Eurasian Journal of Economics and Finance, 8(3), 2020, 154-167
DOI: 10.15604/ejef.2020.08.03.003

EURASIAN JOURNAL OF ECONOMICS AND FINANCE

www.eurasianpublications.com

THE CONTRIBUTION OF AGRICULTURAL PRODUCTION ON SELECTED SUSTAINABLE DEVELOPMENT GOALS IN THE BRICS: A PANEL ANALYSIS

Rufaro Garidzirai
Walter Sisulu University, South Africa
Email: rgaridzirai@wsu.ac.za

Received: June 2, 2020 Accepted: August 22, 2020

Abstract

Does agriculture contribute to Sustainable Development Goals in the BRICS countries? This question remains one of the unanswered questions in the academic arena. Thus, an examination of this question is crucial. Accordingly, the objectives of the study are twofold. The first objective was to examine the contribution of agriculture on economic growth in the BRICS bloc. The second objective was to investigate the contribution of agriculture on income inequality. The study employed Pooled Mean Group over a period 1995-2018 and found that agriculture production contributes to economic growth and reduces income inequality in the BRICS countries. All the variables met the expected priori and the study confirmed that all the disequilibrium in the short-run could be corrected in the long-run. Therefore, the BRICS government should strengthen the agricultural sector since it is one of its strongholds sector.

Keywords: Agriculture, Sustainable Development Goals, BRICS, Pooled Mean Group

JEL Classifications: F62, O11, O13

1. Introduction

The number of people who are food insecure keeps on rising globally each and every year. This notion is illustrated by a rise in the food insecure statistics from 770 million in 2015 to 821 in 2018 (Food and Agriculture Organization, 2019). Today, 1 in every 9 people is hungry which makes it almost impossible for emerging and developing countries achieve the Sustainable Development Goal (SDG) number 2 of zero hunger by 2030 (United Nations, 2020). Since the hunger problem is multidimensional, it has also compromised the SDGs 8 and 10 of sustainable economic growth and reduced inequality (Fonseca *et al.* 2010). For instance, the study population (BRICS) economic growth is averaged at 4 percent, which is significantly lower than the envisioned 7 percent (United Nations, 2020). Furthermore, the income inequality (46 percent) in the bloc is significantly high (World Bank, 2020). The sad reality is that the above sustainable development goals are still to be worsened by the global pandemic of corona virus. Despite these challenges, agriculture is envisioned to contribute to economic growth and reduced inequality since it is the backbone of every economy. Notable is that there is more need for sustainable agriculture since population continues to grow. Therefore, more emphasis should be put on improving crop and livestock production in an attempt to tackle multiple SDGs.

Since agriculture is envisaged to promote Sustainable Development Goals, one cannot overlook the role it plays in our daily lives. For instance, agriculture is the catalyst to food security, which is a right of every citizen (Calicioglu *et al.* 2019; Linderhof *et al.* 2019). In a quest to provide food, the sector is one of the mainstay of employment globally contributing about 28 percent to the global employment (Agrivi, 2020). In return, the employees are rewarded with income above the minimum wages and this tends to close the income inequality. In addition to food security, employment and income, the agriculture sector acts as the main source of raw materials to other key economic sectors (Pfunzo, 2017). Furthermore, the sector provides foreign currency through exports sales. Against this background, the agriculture pessimists argued that the main contribution of agriculture is only evident in ensuring food security and all other functions can be transferred to service sector such as manufacturing and tourism (Gardner, 1969; Mackie, 1964). This notion stirred an unending debate on the role of agricultural sector to multidimensional socio-economic goals. Thus, a bulk of studies were done to test the notion shared by Gardner (1969) and Mackie (1964).

Contemporary studies such as Chakravorty and Naraparaju (2019); Khan *et al.* (2014); Odusola (2017); Tahamipour and Mahmoudi (2018) have reached a consensus that agriculture is one of the key sectors that contribute to macroeconomic objectives. On the other hand, studies such as Garidzirai and Pasara (2020); McArthur and Sachs (2019); Severini *et al.* (2019) subscribe to the idea that modern sectors such as manufacturing sector are the major contributors to economic growth and inequality. Though the debate exists, the agro-optimists have bemoaned the scarcity of evocative academic inquiry into the contribution of agriculture to Sustainable Development Goal 8 and 10. To a greater extent, the empirical literature on the contribution of agriculture has generalized agriculture and lacked depth leading to research gaps within the agriculture and sustainable development goals (Bekun and Akadiri, 2019; Richards *et al.* 2015). Furthermore, the empirical literature is critiqued to be inadequate and centralistic.

Due to inconsistences in the literature, this study seeks to make three contributions. First, there is little/no evidence of agriculture and SDGs studies in the BRICS countries. The few studies done are individual country-based. Thus, according to researcher's knowledge, there is no study that examined the contribution of agriculture to economic growth and inequality. Second, studies that have examined the relationship between agriculture and Sustainable Development Goals have focused on agricultural productivity and agriculture value added as proxies of agriculture. However, this study takes a different route by focusing on two major agriculture subsectors: crop production and livestock production. Lastly, the study contributes to two Sustainable Developmental Goals literature: economic growth and inequality. Majority of the studies on agriculture focused more on poverty alleviation and agricultural productivity and less of inequality and economic growth. Therefore, the aim of this study is to examine the contribution of agriculture to economic growth and inequality in the BRICS countries.

The rest of the paper is organized as follows: Section 2 provides stylized facts on BRICS economies, while Sections 3 discusses the literature review. Section 4 presents the data and methodology of the study and Section 5 discusses the empirical results of the study. Lastly, Section 6 concludes and provides the recommendations of the study.

2. BRICS stylized facts

BRICS is an amalgamation of five countries namely Brazil, Russia, India, China and South Africa (Guillotin, 2019). The formation of this bloc was to pursue cultural, economic, political and commercial collaboration within the BRICS countries (Mazenda 2016). At the heart of this bloc is the quest to solve socio-economic challenges facing their countries. This includes poverty, stagnant economic growth, inequality and hunger. Worth mentioning is that the bloc is dominated by high-income inequality. The World Bank (2020) reports an average of 0.46, which is significantly high comparing with other blocs such as Organization for Economic Co-operation and Development (OECD). South Africa and Brazil have significantly high inequality rates in the bloc and currently these countries at sitting at 0.69 and 0.59 respectively (OECD, 2019). On the other hand, China, Russia and India have low-income inequality in the bloc. In line with the income inequality, Rodgers (1983) claims a positive relationship between population growth and high

income inequality and remarkably the bloc constitutes more than 40 percent of the world`s population (Ren *et al.* 2020).

BRICS bloc contributes about 30 percent of the world's GDP (World Bank, 2019). This implies that BRICS countries economically compete with the rest of the world such as OECD (Abdou and El Adawy, 2018). Among the BRICS countries, China is the highest contributing country with an average economic growth of 7.1 percent per year, which is above the target of the Sustainable Development Goal number 8 (United Nations, 2020). India is the second growing economy averaging about 4 percent yearly (Macrotrends, 2020). It is specializing in the ICT sector that tends to boost the economy. On the other hand, Brazil and Russia are the least growing economies in the bloc. Both countries' average economic growth is below 1 percent, which worsens the socio-economic challenges. Against this backdrop, agriculture is envisaged as the catalyst to both economic growth and income inequality.

Ren *et al.* (2020) report that the BRICS agricultural production accounts to more than 50 percent of the world's agriculture production. Ren *et al.* (2020) further mention that Brazil and Russia are the leading countries in agriculture production for both local and international consumption. Of note Brazil has comparative advantage in both crop and livestock production. For crop production, the country relies with the food oil, orange juices and soybeans while chicken and beef are the main livestock production in the country (FAO, 2019). Russia has a comparative advantage in barley wheat. Potatoes, sunflower seed and oats (FAO, 2019). These products are mostly done in a small scale. As shown in the Table 1, India, China and South Africa exports common crops such as wheat, sugar and fruits. China has a comparative advantage in fish while India and South Africa share the advantage in the beef, goats and milk production (FAO, 2019). Worth mentioning is that these countries trade with each other and countries import foodstuffs that they do not have comparative advantage in for food security.

Table 1. Agricultural production in the BRICS bloc

Brazil	Russia	India	China	South Africa
Crop production				
soybean	wheat	cotton	fruits	citrus fruits
coffee	barley	rice	rubber	maize
orange juice	sunflower seed	sugar	cotton	sugar
	oats	corn	oils	wheat
	potatoes	wheat	vegetable	
Livestock production				
beef	fish	beef (buffalo)	fish	sheep
poultry	seafood	goat		cattle
cattle semen	dairy	animal casing		goats
	eggs	milk		ostrich

Source: Food and Agriculture Organization (2019)

3. Literature review

3.1. Inequality and agriculture

Findeis and Reddy (1987) examined the role of agriculture sector on rural households in the United States to assess whether agriculture has a role to play on reducing inequality and found a positive impact on income inequality. After some decades, Ayinde *et al*. (2012) examined the impact of agriculture on income inequality in Ekiti state, Nigeria. The study used regression analysis and descriptive statistics and found that agriculture widens the income inequality. The difference between these two studies is that in Nigeria, agriculture plays a crucial role in reducing inequality only in the rural areas whereas in the United States agriculture was found to be insignificant. One can conclude that the role of agriculture depends with the geographical setup.

Using a panel regression analysis, Odusola (2017) investigated the effects of agriculture on poverty and inequality in Sub-Saharan countries. The results reveal that 1 percent increase in agriculture activities reduces income inequality by 0.7 percent. Similar result was obtained by Severini *et al.* (2019), who used stochastic simulations to examine the relationship income

inequality and agriculture in Italy. The authors found that farmers who used income stabilizers managed to reduce income inequality compared to those who did not use income stabilizers. Severini *et al.* (2019) reached at this conclusion after some simulations that included about 2,800 farmers. These two studies share the same sentiments that agriculture can improve income gap between the rich and the poor when it is well harnessed.

An interesting result was found by Ceddia (2019) who used the used the multivariate models to investigate the relationship between agricultural productivity and inequality in 10 Latin American countries from 1990-2010 and found that income inequality causes an increase in the agriculture productivity. These results are opposed by Chakravorty and Naraparaju (2019), who found a negative relationship between agriculture activities and income inequality in India. The study used the regression-based models. Diverting from agricultural production to inflation, Siami-Namini and Hudson (2019) examined the impact of inflation on income inequality in both developing and developed countries from 1990-2014 and used panel data and found that inflation is an important determinant of income inequality. Thus, there is bi-directional granger causality between inflation and income inequality in both the developing and developed countries. Chee-Hong and Soon (2020) confirmed that inflation increases the income inequality in both developing and developed countries. The study reached this decision after employing the generalized method of moment. Ciani (2017) investigated the link between income inequality and food import using a heterogeneous trade model and found a positive relationship between income inequality and food imports. The same finding was found by Otsuka (2013) argued that food imports will solve hunger, create more income via the multiplier process and eventually solve income inequality.

3.2. Economic growth and agriculture

Awokuse (2009) examined the impact of agriculture on economic growth in developing countries. The study employed panel data analysis and found that agriculture positively influences economic growth in developing countries. Using time series data, Khan *et al.* (2014) also examined the relationship between agriculture and economic growth in Pakistan from 1981-2005. The study found that agriculture plays a crucial role in promoting the Sustainable Development Goal 8. A different result was found by Tahamipour and Mahmoudi (2018), who examined the effects of agriculture on economic growth in Iran over a period 1991-2010. The study employed the Solow residual model and found a negative relationship between agriculture and economic growth. Thus, a 1 percent increase in agriculture leads to 0.72 percent decrease in the economic growth.

McArthur and McCord (2017) examined the role of crop production on economic growth and found that crop production has a crucial role to play on economic growth. McArthur and McCord (2017) used simulations and found that crop production positively affects economic growth. Furthermore, Richards *et al* (2015) investigated the effect of crop production on economic growth in Mato Grosso. The study used some simulations and found that crop production creates employment and improves economic growth. Richards *et al* (2015) further propound that crop production creates raw materials to other non-agricultural sectors. McArthur and Sachs (2019) posed a question whether agriculture leads to economic growth in Africa and employed some simulations and found that agriculture has a crucial role to play on economic growth though the contribution is small compared to other sectors. On the other hand, a study done in Southern Africa found that agriculture has a crucial role in its economic growth (Bekun and Akadiri, 2019). The authors reached this decision after employing a panel data approach to investigate the role of agriculture on poverty alleviation and economic growth in nine countries in Southern Africa over a period 1990-2015.

United Nations (2014) examined the role of livestock production on the economy. The study found that livestock demand is increasing leading to employment of households and this improves economic growth especially in the developing countries. Birthal and Rao (2004) share the same sentiments of the United Nations (2014) that livestock production improves food security, generates employment and income that improves economic growth. Kavallari *et al*. (2014) argued that a country could not produce all the food it desires; rather countries should import certain foodstuffs. The authors, therefore, examined the relationship between food import

and economic growth in both the developed and developing countries using simulation (Kavallari *et al.* 2014). The results of the study reveal that developing countries tend to import more than developed countries and this has increased the economic growth. Same results were found by Jaworski (2018) and Liefert *et al.* (2019), who reached a consensus that food import ensures food security, increases government expenditure that improves economic growth through the multiplier effect in Russia and Unites States.

An econometric analysis by Chowdhury and Hossain (2018) examined the association between population growth and economic growth in Bangladesh from 1979-2017. The authors found that population growth improves economic growth but the economic growth cannot lead to economic development. These results were confirmed by Peter and Bakari (2018), who studied the impact of population growth and economic growth in African countries. Peter and Bakari (2018) used panel data analysis and found that population growth has a positive impact on economic growth. Svigir and Josipa (2017) examined the association between economic growth and inflation in Italy and Austria from 1989-2016 and found that inflation is one of the important determinants of economic growth in both countries. In the same year, Nkikabahizi *et al.* (2017) studied the impact of inflation on economic growth in Rwanda from 2000-2015. The study used time series analysis and found a negative relationship between inflation and economic growth. Thus, an increase in inflation leads to a decrease in the economic growth.

4. Data and methodology

Data properties and the research methodology were discussed in this section. The following section gives data properties in detail.

4.1. Data description

The study used a quantitative approach to examine the contribution of agricultural production on two Sustainable Development Goals. The data used was sourced from the World Bank database development indicators. The data employed in this study is over a period 1995-2018. The study used two dependent variables and six independent variables. Economic growth and income inequality were used as dependent variables representing the SDGS goals while livestock production, crop production, inflation, food imports, and population were used as independent variables. Economic growth was measured by GDP per capita which is the number of goods and services produced in a country taking into consideration of the population of that country (Dynan and Sheiner, 2018; Sulaiman and Abdul-Rahim, 2019). The second dependent variable is income inequality measured by Gini coefficient. Peterson (2017) defined Gini coefficient as the statistical measure of income in the nations or provincial residents. Several researchers have also used Gini coefficient as a measure of income inequality (Leve and Kapingura, 2019; Naceur and Zhang, 2016).

Crop production was measured using all the production of crops relative to the base period 2004-2006 (World Bank, 2020). This measure is in line with the empirical literature (Yu *et al.* 2019; Huang and Ding, 2016). Since crop production ensures food security, employment and income, the variable is expected to have a positive relationship on economic growth and an inverse relationship with income inequality. Likewise, livestock production is also expected to have a positive relationship on economic growth and inverse relationship with income inequality. Livestock production was measured by all dairy and meat products (FAO, 2020). This measure is in accordance with the empirical literature (Duguma and Debsu, 2019; World Bank, 2020).

Food imports were measured by the movement of food products from one country to another (FAO, 2019). This includes all the products that are not readily available in that country. The study expects food imports to positively influence economic growth and negatively influence income inequality. Inflation was measured by Consumer Price Index (CPI) which is a measure of all the changes in the prices of basic commodities such as agricultural products measured yearly (World Bank, 2020). This measure is in line with the empirical literature (Hatmanu *et al.* 2020; Demir, 2019). The coefficient of CPI is expected to negatively influence both economic growth and income inequality. A fall in the purchasing power reduces the number of goods and services

produced, thus, decreasing economic growth and the gap between the rich and the poor. The last independent variable used in the study is population growth rate measured by the rise in the number of people in a population (Peterson, 2017). This measure is in accordance with the existing literature and the coefficient of population is expected to positively influence economic growth and income inequality (Pegkas, 2018).

Prior to the actual methodology, panel unit root tests were performed. The unit root tests were performed to determine the whether the variables understudied are stationary; ascertain the order of integration and appropriate methodology to employ. In achieving these aims, the empirical literature has prescribed two main panel unit root tests: Levin *et al.* (2002) and Im *et al.* (1997). The rule of thumb is to reject the null hypothesis of unit root when the probability value is more than 10 percent.

4.2. Methodology

The study objectives are twofold. First, the study examines the contribution of agriculture on economic growth in the BRICS bloc. Second, the study examined the contribution of agriculture on income inequality in the BRICS bloc. In line with the objectives of the study, two specifications were used namely the economic growth and income inequality using the PMG that was developed by Pesaran *et al* (1999). The PMG model pools and averages the individual estimates in the short-run to the extent that the coefficients do differ across individual countries (Moyo and Le Roux, 2019). On the other hand, the long-run coefficients are assumed homogenous across the individual countries (Pesaran *et al.* 2001). This model is unique since it is the only model that allows variables to be integrated at different levels: a mixture of 1(0) and 1(1). Other techniques allow variables integrated at the same order. Furthermore, the PMG model assumes the absence of serial correlation and exogeneity (Samargandi *et al.* 2015). To check the robustness of the results, the study also compared the PMG results with the Mean Group (MG) and Dynamic Fixed Effect (DFE). For robustness checks, the results of PMG should not differ much with the results of the MG and DFE. To achieve that, a Hausman test was used to select the appropriate method to employ. The rule of thumb is to accept the null hypothesis and conclude that PMG is consistent, appropriate and efficient.

The PMG equation is shown in equation:

$$y_{it} = \sum_{v=1}^{l} \lambda_i y_{i,t-j} + \sum_{v=0}^{j} x_{i,t}\, \delta_{i,j} + \alpha_i + \varepsilon_{it} \quad t = 1, 2, T \ldots\ldots N \tag{1}$$

where y_{it} is a dependent variable, while λ_i represents parameters and $x_{i,t}$ represents explanatory variables. The short-run analysis is shown in the equation 2:

$$\Delta y_{it} = \emptyset_i y_{i,t-1} + x_{it}\beta_i \sum_{v=1}^{i} \lambda_i \Delta y_{i,t-j} + \sum_{v=0}^{j} \Delta x_{i,t}\, \delta_{i,j} + \alpha_i + \varepsilon_{it} \tag{2}$$

where ε_{it} is independent and normally distributed, while α_i represents the error correction term. The error correction term is negative and will converge to equilibrium at a specific point in time.

For the purpose of this study, two long-run equations were formulated as follows. The following equation represents the economic growth specification.

$$GDP_{it} = \beta_0 + \beta_1 Crop_{it} + \beta_2 livestock_{it} + \beta_3 pop_{it} + \beta_4 f\_import_{it} + \beta_5 CPI_{it} + \alpha_{it} + \varepsilon_{it} \tag{3}$$

where GDP is the economic growth in the BRICS nations, Crop is the crop production, pop is the population growth in the BRICS, f_import is the food import in the BRICS nations and CPI is the inflation rate in the BRICS country. α_{it} and ε_{it} represent country specifications and the error term respectively.

Equation 4 represents the income inequality equation.

$$gini_{it} = \beta_0 + \beta_1 crop_{it} + \beta_2 livestock_{it} + \beta_3 pop_{it} + \beta_4 f\_import_{it} + \beta_5 CPI_{it} + \alpha_{it} + \varepsilon_{it} \tag{4}$$

where $gini$ is income inequality (dependent variable), crop is the crop production, livestock is the livestock production in the BRICS countries, pop is the population growth, f_import is the food import in the BRICS nations and CPI is the inflation rate in the BRICS countries.

5. Empirical results

5.1. Descriptive statistics

This section presents and discusses the descriptive statistics used in the study and the results are shown in Table 2. Table 2 shows an average of crop production and livestock production as 105 percent and 102 percent respectively. Thus, the crop production and livestock production is dominant in the BRICS bloc. The Gini average is 46 percent implying that the income inequality in the BRICS country is high especially in South Africa and Brazil. Interestingly, the population growth rate (19 percent) percent is growing more than the economic growth (4 percent).

Table 2. Descriptive Statistics

Variable	Mean	Maximum	Minimum	St.Dev	No.Observ
gini	46.16139	64.80000	34.00000	9.999330	101
GDP	3.981674	13.63634	-7.827755	3.955272	101
Crop	105.3274	160.5500	65.58000	22.57509	101
F_imports	7.587597	23.19625	2.492320	4.879689	101
pop	19.24672	63.88856	7.617737	19.70138	101
livestock	102.4236	152.7100	62.21000	20.69316	101
trade	42.81761	72.86539	15.63559	14.29978	101

Source: Own compilation

5.2. Panel unit root results

Table 3 illustrates the results of the panel unit root tests with the intercept and trend option. The results show that crop production, food imports and economic growth are stationary at level since their probability values are less than 10 percent. Thus, the decision is that these variables are integrated at 1(0). Conversely, population growth, Gini, inflation and livestock production were found not to be stationary at levels and were tested at difference and found to be stationary at 1(1).

Table 3. Panel unit root testing

Variable	LLC	IPS	Decision
crop	-1.36972*	-1.16335	1(0)
F_imports	-2.85724***	-1.37870*	1(0)
pop	-0.28014	0.68608	
D(pop)	0.38998***	0.67390**	1(1)
GDP	-2.75403***	-1.53388*	1(0)
gini	1.59430	1.60340	
D(gini)	-0.43379	-1.40229	1(1)
livestock	-0.44229	1.85583	
D(livestock)	-3.09262***	-1.84227**	1(1)
trade	-0.38059	-0.08845	
D(trade)	-1.88015**	-2.53141***	1(1)

Note: *, ** and ** represents 10%, 5% and 1% level of significance.
Source: Authors compilation

Since the variables are a combination of 1(0) and 1(1) the Pooled Mean Group (PMG) is deemed appropriate (Garidzirai and Muzindutsi, 2020; Pesaran *et al.* 2001). Thus, the next section discusses the methodology employed in this study.

5.3. Cointegration analysis results

Table 4 reports the results of all seven cointegration tests using the Pedroni option. The results reveal that 5 of the seven tests are statistically significant at 5 percent and 1 percent level of significance. Kao (1999) further claims that the null hypothesis of no cointegration can be rejected if at least four of the seven tests are significant. Following this analogy, one can conclude that a long-run relationship exists among the variables under study.

Table 4. Cointegration results

Variables	Without trend	With trend
Panel v stat	-1.538391	-0.642756
	(0.9380)	(0.7398)
Panel rho stat	-0.187763	0.571336
	(0.0045)***	(0.0716)**
Panel PP	-4.42703	-2.696895
	(0.0000)***	(0.0035)***
Panel ADF	0.154456	-1.700722
	(0.0561)**	(0.0445)**
Between Dimension		
Group rho stat	1.345795	0.609285
	(0.0000)***	(0.0000)***
Group PP stat	-2.434268	-0.519532
	(0.0075)***	(0.0862)*
Group ADF Sta	-0.956389	0.195188
	(0.1694)	(0.1976)

Note: Figures in the parentheses ( ) are p-values while *, ** and *** represent 10%, 5% and 1% level of significance respectively.

Source: Authors compilation

5.4. Long-run analysis

Since cointegration results confirm the existence of long-run relationship, the subsequent section discusses the long-run results. Table 5 illustrates the PMG, MG, DFE and Hausman results. The Hausman tests show a Chi-square probability value of 0.6981 that is greater 0.10. Thus, the Hausman tests confirms that the PMG is preferred to MG and DFE because it is efficient, accurate and consistent. Therefore, the analysis of this study employed the PMG model. Remarkable is that the results for all these estimators are not different and this confirms the robustness of the study's results.

Table 5. Economic growth model

Variables	PMG	MG	DFE	Hausman test
Crop	1.213307	0.170184	0.129173	
	(0.0000)***	(0.0619)*	(0.0919)	
livestock	0.412040	0.308710	0.239810	
	(0.0000)***	(0.0029)***	(0.0719)	
F_imports	0.279380	0.202981	0.129870	
	(0.0689)*	(0.0891)	(0.1093)	
inflation	-0.781039	0.610938	0.209818	
	(0.0281)	(0.0139)	(0.0718)	
Pop	0.590193	0.319378	0.108620	
	(0.0178)**	(0.0718)*	(0.2019)	
Haus test				2.20
				(0.6981)

Note: Figures in the parentheses ( ) are p-values while*, ** and *** represents 10%, 5% and 1% level of significance respectively.

Source: Authors compilation

The results (PMG model) in Table 4 illustrate that crop production is statistically significant at 1 percent and positively contribute to economic growth. Thus, a 1 percent increase in the crop production increases economic growth by 1.21 percent. In other words, an increase in crop production implies an increase in employment, food security and income that all contributes positively to economic growth (Bekun and Akadiri, 2019; Tahamipour and Mahmoudi, 2018). This is also true for livestock production that an increase in livestock production improves economic growth by 0.41 percent. This variable met the expected priori and it was found significant at 1 percent. These results are in line with the findings of McArthur and Sachs (2019). Furthermore, food import was found to be statistically significant at 10 level and positively influencing economic growth. Hence, a 1 percent increase in the food import improves economic growth by 0.28 percent. This is in synch with the studies done by Liefert *et al.* (2019) and Bekun and Akadiri, (2019). Likewise, population growth was positively related to economic growth and statistically significant at 5 percent level of significance. This means that an increase in the population growth by 1 percent increases economic growth by 0.59 percent. Peter and Bakari (2018) also found similar findings. Conversely, inflation was found to be significant and inversely related to economic growth. Thus, a percent increase in inflation reduces the economic growth by 0.78. The notion behind this result is that inflation erodes the purchasing power of consumers thereby reducing consumption, aggregate demand and eventually economic growth. This is in line with the studies done by Svigir and Josipa (2017) and Nkikabahizi *et al.* (2017).

Table 6 illustrates the income inequality model results. According to Table 6, the effects of crop production has a negative impact on income inequality. The result has an expected priori and it is statistically significant at level 1. Therefore, a 1 percent increase in crop production reduces inequality by 0.49 percent. Crop production provides employment and income that reduces the gap between the rich and the poor. The result is in synch with the findings of Severini *et al.* (2019) and Odusola (2017). Similarly, livestock production was found to be statistically significant at 1 percent and inversely influencing income inequality. The results have an expected priori and an increase in livestock production provides income that minimizes the gap between the rich and poor. Same results were obtained by Yang *et al* (2020) and Carr *et al* (2016).

The expected priori of food import has been met and the variable is statistically significant at 1 percent. A 1 percent increase in food import reduces the income inequality by 0.29 percent. This is in synch with other studies such as Ciani (2017) and Otsuka (2013). Conversely, inflation and population growth are statistically significant at 5 percent and 1 percent respectively. Both of these variables met the expected priori of a positive relation with the income inequality. Thus, a 1 percent increase in the inflation and population growth increases the income inequality by 0.65 and 0.21 percent respectively. The inflation result is in line with the Siami-Namini and Hudson (2019) and Chee-Hong and Soon (2020) while the population growth results are in line with the studies by Chen *et al.* (2017) and Berman *et al.* (2016).

Table 6. Income inequality model

Variables	PMG	MG	DFE	Hausman test
Crop	-0.490194	0.391039	0.281083	
	(0.0000)***	(0.0019)*	(0.0000)	
livestock	-0.309183	0.210951	0.140217	
	(0.0000)***	(0.0491)***	(0.0917)	
F_imports	-0.291072	0.210981	0.199104	
	(0.0031)***	(0.0098)***	(0.0219)**	
inflation	0.652319	0.592309	0.409018	
	(0.0102)**	(0.0229)**	(0.0718)*	
Pop	0.209818	0.170913	0.029681	
	(0.0038)***	(0.0824)*	(0.19028)	
Haus				1.89
				(0.2390)

Note: Figures in the parentheses ( ) are p-values while *, ** and *** represent 10%, 5% and 1% level of significance respectively.

Source: Authors compilation

5.5. Short-run analysis

This section discusses the short-run analysis for both economic growth and income inequality models. Both the short-run results based on (coefficients) are shown in Table 7. The results of economic growth model show an expected sign of ECT (-0.319250) which is statistically significant at 1 percent level of significance. This negative ECT of -0.319250 signifies and confirms that a long-run relationship between agriculture and economic growth exists, thus, 32 percent of the disequilibrium will be rectified after 3.13 years (1/0.319250). Furthermore, the Table 7 reports an ECT of -0.438403 that is statistically significant at 1 percent. Thus, 44 percent of income inequality is corrected after 2.28 years by agricultural production. Interestingly, the short-run and long-run results do not differ much.

Table 7. Short-run results

Economic growth model			
Variables	**PMG**	**MG**	**DFE**
ECT	-0.319250***	-0.220617***	-0.171820***
Crop	0.692109***	0.409193**	0.303910*
livestock	0.501839**	0.481930**	0.330819*
F_imports	0.325418***	0.293013**	0.219170
inflation	-0.791049***	0.520185*	0.429108
Pop	0.205201*	0.114190	0.093912
Income inequality model			
ECT	-0.438403***	-0.320371*	-0.218421*
Crop	-0.202019*	-0.190928*	0.182091
livestock	-0.271701**	0.159871*	-0.091820*
F_imports	-0.129131*	0.094721	0.002192*
inflation	0.291038*	0.100211	0.122931*
Pop	0.137632	0.122608*	0.109133*

Note: *, ** and *** represent 10%, 5% and 1% level of significance respectively.
Source: Authors Compilation

The last test employed in the study was the cross-dependency and the results are shown in Table 8. All the three tests: Breusch-Pagan, Pearson LM and Pearson CD probabilities values are less than 10 percent, which is a sign that the model used is stable and did not produce spurious results.

Table 8. Cross-sectional dependency

Test	**Probability**
Breusch-Pagan Chi-Square	0.0310***
Pearson LM	0.0900***
Pearson CD	0.0006**

Note: ** indicates 5% and *** indicates 1% significance respectively.

6. Conclusion

The study's objectives were twofold. The first objective was to examine the contribution of agriculture on economic growth in BRICS countries. The second objective was to examine the contribution of agriculture on income inequality in BRICS countries. The study provides crucial intuitions into the impact of agriculture on economic growth and income inequality from an emerging countries perspective. The study used the panel quantitative data set over the period 1995-2017. The findings of the first objective revealed that crop production, livestock production, food import and population growth positively influenced economic growth while inflation negatively influenced economic growth. The income inequality model's results reveal that livestock production, crop production, food imports reduce income inequality. Conversely, population growth and inflation positively influence income inequality. Noteworthy is that all the variables met

the expected priori and the study confirmed that the economy equilibrium will be restored in the long-run.

Given the absolute potential agriculture has on Sustainable Development Goals, governments should strengthen the agricultural sector policies. For instance, the bloc can come up with a scheme that provides food and crop production globally. This includes the investment schemes that train and improve skills for agricultural development. Although the study achieved its objectives, the study has identified one weaknesses that can be addressed in the upcoming study. The study should have incorporated more blocs for comparison purposes.

References

Abdou, D. M. C., El Adawy, N. S., 2018. BRICS challenges: Economic position, tourism and environmental. *International Journal of Environmental Monitoring and Protection,* 5(2), pp. 64-72.

Agrivi, 2020. *Bringing smart agriculture solutions to farmers and agri-businesses*. [online] Available at: <https://blog.agrivi.com/en?p=8> [Accessed on 6 February 2020].

Awokuse, T. O., 2009. Does agriculture really matter for economic growth in developing countries? *Selected paper prepared for presentation at the American Agricultural Economics Association Annual Meeting*.

Ayinde, O. E., Muchie, M., and Olatunji, G. B., 2012. Effect of climate change on agricultural productivity in Nigeria: A co-integration model approach. *Journal of Human Ecology,* 35(1), pp.189–194. https://doi.org/10.1080/09709274.2011.11906406

Bekun, F., Akadiri, S. S., 2019. Poverty and agriculture in Southern Africa revisited: A panel causality perspective. *SAGE Open, 9(1),* pp. 1-10. https://doi.org/10.1177/2158244019828853

Berman, Y., Ben-Jacob, E., Shapira, Y., 2016. The dynamics of wealth inequality and the effect of income distribution. PLoS ONE 11(4), pp. e0154196. https://doi.org/10.1371/journal.pone.0154196

Birthal, P. S., Rao, P., 2004. Intensification of livestock production in India: Patterns, trend and determinants. *Indian Journal of Agriculture Economics*, 59(2), pp. 20-39.

Calicioglu, O., Flammini, A., Bracco, S., Bellù, L., and Sims, R., 2019. The future challenges of food and agriculture: An integrated analysis of trends and solutions. *Sustainability*, 11(4), pp. 22-32. https://doi.org/10.3390/su11010222

Carr, J. A, D'Odorico, P., Suweis S., Seekell, D. A., 2016. What commodities and countries impact inequality in the global food system? *Environmental Research Letters 11(9), pp.* 1-11. https://doi.org/10.1088/1748-9326/11/9/095013

Ceddia, M. G., 2019. The impact of income, land, and wealth inequality on agricultural expansion in Latin America. *Proceedings of the National Academy of Sciences of the United States - PNAS*, 116(7), pp. 2527-2532. https://doi.org/10.1073/pnas.1814894116

Chakravorty, S., and Naraparaju, K., 2019. Land distribution, income generation and inequality in India's agricultural sector. *International Association for Research in Income and Wealth*, 65(2), pp. 182-203. https://doi.org/10.1111/roiw.12434

Chee-Hong, L., and Soon, S. V., 2020. The impact of inflation on income inequality: The role of institutional quality. *Applied Economics Letters*, pp. 1-4. https://doi.org/10.1080/13504851.2020.1717425

Chen, B., Liu, D., and Lu, M., 2017. *City size, migration, and urban inequality in the People's Republic of China.* ADBI Working Paper, No. 723, Asian Development Bank Institute (ADBI), Tokyo.

Chowdhury, S. A., and Hossain, S. S., 2018. Usability of adaptive cluster sampling for identifying the land producing 'Hybrid Borocrop' in Bangladesh. *Bangladesh Journal of Agricultural Economics*, 38(1), pp. 12-36.

Ciani, A., 2017. *Income inequality and the quality of imports.* DICE Discussion Paper No. 245. Düsseldorf Institute for Competition Economics.

Demir, C., 2019. Macroeconomic determinants of stock market fluctuations: The case of BIST-100. *Economies, 7(1)*, pp. 1-14. https://doi.org/10.3390/economies7010008

Duguma, A. L., Debsu, J. K., 2019. Determinants of livestock production development of smallholder farmers. *Journal of Applied Science Environment Management*, 23(8), pp 1535-1540. https://doi.org/10.4314/jasem.v23i8.18

Dynan, K., and Sheiner, L., 2018. *GDP as a measure of economic well-being.* Huthcins Center Working Paper No. 43, Brookings Inst., Washington, DC.

Findeis, J. L., Reddy, V. K., 1987. Decomposition of Income Distribution Among Farm Families. *Northeastern Journal of Agricultural and Resource Economics,*16(2), pp. 165-173. https://doi.org/10.1017/S0899367X00001495

Fonseca, L. M., Domingues, J. P., and Dima, A. M., 2020. Mapping the sustainable development goals relationships. *Sustainability* 12(2), pp. 33-59. https://doi.org/10.3390/su12083359

Food and Agriculture Organization (FAO), 2019. *Prevalence of undernourishment.* [online] Available at: <http://www.fao.org/state-of-food-security-nutrition> [Accessed 30 December 2020].

Gardner, B. L., 1969. Determinants of farm family income inequality. *American Journal of Agricultural Economics*, 51(2), pp. 753–769. https://doi.org/10.2307/1237772

Garidzirai, R., and Muzindutsi, P. F., 2020. A panel ARDL analysis of the productivity of key economic sectors contributing to local economic growth in an emerging country. *Studia Universitatis Babes-Bolyai, Oeconomica,* 65(1), pp. 39-54. https://doi.org/10.2478/subboec-2020-0003

Garidzirai, R., Pasara, M. T., 2020. An analysis of the contribution of tourism on economic growth in South African provinces: A panel analysis. *GeoJournal of Tourism and Geosites*, 29(2), pp. 554–564. https://doi.org/10.30892/gtg.29214-489

Guillotin, B., 2019. Using unconventional wisdom to re-assess and rebuild the BRICS. *Journal of Risk Financial Management, 12*(1), pp. 8-28. https://doi.org/10.3390/jrfm12010008

Hatmanu, M., Sandu, C. B., Jaba, E., 2019. Comparative study on drivers for corporate environmental responsibility, EU15 vs. EU-NMS13. *Sustainability*, *11(2)*, pp. 6397. https://doi.org/10.3390/su11226397

Huang, J., and Ding, J., 2016. Institutional innovation and policy support to facilitate small-scale farming transformations in China. *Agricultural Economics,* 4(1), pp. 227-237. https://doi.org/10.1111/agec.12309

Im, K. S., Pesaran, M. H., and Shin, Y., 1997. *Testing for unit roots in heterogeneous panels.* Cambridge Working Paper 9526, University of Cambridge.

Jaworski, A., 2018. *Encouraging climate adaptation through reform of federal crop insurance subsidies.* [online] Available at: <https://www.nyulawreview.org/wp-content/uploads/2018/08/NYULawReview-91-6-Jaworski.pdf> [Accessed on 24 November 2019]

Kao, C., 1999. On the estimation and inference of a cointegrated regression in panel data. *Journal of econometrics*, 90 (1), pp. 1-44. https://doi.org/10.1016/S0304-4076(98)00023-2

Kavallari, A., Fellmann, T., and Gay, S. H., 2014. Shocks in economic growth = shocking effects for food security? *Food Security,* 6(3), pp. 567–583. https://doi.org/10.1007/s12571-014-0368-y

Khan, Z. R., Midega, C. A. O., Pittchar, J. O., 2014. Achieving food security for one million sub-Saharan African poor through push–pull innovation by 2020, *Philosophical Transactions of the Royal Society B; Biological Sciences*, 20(1), pp. 36-49. https://doi.org/10.1098/rstb.2012.0284

Leve, S., and Kapingura, F. M., 2019. Financial development and income inequality in the selected Southern African development community countries. *Journal of Reviews on Global Economics*, 8(1), pp. 1438-1451. https://doi.org/10.6000/1929-7092.2019.08.128

Levin, A., Lin, C. F., and Chu, C., 2002. Unit root tests in panel data: Asymptotic and finite-sample properties. *Journal of Econometrics*, 108(1), pp. 1-24. https://doi.org/10.1016/S0304-4076(01)00098-7

Liefert W. M., Liefert O., Seeley R., and Lee T., 2019. The effect of Russia's economic crisis and import ban on its agricultural and food economy. *Journal of Eurasian Studies*, *10* (2), pp. 119–135. https://doi.org/10.1177/1879366519840185

Linderhof, V., Janssen, V., and Achterbosch, T., 2019. Does agricultural commercialization affect food security: The case of crop-producing households in the regions of post-reform Vietnam? *Sustainability, 11,* pp. 1263-1280. https://doi.org/10.3390/su11051263

Mackie, A. B., 1964. The role of agriculture in economic growth and development. *Illinois Agricultural Economics*, 4(1), pp. 1–10. https://doi.org/10.2307/1349016

Macro Trends, 2020. *India GDP growth rate 1961-2020.* [online] Available at: <https://www.macrotrends.net/countries/IND/india/gdp-growth-rate> [Accessed on 2 February 2020].

Mazenda, A., 2016. *The effect of BRICS trade relations on South Africa's growth.* EERI Research Paper Series, No. 11/2016, Economics and Econometrics Research Institute (EERI), Brussels

McArthur J. W., Sachs, D. J., 2019. Agriculture, aid, and economic growth in Africa. *World Bank Economic Review*, 33(1), pp. 1-20. https://doi.org/10.1093/wber/lhx029

McArthur, J. W., and McCord, G. C., 2017. Fertilizing growth: Agricultural inputs and their effects in economic development. *Journal of Development Economics, 127(3)*, pp. 133–152. https://doi.org/10.1016/j.jdeveco.2017.02.007

Moyo, C., and Le Roux, P., 2019. Interest rate reforms and economic growth in SADC countries: The savings and investment channel. *Scientific Annals of Economics and Business,* 66(4), pp. 507-523.

Naceur, S. B., and Zhang, R., 2016. *Financial development, inequality and poverty; some international evidence.* IMF Working Papers 16/32, International Monetary Fund. https://doi.org/10.5089/9781498359283.001

Nkikabahizi, F., Ndagijimana, J., Musabanganji, E., 2017. Relationship between inflation and real economic growth in Rwanda. In: Heshmati A. ed. 2017. *Studies on economic development and growth in selected African countries. Frontiers in African business research*. Singapore: Springer. pp. 103-123. https://doi.org/10.1007/978-981-10-4451-9_6

Odusola, A., 2017. *Agriculture, rural poverty and income inequality in sub-Saharan Africa.* UNDP Africa Economists Working Papers 266998. United Nations Development Programme (UNDP).

Organization for Economic Co-operation and Development (OECD), 2019. *Inclusive growth*. [online] Available at: <https://www.oecd.org/inclusive-growth/inequality-and-opportunity/> [Accessed on 28 December 2019].

Otsuka, K., 2013. Food insecurity, income inequality, and the changing comparative advantage in world agriculture. *Agriculture Economics*, 44(3), pp. 20-40. https://doi.org/10.1111/agec.12046

Pegkas, P., 2018. The effect of government debt and other determinants on economic growth: The Greek experience. *Economies*, 6(10), pp. 1-19. https://doi.org/10.3390/economies6010010

Pesaran, M. H., Shin, Y., and Smith, R. P., 1999. Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association*, 94 (6), pp. 621-634. https://doi.org/10.1080/01621459.1999.10474156

Pesaran, M. H., Shin, Y., and Smith, R.P., 2001. Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics*, 16 (3), pp. 289-326. https://doi.org/10.1002/jae.616

Peter, A., and Bakari, I., 2018. Impact of population growth on economic growth in Africa: A dynamic panel data approach (1980-2015). *Pakistan Journal of Humanities and Social Sciences*, 6(4), pp. 412-427. https://doi.org/10.2139/ssrn.3432263

Peterson, E. W. F., 2017. The role of population in economic growth. *SAGE Open*, 7(4), pp. 1-15.

Pfunzo, R., 2017. *Agriculture's contribution to economic growth and development in rural Limpopo Province: a SAM multiplier analysis.* [online] Available at:

<http://scholar.sun.ac.za/handle/10019.1/101160> [Accessed on 2 January 2020]. https://doi.org/10.1177/2158244017736094

Ren, S., Yuan, B., Ma, X., and Chen, X., 2020. International trade, FDI (foreign direct investment) and embodied CO2 emissions: A case study of China's industrial sectors. *China Economics Review*, *28(2)*, pp. 123–134. https://doi.org/10.1016/j.chieco.2014.01.003

Richards, M. B., Wollenberg, E., Buglion-Gluck, S., 2015. *Agriculture's contributions to national emissions. CGIAR Research Program on Climate Change*. Agriculture and Food Security (CCAFS), Copenhagen.

Rodgers. E. M., 1983. *Diffusion of innovation*. New York: MacMillan.

Samargandi, N., Fidrmuc, J., Ghosh, S., 2015. Is the relationship between financial development and economic growth monotonic? Evidence from a sample of middle-income countries. *World Development*, 68(2), pp 66–81. https://doi.org/10.1016/j.worlddev.2014.11.010

Severini, S., Di Tommaso, G., and Finger, R., 2019. Effects of the income stabilization tool on farm income level, variability and concentration in Italian agriculture. *Agriculture Economics,* 7(1), pp. 1-23. https://doi.org/10.1186/s40100-019-0141-9

Siami-Namini, S., and Hudson, D., 2019. Inflation and income inequality in developed and developing countries. *Journal of Economic Studies*, 46(3), pp. 611-632. https://doi.org/10.1108/JES-02-2018-0045

Sulaiman, C., and Abdul-Rahim, A. S., 2018. Population growth and CO2 emission in Nigeria: A recursive ARDL approach. *SAGE Open*, 8(2), pp. 1-14. https://doi.org/10.1177/2158244018765916

Svigir, M., and Josipa, M., 2017. Relationship between inflation and economic growth; comparative experience of Italy and Austria. *Financije i pravo,* 5(2), pp. 91-101.

Tahamipour, M., and Mahmoudi, M. 2018. The role of agricultural sector productivity in economic growth: The case of Iran's economic development plan. *Research in Applied Economics*, 10(1), pp. 1-17. https://doi.org/10.5296/rae.v10i1.12809

United Nations, 2020. *Sustainable development goals*. [online] Available at: <https://sustainabledevelopment.un.org/?menu=1300> [Accessed on 20 March 2020].

World Bank, 2019. *Agriculture and food. 2019.* [online] Available at: <https://www.worldbank.org/en/topic/agriculture> [Accessed on 23 December 2019)

World Bank, 2020. *World bank indicators.* [online] Available at: <https://data.worldbank.org/> [Accessed on 1 January 2020].

Yang, F., Jiang, Y., and Zeng, W., 2020. Livelihood capitals on income inequality among rural households: evidence from China. *Ciência Rural*, *50*(2), pp. 1-23. https://doi.org/10.1590/0103-8478cr20190461

Yu, S., Jiping, D., and Jikun, H., 2019. The relationship between farm size and productivity in agriculture: Evidence from maize production in Northern China. *American Journal of Agricultural Economics*, 101(3), pp. 790–806. https://doi.org/10.1093/ajae/aay104