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Agricultural Value Added in BRICS: A Panel Data Study

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ABSTRACT

Sustainable agricultural development is essential for ensuring food security, economic growth and ecological balance, which is a challenging phenomenon to achieve. This phenomenon is studied in the case of BRICS, considering agricultural value added, economic growth, openness to trade, carbon dioxide emission and net foreign direct investment. Panel unit root test, Fixed and Random Effect Model, Panel Cointegration test and Panel Causality are studied. Results of the analysis indicate that in all the BRICS countries, agricultural value added is significant to economic growth, inward foreign direct investment is reduced with agricultural growth, and inward foreign direct investment causes trade openness.

Keywords: Agricultural Value-added, Carbon Dioxide Emission, Foreign Direct Investment, Panel Data, Fixed Effect, Cointegration
JEL Classifications: F21, F430, Q17, Q27

1. INTRODUCTION

One of humanity's biggest challenges today is achieving the Sustainable Development Goal (SDG) of ensuring zero hunger (Goal Two) by 2030. "Zero Hunger" commits to eradicating hunger while promoting sustainable agriculture, achieving food security, and improving nutrition (UN, 2023). Agricultural capacity utilisation and enhancement are vital elements for achieving this goal. Investment in agriculture is the best approach for enhancing agricultural productivity and capacity utilisation and preventing food calamities (Ahmed et al., 2022). The Agriculture Led Growth Hypothesis (ALGH) is validated in countries like Brazil, China, Russia, and the United States of America (USA) and many more (Etokakpan et al., 2019; Tiffin and Irz, 2006). Increasing agricultural output by expanding investments and maintaining ecological balance is a challenging phenomenon that needs a substantial flow of capital (Havemann et al., 2020). Many developing countries are facing under-investment in their primary sector due to limited income and insufficiency of credit sources (Awunyo-Vitor and Sackey, 2018).

International capital flows in the form of Foreign Direct Investment (FDI) have the inherent potential to face the challenges of enhancing food production, ensuring agricultural sustainability, creating new economic growth, and positively handling ecological and environmental sustainability (Sharmiladevi, 2023; World Bank, 2020). FDI has become a prime focus for its ability to contribute to economic growth, employment generation, and technological innovation in developing countries (Edeh et al., 2020; Arif et al., 2022). Primary sector resources are essential in determining inward FDI, as they influence economic growth (Hayat, 2018). A stable and sustained agricultural output supported by a perennial credit supply ensures food security, environmental sustainability and ecological balance that ensure health and well-being, leading to an increase in economic growth (Liu, 2014; Castaneda et al., 2016; Gollin et al., 2002; Schultz, 1964; Singer and Thorbecke, 1971). The functional dependent relationship among agriculture value added, carbon emission, FDI, food production, trade openness and economic growth is shown in Figure 1.

In the process of economic development derived from industrialisation, environmental sustainability took a back seat in many nations, and this is also true in BRICS, as evident from their rapid industrialisation, urbanisation, and increasing energy use patterns (Lamba et al., 2019; Ali et al., 2021; Zhao et al., 2021).

As per the UNCTAD (2023), the share of BRICS in global gross domestic product increased from 18% in 2010 to 26% in 2021. Parallelly, BRICS actively participate in the Paris Agreement to mitigate global warming and engage to play a significant role in achieving this agreement's targets (Khan et al., 2020). With this preliminary discussion, this study spotlights the importance of agricultural value added, foreign direct investment, carbon dioxide emission, economic growth and trade openness in BRICS countries, with the objective of understanding the influence of agriculture value added on other growth, environment and trade variables by using fixed and random effect panel models and cointegration relationships.

The current study covers one of the fastest-growing economies of the world, BRICS: Brazil, Russia, India, China, and South Africa. The gross agricultural production of BRICS is more than 50% of the world's total, which makes this region vulnerable to be studied not only from agricultural production and investment but also from a food security and sustainability point of view (Ren et al., 2020). These geopolitical regions have diverse socio-cultural and economic backgrounds, but the region's most significant and unique feature is that all the nations are halfway towards development. BRICS are traditional economies showing fast and consistent growth rates post-2009; Brazil was steadily showing 6%. China at 8.1% and India at 5.9% (Zakarya et al, 2015). As they are fast-growing, the impact of agriculture value added, trade, environment and international capital flow are more impactful (Akpan et al., 2014). India and China have a significant role in the global production of manufacturing and software, Brazil and Russia are prominent in energy resources and raw materials. South Africa is rich in mineral resources (Kobayashi-Hillary, 2007).

In 2021, BRICS nations attracted 22.45% of the global FDI. In 2021, China attracted the highest amount of FDI inflow, amounting to \$181 billion, followed by Brazil, India, South Africa and Russia, at \$50 billion, \$45 billion, \$41 billion, and \$38 billion, respectively. BRICS nations contributed 16% of global trade, 41% of the global population, and 24% of the global GDP, producing more than one-third of the world's agricultural output. BRICS nations play an important role in assuring agricultural sustainability, global nutritional well-being and food security (BRICS, 2023). Brazil and Russia lead in agricultural production for domestic and international consumption; Brazil have a comparative advantage in crop and livestock production, while Russia has on barley, wheat, potatoes, sunflower seeds and oats; China has a comparative advantage in fish, India and South Africa compliment their comparative advantage in beef, goats and milk production (FAO, 2019). The gaps in their comparative advantage in foodstuffs are filled through inter-BRICS trade (Garidzirai, 2020).

2. REVIEW OF LITERATURE

The development of the agricultural sector gets shared across all other sectors and leads to the prosperity of an economy (Castaneda et al., 2016; Gollin et al., 2002; Schultz, 1964; Singer and Thorbecke, 1971), so, investment in agriculture and allied sector is a prerequisite for economic growth, income generation, industrialisation, food chain and for many upstream activities (Amendolagine et al., 2019; Datt and Ravallion, 1998; Dowrick and Gemmell, 1991; Punthakey, 2020; Schultz, 1964; Thirtle et al., 2003). Agricultural productivity influences food security positively, which creates the same effect on a country's macroeconomic parameters (Costa et al., 2013; Ogundari, 2014; Brümmer et al, 2006). Studies conducted by (Almfraji and Almsafir, 2014 Bilal Khan et al., 2019 Magombeyi et al., 2018 Shamim et al., 2014; Ucal, 2014; Zaman et al., 2012) indicated that FDI established strong linkages, and these linkages are utilised for creating growth. Contrary to the above, studies also indicate that FDI in the primary sector downsizes economic growth in developing countries, which leads to underdeveloped human capital (Alfaro, 2003; Aykut and Sayek, 2007). Increasing agricultural production can lead to environmental concerns, as agricultural activities create considerable pollutants like nitrate, methane and nitrous oxides (Nelson and Maredia, 2001). The share of carbon dioxide emission by BRICS from 2000 to 2020 increased gradually from 26% to 46%, and they are the leading carbon dioxide emitting countries in the world, especially China, India and Russia (Zhang et al., 2019; World Bank, 2023). Literatures established that openness to trade is a pre-requisite for economic growth as it facilitates and leads to higher absorption of knowledge and advanced technologies in developed countries (Romer, 1986; Lucas, 1988; Balassa, 1982).

Climate risk has an important influence on the economic and financial development of BRICS countries, as reflected in Zhang's (2023) study, which indicates that China, India and Russia are vulnerable, and India and South Africa are more sensitive to climate change. Enhancing agrarian development also has its flip side of creating nitrate, ammonia, methane and nitrous oxide pollutants, causing changes in biodiversity, that lead to pollution, ecological imbalance, and climate change (Nelson and Maredia, 2001; Nyiwul and Koirala, 2022). Mitigation measures need a huge credit flow to manage higher agricultural production without compromising the environment. On the one hand, multiple geopolitical events like war, internal and external insurgency, policy changes by international and domestic bodies and on the other hand, environment-induced climate deterioration create significant implications for food production, agricultural supply chain, trade in agriculture, international capital flow and economic growth (Searchinger et al., 2019; Behnassi and El Haiba, 2022; Osendarp et al., 2022; Parker, 2022).

Globalisation led to economic growth and also helped to invest in green technologies, infrastructure, renewable energy and sustainable business practices in BRICS, but the increasing demand for food, energy and resources created higher levels of pollution, deforestation and poor health (Scott et al., 2017). At the same time, these countries are working together to improve green growth by sharing best practices about control mechanisms. BRICS need to focus more on environmental sustainability through policy implementations and stakeholder practices (Ullah et al., 2021). Between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year, from malnutrition, malaria, diarrhoea, and heat stress alone, with a direct cost due to health damage estimated to be between 2 and 4 billion USD per year by 2030 (WHO, 2021). Summary of important literatures are shown in Table 1.

Table 1: Summary of literature review

Authors	Study objectives	Variables	Technique/ Methodology	Study outcomes/findings
Brink et al., 2013	Examines agricultural policy of BRIC through WTO's rules, ceiling, and commitments on domestic economy	--	--	BRIC exhibits different agricultural interests, with dissimilar focus and contributions of this sector to the domestic economy
Balsalobre-Lorente et al., 2019	Examines EKC hypothesis of BRICS from 1990 to 2014	Agricultural activities, energy use, trade openness and mobile use, and environmental degradation.	Dynamic Ordinary Least Squares and Fully Modify Ordinary Least Square regression	Negative impact of agriculture on the environment
Liu et al., 2017	Examines the relationship between renewable energy, agriculture, environment in BRICS from 1992 to 2013	Per capita renewable energy, agriculture, CO_2 emissions, output and non-renewable energy	Panel unit root tests and Panel Cointegration	Per capita output and renewable energy are negatively related to agriculture, and per capita, non-renewable energy and agriculture are positively related to emission
Shah et al., 2022	Agriculture-induced EKC hypothesis in BRICS from 1990 to 2019	Economic growth, agriculture, renewable energy, ICT, human capital, and carbon emission.	Pedroni Cointegration test, Mean Group techniques and Pairwise Granger Causality	Unidirectional relationships from renewable energy to emissions and non-renewable energy, from agricultural value added to output, and from output to non-renewable energy in the short-run.
(Ren et al., 2020)	Food security in BRICS	Food Self-Sufficiency Rate and Food Security Cooperation Potential Index	--	BRICS have achieved food security and food self-sufficiency, which varies with countries and type of food, that demands an alteration on structural food security risks in future
Usman and Makhdum, (2021)	Influence of renewable energy, non-renewable energy, agriculture, forest area and financial development in BRICS and Turkey from 1990 to 2018	Ecological footprint, agriculture value-added, forest area, non-renewable and renewable energy utilization, and financial development	Second-generation panel unit root test, cointegration, long-run elasticity, and causality tests.	1% increase in agriculture enhances ecological footprint by 0.2%, 1% increase in non-renewable energy and financial development produces ecological footprint by 0.5% and 0.04%, respectively, 0.7 and 0.2% reduction in ecological footprint is due to a 1% increase in forestry and renewable energy utilisation, respectively.
Pata, (2021)	Examines the effect of renewable energy in BRIC from 1971 to 2016	Renewable energy generation, globalization, agricultural activities, ecological footprint and carbon dioxide emissions in BRIC countries for the period 1971-2016	Fourier cointegration and causality tests	Globalization increases pollution indicators, while renewable energy generation significantly reduces environmental pressure. Bidirectional causality between agriculture and environmental degradation; unidirectional relationships from globalization to the ecological footprint and CO_2 emissions and renewable energy generation to the ecological indicators.
Garidzira, (2020)	Examines contribution of agricultural production on selected sustainable development goals for BRICS	Economic growth, income inequality, livestock production, crop production, inflation, food imports, and population	Pooled Mean Group	Crop production, livestock production, food import and population growth positively influenced economic growth; inflation negatively influenced economic growth, and livestock production, crop production, and food imports reduced income inequality.
Kilinc-Ata and Dolmatov (2023)	Identifies factors influencing investment on renewable energy in OECD and BRICS	Installed cumulative renewable capacity, per capita GDP, energy consumption,	Generalized moment method, fixed and random effects models,	Economic growth, renewable energy policy, research and development expenditures have a statistically significant and positive relationship

(Contd...)

Table 1: *(Continued)*

Authors	Study objectives	Variables	Technique/ Methodology	Study outcomes/findings
		electricity power consumption, renewable policies, research and development, carbon dioxide emission	panel regression techniques	with renewable energy capacity. Renewable energy investment is inversely related to energy use, electricity use, and carbon emissions.
Jiaduo et al., 2023	Impact study of agricultural employment and technological innovation on the environment for BRICS from 1992 to 2020	Load Capacity Factors, natural resource rent, technological innovation, renewable energy use, agricultural employment	Pooled Mean Group–Autoregressive Distributed Lag	Agricultural employment significantly enhances load capacity factors in the short and long run

Table 2: Results of random effect model

Variables	Random effect			
	Coefficient	Standard Error	t-Statistics	Prob (5% level of Significance)
Intercept	4.27	4.02	1.06	0.29
CO2	470230	803	0.58	0.55
GDP	0.04458	0.00	4.93	0.00
TOP	5.87	4.16	0.14	0.88
IFDI	-1.40	1.86	-0.74	0.45
NFDI	-0.28	0.97	-0.29	0.76

R Square: 0.22, Adjusted R Square: 0.18, Durbin-Watson Stat: 2.01, Prob (F -statistic): 0.00

3. METHODOLOGY, DATA ANALYSIS AND INTERPRETATION OF RESULTS

Data for the variables are collected from the World Bank, World Development Indicators from 2000 to 2022 for BRICS. This period was found to be showing robust growth for all the BRICS countries. Gross domestic product, carbon dioxide emission, trade openness, inward FDI and net FDI are taken as independent variables and agricultural value added is taken as dependent variable. The variable descriptions are shown in Appendix 1. The variables are checked for stationarity, and it is found that all the variables are stationary at first difference. The results of the stationarity checking are shown in Appendix 2. After conducting Panel Ordinary Least Square Regression (OLS), the understanding was to check the suitability of Panel OLS using the Bruch Pegan Test. The values of the Bruch Pegan test indicated that compared with Panel OLS, the Fixed Effect Model or Random Effect Model of identifying the variability and difference among variables, are more appropriate for the data set. Results of the Hausman test indicated that the Random Effect model is appropriate for the study, and the results of the random effect model is shown in Table 2.

Results of the Panel random effect indicate that there is a positive relationship between agricultural value added, carbon dioxide emission, economic growth, and trade openness in BRICS. Inward FDI and Net FDI have negative relations with agricultural value added. Further, from the probability scores, we can understand that the variables carbon dioxide emission, economic growth, and trade openness have a positive relation; it must be noted that they are not significant. Of the three variables, only GDP is positive and significant. This means that agriculture value added is directly, positively and significantly related and dependent on economic growth in all BRICS countries. This result goes in line with the previous results of Patel and Joshi (2023) and Qamruzzaman (2022). A 1% increase in agriculture value added will lead to a 47% increase in CO_2 emission, a 0.04% increase in economic growth, and a 5.9% increase in trade openness. But at the same time, it will also lead to a 1.4% decrease in inward FDI and a 0.28% decrease in net FDI. R square value is 22%, indicating that the explanatory variables are responsible for 22% of changes in agricultural value added in BRICS countries. Even though the regression coefficient is not very high, the model is significant as the F stat is 0.00. This phenomenon takes us into areas that need to be explored to understand the different avenues upon which the contribution of agricultural value added will depend more on BRICS. In order to ensure the long-term association of the tested variables, the Panel Cointegration test is studied. The results of the Pedroni Panel Cointegration Test is shown in Table 3.

Table 3: Pedroni residual panel cointegration test

Model estimates	Statistic	Prob	Weighted Statistic	Prob
Panel V Stat	−1.49	0.93	−1.27	0.89
Panel Rho Stat	−1.05	0.14	−0.91	0.18
Panel PP Stat	−6.60	0.00	−5.96	0.00
Panel ADF Stat	−6.09	0.00	−5.53	0.00
Group Rho Stat	−0.37	0.35		
Group PP Stat	−6.37	0.00		
Group ADF Stat	−5.90	0.00		

Panel Cointegration equation

$$dava_{it} = \propto_1 + \beta 1_i \, dco2_{it} + \beta 2_i \, dgdp_{it} + \beta 3_i \, dtop_{it} + \beta 4_i \, difdi_{it} + \beta 5_i \, dnfdi_{it} + \varepsilon_{it}$$

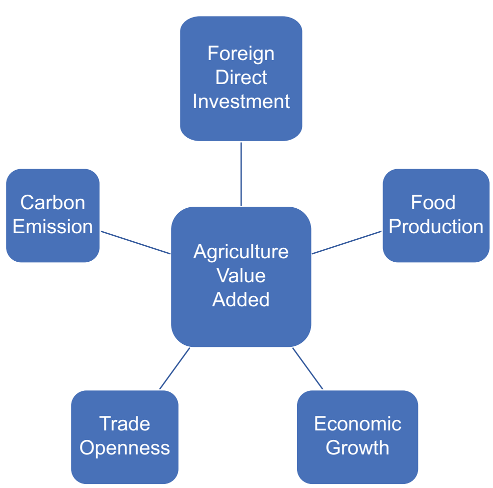
Out of the eleven statistics, six statistics are significant, and five statistics are not significant. Panel PP Stat, Panel ADF stat, Weighted stat of Panel PP and Panel ADF, Group PP and Group ADF stats are significant. As the majority of the values are significant, we need to accept the alternative hypothesis of the presence of panel cointegration and reject the null hypothesis of no cointegration among the variables. From the cointegration analysis, we can understand that. the study variables have long-term equilibrium cointegrating relationships.

After ensuring a long-term relationship among the variables, the causality relationship is checked in order to identify the direction of causality. Pairwise Granger Causality test is conducted, and the results are given in Table 4. Results of causality analysis indicate that agricultural value added causes gross domestic product to be unidirectional, and inward FDI causes trade openness to be unidirectional. The unidirectional relationship between agricultural value added and the gross domestic product goes in concurrence with the results of the random effect model. Other variables do not show any causal relationships and their null hypothesis are accepted.

Table 4: Pairwise panel granger causality test

Null Hypothesis	F Stat	Prob	Causality
CO_2↔AVA	1.65	0.19	Accept
AVA↔CO_2	0.94	0.39	Accept
IFDI↔AVA	0.16	0.84	Accept
AVA↔IFDI	0.00	0.99	Accept
TOP↔AVA	0.03	0.97	Accept
AVA↔TOP	0.09	0.91	Accept
GDP↔AVA	11.5	3.10	Accept
AVA↔GDP	7.37	0.00	Reject
IFDI↔CO_2	2.31	0.10	Accept
CO_2↔IFDI	0.17	0.84	Accept
TOP↔CO_2	0.26	0.77	Accept
CO_2↔TOP	0.16	0.84	Accept
GDP↔CO_2	0.22	0.79	Accept
CO_2↔GDP	1.12	0.33	Accept
TOP↔IFDI	1.29	0.27	Accept
IFDI↔TOP	8.29	0.00	Reject
GDP↔IFDI	0.21	0.80	Accept
IFDI↔GDP	0.14	0.86	Accept
GDP↔TOP	0.02	0.97	Accept
TOP↔GDP	0.01	0.98	Accept

Figure 1: Connections showing the dependency of agricultural value added



4. CONCLUSION, DISCUSSION AND DIRECTION FOR FUTURE RESEARCH

To successfully reduce poverty and overcome food insecurity, agricultural development is essential, which can be successfully achieved through increased agricultural productivity and efficiency with the help of industrial and institutional development (POSTnote, 2006). The objective of this study is to understand the influence of agriculture value added on economic growth, environment and trade variables. Gross domestic product, carbon dioxide emission, trade openness, inward FDI and net FDI are taken as independent variables and agricultural value added is taken as dependent variable. Panel data model using fixed and random effects was decided to study to understand the influence of the different variables. After making the initial data adjustments and ensuring stationarity, the random effect panel model was found appropriate for the data set for BRICS countries for the years 2000-2022.

Results indicate that there is a positive relationship between agricultural value added, carbon dioxide emission, economic growth, and trade openness in BRICS, but, inward FDI and net FDI have negative relations. Only gross domestic product is positive and significant, but, trade openness and carbon dioxide emission are insignificant with agricultural value added. This means that agriculture value added is significantly and positively related to economic growth in all BRICS countries and this is not the case with emission, openness and capital flow. One per cent increase in agriculture value added will lead to a 47% increase in CO_2 emission, a 0.04% increase in economic growth, a 5.9% increase in trade openness, a 1.4% decrease in inward FDI and a 0.28% decrease in net FDI. These results remained the pioneering study of Alfaro (2003), indicating, that the effects of FDI are not uniform but ambiguous across sectors. The Panel Cointegration test indicates the presence of long-term equilibrium relations among the tested variables. The reasons for this relationship, as per the available studies, indicate that primary sector developments are more connected with international policy and development outcomes than national policies (Nayyar and Sen., 1994). As nations trade with those trading countries whose comparative advantages are significant, agrarian investment and development will be more oriented towards the international development scenario.

This study is significant in the current time period from the health and well-being point of view, because the World Health Organisation, in its 2021 study, indicates that from 2030 to 2050, climate change can cause, on a yearly basis, approximately 2,50,000 additional mortality, malnutrition, various communicable diseases, stress, that cost 2-4 billion USD per year (WHO, 2021). Green growth is the solution for ensuring sustainability and environmental responsibility (Wassie, 2020). As mentioned by Suk et al., (2016), there must be adequate realisation of the pollution-related health outcomes among all sections of the public in high and low-income countries. Even though efforts are taken towards control of pollution and ensuring sustainability, they are found to be very meagre in accordance with the emissions. Enhancing the forest cover is one of the solutions, similar to adopting renewable energy sources, suggested to overcome the problems of emissions (Farooq et al., 2019; Zhou et al., 2017; Waheed et al., 2018).

The future developmental prospects of BRICS can be significantly influenced by the use of renewable energy resources, that are abundant in these countries. China is abundant in wind resources, India and South Africa have solar energy; Brazil is bestowed with water resources for generating hydroelectric power; Russia possesses many renewable energy sources (Meisen and Hawkins, 2009; Nautiyal, 2012; Mulaudzi and Bull, 2016; Meisen and Hubert, 2010; Kirsanova et al., 2018; Cherepovitsyn and Tcvetkov, 2017; Pristupa and Mol, 2015). BRICS should come up with a comprehensive plan for sustainable development that can ensure economic development with ecological balance.

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APPENDICES

Appendix 1

Variables Description
Variable Representation Description
Agriculture Forest and
Fishing Value added AVA Agriculture, forestry, and fishing, value added (constant LCU)
Carbondi oxide Emission CO_2 Carbon di Oxide Emission in KT
Economic Growth GDP GDP Constant Local Currency Units
Inward FDI IFDI Foreign direct investment, net inflows (% of GDP)
Foreign direct investment net FDI NFDI Foreign direct investment, net (BOP, current US$)
Trade Openness TOP Exports added to imports and divided by GDP

Appendix 2

Panel Unit Root Test
Variables at level at first difference Summary
AVA 1.00 0.000
CO2 0.73 0.000
GDP 0.97 0.000
TOP 0.06 0.000
IFDI 0.57 0.000
NFDI 0.07 0.000

Author's calculation in EViews, *at 1% level of significance