

## Impact of FDI and energy consumption on the agricultural productivity of BRICS nations

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**Abstract.** *Agricultural development is essential for world trade and the global economy. This research investigates the relationship between Foreign Direct Investment (FDI) and fossil fuel energy consumption with agricultural productivity (AP). The study used the panel data of BRICS nations from 1991-2019. For data analysis, panel regression analysis along with descriptive statistics was used. The study's findings are that FDI and FFEC significantly influence the AP of BRICS nations. The FFEC has a positive influence on the AP, while FDI has a negative influence on the AP of BRICS nations. Further, the results revealed that trade openness and gross capital formation have a weak but significant influence on agricultural productivity.*

**Keywords:** agricultural productivity, BRICS nations, FDI, panel regression analysis, FFEC.

**JEL Classification:** O13, P45, Q14, Q15, Q16.

## 1. Introduction

One of the biggest challenges confronting humanity today is achieving the Sustainable Development Goal (SDGs) of ensuring there is zero hunger (Goal two) by 2030. “Zero Hunger” commits to eradicating hunger while promoting sustainable agriculture, achieving food security, and improving nutrition (UN, 2022). Utilizing and maximizing the capacity of the agriculture sector is one activity that must be taken to achieve these aims. Investment in agricultural production is the best approach to preventing food calamities (Ahmad et al., 2020).

In 2021 BRICS nations attracted 22.45% of the Global FDI. In 2021 China attracted the highest amount of FDI inflow, \$181 billion, followed by Brazil, India, South Africa and Russia, \$50 billion, \$45 billion, \$41 billion, and \$38 billion, respectively (UNCTAD, 2022). BRICS nations contributed 16% of global trade, 41% of the global population, and 24% of the global GDP; these are the most developing economies. BRICS nations produce more than one-third of the world's agricultural output. BRICS nations play an important role in assuring the agriculture sector sustainability, as well as global nutritional well-being and food security (BRICS, 2021). The agriculture sector also supplies raw materials to the manufacturing sector and helps the nations to export agricultural goods to earn foreign exchange. FDI has become a prime focus of all countries around the world because it significantly contributes to economic growth, employment generation, technological innovation, and the development of countries (Edeh et al., 2020; Arif et al., 2022).

Scanty of empirical studies examine the linkage between renewable energy consumption along with FDI on agricultural production (Naseem et al., 2021; Qamruzzaman, 2022). There is no evidence of studies that emphasized the influence of FFEC along with FDI on AP. FFEC represents the energy consumption in the study. The total primary consumption of coal, natural gas, and petroleum are included in FFEC. The present study emphasizes the influence of FFEC on the AP of BRICS nations. The FFEC in agriculture production are used to supply power to mechanical equipment such as tractors and to manufacture fertilizers. Energy use in the agriculture sector can be divided into direct and indirect sources to evaluate consumption. The usage of fuels like diesel and natural gas for agricultural operations would be considered the direct source of energy consumption. The production of agricultural chemicals like pesticides and fertilizers uses fuels like natural gas and diesel, which are indirect sources of energy use.

This study contributes to the existing literature by examining the effect of foreign direct investment along with fossil fuel energy consumption on the agricultural productivity of BRICS nations from 1991 to 2019 by using the panel regression analysis. This study consists of five parts, followed by (1) introduction, (2) review of literature, (3) research methodology, (4) data analysis and interpretation, (5) conclusion, suggestion, and limitations.

## 2. Review of literature

Agricultural development is essential for world trade and the global economy. Numerous of empirical research found a positive impact of FDI on agriculture (Ahmad et al., 2020; Dhahri and Omri, 2020a; Ding et al., 2021; Hasan and Abd-Elmotaal, 2021; Qamruzzaman,

2022; Wang et al., 2019). Dahri and Omri (2020a), Sikandar et al. (2021) employed the panel regression analysis to examine the influence of FDI on agriculture production or development in developing nations. The authors found the significant influence of FDI on agriculture production. Hassan and Abd-Elmotaal (2021), and Alnafissa et al. (2022) analyzed the effect of FDI on agricultural exports with other economic variables in Arab countries and Sudan using the panel regression analysis and two stage least square model. (Ahmad et al., 2020) used the ARDL and Granger Causality test to elucidate the short-run and long-run association between Chinese FDI, CO<sub>2</sub> emissions, and climate change on the growth of agriculture productivity in Pakistan from 1984-2017. The results reveal the significant and positive influence of Chinese FDI on agricultural productivity in both the short and long run in Pakistan. On the other hand, Co<sub>2</sub> emission and climate change have no long-run and short-run associations with agricultural growth in Pakistan.

Qamruzzaman (2022) employed the panel regression analysis and GMM method to investigate the influence of FDI and renewable energy with the moderating effect of carbon emission on agro productivity. The study concluded that the positive and statistically significant influence of FDI and renewable energy on agriculture productivity and carbon emission has mixed effects on agriculture productivity. Wen et al. (2020) measure the effect of the import and export effect of technological agricultural FDI on agricultural products in China by using the OLS and GMM method from 1998-2017. The authors found a significant effect of agricultural FDI on the import and export of agricultural products. Wang et al. (2019) empirically measured the agricultural FDI influence on the growth of agricultural green total factor productivity from 2004-2016 in 24 provinces of China. The authors used the two-step system GMM model for the study. The results demonstrate that agricultural FDI significantly and favourably affects China's agricultural GTFP growth. Using panel data from 1995 to 2018 from 31 developing and 40 least-developed countries, empirical research was carried out on the influence of foreign capital inflow on food production. The study's conclusions show that foreign capital inflow has a favourable and significant influence on developing nations' food production. While in the least-developed nations, foreign capital has a favourable and insignificant influence on food production (Ding et al., 2021). Most of the studies found that FDI is not the only factor that affects agriculture production; there are several other factors also, like the nature and origin of foreign inflow, along with the latest production techniques and effective utilization of resources.

Furthermore, few studies showed a mixed and negative influence of FDI on agricultural production. Santangelo (2018) revealed the beneficial effects of FDI in land by investors from developed countries on cropland and food security. On the other side, FDI on land by investors from developing nations has a negative influence on the food security and cropland of developing nations. Paul et al. (2021) used the OLS, POLS, 2SLS, and GMM methodologies to measure the relationship between FDI, agriculture, and rural development in 46 Asian nations. The findings of the study showed mixed results between FDI, agriculture, and rural development. The Generalized Method of Moments was used by Ju et al. (2022) to analyze the effects of FDI and trade openness on sustainable agriculture in Africa from 2005 to 2019. The findings of their study show that FDI and trade openness have a negative and significant influence on sustainable agriculture.

## 2.1. Research gap

It is evident there is a shortage of literature on assessing the influence of FFEC along with FDI on the agricultural productivity of BRICS nations. Therefore, this study is carried out to fill this gap and to ascertain whether there is an influence of FFEC along with FDI on agricultural productivity.

## 2.2. Objectives and hypothesis of the study

The study aims to examine the influence of FDI and FFEC on the BRICS nation's agricultural productivity. The hypotheses are:

H0: There is no significant influence of FDI and fossil fuel energy consumption on the BRICS nation's agricultural productivity.

H1: There is a significant influence of FDI and fossil fuel energy consumption on the BRICS nation's agricultural productivity.

## 3. Research methodology

### 3.1 Sample and source of data

The data is collected from the world development indicators (WDI) and U.S Energy Information Administration of BRICS nations. The study's time frame is from 1991 to 2019.

### 3.2. Variables of the study

These are the following variables of the study (Table 1):

**Table 1.** Variables of the study

Abbreviation	Variable Description	Variable Type	Sources
AP	Agricultural productivity is computed as an agricultural value added as a % of GDP per capita (Qamruzzaman, 2022; Yao et al., 2020).	Dependent Variable	World Development Indicators (WDI)
LNFDI	Log of Foreign direct investment into economies at current US\$ (Hassan and Abd-Elmotaal, 2021).	Independent Variable	World Development Indicators (WDI)
FFEC	Fossil Fuel Energy Consumption is computed as a % of total energy consumption (Rath et al., 2019).	Independent Variable	U.S Energy Information Administration
TO	Trade Openness is measured as the sum of export and import as a % of the GDP (Hassan and Abd-Elmotaal, 2021).	Control Variable	World Development Indicators (WDI)
GCF	Gross Capital Formation in economies as a % of GDP per capita (Qamruzzaman, 2022).	Control Variable	World Development Indicators (WDI)

**Source:** Author's compilation.

### 3.3. Regression model

The cross-section and time series dimensions are constructed for the panel data in this research. The study considers the 29-year balanced panel data of BRICS nations. Therefore, the panel data model is used. The regression model of the study is given below:

$$AP_{i,t} = \beta_0 + \beta_1 LNFDI_{i,t} + \beta_2 FFEC_{i,t} + \beta_3 GCF_{i,t} + \beta_4 TO_{i,t} + \varepsilon_{i,t}$$

In the above regression model, (i) indicates the individual country, (t) represents the time, and ( $\varepsilon$ ) represents the error term in the model.

## 4. Data analysis and interpretation

### 4.1. Descriptive statistics

The results of the descriptive statistics of the study highlight that the average growth rate of agricultural productivity in BRICS nations is 9.153% annually (Table 2). The average FDI inflow in BRICS nations is 23.171%. The average FFEC in BRICS nations is 86.145% of total energy consumption, which indicates higher consumption of FFEC in BRICS nations. The maximum and minimum value of FFEC in BRICS nations is 98.386% and 56.982%. The average GCF and TO are 26.268% and 41.114% in BRICS nations, respectively.

**Table 2.** Descriptive statistics of variables

	AP	LNFDI	FFEC	GCF	TO
Mean	9.153	23.171	86.145	26.268	41.114
Median	5.751	23.622	90.796	22.615	42.301
Maximum	27.662	26.396	98.386	46.660	110.577
Minimum	1.926	15.026	56.982	14.161	15.635
Std. deviation	7.155	1.993	13.341	9.695	15.054
Observations	145	145	145	145	145

**Source:** Author's compilation.

### 4.2. Correlation matrix

The result of the correlation matrix displayed the degree of relationship between the independent and dependent variables (Table 3). FFEC and GCF ( $r = 0.230$ ,  $r = 0.569$ ) have a positive degree of correlation with AP; on the other hand, LNFDI and TO ( $r = -0.007$ ,  $r = -0.303$ ) have a negative degree of correlation with AP. The findings also show no issue with multicollinearity among the independent variables because the correlation between them is less than 0.80 (Kennedy, 1985).

**Table 3.** Correlation matrix results

	AP	LNFDI	FFEC	GCF	TO
AP	1.000				
LNFDI	-0.007	1.000			
FFEC	0.230	-0.227	1.000		
GCF	0.569	0.514	0.327	1.000	
TO	-0.303	0.036	0.585	0.131	1.000

**Source:** Author's compilation.

### 4.3. Random effects model

The result of the random effect panel model (Table 4). Selected the best model between random effects and fixed effects panel models; the Hausman specification test is used for empirical analysis (Yao et al., 2020). The result of the Hausman test shows that the chi-square value is insignificant at a 5% level of significance, and the null hypothesis is approved random effects model is selected over the fixed effects model (Gupta and Singh, 2016). AP is the explained variable, and LNFDI and FFEC are the explanatory variables of the model. The result of random effect models displays the influence of FFEC and FDI on the AP with control variables in the study. Table 4 displays  $R^2$  value of the model as 0.624; this shows that the model explained the AP is 62.4%. The relationship between foreign direct investment inflow and agricultural productivity is negative but significant at a 5%

level of significance in BRICS nations; the results of the random effects model are supported by (Santangelo, 2018; Naseem et al., 2021; Ju et al., 2022). This shows that when there is a 1% in FDI, this leads to a -1.09% decrease in AP of BRICS nations.

**Table 4.** *Random effects model results*

Variables	Random Effect	
	Coefficient	Std. Errors
Intercept	20.212 <sup>*</sup> (2.763)	7.315
LNFDI	-1.099 <sup>*</sup> (-4.148)	0.265
FFEC	0.124 <sup>*</sup> (2.814)	0.044
GCF	0.531 <sup>*</sup> (9.651)	0.055
TO	-0.248 <sup>*</sup> (-7.649)	0.032
R <sup>2</sup>	0.624	
Adjusted R <sup>2</sup>	0.613	
F-Statistic	0.000	

**Notes:** (\*) indicates the model is significant at a 5% level of significance. The parenthesis with the coefficient value displays t-statistics.

**Source:** Author's compilation.

The relationship between FFEC and the agricultural productivity of BRICS nations is significant and positive at a 5% level of significance; this demonstrates the positive influence of energy consumption on the growth of agricultural productivity of BRICS nations (Qamruzzaman, 2022). The 1% increase in the consumption of fossil fuel energy results in a 0.12% increase in the agricultural productivity of BRICS nations. Gross capital formation also has a positive and significant relationship with agricultural productivity in BRICS nations at a 5% significance level. With a 1% increase in gross capital formation in BRICS nations, the AP increased by 0.53%. There is a negative and significant relationship between trade openness and the agricultural productivity of BRICS nations at a 5% significance level. The 1% increase in trade openness results in a -0.24% decrease in the agricultural productivity of BRICS nations (Ju et al., 2022). The study's null hypothesis is rejected because FDI and FFEC significantly influence the AP at a 5% level of significance. The alternative hypothesis of the study is accepted that there is a significant influence of FDI and FFEC on AP of BRICS nations. Therefore, it can be said that fossil fuel energy consumption is the most important variable of the study for the agricultural productivity of BRICS nations.

## 5. Conclusion, suggestions and limitations

This study measured the influence of fossil fuel energy consumption and foreign direct investment on the agricultural productivity of BRICS nations. The objective of this research was to measure the influence of FDI inflow and FFEC on the agricultural productivity of the BRICS nations from 1991 to 2019 by using the panel regression analysis. The results of the Hausman specification tests display that the random effect model of panel regression analysis is considered the most appropriate model for the empirical analysis of variables. The outcomes of the random effect model indicate that both FDI and fossil fuel energy consumption have significant effects on the AP of BRICS nations. This research reveals the negative relationship between FDI and AP of BRICS nations. This may be due to farmers are not ready to accept modern technologies, imported seeds, and funds from

foreign investors in AP. While on the other hand, there is a positive impact of FFEC on the AP of BRICS nations. The consumption of fossil fuel energy in the production process of BRICS nations increases the output of agricultural productivity.

This research further revealed a significant relationship between the control variables of the study (GCF & TO) and AP. GCF has a positive and significant impact on the AP of BRICS nations, while TO has an adverse and significant impact on the AP of BRICS nations. Trade openness has a negative influence on the AP, so policies that increase local output and promote exports should be supported. At last, this study can conclude that both FDI and fossil fuel energy consumption have significant effects on the AP of BRICS nations. After reviewing the earlier study, this research also reveals that FDI and FFEC is not the only factor affecting agriculture production; there are several other factors, like the nature and origin of foreign inflow along with the latest production techniques, urbanization, renewable energy consumption, and effective utilization of resources.

This study recommends that policymakers should focus on the use of fossil fuel energy consumption and gross capital formation to increase the AP of BRICS nations. The use of FFEC in agriculture production can increase the level of GHGs emissions. So, policymakers first frame adequate policies related to controlling the level of GHGs emissions due to FFEC. This study is limited to BRICS countries. Further studies can be carried out on Asian countries, developing countries, and developed countries to get more insight into the effect of FDI and FFEC on the AP globally. Further research can also focus on the use of renewable energy consumption along with fossil fuel energy consumption to measure the impact on AP.

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