transfers, payment systems, credit, savings, insurance, and wealth management employing mobile payment, electronic money, investment management, crowdfunding, and other related businesses (Sanchez, 2022).

[9] Leveraging artificial intelligence algorithms, these platforms swiftly analyze the applicant's credit information to make financing decisions. This mechanism small to medium-sized entrepreneurs and enables families with favorable credit histories to secure financing.

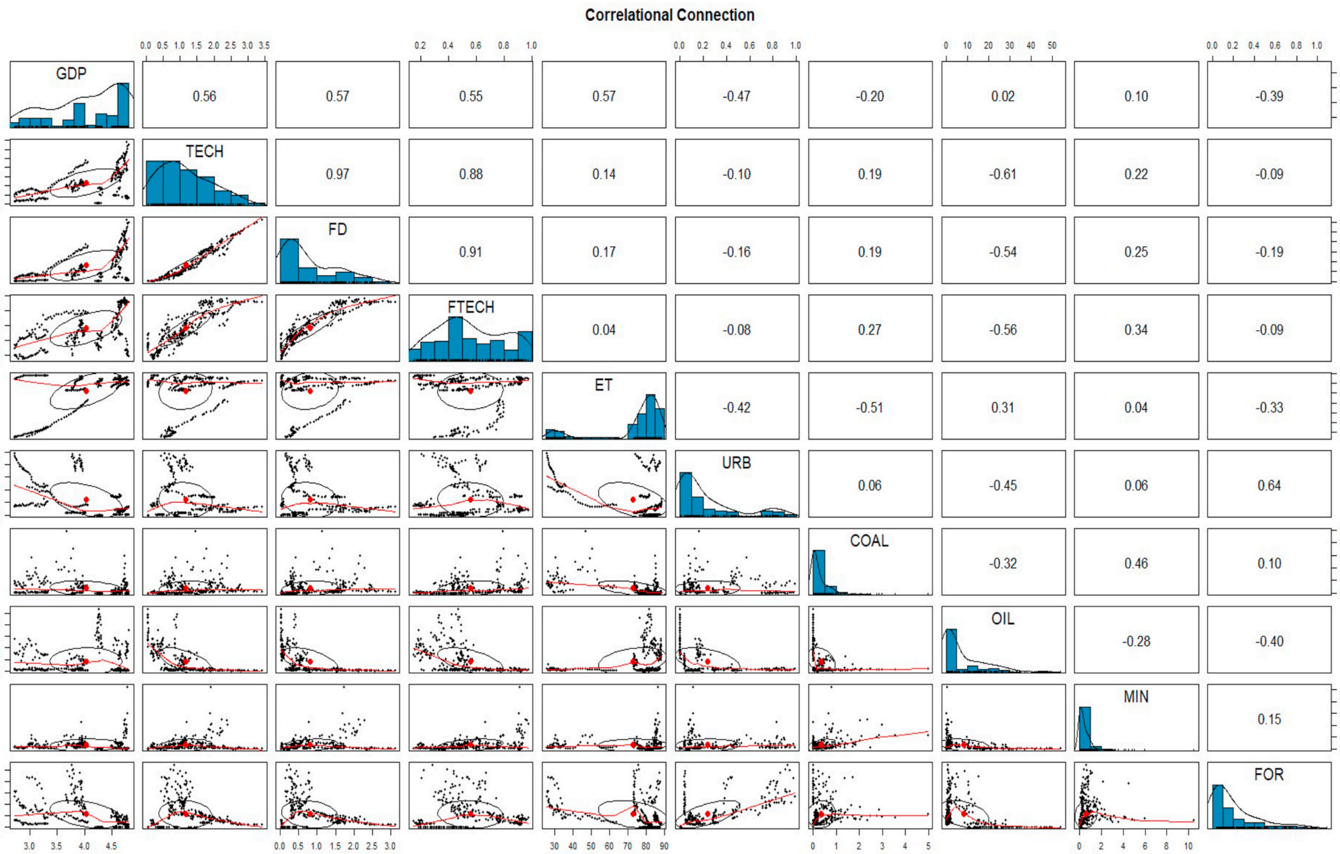

Fig. 3. Correlational plots for all the study variables of resource-rich countries.

Table 6
Findings of the 2nd generation cointegration test.

Estimates	Gt	Ga	Pt	Pa
Model 1				
Value	−3.995	−0.611	−4.130	−15.835
Z-value	−4.293	4.610	1.806	−8.841
Prob.	0.000	1.000	0.965	0.000
Robust Prob.	0.000	1.000	0.200	0.000
Model 2				
Value	−9.310	−8.780	−1.164	−2.862
Z-value	1.259	−2.858	3.223	−0.716
Prob.	0.896	0.002	0.999	0.237
Robust Prob.	0.000	0.000	0.400	0.000
Model 3				
Value	−2.653	−2.792	−3.363	−7.945
Z-value	−0.020	−0.485	3.831	−0.408
Prob.	0.492	0.314	1.000	0.342
Robust Prob.	0.000	0.000	0.900	0.000
Model 4				
Value	−2.600	−3.014	−2.115	−7.684
Z-value	3.307	−1.884	4.934	−0.822
Prob.	1.000	0.030	1.000	0.206
Robust Prob.	0.000	0.000	0.600	0.000

these groups can use funds obtained from FinTech platforms for activities such as family member education or venture investments (Karim et al., 2022). These endeavors are closely associated with the concept of inclusive economic growth (Fan et al., 2023).

The World Trade Organization defines natural resources as useable for consumption and production either with minimal or in their raw state processing (Bayramov, 2018). Economic development has led to rapid global urbanization and industrialization, consequently escalating the demand for natural resources, and posing significant environmental challenges (Hassan et al., 2019; Jahanger et al., 2022; Mahmood et al., 2023a; Rafei et al., 2022). The employment of mineral resources has become a central focus for the international society, particularly in developing countries (Hailu and Kipgen, 2017; Mahmood et al., 2023b). Natural resources hold great importance for GDP, but there is no unanimous consensus among scholars on this matter, with existing research presenting mixed results. For instance, Haseeb et al. (2021) explored this by utilizing panel data from Asian countries that revealed varied outcomes. In the context of India, the relationship between NRR and GDP was found to be inverse, supporting the resource curse hypothesis. However, for other Asian countries included in the panel, the association between NRR and GDP was positive, indicating the potential blessing of resources. Similarly, Zallé (2019) utilized African data, focusing on 29 economies from 2000 to 2015, and identified the existence of the resource curse.

Moreover, Erum & Hussain (2019) discovered the connection between per capita GDP and natural resources, incorporating corruption's role in this association. Utilizing data from Organisation of Islamic Cooperation (OIC) countries spanning 1984 to 2016, their study applied the CS-ARDL statistical technique for empirical analysis. The overall assessment revealed a positive connection between GDP and natural resources. However, upon categorizing nations into two distinct groups—one with low and the other with high technology diffusion—they observed that, in nations with low technology diffusion, natural resources exhibited an inverse link with GDP. Conversely, in countries with high technology diffusion, the connection between NRR and economic development seems to be positive. This study highlights that various factors can affect the relationship between NRR and GDP. In another investigation, Gerelmaa and Kotani (2016) utilized data for the period 1970–2010 to examine the role of NRR in the economic development of countries. Their findings indicated a negative link between GDP and NRR in the initial years (1970–1990), aligning with the resource curse hypothesis during that period. However, the results

Table 7
Findings of the cross-sectional ARDL test.

Variables	Model 1		Model 2		Model 3		Model 4	
	Coef.	St. Errors	Coef.	St. Errors	Coef.	St. Errors	Coef.	St. Errors
	Long Run Estimates							
FD	0.595*** (0.000)	0.141	0.697*** (0.000)	0.140	0.698*** (0.000)	0.140	0.866*** (0.000)	0.150
TECH	0.479*** (0.000)	0.114	0.686*** (0.000)	0.121	0.681*** (0.000)	0.123	0.798*** (0.000)	0.128
FTECH	1.910*** (0.000)	0.221	1.976*** (0.000)	0.215	1.990*** (0.000)	0.224	2.065*** (0.000)	0.223
ET	0.013*** (0.000)	0.001	0.012*** (0.000)	0.001	0.012*** (0.000)	0.002	0.012*** (0.000)	0.002
URB	−0.710*** (0.000)	0.084	−0.483*** (0.000)	0.097	−0.481*** (0.000)	0.098	−0.357*** (0.001)	0.106
COAL	−0.158*** (0.000)	0.042	−0.136*** (0.000)	0.042	−0.130*** (0.009)	0.049	−0.138*** (0.005)	0.049
OIL			0.013*** (0.000)	0.003	0.013*** (0.000)	0.003	0.011*** (0.000)	0.003
MIN					0.628 (0.804)	2.535	0.653 (0.798)	2.544
FOREST							0.348*** (0.004)	0.119
F-Stat	121.87		112.68		98.32		90.38	
p-value	0.000		0.000		0.000		0.000	
N	310		310		310		310	

Variables	Model 1		Model 2		Model 3		Model 4	
	Coef.	St. Errors	Coef.	St. Errors	Coef.	St. Errors	Coef.	St. Errors
	Short Run Estimates							
FD	0.852*** (0.000)	0.154	0.824*** (0.000)	0.152	0.863*** (0.000)	0.149	0.766*** (0.000)	0.161
TECH	0.669*** (0.000)	0.123	0.651*** (0.000)	0.121	0.792*** (0.000)	0.125	0.896*** (0.000)	0.138
FTECH	1.973*** (0.000)	0.222	2.053*** (0.000)	0.220	2.079*** (0.000)	0.216	1.700*** (0.000)	0.235
ET	0.016*** (0.000)	0.001	0.013*** (0.000)	0.001	0.012*** (0.000)	0.001	−1.045*** (0.000)	0.097
URB	−0.442*** (0.000)	0.099	−0.506*** (0.000)	0.099	−0.356*** (0.001)	0.106	−0.522*** (0.000)	0.112
COAL	−0.462*** (0.000)	0.119	−0.434*** (0.000)	0.117	−0.343*** (0.004)	0.117	−0.368*** (0.000)	0.041
OIL			−0.147*** (0.000)	0.042	0.011*** (0.000)	0.003	0.017*** (0.000)	0.003
MIN					1.309*** (0.002)	0.412	0.936*** (0.000)	0.245
FOREST							0.372*** (0.000)	0.129
F-Stat	122.60		110.57		101.96		80.95	
p-value	0.000		0.000		0.000		0.000	
N	310		310		310		310	

Notes: *** denotes the significant levels at 1%, whereas p-values are shown in parathesis.

showed a positive relationship between NRR and economic growth, suggesting a transformation from a resource curse to a resource blessing. The general evaluation of the current studies presents mixed findings regarding the relationship between NRR to measure economic growth, emphasizing the need for new empirical evidence.

2.2. Theoretical framework

The conceptual framework guiding this study is rooted in the resource blessing theory (RBT). As per the findings of the RBT, nations abundant in resources typically exhibit better development rates compared to those with fewer mineral resources. This phenomenon is attributed to various factors, including the support of mineral resources exports in the economy. Such dominance often leads to increased diversification[10], driven by rent-seeking, collaboration, and better institutional structures (Zheng et al., 2023). Similarly, FinTech posits that the extraction of mineral resources can result in an appreciation of the exchange rate, subsequently escalating the competitiveness of other sectors like manufacturing and agriculture. For instance, the discovery of oil can lead to upturns in certain industries. To further elaborate on these effects, suggested policies include currency expansion, investments in mineral resource sectors, and prudent fiscal management, aiming to enhance the positive impacts of NRR on the overall economy. This study investigates the impact of FinTech on managing mineral resources on growth output in resource-rich economies by employing various econometric methods, including dynamic panel (CS-ARDL) and Granger Non-causality analysis. To conduct a thorough examination of the factors influencing GDP in these countries, I incorporated financial development, technology, energy transition and urbanization along with minerals including coal, oil, minerals, and forests as independent variables. The objective of the study is to contribute to the existing body of research on whether FinTech helps mineral management achieve the inclusive goal of economic growth, considering the resource curse hypothesis in resource-rich countries.

3. Data and methodology

3.1. Data

This study probes the dynamic association between financial development, technology, FinTech, energy transition, urbanization, and minerals management (coal, oil, minerals, and forests) with economic growth in the top 10 natural resources-rich countries[11] for the years 1990–2022. Among the countries abundant in resources, these nations are rich in oil, gas, coal, minerals, and other rare metals. Over the past three decades, these economies have demonstrated a varied pattern in terms of NRR as a percentage of GDP. This section of the research exposes the study variables' nature and their potential connection with economic growth. Economic growth (GDP) (current GDP amount in US dollars) is retrieved from the World Development Indicators (WDI). GDP is transformed into logarithmic form to present better conclusions. The data on the financial development (FD) (Irfan et al., 2022) (FD incorporates efficiency, access, and depth of financial institutions and markets, expected direction $\frac{\Phi GDP}{\Phi FD} < 0$) and technology (Fareed et al., 2022) (research and development expenditure, expected direction $\frac{\Phi GDP}{\Phi TECH} < 0$) are collected from International Monitoring Fund (IMF) and WDI,

[10] According to this perspective, the favorable effects of an excess of mineral resources can be encouraged by implementing policies that promote enhanced governance, economic diversification, increased investments in human capital and transparency.

[11] It includes Australia, Brazil, China, Canada, Russia, Saudi Arabia, India, UEA, USA and Venezuela.

Table 8
Findings of Granger Non-causality test.

Null Hypothesis	HPJ Wald-Stat	HPJ p-value	BIC	Coef.	Stand. Errors	p-value
FD is not Granger-caused by GDP	12.404***	0.002	−1519.132	0.710***	0.271	0.009
GDP is not Granger-caused by FD	42.170***	0.000	−1737.276	0.040***	0.013	0.003
TECH is not Granger-caused by GDP	72.917***	0.000	−1246.241	1.100***	0.396	0.005
GDP does not Granger-cause TECH	34.241***	0.000	−1909.494	0.216**	0.102	0.033
FTECH is not Granger-caused by GDP	25.375***	0.000	−1992.504	0.546***	0.109	0.000
GDP does not Granger-cause FTECH	25.217***	0.000	−1949.013	0.780***	0.287	0.007
ET is not Granger-caused by GDP	62.461***	0.000	−1453.051	0.830***	0.105	0.000
GDP is not Granger-caused by ET	14.554***	0.000	−2436.741	−0.208**	0.084	0.013
URB is not Granger-caused by GDP	6.032	0.110	−2204.842	0.155**	0.065	0.017
GDP is not Granger-caused by URB	1.934	0.164	−2502.865	−0.041	0.030	0.164
COAL is not Granger-caused by GDP	2.970	0.227	−2404.092	−0.002	0.002	0.278
GDP is not Granger-caused by COAL	3.220	0.200	−2406.125	−0.048*	0.027	0.078
OIL is not Granger-caused by GDP	3.932**	0.047	651.804	−2.823**	1.424	0.047
GDP is not Granger-caused by OIL	66.409***	0.000	−2090.275	0.105***	0.003	0.003
MIN is not Granger-caused by GDP	56.478***	0.000	−358.577	1.710***	0.228	0.000
GDP is not Granger-caused by MIN	47.171***	0.000	−2490.525	0.101***	0.015	0.000
FOR is not Granger-caused by GDP	16.324***	0.000	−1692.823	−0.156***	0.039	0.000
GDP is not Granger-caused by FOR	16.734***	0.000	−2486.893	0.038***	0.009	0.000

Notes: * and ** denote significance at the 10% and 5% levels, respectively, while *** signifies significance at the 1% level.

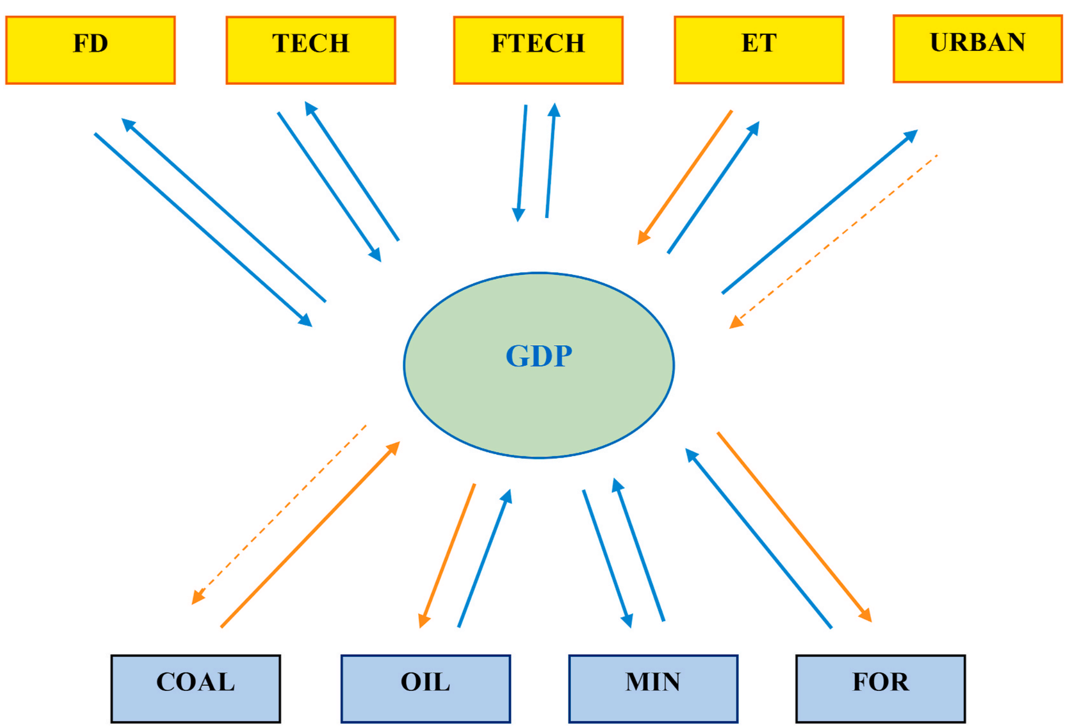

Fig. 4. The Orange (Blue) color illustrates the negative (positive) direction of Granger Non-causality, respectively. Solid indicates a significant connection, whereas dotted lines illustrate an insignificant connection between the study variables.

respectively. The IMF's FD data[12] ranges from 0 to 1. Further, financial technology (FTECH) (Aleksandrova et al., 2022) (FTECH is a merged variable by combining financial development and technology, expected direction $\frac{\Phi GDP}{\Phi FTECH} < 0$) and energy transition (Irfan et al., 2023) (ET) (ET is the ratio of renewable to non-renewable energy, expected direction $\frac{\Phi GDP}{\Phi ET} < 0$) are author's own estimated indices. The data on urbanization (URB) (Irfan et al., 2022) (urban population of the countries, expected direction $\frac{\Phi GDP}{\Phi URB} > 0$), coal (COAL) (coal rents as % of GDP, expected direction $\frac{\Phi GDP}{\Phi COAL} > 0$), oil (OIL) (oil rents as % of GDP, expected direction $\frac{\Phi GDP}{\Phi OIL} < 0$), minerals (MIN) (Haseeb et al., 2021) (mineral rents as % of GDP, expected direction $\frac{\Phi GDP}{\Phi MIN} < 0$) and forests (FOR) (forests rents as % of GDP, expected direction $\frac{\Phi GDP}{\Phi FOR} < 0$) are aggrandized from WDI. The model[13] of this research is offered below.

$$GDP_{it} = \Phi_O + \Phi_1 FD_{it} + \Phi_2 TECH_{it} + \Phi_3 FTECH_{it} + \Phi_4 ET_{it} + \Phi_5 URB_{it} + \Phi_6 COAL_{it} + \Phi_7 OIL_{it} + \Phi_8 MIN_{it} + \Phi_9 FOR_{it} + \varepsilon_{it} \quad (3.1)$$

[12] This dataset offers a comprehensive assessment and a wider scope of financial sector advancement, employing eight distinct indicators.

[13] To scrutinize the short- and long-run results, this research utilizes a CS-ARDL method as outlined by (Chudik and Pesaran, 2015).

Φ_O shows the slope, Φ_1 to Φ_9 are coefficients of independent variables, whilst ε_{it} claims the residuals. t denotes the cross-sections (10 resource-rich countries), whilst i represents the period (from 1990 to 2022).

3.2. Econometric modeling

3.2.1. CSD and SH tests

This research conducts slope heterogeneity (SH) and cross-sectional dependence (CSD) coefficient tests for all the considered variables. Conventional statistical techniques have overlooked these fundamental initial tests,[14] and their omission could result in unreliable estimates (Rehman et al., 2023a; Ulucak and Khan, 2020). The comprehensive formula for this test is presented as follows:

$$\Delta_{SH} = (X)^{\frac{1}{2}}(2h)^{-\frac{1}{2}} + \left(\frac{1}{X}P - h\right) \tag{3.2}$$

$$\Delta_{ASH} = (X)^{\frac{1}{2}}\left(\frac{2h(T-h-1)}{T+1}\right)^{-\frac{1}{2}} + \left(\frac{1}{X}P - 2h\right) \tag{3.3}$$

here, Δ_{SH} and Δ_{ASH} indicate the homogeneity of slope coefficients in delta SH and delta SH (adjusted), respectively.

3.2.2. Unit root test

In this study, both first-generation, namely IPS (Im et al., 2003) and ADF, and second-generation CIPS (Pesaran, 2007) and CADF (Pesaran, 2003) have been applied. The general method for the non-stationarity test is presented as follows:

$$\Delta Y_{it} = \rho_i + \rho_i Y_{it-1} + \rho_i \bar{A}_{t-1} + \sum_{h=0}^{u} \rho_{ih}\Delta\overline{Y}_{t-1} + \sum_{h=1}^{u} \rho_{ih}\Delta Y_{it-h} + \varepsilon_{it} \tag{3.4}$$

Consequently, the statistical outcomes of the CIPS unit root test are presented here:

$$CIPS = 1 \Big/ X \sum_{i=1}^{u} CADF_i \tag{3.5}$$

in equation (3.5), cross-sectional ADF is represented by CADF as reported in equation (3.4), where H_0 denotes the unit root of the data.

3.2.3. Cointegration test

To analyze the long-term cointegration among the variables under investigation, this research utilized both 1st generation, specifically, Pedroni (2004) and Kao (1999), and 2nd generation approaches, such as the Westerlund bootstrap (Westerlund, 2007). The general structure of the cointegration test is expressed bellow:

$$P_t = \rho / SE(\rho) \tag{3.6}$$

$$P_a = t(\rho) \tag{3.7}$$

$$G_t = 1 \Big/ X \sum_{i-1}^{v} \frac{\rho_i}{SE(\rho_i)} \tag{3.8}$$

$$G_a = 1 \Big/ X \sum_{i-1}^{v} \frac{T\rho_i}{\rho_i(1)} \tag{3.9}$$

Equations (3.6) and (3.7) for P_t and P_a investigate the panel means, whilst equations (3.8) and (3.9) for G_t and G_a depict group means statistics, with the null hypothesis (H_0) indicating no cointegration.

[14] Notably, when confronted with heterogeneity, the SH test proves effective in addressing assumptions related to homogeneous coefficients (Baltagi and Pesaran, 2007).

3.2.4. CS-ARDL modeling

Furthermore, in pursuit of this research goal, the researcher employs CS-ARDL for both short- and long-run estimations (Chudik and Pesaran, 2015). This method proves to be more resilient to challenges such as endogeneity, SH coefficients, CSD, non-stationarity and unobserved common factors (Danish, 2019; Rehman et al., 2023b) when compared to traditional panel estimations. The general structure of CS-ARDL is outlined as below:

$$\mathrm{GDP}_{it} = \alpha_0 + \sum_{r=1}^{u} \lambda_{it}\mathrm{GDP}_{it-r} + \sum_{r=0}^{u} \beta_{it}\mathrm{K}_{t-r} + \sum_{r=0}^{3} \mathrm{X}_{t-r} + \varepsilon_{it} \tag{3.10}$$

here $X_t = (\Delta GDP_{it}, K_{t'})'$ and K_{it}[15] $= (FD_{it}, TECH_{it}, FTECH_{it}, ET_{it}, URB_{it}, COAL_{it}, OIL_{it}, MIN_{it}, FOR_{it})'$.

3.2.5. Robustness test

This research aims to examine the Granger relationship among the specified study variables as detailed below.

$$\mathrm{GDP} = f\ (\mathrm{FD} + \mathrm{TECH} + \mathrm{FTECH} + \mathrm{ET} + \mathrm{URB} + \mathrm{COIL} + \mathrm{OIL} + \mathrm{MIN} + \mathrm{FOR}) \tag{3.11}$$

The model employed in this study necessitates that the study variables exhibit stationarity. Since Granger (1969) introduced the causality approach, it has gained widespread use in the existing studies due to its distinctive framework. Building on this, Dumitrescu and Hurlin (2012) proposed a causality estimation model capable of addressing CSD and SH simultaneously. Nevertheless, traditional bidirectional causality models have failed to consider the "Nickell bias." In addressing this issue, Dhaene and Jochmans (2015) introduced the Half Panel Jackknife (HPJ) approach, effectively mitigating the distortions (size and parametric bias). Addressing this issue, Juodis et al. (2021) established a novel Granger non-causality approach that can adeptly estimate in both heterogeneous and homogeneous panels. Consequently, the methodology of this study is outlined as follows:

$$\mathrm{M}_{it} = \delta_{0i} + \sum_{g=1}^{G} \delta_{gi}\mathrm{M}_{it-g} + \sum_{h=1}^{H} \theta_{hi}\mathrm{N}_{it-h} + \varepsilon_{it} \tag{3.12}$$

here $t = 1, 2, 3, \ldots, T$, $i = 1, 2, 3, \ldots, S$ and $\varepsilon_{it} \sim S\ (0, \sigma^2)$. S and T denote cross-sections (top 10 resources-rich countries) and (1990–2022), respectively. Moreover, δ_{gi} denotes the autoregressive coefficient, δ_{0i} symbolizes individual fixed effects, and θ_{hi} indicates the parameter for feedback coefficient. It is crucial to note that these coefficients exhibit heterogeneity.

Building on the work of Juodis et al. (2021), the "Granger Non--Causality" method brings several advantages. Firstly, it effectively addresses the Nickell bias, distinguishing itself from conventional causality models. Additionally, this technique mitigates issues related to scale distortion and coefficient bias when T is substantial compared to S. As a result; it assesses the relationship among study variables within both homogeneous and heterogeneous panels. Secondly, the Granger non-causality technique demonstrates robustness in handling the transboundary nature of economies, particularly in dealing with CSD, enabling accurate decisions in panel data analysis. Lastly, aiming to enhance both the quality and quantity of data, this technique facilitates more reliable findings, minimizing concerns related to omitted variables (You et al., 2022).

[15] K claims the pool of independent variables including FinTech, energy transition, urbanization, and minerals.

4. Results and discussion

4.1. Preliminary outcomes

Table 1 reports the summary statistics of the study variables, including GDP, financial development, technology, FinTech, energy transition, urbanization, coal, oil, minerals, and forests in the top 10 natural resource-rich countries. The table shows that the mean and SD of the energy transition are higher among other variables, whereas FinTech (FTECH) has a mean of 0.557 units. In the case of natural resources, oil and coal have the highest (8.491) and lowest (0.364) mean values, respectively. Most of the study variables are positively skewed and Leptokurtic. Fig. 1 shows the tendency of the overall GDP from 1990 to 2020 for resource-rich countries. Since 1990, the GDP has gradually increased from 38.5 units to 42 units in the given three decades, asserting that the GDP is constantly expanding.

To explore the CSD between the study variables, CSD tests such as Breusch-Pagan and Pesaran CD are employed in 4 models. The outcomes presented in Table 2 indicate the presence of CSD among the study variables by rejecting the null hypothesis that there is no CSD. This implies interconnectedness among resource-rich economies, illustrating regional connectivity, globalization and global economic spillover effects (Rehman et al., 2023b). Table 3 interprets the findings of the SH, elucidating the H_0 (There is SH among the study series). The test results affirm the presence of heterogeneity among the slope coefficients across cross-sections. Furthermore, this research reports the distributions of the GDP and FinTech for resources-rich economies in 1990 and 2022 in Figs. 2a and b. 6 allocations were allotted to the economies, where bright color illustrates greater. In contrast, light color represents a lower magnitude of the relevant variable. Figs. 2a and b claim the GDP and FinTech distributions are showing a gradually increasing trend. In the given 33 years, as conspicuous in the figure, every resource abundance country has been changed blatantly.

More so, the subsequent step involves assessing stationarity. The author utilized first (IPS and ADF) and second-generation (CIPS and CADF) non-stationarity tests to examine the data's integration properties. The key results of the four-panel non-stationarity tests employed in this study, aimed at investigating the series' integration order, are presented in Table 4. When dealing with SH and CSD, it is advisable to employ second-generation unit root tests such as CIPS and CADF, as suggested by Rehman et al. (2023b). All the variables demonstrate stationarity at the first difference *I(1)*, indicating that they are order one integrated. Given the current scenario, this study employs Kao, Pedroni, and Westerlund cointegration tests, as indicated in Table 5. The outcomes of these tests confirm the existence of long-term relationships among the independent variables with GDP posited in the hypothesis, rejecting the H_0 of no cointegration. Fig. 3 defines the correlational plots for all the study variables. These bidirectional charts illustrate the binary connections among all the variables under examination spanning from 1990 to 2022.

To address the challenges associated with slope heterogeneity and CSD, this study employs the 2nd generation (bootstrap Westerlund) panel cointegration test, as detailed in Table 6. According to the results of the Westerlund test, both group mean statistics (Ga and Gt) and panel mean statistics (Pa and Pt) provide evidence supporting the existence of cointegration by rejecting the H_0 of no cointegration. As a result, the variables in the panel data display significant interconnections. This robust cointegration satisfies two critical conditions: the coefficients are valuable for estimations and the connection is not spurious.

4.2. Panel outcomes

In pursuit of the study's objectives, this research employs the CS-ARDL (Chudik and Pesaran, 2015) methodology to gauge the dynamic interconnections among the variables under investigation. The outcomes in Table 7 report four models in short- and long-run estimations. All four models include minerals management (coal, oil, minerals, and forests) added successively to comprehend the statistical results of the study. Long-run estimates, as claimed in the table, explain the conclusions, which infer that financial development and technology are positively significant to the GDP in resource-rich countries. In the case of FD, short- and long-run coefficients are significant and positive, ranging from 0.595 to 0.866 in the long-run and 0.766 to 0.852 in the short-run. It concludes that economic growth in resource-rich countries depends on financial resources to boost financial access and activities. These conclusions are supported by the current studies (Muhammad et al., 2022). Similarly, technology also discloses the direct relation with economic growth as there is a positive relation between the two variables in both short- and long-run estimations and these results are verified by the current studies (Aleksandrova et al., 2022; Fan et al., 2023). The table further shows that the positive influence of FD and technology is more dominant in such countries. Rapid financial and technological innovation has also changed mineral management, consumption, and efficiency.

Financial technology is positively influencing GDP for resource-rich economies. The coefficients of FinTech claim that in the case of the long-run, 1 unit increase in FinTech improves the GDP by 1.990 and 1.700 units in Model 4 in the long- and short-run, respectively. These outcomes are aligned with the current studies (Aleksandrova et al., 2022). FinTech has developed as a transformative force to escalate economic growth, leveraging cutting-edge technologies such as artificial intelligence, cloud computing, and blockchain mobile apps to enhance traditional financial systems. Its impact extends across various domains, including wealth management, encompassing personal finance, regulatory technologies, insurance, and financial inclusion. Crucial characteristics of FinTech include optimizing operations and efficiency, promoting responsibility and sustainability, and increasing stakeholder engagement. Table 7 explains that energy transition and urbanization have a positive and negative connection with economic growth in resource-rich countries for the period 1990–2022, and these results are confirmed by the current literature (Irfan et al., 2022).

In the case of minerals management in this research, four variables, including coal, oil, minerals, and forests, are employed in four different models to observe the resources blessing theory. It is evident that mineral resources are beneficial to enhance the growth rate in the top resource-rich economies. Table 7 further reports that coal is negatively impacting economic development, whilst oil, minerals and forests are favorable to increasing the GDP. Hence, it is confirmed that minerals management asserts an inclusive advantage to raise economic growth, and these results are confirmed by the current literature (Erum and Hussain, 2019). In the realm of mineral resource management, FinTech contributes significantly by enabling automation and remote monitoring, social impact assessments and conducting environmental monitoring, facilitating crowd-sourcing and citizen engagement, implementing intelligent contracts, promoting energy transition and efficiency, ensuring regulatory compliance and supporting trade finance. These diverse applications highlight FinTech's influential and versatile role in reshaping practices related to the extraction, processing, and consumption of mineral resources.

This section of the research in Table 8 elaborates on the outcomes of the Granger panel non-causality among financial development, technology, FinTech, energy transition, urbanization, and minerals management (coal, oil, minerals, and forests) with economic growth in the top 10 natural resources-rich countries for the years 1990–2022. Financial development, technology and FinTech represent a positive relation with economic growth, clarifying the robust results of Table 7. Moreover, minerals generally show positive interconnection with economic growth, validating the resources blessing hypothesis as their direction is shown in Fig. 4. To visually comprehend the results, the reciprocal causality among the variables in the study appear closely connected, yet they reveal distinct findings, as depicted in Fig. 4. The relationship of GDP is positive and two-direction with FinTech indicating that both of them directly linked with each other. Further, minerals management (coal, oil minerals and forests) leads to escalating economic growth in resources-rich countries to improve economic development performance.

5. Conclusion and policy recommendations

Financial technology is decisive for economic growth as it fosters accessibility, efficiency, and innovation within financial systems. By leveraging advanced technologies, FinTech facilitates seamless transactions, expands financial inclusion, and stimulates entrepreneurial activities. Its transformative impact enhances economic resilience, fosters competition, and catalyzes productivity, contributing significantly to overall economic development. This study has been done on panel data of the top 10 resource-rich economies globally, taking financial development, technology, FinTech, energy transition, urbanization, and minerals management (coal, oil, minerals, and forests) to explore their impact on economic growth for the years 1990–2022. This study has employed 2nd generations of preliminary tests and novel panel estimations, for instance, Cross-sectional ARDL (Chudik and Pesaran, 2015) and panel Granger non-causality (Juodis et al., 2021). These advanced statistical techniques provide efficient and more robust outcomes to draw necessary policy recommendations. The outcomes of the study explain that the positive influence of financial development and technology is more dominant in increasing economic growth. Rapid financial and technological innovation has also changed mineral management, consumption, and efficiency in resource-rich countries. FinTech is positively influencing GDP in both the long- and short-run. Crucial characteristics of FinTech include optimizing operations and efficiency, promoting responsibility and sustainability, and increasing stakeholder engagement. The outcomes further reveal that minerals management (coal, oil, minerals, and forests) becomes a part of enriching GDP to confirm the resources blessing theory. It is evident that mineral resources are beneficial to enhance the growth rate in the top resource-rich economies.

The current analysis carries several policy implications. As the study underscores FinTech's substantial role in enhancing economic growth, governments should formulate policies to encourage its proliferation. Allocating funds to green financing can further support the FinTech sector. Increasing consumer awareness about eco-friendly products through the promotion of blockchain technology is crucial. Incentivizing the FinTech industry is imperative for sustainable growth and overall economic development. The paper also highlights effective financial inclusion as a positive driver for economic growth, emphasizing the need for stability in this sector. Adopting a *"one nature, one planet"* approach is essential to prevent further environmental damage, requiring coordinated international efforts for policies favoring sustainable economic growth.

In addition to contributing to existing literature, this research analysis acknowledges certain limitations and proposes avenues for future exploration. While the present study focused on the top 10 resource-rich countries, future research could broaden the sample to include higher and lower-income resource nations. Comparative analyses between regions and countries with different income levels could offer more nuanced insights. The study's reliance on four minerals management models measuring for FinTech could be expanded to encompass additional variables, capturing diverse dimensions of FinTech. Furthermore, extending the analysis to include a longer period and a broader range of countries would enhance its scope. Lastly, considering the panel data nature of the analysis, future research might compute the same model for individual economies to provide more refined inferences and policy recommendations.

Ethical approval

Manuscript does not report on or involve the use of any animal or human data etc.

Consent to participate

I agree for authorship, read and approved the manuscript, and given consent for submission of the manuscript.

Consent to publish

The author has given consent for subsequent publication of the manuscript.

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The data will be provided upon a reasonable request to the corresponding author.

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Mubeen Abdur Rehman: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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