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Dynamics of the interplay between economic complexity, governance and economic growth in the BRICS countries: a panel GMM approach

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Abstract. *This study tried to understand how economic complexity can unravel economic growth, resisting resource curse phenomena within the dynamics of governance factors in the BRICS countries. We used the panel GMM model for the period 1996 to 2022. We employed Arellano and Bover's (1995) GMM method for dynamic panel data estimation. Further, we used the Wald test to identify endogeneity. The results show that natural resources are a robust driver of economic growth, while the economic complexity index is pivotal in enhancing economic growth in the BRICS countries. Governance quality encompassing political stability, regulatory quality, rule of law, and control of corruption, exerts substantial influence on economic growth. While resource rents can determine economic growth, robust outcomes depend on economic complexity and the quality of governance of an economy in the context of the BRICS economies.*

Keywords: natural resources, economic complexity, economic growth, governance, resource curse.

JEL Classification: O43, O47, O13, Q2, Q3, Q56.

1. Introduction

Why do some countries fail amidst plenty of natural resources, however, some countries prosper with little or no availability of natural resources. Empirical studies reflect a prevailing viewpoint that considers resource availability a conceivable growth catalyst, thus labelling natural resources as advantageous (Robinson et al., 2006; Brunnschweiler and Bulte, 2008; Bhattacharyya and Hodler, 2010; Tsui, 2011; Cavalcanti et al., 2011). However, studies also contradict this resource-driven notion, as numerous resource-rich economies grapple with poverty and low living standards (for example several African countries suffer from acute poverty despite abundant natural resources like gold, and other minerals). For instance, research conducted by Gylfason and Zoega (2006), Papyrakis and Gerlagh (2007), Murshed and Serino (2011), and Badeeb et al. (2017) substantiated the principles of the Dutch disease and resource curse theory. The findings highlighted how natural resource endowment does not guarantee automatic economic advancement, indicating a missing link hindering the effective translation of resource abundance into growth (Xu et al., 2019). In recent years, economists have developed a model called the economic complexity index to examine this complexity of economic development to understand why nations fail amidst an abundance of natural resources and why some countries continue to develop without being endowed with an abundance of natural resources.

Therefore, this study tries to examine the economic complexity influencing BRICS countries' economic growth trajectories, primarily focusing on the potential to overcome the resource curse. Economic complexity is a multi-dimensional concept that encompasses factors such as product diversification and a country's skill in leveraging knowledge and resources to expand its spectrum of exports. The economic complexity of a country is measured through the Economic Complexity Index (ECI)[(1)]. This comprehensive index covers human development, innovation, and trade dynamics. Rooted in Hidalgo and Hausmann's (2009; 2011) seminal works asserted the reliance of economic growth on productive knowledge and skills, enabling diversified productivity. Notably, all BRICS countries have low ECIs, indicating limited productive enhancement. In the 2023 report of the Organization of Economic Complexity, Japan ranks the highest in the ECI (2.48), while China, India, Russia, Brazil, and South Africa score 1.07, 0.60, 0.46, 0.33, and 0.10, respectively (OEC, 2023).

This research aims to uncover the intricate intertwining between resource abundance, economic complexity, and sustainable economic growth within the BRICS countries. Beyond surface analysis, it seeks to unveil patterns crucial for overcoming the resource curse and achieving lasting economic prosperity. We seek to address a gap in the current literature by examining the impact of the interplay between natural resources and economic complexity on economic growth within the dynamics of governance in the BRICS countries. Therefore, it explores whether resources affect growth and whether economic complexity and governance play a role in the economic growth of a nation. And if it (economic complexity) plays, how does it play? These are the questions that are being explored in this study. Therefore, employing data from 1996 to 2022 for the BRICS economies, the study measures the moderating effect of economic complexity on economic growth.

This paper is divided into seven sections. The next section is the background of the study. The third section is the Review of Literature; the fourth section is Data and Methodology; section fifth is Empirical Results; section sixth is Discussion; and section seventh is the conclusion and Policy Implications.

2. Background of the study

The BRICS countries—Brazil, Russia, India, China, and South Africa—constitute a significant portion of the world's population and landmass, and their collective economic influence has grown substantially in recent decades. These countries are richly endowed with diverse natural resources, ranging from Russia's vast mineral reserves and China's manufacturing prowess to Brazil's agricultural output and South Africa's mineral wealth. However, paradoxically, these countries grapple with profound regional disparities, escalating inequalities, alarming levels of unemployment, and pervasive poverty, as documented by Jha et al. (2013). In stark contrast, Asian counterparts such as Japan, Hong Kong, Singapore, and Taiwan, despite their lack of significant natural resources, demonstrate remarkable economic efficiency and boast high per capita GDP, thereby highlighting the presence of the natural resource blessing. This perplexing phenomenon prompts a fundamental inquiry into the reasons behind the paradox of plenty syndrome prevailing in the BRICS countries and the underlying factors that form the elusive link between resource abundance and their economic growth dynamics. Rajiv (2023) cogently attributes the paradoxical situation to the prevailing tendency to consider natural endowments in isolation, neglecting the imperative of diversification. Given the resource advantages, the economic trajectories of these BRICS countries have been marked by complexities. While China's rapid industrialization and export-oriented growth have propelled it to the forefront as a global supply chain hub, Russia's heavy reliance on oil exports has made its economy vulnerable to fluctuations in global oil prices. Brazil faces challenges in sustainable land use and deforestation, while India grapples with issues related to poverty alleviation, income inequality, and bureaucratic hurdles. Trade dynamics within the BRICS bloc significantly fabricated their economic landscapes. Intra-BRICS trade has increased over the years, reflecting their efforts to strengthen economic ties. Among the BRICS countries, China's role as the "world's factory" has trade imbalances, as it exports manufactured goods to other BRICS countries and imports raw materials to sustain its production. This trade pattern underscores the interdependence and complexities of their economic relationships. Governance quality is another crucial factor influencing the utilization of resources and economic growth within the BRICS countries. Transparency, corruption, and regulatory efficiency impact their ability to convert resource wealth into sustainable development. Each nation's approach to governance varies, with implications for resource management, trade negotiations, and investor confidence.

Therefore, the BRICS countries' natural resource endowments, economic complexities, trade dynamics, and governance quality collectively define their paths in the global financial arena. Their efforts to leverage their resource wealth for development while addressing internal challenges and external dynamics showcase the intricate balancing act they navigate. As the BRICS countries continue to evolve, their approaches to resource

utilization, economic diversification, trade cooperation, and governance reforms will shape their roles in the global economy and their ability to tame the existing complexities. Therefore, uncovering intricate connections between resource abundance, economic complexity, and sustainable growth within the BRICS countries is prudent.

3. Review of literature

The discourse on natural resource-led economic growth has yielded mixed empirical findings within the literature. Nevertheless, this study strides ahead by seamlessly integrating economic complexity into the framework of the natural resource-led growth model. The division of the literature review unfolds into dual strands of thought. Primarily, the existing evidence illuminates the advantageous aspects of natural resource endowment. Conversely, a contrasting viewpoint emerges, highlighting the presence of a resource curse exacerbated by the intricate interplay of economic complexity and growth. Eminent scholars such as Cavalcanti et al. (2011), Tsui (2011), Bhattacharyya and Hodler (2010), Brunnschweiler (2008), Mesagan et al. (2019), and Haseeb et al. (2021) have meticulously documented a direct nexus between natural resources and economic growth. For instance, Cavalcanti et al. (2011) unearthed a positive correlation between natural endowment and growth across 53 countries from 1980 to 2006. Tsui (2011) delved into the repercussions of oil-rich economies on both democracy and growth, shedding light on the adverse impact of oil on democracy while also highlighting its positive contribution to growth.

Zall'e (2019) explored the intricate interplay between resources, institutional quality, and human capital in the context of Africa. The study underscores the imperative of investing in human capital and eradicating corruption. Havranek et al. (2016) brought to the fore a nuanced perspective, emphasizing the tenuous link between resources and growth when accounting for factors such as publication bias and approach disparities. This underscores the need for methodological rigour, including considering institutional frameworks, investment patterns, resource categorization, and the distinction between resource dependence and abundance.

Zhu and Li (2019) have taken a proactive approach to predict and explain how economies grow by using the concept of economic complexity. They have shown how economic complexity positively impacts, especially in larger economies, where its long-lasting effects are noticeable. While managing natural resources effectively can kickstart growth, it could act as a catalyst. The connections between economic complexity and the increase in GDP provide examples of how countries with higher incomes handle more complex challenges and responsibilities.

Bhattacharyya and Hodler (2010) thoroughly studied the period from 1980 to 2004 across 124 countries, whereby the analysis pointed to specific conditions necessary for growth driven by resources. These conditions include having high-quality institutions and a thriving democratic framework. In a broad study spanning five diverse regions, Brunnschweiler (2008) supports how natural resources could lead to economic growth. The study found a strong link between abundant resources and maintaining high-quality institutions. Mesagan et al. (2019) carefully examined the influence of resources on growth

in African countries such as Angola, Egypt, Nigeria, and Tanzania, challenging the widely accepted idea of a "resource curse." The study established direct connections between resources and growth.

The complexity of growth also involves the core concepts of trade and economic collaboration among countries. Guo et al. (2019) highlight that well-organized trade agreements and integration can drive resource optimization and economic growth. It relies largely on establishing strong governance systems that ensure fair distribution of these advantages to achieve the benefits.

On the contrary, there exists a body of research by Sachs et al. (1995), Gylfason and Zoega (2006), Papyrakis and Gerlagh (2007), Brückner (2010), Murshed and Serino (2011), Boschini et al. (2013), Ahmed et al. (2016), Badeeb et al. (2017), and P'erez and Claveria (2020) that supports the notion of the resource curse and Dutch disease theory. For instance, Sachs et al. (1995), through a cross-country analysis, established a negative correlation between resource abundance and economic output within the context of an endogenous growth model. Further, Auty (1993) extended this investigation across 85 countries, corroborating the existence of a resource curse phenomenon. The quality of governance plays a pivotal role in shaping economic growth trajectories. Findings from studies such as Kaufmann et al. (2003) and Mauro (1995) underscore that effective governance, encompassing attributes like the rule of law, corruption control, and political stability, creates an environment conducive to sustainable economic advancement—governance of high calibre aids in efficiently utilising resources and acts as a magnet for investments. Brückner (2010), in an examination spanning 39 countries from 1970 to 1990, delved into the impact of institutional instability and governance, attributing the emergence of the resource curse hypothesis to these factors. Investigating trade and growth across 49 economies from 1960 to 2005, Murshed and Serino (2011) found a positive correlation between diversified processed exports and growth that diversified processed exports were correlated with positive growth outcomes, while economies rich in primary product exports experienced detrimental growth effects. Papyrakis and Gerlagh (2007), focusing on the USA between 1986 and 2000, revealed an inverse relationship between resource endowment and indicators like investment, schooling, trade openness, and expenditure on research and development, while corruption exhibited a positive correlation. Brunnschweiler (2008) reinforces the pivotal role of institutional quality in shaping the impact of resources on economic growth. The efficacy of governance mechanisms proves indispensable in translating the wealth derived from resources into sustainable development, underscored by the success of resource-abundant countries such as Norway.

In the exploration of the intricate dynamics surrounding natural resource abundance, Boschini et al. (2013) ventured to dissect minerals, leading them to an insightful revelation. Their analysis unveiled positive growth effects stemming from ore and metal resources, while other types of resources exerted negative impacts. They put forth a compelling argument for institutional quality's pivotal role in countering the resource curse's potential adverse effects. Building upon this foundation, Ahmed et al. (2016) conducted a meticulous investigation applying the Cobb-Douglas function to the Iranian context. The findings aligned with the resource curse hypothesis, as they verified a decline of 4% in growth for

every 1% rise in resources. The reflections of Badeeb et al. (2017) cast a wide net over the landscape of resource curse literature. The study also pointed towards the applicability of the resource curse notion, especially within developing countries characterized by weaker institutions. Eregha and Mesagan (2020) delved into the Next-11 countries by expanding the geographical scope. Through an intricate analysis involving nonlinear panel data spanning from 1960 to 2016, the study uncovered a critical juncture. Specifically, when financial deepening stayed below the 45% threshold, it triggered an inverse relationship between resources and growth. Conversely, crossing the 45% mark paved the way for resource-led growth. Shifting the focus, the investigation into the role of economic complexity in driving growth emerges as another important dimension. Du and O'Connor (2021) harnessed cross-country data to present a compelling argument – entrepreneurship, acting as a catalyst for growth through economic complexity, fuels progress. Further amplifying the significance of economic complexity, Hartmann et al. (2017) embarked on a journey involving 150 countries. The findings established a strong connection between high economic complexity and lower levels of income inequality. Delving deeper into this arena, Zhu and Li (2016) conducted a study across 210 countries, revealing a profound link between economic complexity, human development, and positive economic growth. On the other hand, Ch'avez et al. (2017) unveiled the role of economic complexity in shaping wealth disparities among Mexican states.

In this landscape of research, few studies firmly support the resource curse theory, while others, like Brückner (2010), Boschini et al. (2013), Badeeb et al. (2017), Eregha and Mesagan (2020), and Usman et al. (2022), advocate for a distinct path. They proposed that certain institutions, governance, and financial deepening qualities could act as potent tools to reverse the curse, thereby transforming resources from burdens into blessings. Conversely, an intriguing gap becomes evident in the existing body of research. While some studies have highlighted the role of economic complexity in driving growth—such as Hartmann et al. (2017), Ch'avez et al. (2017), Zhu and Li (2016), and Zhang et al. (2022)—they have yet to connect it as the conduit through which natural resources foster growth. In its innovative approach, the current study steps into this uncharted territory. It expands the horizon by intertwining economic complexity into the interplay between natural resources and economic growth, particularly within the dynamic context of the BRICS countries. This novel perspective seeks to unravel whether the inherent complexities within the BRICS countries could transform natural resources into dynamic sources of growth or amplify their potential to propel economic progress significantly.

4. Data and Methodology

Model and data

The current study examines the interplay among natural resources, economic complexity, and growth in BRICS economies, building on insights from Solow (1956), Hidalgo and Hausmann (2009), and Eregha and Mesagan (2020). These previous works lend support to the chosen model and variables. Solow's growth theory, which underscores the roles of labour and capital, provides the fundamental basis (Solow, 1956). Equation (1)

incorporates these foundational factors and extends its scope to encompass resource rent and other relevant control variables. The significance of knowledge is represented through the economic complexity index, as inspired by Hidalgo and Hausmann (2009), who established a link between complexity and the relationship between natural resources and growth. Consequently, equation (1) can be expressed as follows:

$$PCGDP_{it} = \alpha + \beta_1(NR_{it}) + \beta_2(ECI_{it}) + \beta_3(LFPR_{it}) + \beta_4(CF_{it}) + \beta_5(FDI_{it}) + \beta_6(TO_{it}) + \beta_7(PS\&V_{it}) + \beta_8(RQ_{it}) + \beta_9(ROL_{it}) + \beta_{10}(CC_{it}) + \mu_{it} \quad (1)$$

Where per capita GDP (PCGDP) measures economic growth, natural resources are represented by the natural resources rent (NR) and economic complexity is quantified by the economic complexity index (ECI). The growth model incorporates the labour force participation rate (LFPR) and gross capital formation (CF) to account for labour and capital effects. Control variables encompass Foreign Direct Investment (FDI), Trade openness (TO), Political stability and violence (PS&V), Regulation Quality (RQ), Rule of Law (ROL), and corruption control (CC). The model's components include an intercept (α), estimated parameter coefficients ($\beta 1 - \beta 10$), stochastic disturbance (μ), and cross-sectional (i) and time-related (t) variations. To assess the combined impact of natural resources and economic complexity on growth, equation (2) is presented.

$$PCGDP_{it} = \alpha + \beta_1(PCGDP_{it-1}) + \beta_2(NR * ECI_{it}) + \beta_3(LFPR_{it}) + \beta_4(CF_{it}) + \beta_5(FDI_{it}) + \beta_6(TO_{it}) + \beta_7(PS\&V_{it}) + \beta_8(RQ_{it}) + \beta_9(ROL_{it}) + \beta_{10}(CC_{it}) + \mu_{it} \quad (2)$$

In equation (2), $PCGDP_{it-1}$ is the time lag of PCGDP that could determine the growth and NR*ECI captures the joint ECI impact while other estimators remain constant. Data spans from 1996 to 2022 for 5 BRICS countries selected for data availability. This period reflects substantial growth, trade expansion, and global influence, albeit with varied trajectories due to distinct complexities, internal challenges, external factors, and governance enhancement efforts.

The study employs Arellano and Bover's (1995) GMM method for dynamic panel data estimation. GMM corrects sample biases, addresses endogeneity, curbs over-identification, and controls cross-sectional dependence. It suits scenarios with more cross-sections (N = 5) than time series (T = 26). Instruments chosen through the Sargan Test (results undisclosed) use lagged explanatory variables. GMM outperforms OLS and fixed effects, tackling issues like serial correlation, multicollinearity, and measurement biases. It handles misspecification and proxy variable errors. Pre-conditions include endogeneity diagnosis. The study employed the Wald test to identify endogeneity; insignificant J-statistics accept instrument validity. Moreover, the Wald test is applied for endogeneity diagnosis. Test results indicate significant ($p \geq 0.05$) correlations between residual terms and explanatory variables, confirming endogeneity issues. This approach aligns with how resource-rich countries leverage resource revenue for economic growth, as observed in studies like Mesagan et al. (2019), Mohamed (2020), and Canh et al. (2020), making it a fitting proxy.

Table I. *Description of Variables*

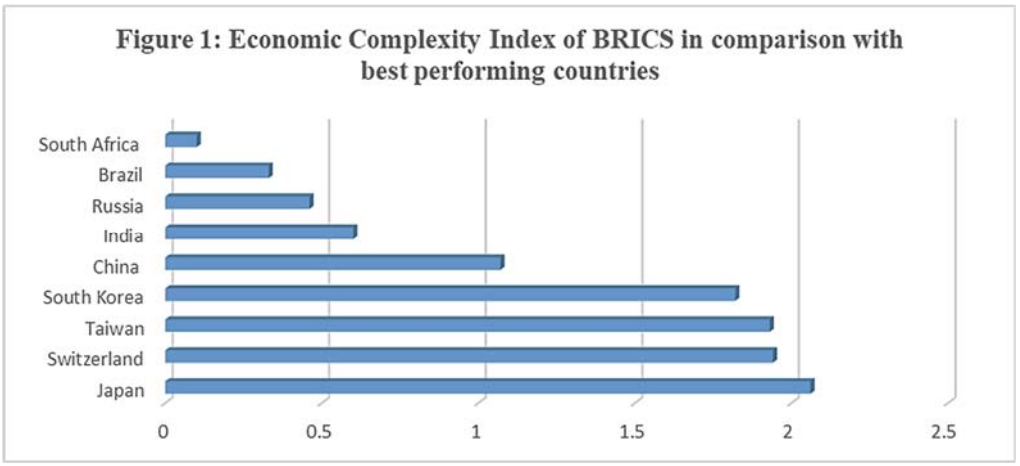
Variables	Name	Measurement	Sources
PCGDP	Per Capita GDP (Economic Growth)	Measures the per capita income of people of a country in Real-term	World Bank 2021
NR	Natural Resources	Measures the resource rent as % of GDP	World Development Index 2021
CE	Complex economy	Measures the productive capabilities of economic systems. The Economic Complexity Index has measured it.	Harvard Dataverse 2021
NRCE	Interrelationship of Natural Resources and Complex Economic System	Measures the joint effect of natural resources and complex economic system (Index)	Derived by Author
CF	Capital Formation	It is measured with gross capital formation as % of GDP of a country	World Development Index 2021
LFPR	Labour Force Participation Rate	It is measured from the total labour force	World Development Index 2021
FDI	Foreign Direct Investment	Measured by the inflow of foreign currency and technology In USD	World Governance Indicator 2021
TO	Trade Openness	The ratio of the sum of exports and imports	World Bank/IMF
PS&V	Political Stability and Violence	This index assesses the perceptions regarding the potential for the government to experience destabilization or removal through unconstitutional or violent methods, encompassing politically motivated acts of violence and terrorism.	World Governance Indicator 2021
RQ	Regulatory Quality	This index reflects the perceptions regarding the government's capacity to create and enforce effective policies and regulations that facilitate and encourage the growth of the private sector.	World Governance Indicator 2021
ROL	Rule of Law	This index encompasses the perceptions of how much individuals trust and adhere to societal norms and regulations. It mainly assesses the quality of contract enforcement, property rights, law enforcement, and judicial systems and also considers the potential for criminal activities and violence.	World Governance Indicator 2021
CC	Control on Corruption	This index gauges the perceptions regarding the degree to which governmental authority is wielded for personal benefit, encompassing various forms of corruption, both minor and significant. It also includes instances of the state being influenced or controlled by privileged groups and private interests.	World Governance Indicator 2021

Source: Authors' compilation.

5. Empirical Results

Descriptive analysis is presented in Table II, showcasing variable trends via mean, standard deviation, and minimum and maximum values. For instance, PCGDP has a mean of 7337.7, reflecting the BRICS economies' average trajectory. Similarly, NR (natural resources) averages 2.61, representing rent from diverse natural resources. ECI (economic complexity index) has an average of 0.51, depicting relatively good (not better) ECI state in BRICS countries, with the benchmark ranging between 2 (favourable) and -2 (poorest). Likewise, CC (corruption control) holds a mean of 0.52, reflecting not-so-good conditions in BRICS. The labour force participation rate (LFPR) mean is 58.9, and CF (capital formation) averages 18.21, representing relatively better regional trends. Furthermore, FDI and TO (trade openness) have respective mean values of 18.79 and 21.55, both in logarithmic form, indicating inflow volume and trade openness level. The economic complexity Index among BRICS countries compared to top-performing countries in the ranking is depicted in Figure 1.

Figure 1. *Economic Complexity of BRICS countries compared to other best-performing countries*



Sources: Complexity rankings, "The Observatory of Economic Complexity", OEC, 2023.

In Figure 1, the resource utilization and productive capacity of BRICS countries are compared with top performers like Japan, Switzerland, Taiwan, and South Korea. This highlights BRICS' comparatively weaker performance, indicating less diversification of its productive activities for exports and further lesser competitive pricing capacity of export products for the BRICS economies. Furthermore, this could also give some inference about uneven socio-economic indicators across their populations and substantial inequality across different levels that lead to lower knowledge base economy and innovation in these economies.

Table 2. *Descriptive Statistics*

Variables	Mean	Std. Dev	Max.	Min.	Obs
PCGDP	7337.75	3440.21	10511	1928	111
NR	2.61	2.84	18.5	1.8	111
ECI	0.51	1.2	1.02	-0.98	111
NRCE	-1.89	0.71	0.56	-0.24	111
CF	18.21	1.54	43.8	13.05	111
LFPR	58.9	0.69	63.8	36.2	111
FDI	18.79	0.71	-0.71	-1.89	111
TO	21.55	0.21	-0.89	-2.01	111
PS&V	0.42	0.74	0.59	-1.8	111
RQ	0.51	0.82	-0.25	-1.81	111
ROL	0.39	0.46	-0.32	-1.78	111
CC	0.52	0.85	-0.11	-1.91	111

Sources: Authors' calculation.

Unit root testing

Given the inclusion of numerous macroeconomic variables, assessing their stationarity is crucial. To this end, the unit root tests employed Im, Pesaran, and Shin (2003) and ADF (Dickey and Fuller, 1979) tests. Results, detailed in Table III, demonstrate stationarity at the first difference of all variables. The statistically significant values ($p \geq 0.05$) from both techniques reject the null hypothesis of non-stationarity.

Table 3. *Estimated Results of Unit Root Test*

	IPS (Im, Pesaran and Shin) W-Statistics			
Variables	Level		First Difference	
	Statistic	Prob.	Statistic	Prob.
PCGDP	-0.151	0.7284	-5.673	0.0000*
NR	0.731	0.7706	-5.798	0.0000*
CE	0.757	0.9808	-6.236	0.0000*
NRCE	-1.631	0.4006	-14.887	0.0000*
CF	-0.193	0.6124	-10.591	0.0000*
LFPR	0.673	0.6581	-5.019	0.0005**
FDI	0.181	0.9958	-4.487	0.0000*
TO	-1.63	0.992	-12.253	0.0000*
PS&V	-1.66	1.000	-14.262	0.0000*
RQ	3.249	0.5256	-22.410	0.0000*
ROL	0.560	0.0921	-12.928	0.0010**
CC	-1.820	0.0341	-10.113	0.0033**

Note: * 1%, ** 5% level of Significance.
Sources: Authors' calculation.

Endogeneity Test

The endogeneity identification test is designed to determine endogeneity, that is, the existence of a correlation between explanatory variables and the error term in a regression model. These tests help detect potential biases in regression estimates and assess the reliability of the model's results. The results presented in Table IV depict the absence of any endogeneity issue; hence, no relationship exists between explanatory variables and error terms, which may impact coefficients and level of significance.

Table 4. *Endogeneity Identification*

Test	Statistic	Degree of Freedom	Prob.
F-Statistic	3545.162	8, 87	0.0001*
Chi-Square	2981.284	8	0*
Testing H0 = C(n)=0			
Restriction Terms		Value	Std. Error
C(1)		0.261	0.023**
C(2)		0.009	0.0004*
C(3)		0.005	0.005*
C(4)		0.0078	0.012*
C(5)		0.003	0.021**
C(6)		0.002	0.0001*
C(7)		0.0036	0.005*
C(8)		0.0001	0.002*

Note: * 1%, ** 5% level of Significance
Sources: Authors' calculation.

Correlation analysis

In Table V, variable correlation coefficients are displayed. Evidence indicates mild correlations between the series, indicating minimal collinearity and the absence of multicollinearity issues in the model. The only notable strong correlation is 0.959 between NR & ECI, 0.914 between NR & NRCE, and 0.909 between PS&V & ROL. To prevent multicollinearity among regressors, the regression models estimated have been divided accordingly.

Table 5. *Correlation Analysis*

	PCGDP	NR	CE	NRCE	CF	LFPR	FDI	TO	PS&V	RQ	ROL	CC
PCGDP	1.000											
NR	0.065	1.000										
CE	0.079	0.959	1.000									
NRCE	0.070	0.914	0.229	1.000								
CF	0.715	0.123	0.149	0.137	1.000							
LFPR	0.849	0.043	0.008	0.008	0.052	1.000						
FDI	0.730	0.069	0.539	0.126	0.253	0.012	1.000					
TO	0.076	0.211	0.102	0.197	0.067	0.126	0.033	1.000				
PS&V	0.104	0.275	0.077	0.232	0.322	0.124	0.828	0.149	1.000			
RQ	0.049	0.043	0.008	0.008	0.052	0.539	0.126	0.126	0.253	1.000		
ROL	0.130	0.069	0.539	0.126	0.253	0.012	0.891	0.070	0.909	0.229	1.000	
CC	0.076	0.211	0.102	0.197	0.067	0.126	0.033	0.069	0.539	0.126	0.253	1.000

Sources: Authors' calculation.

Regression assessment

Using the GMM (Generalized Method of Moments) technique recommended by Arellano and Bond (1995), the results are presented in Tables VI and VII. This method, commonly called the AB model, is consistent with prior research on similar topics (Canh et al., 2020; Farooq, 2021a). Table VI outlines the step-by-step impact of the main predictors, while Table VII focuses on the moderating effects. In Table VI, the lag of Per capita GDP (PCGDP) stands out significantly at the 1% level, indicating that the current year's PCGDP relies on the previous year's value. This finding reinforces the implication of the system GMM model, which suggests that PCGDP depends on its lag (Farooq et al., 2021). Shifting our attention to the core variables, the coefficient associated with natural resource rents stands at 2.418, significantly impacting economic growth within the BRICS countries at a confidence level of 1%. This implies that a single-unit alteration in natural resource rents corresponds to a notable growth increase of 2.148%. On the contrary, the positive coefficient linked to the economic complexity index (ECI) (1.082) underscores the pivotal role of ECI in bolstering economic growth (GMM Model 2). This coefficient holds statistically significant at 5% level, signifying that a one-unit elevation in ECI corresponds to a substantial growth augmentation of 1.082%.

Table 6. *Estimated results of GMM models*

	System GMM Model 1		System GMM Model 2	
	Coefficients	Std. error	Coefficients	Std. error
Per capita GDP (-1)	1.891***	1.101	1.762***	1.110
Natural resources	2.418***	0.014	–	–
complexity of Economy	–	–	1.082**	0.910
Labour force participation	0.495	3.142	0.375	3.498
Capital-formation	0.841 **	1.891	0.745 **	1.752
FDIs	1.546 **	0.201	-	-
Trade Openness	1.484**	0.010	1.074**	0.854
Pol. Stability and Violence	-	-	-0.454***	0.089
Regulatory Quality	0.807	5.222	0.674	4.852
Rule of Law	0.785**	0.003	-	-
Control of Corruption	-0.838***	1.451	-0.603***	1.036
Adjusted R-square	0.701		0.668	
S.E. of regression	1.022		1.436	
Prob (J-statistic)	0.845		0.731	

Note: ***significant at 1%, **significant at 5%, *significant at 10%.
Source: Authors' calculation.

The labour force participation rate notably displays a positive yet insignificant correlation with economic growth. Capital formation exhibits a positive and significant relationship with economic growth. Findings suggest that a 1% rise in capital formation induces a 0.841% increase in the economic growth of BRICS economies. Further, trade openness emerges as a vital determinant of economic growth within BRICS countries. The estimates reveal a 1% growth in trade openness (trade surplus) corresponds to a 1.484% economic growth increase. These outcomes hold significance at 5% level. Concerning governance quality (control variables), political stability and violence reveal a notably negative relationship with economic growth. The estimates indicate economic growth in the BRICS region responds positively to natural resource utilization and enhanced economic complexities under stable political conditions without violence. However, economic growth could decrease by -0.454% during political instability and violence. A similar scenario applies when regulatory quality and the rule of law thrive. For a 1% improvement in regulatory quality and the rule of law, economic growth increases by 0.807% and 0.785%, respectively. While regulatory quality remains insignificant, the rule of law holds significance at the 5% level.

Furthermore, the control of corruption significantly affects economic growth. Therefore, the estimates demonstrate that a 1% strengthening of corruption control mechanisms results in a 0.838% economic growth increase. This coefficient is statistically significant at the 1% level of significance. The aforementioned findings underscore the substantial impact of resource utilization capacity and economic complexity on economic growth in BRICS countries. Nevertheless, realizing the full potential of their resources and productive capabilities (knowledge, urban centres, income, and economic systems) hinges upon achieving elevated levels of governance quality and economic openness. In the absence of robust governance quality and open economies, BRICS countries may experience constrained and volatile economic growth.

To evaluate the combined or moderating influence of natural resources and economic complexities, we computed equation 2 from the study. As shown in Table VII, the interaction between natural resources and economic complexities directly and significantly affects the economic growth of BRICS countries. The estimations indicate a 1% rise in the combined impact of NR and ECI leads to a 3.458% increase in economic growth (GMM model 1) and a 3.624% increase (GMM model 2). Similarly, the coefficients for governance quality (PS&V, RQ, ROL, and Control of Corruption) and economic openness (FDI and TO) reveal their considerable impact on the economic growth of BRICS countries.

Table 7. *Estimated results of moderating/joint effect equation*

Variables	Panel Generalized Method of Moment (GMM) Model 1 Coefficients	Panel Generalized Method of Moment (GMM) Model 2
Per Capita GDP (-1)	1.566***	1.751***
NR*ECI	3.458***	1.624***
Labor force participation	0.884	0.793
Capital-formation	1.027***	0.952
FDI	2.010***	-
Trade Openness	1.183*	1.009*
Pol. Stability and Violence	-	-0.808**
Regulatory Quality	0.856	0.767
Rule of Law	0.775**	-

Variables	Panel Generalized Method of Moment (GMM) Model 1 Coefficients	Panel Generalized Method of Moment (GMM) Model 2
Control of Corruption	-0.915***	-0.887***
Adjusted R-square	0.655	0.678
S.E. of regression	0.983	1.581
Prob (J-statistic)	0.875	0.795

Note: ***significant at 1%, **significant at 5%, *significant at 10%.
Source: Authors' calculation.

6. Discussion

This study explored how natural resource rents and economic complexity impact countries' economic progress in the BRICS region. On employing a statistical analysis centred around the implications of the system GMM model, the findings unveiled the significance of natural resource rents to foster economic growth, thereby challenging the prevailing notion that resources are inherently detrimental (i.e., resources are a curse). Therefore, it reveals that the judicious harnessing of resources to fuel various ambitious objectives significantly contributes to economic expansion, underscoring the argument that presumes the excess use of resources within a framework of controlled regulatory quality, adherence to the rule of law, and robust corruption control mechanisms bestow a boon upon a country. Consequently, the outcomes derived from this investigation run counter to the conclusions drawn by Ampofo et al. (2020) where it was found the resource curse phenomenon operating in Australia, India and the Democratic Republic of Congo indicating that the availability of natural resources does not determine economic growth in these economies. However, our finding suggests that the combined effects of natural resource rent and economic complexity in BRICS economies has positive impact on economic growth.

The economic performance of the BRICS countries—Brazil, Russia, India, China, and South Africa—has garnered substantial attention and scrutiny due to their collective influence on global GDP, trade, and population (Garcia and Bond, 2017). For instance, the share of BRICS in the Global GDP was 16.9% in 1995, and the latest IMF estimates reveals that the BRICS share to Global GDP in 2023 will go up to 32.1%, which is higher than the G7 countries share of 29.9% (IMF). Factors such as natural resources, demographic trends, technology advancements, and policy choices have all shaped their economic trajectories (Gupta & Nayak, 2018) Despite their resource abundance and population diversity, these countries have exhibited varying levels of growth, challenges, and resilience. China and India have seen rapid industrialization, while Brazil and South Africa have faced inequality and political instability. Energy exports and geopolitical dynamics have swayed Russia's economic performance (Zhao and Ehsan, 2023). The COVID-19 pandemic has introduced multiple challenges and collaborative opportunities, such as joint efforts in vaccine development and economic recovery (Dogen et al., 2022). In totality, the intricate economic performance of BRICS countries results from the interplay between resource use, domestic and global factors, and their evolving role in the world economy.

The progress of BRICS is entangled with unsustainable economic growth and challenges to address multiple socioeconomic inequalities. Studies have advocated that natural

resources and economic capabilities are pivotal in achieving economic ambitions within the BRICS countries (Liu et al., 2023; Adebayo et al., 2023; He et al., 2022; Bai et al., 2022).

Consistent with these perspectives, the estimated outcomes of the GMM model, as presented in Table VI, further underscore the noteworthy and affirmative relationship between the economic complexity index and economic growth (Zhao & Ehsan, 2023). Economic complexity signifies the enhancement of prevailing economic endeavours through a combination of diversification and advancements in production technology and knowledge. Numerous economies amplify trade by focusing on product complexity, boosting economic growth (Guo et al., 2022). A heightened economic complexity index indicates product diversification and a knowledge-driven economy, reflecting a nation's productive capabilities that contribute favourably to economic growth through exports channel. This aligns with Hodey et al.'s (2015) empirical analysis, which illustrated the beneficial effects of export diversification, closely associated with economic complexity, on economic growth.

Apart from individual analyses, this study also investigated the combined impact of economic complexity and natural resource rents on the economy's progress. The statistical results presented in Table VII suggest that a higher level of economic complexity has the potential to amplify the positive influence of natural resource rents on economic growth. The noteworthy coefficient value of the interaction term (NR*ECI) supports this proposition, underscoring a significant and affirmative effect on the economic growth in the BRICS region. Economic complexity enhances efficiency and outcomes in utilising natural resources, boosting trade endeavours. This correlation aligns with empirical findings by Zhao & Ehsan (2023), Liu et al. (2023), Islam and Managi (2019), and Ikram et al. (2021). Furthermore, this empirical examination delves into the dynamic impacts of economic factors such as the total labour force, gross capital formation, FDI inflow, and trade openness on economic growth (which is also studied by Constantinl et al., 2008; Wang et al., 2022; Ma et al., 2022). Conversely, the total labour force has a direct influence on economic growth. A larger pool of human capital, particularly skilled workers, has the potential to uplift economic growth by enhancing production efficiency. However, our analysis indicates insignificant effect in this aspect, which differs from the conclusions drawn by Zhang et al. (2018). Furthermore, gross capital formation positively affects real per capita gross domestic product. The accumulation of fixed capital assets, known as gross capital formation, amplifies production capacity, leading to increased exports and economic growth (Dittrich et al., 2010; Zhang et al., 2022). This could be because, through capital formation, innovative ideas could be put into action to produce varieties of new products and services which help to enhance the economic complexity index. Therefore, the studies suggested that BRICS prioritize infrastructure development and fortification of production sources to accelerate economic growth. Similarly, the positive impact of FDI inflow on economic growth arises from enhanced employment, improved total factor productivity, and increased industrial momentum within the host nation (Ma et al., 2022). FDI inflow facilitates knowledge transfer from developed to developing economies, fostering rapid economic growth (Hartmnan et al., 2017; Zhang et al., 2022).

Likewise, the significant effect of trade openness on BRICS's economic growth underscores opportunities for domestic industries to expand by producing export-oriented goods (Zhang et al., 2022; Wang et al., 2022). However, note that less developed BRICS countries (like South Africa and Brazil) might face challenges due to lower product quality, and the export baskets of these economies mainly consist of primary goods, thus, hindering benefits from trade openness policies. As BRICS economies exhibit changing import-export proportions over time, trade openness boosts trade volume and domestic economic growth by reducing trade deficits (Wang et al., 2022; Farooq et al., 2022). Lastly, governance quality positively and substantially impacts BRICS's economic growth. The factor directly linked to economic growth, controlling corruption, is more likely to contribute significantly to production efficiency and institutional efficiency through strict anti-corruption measures (Bhattacharyya & Hodler, 2010). On the other hand, political stability and violence negatively correlate with economic growth. Sound institutional structures can effectively shape and enforce economic regulations, fostering a corruption-free, rule-based society (Biswas et al., 2012; Hosseini & Kaneko, 2013). Similarly, regulatory quality and the rule of law significantly affect economic growth. Favourable citizen behaviour, civil liberties, political rights, and literacy drive economic development, improving quality of life and overall economic growth (Farzin and Bond, 2006).

In summary, our empirical findings affirm the positive impact of natural resource rents and underline the constructive link between economic complexity and economic growth in BRICS countries. This study underscores that economic complexity augments the positive effects of natural resources on vibrant economic growth. The results reaffirm that natural resources are a blessing in disguise when coupled with economic complexity and robust governance encompassing the rule of law, regulatory quality, anti-corruption measures, and political stability.

7. Conclusion and Policy Implications

This study contributes significantly to the existing literature by examining the interplay between natural resource rents, economic complexity, and economic growth within the context of the BRICS countries. The empirical analysis using the system GMM model substantiates key propositions: the beneficial role of natural resources is underscored by the lens of economic complexity, governance quality, and economic openness. The empirical findings reaffirm a substantial and positive nexus between natural resource rents, economic complexity, and economic growth. Moreover, the results of our analysis illuminate a positive relationship between governance quality, economic openness, and economic growth. This underlines the importance of economic complexity and governance quality in optimizing the advantages of available natural resources.

To put it in perspective, robust economic outcomes from natural resources in BRICS countries hinge on a combination of economic complexity and governance quality. Remarkably, the positive impact of economic complexity persists even after considering resource endowments, signifying that heightened economic complexity augments natural resource use efficiency, thereby fostering economic growth. This positive influence further

underscores the significance of elevating economic complexity for promoting economic prosperity within the BRICS economies.

The study could not disagree regarding its multifaceted contribution. From a theoretical perspective, it enhances the existing literature by introducing an innovative theoretical framework that combines natural resource-driven economic growth with a specific focus on economic complexity and the quality of governance. In terms of empirical insights, this research presents substantial evidence that sheds light on the potential role of natural resources in shaping economic growth within the BRICS region. Armed with these findings, the BRICS countries can proactively address obstacles that hinder the efficient utilization of resources and constrain economic growth. Economic complexity should be embraced as a viable solution, prompting the formulation of strategies aimed at fortifying it to unleash the latent potential of natural resources. To achieve this, it is imperative to implement robust policies that cultivate economic complexity through skilled development, enhance Research and Development culture, diversify the economic structure that contributes to GDP, easy patenting facilities for innovative products and services to encourage inventors and innovators, export promotions and elevate the quality of institutions. These endeavours can draw inspiration from the experiences of successful Asian economies such as Japan, Taiwan, and South Korea.

Declaration

Availability of data and materials: The datasets used for this study have been obtained from open sources like the World Bank. The sources of data are cited in Table I of the manuscript. The consolidated data is available upon request.

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Note

(1) The ECI measures the diversity and sophistication of a country's productive capabilities through its exports. The ECI, in a nutshell measures a country's different productive capabilities. Productive capabilities are the inputs, technologies, and ideas that all determine the frontiers of what an economy can produce i.e., mixed of products that countries exports. The ECI is included in the Global Innovative Index ranking which is within the Knowledge and Technology output pillar.

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