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Response of Agriculture Production to Change of Foreign Direct Investment and Public Agriculture Expenditure in South Africa: A Monte Carlo Simulation Analysis

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ABSTRACT

The rationale of this paper was to investigate the response of agriculture production to the simultaneous shock of foreign direct investment and public agricultural spending in South Africa during 1991-2019. Data were collected from secondary sources and analyzed using Monte Carlo simulation. Results revealed that agriculture production is maximized at 1.73% if Foreign direct investment inflows, agricultural credit, and the number of employees increase by 10% while public spending is decreased by 10%. Hence, it is recommended that policymakers should combine FDI inflows in agriculture, and agricultural credit in a complementary manner, with emphasis to attract more extensive farm workers to ensure the sustainability of production in the agriculture sector in South Africa. This paper contributes to enhance agriculture sector by using the best combination of input in agriculture in order to maximize production.

Keywords: Foreign Direct Investment, Public Agricultural Spending, Agriculture Production, Monte Carlo Simulation, South Africa
JEL Classifications: C53, O13, F37

1. INTRODUCTION

The failure to meet the 10% national budget for agriculture as stipulated by most Sub-Saharan African countries during the Maputo declaration in 2003 motivated this study from the empirical perspective on whether complementary or supplementary policy measures could be used to sustain the agricultural sector. While some studies have been undertaken in an attempt to determine the relationship between public spending, foreign direct investment, and agriculture production (Izuchukwu, 2011; Udoh, 2011; Djokoto et al., 2014; Yusuf, 2015), only a few studies have look at the direct and indirect simultaneous impact of FDI and public expenditure in agriculture growth (Obekpa et al., 2021; Fani et al., 2020). In line with this obvious background, this study uses multiple probability simulation approaches to examine how South Africa's agricultural production responds to the simultaneous shock of FDI and governmental spending.

Recently with the outbreak of COVID-19, the agriculture sector in emerging countries such as South Africa became the largest single economy sector that contributed to real GDP. The recovery process for South Africa following the economic shocks of COVID-19 is currently underway. The only economic sector that continued to grow positively in 2020 and into 2021 was agriculture, which authorities chose as one of the sectors to spearhead the economic recovery and job creation. Agriculture was one of just four economic sectors to experience growth in 2020 and 2021, according to the Bureau for Food and Agricultural Policy (BFAP), the agriculture, forestry, and fishing industry increased by 12.2% and contributed 0.3 of a percentage point to GDP growth. The increase was mainly owing to the increased production of animal products (Statistic SA, 2021).

This resilience of the agriculture sector was due to the government's response to a range of emergency regulations. According to DAFF (2020), the department provided R1.2 billion to help small-scale and subsistence farmers raise productivity to mitigate the potential negative effects of Covid-19 on these types of farmers, and an additional R100 million was set aside for use by commercial farmers through the Land Bank. The department of agriculture stated that out of the R1.2 billion, R400 million was made aside for farmers taking part in the Pro-Active Land Acquisition Programme, and R20 million was set aside for hygienic supplies for farm employees.

Although these predictions are still valid, it is crucial to make sure that government continues to support the sector's expansion, particularly the smallholders and subsistence farmers. Covid-19 was a disruptive factor, but the government also needs to prepare for other unforeseen events, such as economic shocks, climate change, land degradation, biodiversity loss, water scarcity, pests, and infections. It is time to use this crisis as a chance to shift to a better "new normal," which entails changing the current farming systems into more resilient ones that can lower risks and vulnerabilities to many threats as well as quickly absorb, adapt, and recover. Hence, the need to look for an external source of investment in the agriculture sector such as foreign direct investment.

Foreign direct investment inflow is still regarded as one of the major elements of agriculture production in both advanced and emerging countries. Its significance for agriculture production growth continues to be a leading discussion between economists and policymakers not only in South Africa but all over the globe. The FDI inflows in South Africa have been fluctuating and went up and down until 2009 when they started decreasing until 2011 at a value of 7271.2 million. From 2012 to 2014 we observed a growth of 53.16 % in FDI in agriculture which start decreasing in 2016. However, since 2017 the FDI is expected to restore expectations and update details to ensure a sound investigation of the current situation (FAO, 2019). This high fluctuation is underlined by the difficulty that foreign investors have in investing in the agricultural sector. However, the agriculture sector in South Africa gets the least FDI contrasted with others and albeit little, the significant investment in the area has been immediate ventures into agribusiness which is still growing in South Africa.

Despite the increase in government spending in the agriculture sector, South Africa's population which currently stands at 57.7million is expected to reach an average of 82 million by 2035 (Mateo-Sagasta et al., 2018). However, the population increases at a high rate compared to agriculture production. This implies that the population of South Africa is not theoretically capable of increasing its nutritional quality or, at least, cannot meet its food requirements. To feed the people, the need for food production has to rise dramatically over time and indeed needs to double as the population is growing fast. Therefore, there is a need to increase agricultural production through more FDI inflows to supplement government spending to sustain the natural resources that deplete over time and assure food security in South Africa in the future. However, there is still a conflicting view on which public agriculture spending and foreign direct investment improve faster agriculture production in South Africa. The contention is based on whether public agricultural spending crowds in foreign direct investment or vice versa. This research presents the proverbial "chicken or the egg" dilemma in agricultural subsector output: Which comes first? Hence, this paper investigates the response of agricultural production to simultaneous changes in FDI and public agricultural spending in South Africa.

The rest of the paper is structured as follows: Section 2 reviews the theoretical framework and empirical literature. Section 3 describes the data and methodology employed while Section 4 presents empirical analyses and a discussion of results. Finally, section 5 presents the conclusion and policy recommendations.

2. LITERATURE REVIEW

2.1. Theoretical Framework

The theoretical background of this study is built from the Cobb-Douglas production function. In 1980, Charles Cobb and Paul Douglas showed that production yield is the after-effect of labour measurement and the actual contribution of capital. The production function of Cobb-Douglas reflects the links between inputs (physical capital and labour) and the production quantity (Vasyl'yeva, 2021). It is an instrument to ascertain the effect of information changes, the applicable efficiencies, and the production action outputs. Below is a basic aspect of the output method of Cobb-Douglas:

$$Q = f(L, K)$$

in which labour and capital are the two factors of production with the greatest impact on the quantity of output. Q is the quantity produced, L is the number of labour applied to the production, and K is the capital used in the production (Douglas, 1976).

The principal debate is that the production function thinks about just two sources of info, labour, and capital, and disregards some significant sources of info, similar to crude materials, which are utilized more underway (Ilca and Popa, 2014). It is subsequently, unrealistic to sum up this capacity to multiple sources of input. In the case of this study, the production function focuses on more than two inputs that generalize capital and labour.

Today, despite these criticisms, the Cobb-Douglas production function is still of much importance because, in empirical studies, it has been frequently employed in the manufacturing industry and inter-industry comparisons, because the Cobb-Douglas production function exhibits increased, constant, or decreased returns to scale (Petrin and Levinsohn, 2012). This study is used to compare the desired increase of inputs during the production process with the proportion of total output. This theory of production is used in this paper to determine the best combination among inputs that will maximize output.

2.2. Empirical Literature Review

Many studies have been led in an offer to comprehend the interrelationship between public investment, FDI, private domestic investment, and economic growth. However, limited research focuses on the interrelationship between public agriculture spending, foreign direct investment in agriculture, and total production over the last several decades. Some different examinations have thought of a more methodical investigation of the crowd-in effect between FDI and public spending in agriculture production. For example, Matchaya (2020) analyzed the relationship between domestic and foreign direct investment in Ghanaian agriculture. Using ARDL, the result shows that a ratio of agricultural inward foreign direct investment is significantly affecting domestic capital flow. This is clear evidence that FDI crowd-in government spending into agriculture without comparing agriculture production coming from the simultaneous change of both foreign direct investment and domestic capital flow as intended by this study. Alabi and Abu (2020) in a Nigeria based study analysed the impact of agricultural public expenditure on agricultural productivity in Nigeria between 1981 and 2014. The study used the Error Correction Model (ECM) on a key dataset comprising of agricultural productivity, agricultural public expenditure (capital and recurrent), investment, and labour to carry out its empirical analysis. According to the study's findings, agricultural public capital expenditure has a positive impact on agricultural productivity, which manifests over time even though recurrent and total agricultural public expenditure do not. The study also suggested that public capital spending in agriculture can support private agricultural investment.

In a study in Mali, Maiga et al. (2021) analyzed the effects of government spending on agricultural growth using data from 2000 to 2019. The study used the ARDL model on the variables of agricultural value added per worker, expenditure on agriculture, expenditure on education, expenditure on health, number of jobs in the agricultural sector, fertilizer consumption. The findings of this study demonstrate that, with the exception of agricultural expenditures that have negative effects, public spending has positive and notable effects on agricultural growth. Similar negative effects are also seen in the rate of agricultural employment and fertilizer usage.

Assessing the relationship between government expenditure and agricultural performance, Apata (2021) examined agricultural productivity returns between 1981 and 2018 using public finance data from the agricultural and non-agricultural sectors at the national level in Nigeria. The impact of public spending on agricultural growth-drivers like health care, farm feeder roads, and education on agricultural productivity was also looked at. Three-stage simultaneous equations and descriptive statistics were used to analyze the data. Results of a descriptive statistics analysis showed that between 1981 and 2018, the average percentage of Nigeria's agricultural public spending as a percentage of all public spending was 4.88%. <25% of this budget was used for capital or development projects in agriculture. The access to moderate farm feeder roads variable was 0.045, the access to education variable was 0.071, and the access to health care facilities (within 15-30 min walk to health facility) variable was 0.013, according to elasticity results computed from the 3-stage simultaneous equation. All of these factors were 1% significant. These findings indicated that a 1% increase in funding for health care, farm feeder roads, and educational institutions will increase agricultural productivity per person by 0.043. Consequently, the findings showed that the estimated benefit-cost ratio was 4.3:1. Therefore, a 4.3% increase in public spending on health care, farm feeder roads, and education would result in 1% increase in agricultural output.

Chen et al. (2023). analyzed the development status of fiscal support for agriculture and the agricultural circular economy in the province. Relying on data envelopment analysis (DEA), it measures the efficiency of the agricultural circular economy in Henan province in 2013-2019 using the Charnes, Cooper, and Rhodes (CCR) model, the Banker, Charnes, and Cooper (BCC) model, and super-efficiency DEA models and empirically analyzes the effect of the fiscal expenditure for supporting agriculture on the efficiency of the agricultural circular economy using the fixed effect model. According to the results, (1) the expenditure on comprehensive agricultural development of Henan Province was mainly supported by the government's fiscal funds to such a degree that the proportion of fiscal funds from the central government exceeded 40% throughout the year. Particular stress was laid on the land governance projects of comprehensive agricultural development in the province. (2) The overall development level of the agricultural circular economy in Henan Province was low, and there were considerable gaps between cities (counties). Under the super-efficiency DEA model, only Hebi City, which ranked first in terms of average efficiency, achieved relative efficiency. (3) The fiscal expenditure for supporting agriculture had a positive incentive effect on the efficiency of the agricultural circular economy in Henan province, and the incentive effect became more significant after the time effect was controlled.

Ngobeni and Chiedza (2022) examined the effects of government expenditure in agriculture, annual average rainfall, consumer price index, food import value, and population on the value of agricultural production with a specific focus on government expenditure in agriculture for the period 1983-2019. Using the Johansen cointegration test, the results reveal that there is a long-run relationship among the variables. The Granger causality test results suggest that government expenditure in agriculture does not Granger cause the value of agricultural production. However, the two variables are linked through other variables in the model, such that an increase in government expenditure in agriculture, average annual rainfall, and population were shown to ultimately increase the value of agricultural production based on vector autoregressive (VAR) model analysis. In contrast, an increase in the consumer price index and food import value is detrimental to the value of agricultural production.

Setshedi and Mosikari (2019) studied macroeconomic variables' effects on South Africa's agricultural productivity. They used the vector error correction model (VECM) to analyze time-series data for the period 1975-2016. Findings showed that increasing government expenditure on agriculture could increase agricultural productivity. In addition, the findings showed that an increase in the consumer price index reduces agricultural productivity. The study focused on agricultural productivity, which differs from this present study's focus on the value of agricultural production (the total quantity produced expressed in monetary terms). Similarly, The findings of Endaylalu (2019) revealed that government expenditure in Ethiopia is significant in promoting economic growth.

Chukwudi et al. (2020) investigated the impact of foreign direct investment on the agriculture sector in Nigeria using quarterly time series data for the period 1981-2017 obtained from the Central Bank of Nigeria Statistical Bulletin. Preliminary tests on the time series data were done using the pairwise correlation test, Augmented Dickey-Fuller and Phillips-Perron unit root tests. The results of the Bounds test and Johansen test indicate the presence of cointegration in the model. The Autoregressive Distributed Lagged (ARDL) model, Fully Modified Least Squares (FMOLS) and Dynamic Ordinary Least Squares (DOLS) were used to estimate the parameter estimates of the regression model. Results indicate that foreign direct investment has a positive and significant impact on agricultural sector output.

Nyiwul and Koirala (2022) examined the role that foreign capital inflows play in the development of the agricultural, forestry and fishing sectors in developing countries. Using data from sixteen developing economies, we find that there exists bidirectional causality between foreign direct investments in agriculture, forestry and fishing and value added in these sectors.

Recognizing the links between various sustainable development goals, Dhahri and Omri (2020) used foreign direct investments and other forms of foreign assistance (such as social infrastructure aid, investment aid, agriculture-forestry-fishing aid and non-investment aid) reduce poverty and improve food security through their effects on the agricultural sector. They found that FDI had positive impacts on agricultural production, which in turn reduces food insecurity and poverty. In their three-step approach, no causal link running from agriculture to FDI was established.

Edeh et al. (2020) used quarterly data for the period 1981-2017 to study the impact of foreign direct investment on the agriculture sector in Nigeria. They find that FDI has a positive and significant impact on the output of the agricultural sector and that this impact is stronger in the short run than in the long run.

In a study of how sectoral FDI inflows affect growth of respective sectors in India, Jana et al. (2019) found that FDI inflows do not contribute to output growth in the agricultural sector. Interestingly, they find a reverse causality wherein agricultural output attracts more FDI into the sector. In a study of the effect of FDI on sectoral growth, Opoku et al. (2019) found that the pass-through impact of FDI is significant for the agricultural and service sectors.

However, the above technique used by previous authors is limited to comparing the simultaneous effect of two or more variables on production as taken care of by our study. According to Kroese et al. (2014), Monte Carlo simulation is an easy-to-use model that is quicker when determining the degree of risk associated with studying the systems of agricultural investment, particularly appropriate for investments in food and agricultural products. Cost-effective and justifiable decisions on the appraisal of agricultural investment, help the agricultural industry become more productive and competitive (Bela-Gergely and Botond, 2016). The study of Obekpa et al. (2021) examined the relationship between agricultural growth and public agricultural spending between 1980 and 2018. Monte Carlo simulations were used to examine the secondary-source data. The findings indicated that the best option for ensuring the sustainability of agricultural growth in Nigeria was to boost foreign direct investment and public agricultural spending (scenario 3).

3. DATA AND METHODOLOGY

To achieve the specified empirical objective, this paper employs secondary data transformed into natural logarithms from the period 1991 to 2019. The variables used in this paper were transformed into natural logs and include total production, the number of employees in agriculture, FDI in agriculture, public agriculture spending, and agricultural credit collected from the Department of Agriculture, Forestry and Fisheries (DAFF), Food and Agriculture Organization (FAO) and South Africa Reserve Bank (SARB).

The regression equation of total agricultural production will therefore be of the form:

$$LTPROD_t = \beta_0 + \beta_1 LFDI_t + \beta_2 LPAS2_t + \beta_3 LAC_t + \beta_4 LEMPA2_t + \mu_t \quad (1)$$

The VAR model was estimated to investigate the dynamics of our variables of interest. Thereafter, the dynamic effect of the VAR model is conveniently analyzed. However, it did not give how much change is caused to agriculture production due to simultaneous shocks of explanatory variables, which Monte Carlo Simulation does (Zhang et al., 2013).

Monte Carlo Simulation is the most sustainable method used when it is necessary to analyze a model with uncertain parameters or a dynamic complex system (Creal, 2012). It is important to note that in a scenario, Monte Carlo Simulation provides a probabilistic estimation of the uncertainty. Monte Carlo Simulation uses probability distribution for modeling a stochastic or a random variable. However, given the uncertainty or risk ingrained in a system, it is a useful tool for approximation of reality. According to Harrison (2010), the Monte Carlo simulation is a simple model to apply and faster in determining the amount of risk involved in assessing agricultural investment systems, particularly for food and agricultural goods investment. This aids in enhancing agricultural production and competitiveness through cost-effective and justifiable judgments on agricultural investment evaluation.

In this paper, Monte Carlo Simulation is based on our empirical model by estimating the probability of change in total agriculture production caused by the simultaneous changes in public agricultural spending, FDI, the value of agricultural credit, and the number of employees in agriculture in South Africa over time. Hence the impact of varying scenarios of independent variables was assessed to investigate which combination gives the best agricultural production in South Africa. Specifically, the simulation of agricultural production (TPROD) model is based on Cordero et al. (2015).

$$E\left(f\left(X_i\right)\right)=\theta'_N=\frac{1}{N}\sum_{i=1}^{N}f\left(X_{it}\right)$$

Where X is a vector of determinants such as LPAS2, LFDI, LAC and LEMPA2

θ is the dependent variable (LTPROD).

Agricultural production will be simulated from the stochastic model,

$$LTPROD^*_{it}=\alpha_{0i}+\alpha_1*\left(LFDI_{it}+\vartheta_{1,it}\right)+\alpha_2*\left(LPAS2_{it}+\vartheta_{2,it}\right)$$
$$+\alpha_3*\left(LAC_{it}+\vartheta_{3,it}\right)+\alpha_4*\left(LEMPA2_{it}+\vartheta_{4,it}\right)+\zeta_{it}$$

Where $\vartheta_{1,it}$, $\vartheta_{2,it}$, $\vartheta_{3,it}$ and $\vartheta_{4,it}$ are uncertainties in the measurement of LPAS2, LFDI, LAC and LEMPA2; and ζ_{it}=exogenous white noise disturbance on the model.

Before we start with the simulation, we first generate the baseline using a data generation process (DGP) to create a baseline data set without endogeneity (the exogenous scenario). Accordingly, in each dataset, we substitute the exogenous input (LPAS2, LFDI, LAC, and LEMPA2) with the endogenous inputs. For each endogenous scenario, we follow the next procedure. This implies that for each of the scenarios, the baseline generated from the initial model and data generated from each of the scenarios will be compared to quantify the impacts that endogeneity causes on assessments.

From the Monte Carlo Simulation output displays, the percentage change formula is written as follows:

$$\%Change\ scenario\ n=\frac{agric\ prod\ Scenario\ n-agric\ prod\ Baseline}{agric\ prod\ Scenario\ n}$$

where

$\%\ change\ scenario\ n\ = Percentage\ change\ of\ agriculture\ production\ scenario\ n$

$agric\ prod = Agriculture\ production$

4. EMPIRICAL ANALYSES AND DISCUSSION OF RESULTS

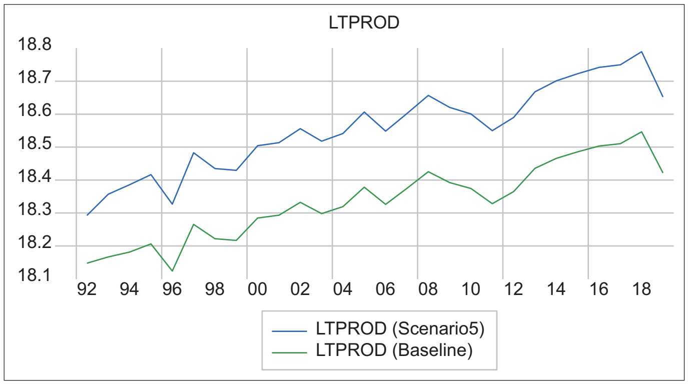
In economics, reaching the level of optimal output is critical as this guarantees that all production factors are used in their best capacity. Adjustments to the output factors depend on the inputs, which have different effects and can be evaluated in various ways. Monte Carlo

Table 1: Monte Carlo simulation results

Scenarios	LFDI	LPAS2	LAC	LEMPA2	Mean of total production (baseline)	Mean of total production for each scenario(n)	Calculate % change in production (LTPROD)	Conclusion
1	Increase LFDI	Increase LPAS2	Increase LAC	Increase LEMPA2	18.33536	18.56873	1.25	Decrease return of scale
2	Increase LFDI	Increase LPAS2	Increase LAC	Decrease LEMPA2	18.33536	18.45930	0.67	
3	Increase LFDI	Increase LPAS2	Decrease LAC	Increase LEMPA2	18.33536	18.26930	−0.36	
4	Increase LFDI	Increase LPAS2	Decrease LAC	Decrease LEMPA2	18.33536	18.15987	−0.96	
5	Increase LFDI	Decrease LPAS2	Increase LAC	Increase LEMPA2	18.33536	18.65987	1.73	Maximise production
6	Increase LFDI	Decrease LPAS2	Increase LAC	Decrease LEMPA2	18.33536	18.44623	0.60	
7	Increase LFDI	Decrease LPAS2	Decrease LAC	Increase LEMPA2	18.33536	18.25623	−0.43	
8	Increase LFDI	Decrease LPAS2	Decrease LAC	Decrease LEMPA2	18.33536	18.14680	−1.03	
9	Decrease LFDI	Increase LPAS2	Increase LAC	Increase LEMPA2	18.33536	18.52392	1.01	
10	Decrease LFDI	Increase LPAS2	Increase LAC	Decrease LEMPA2	18.33536	18.41450	0.42	
11	Decrease LFDI	Increase LPAS2	Decrease LAC	Increase LEMPA2	18.33536	18.22450	−0.60	
12	Decrease LFDI	Increase LPAS2	Decrease LAC	Decrease LEMPA2	18.33536	18.11507	−1.21	
13	Decrease LFDI	Decrease LPAS2	Increase LAC	Increase LEMPA2	18.33536	18.51085	0.94	
14	Decrease LFDI	Decrease LPAS2	Increase LAC	Decrease LEMPA2	18.33536	18.40143	0.35	
15	Decrease LFDI	Decrease LPAS2	Decrease LAC	Increase LEMPA2	18.33536	18.21142	−0.68	

Source: Own calculation using E-views 10.1

Figure 1: Monte Carlo scenario 5



simulation consists to determine which combination(scenarios) maximizes agriculture production, in the long run, to determine which public agricultural spending and foreign direct investment should be prioritized based on the crowding-in or crowding-out effect. For this paper, 10% is chosen randomly and used as a changed rate for public agriculture spending, foreign direct investment, the value of agricultural credit, and the number of employees in agriculture. Results from the Monte Carlo Simulation output are displayed in Table 1 based on fifteen scenarios which are the maximum scenario among the four explanatory variables.

The results from Table 1 present the results of the impact of the different scenarios of foreign direct investment, public agriculture spending, the value of agricultural credit, and the number of employees in agriculture based on the VAR model. It reveals that the best scenario which maximizes agriculture production is scenario five presented in Figure 1 where the increase of foreign direct investment (LFDI) by 10%, decrease of public agricultural spending (LPAS2) by 10%, increase of the value of agricultural credit by 10% and increase of the number of employees in agriculture (LEMPA2) by 10% show an increase of agriculture production by approximately 1.73%. These results are in line with the study of Akber and Paltasingh (2019) who also found a complementarity of public investment with private investment in agriculture.

5. CONCLUSION AND POLICY IMPLICATIONS

The article empirically investigated the response of agriculture production to changes in foreign direct investment inflows and public agriculture expenditure in South Africa. In conclusion, agriculture production in South Africa is maximized if the decrease in public agriculture spending must be complemented by an increase in foreign direct investment after the government and private sector have found a way to increase the value of agricultural credit and create more extensive jobs in the agriculture sector. Therefore, foreign direct investment inflow in agriculture must be prioritized over public agricultural spending as an increase in foreign direct investment inflow in agriculture leads to a decrease in public agricultural spending (crowd-out effect).

The paper recommends that policymakers should improve communication around FDI opportunities in the agriculture sector, through an urgent need to track the scale, existence, and effect of foreign investment and to document best practices in law and policy to better educate South Africans and investors alike.

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