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ACCELERATING AGRICULTURAL PRODUCTIVITY TO ENHANCE ECONOMIC GROWTH IN BOTSWANA

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ABSTRACT

The need to diversify the economy so as to ensure sustainable economic growth has been of great concern. Accelerating productivity in agriculture is seen as one of the alternatives to support the diversification initiatives by the government and drive growth in Botswana. This study discusses the factors contributing to increased long term agricultural productivity and hence its subsequent impact on growth in the short. The study employs the vector error correction model and annual data to explain the connection between key variables. This paper concludes that there is unidirectional causality from agricultural productivity to growth. This study shows that economic growth can be improved in the short term by improvements in agricultural productivity. Agricultural productivity can be enhanced by providing adequate infrastructure, additional farming machinery per hectare of arable land and having a targeted approach in the provision of funding towards agricultural oriented initiatives.

Contribution/ Originality: This study's primary contribution is the finding that the agricultural led growth hypothesis applies to Botswana. The study is one of the few that use the vector error correction model to analyze the determinants of long term agricultural productivity.

1. BACKGROUND TO THE STUDY

The Sustainable Development Goals (SDGs) aim to end extreme hunger and all forms of poverty, achieve food security improve nutrition and promote sustainable agriculture by 2030. This is enhanced by promoting sustainable agriculture and supporting small farmers. SDGs also seek to promote sustained, inclusive growth, full and productive employment and decent work for all [1, 2]. Agriculture enhances sustainable development, poverty reduction and inclusive growth. However the changing weather patterns due to climate change has resulted in severe droughts particularly in Sub Saharan Africa (SSA). The impact of climate change on rainfall patterns has threatened food security especially in agro-based economies. The demand for agricultural produce is increasing and putting immense pressure on governments to increase productivity levels. Increased productivity by farmers has potential to eliminate poverty among the rural populace and to guarantee enough food supplies on a sustainable

basis. It is also argued that an increase in per capita incomes leads to an increase in demand for high value agricultural products. An increase in the supply of high value adding activities increases access to larger markets and more income generating opportunities [3, 4]. Value added agriculture deals with the further processing of food and non-food raw products to add value to the final product. This means agricultural goods are transformed into products that are ready for consumption. This improves farming incomes which sustains farming activities and improves the quality of life for rural communities. Value added products have competitive advantage over others in products markets Danielson and Park [5]. Foltz, et al. [6] defines value added farming as any activity that allows suppliers to capture more value added than would normally be the case using conventional commodity channels. It changes the physical state of the product, or the product is produced in a manner that enhances its value. It is created through production, marketing and processing strategies which differentiate between products and standard agricultural goods. It happens within a value chain where a product is transformed from its raw state to a different form, the way products are stored and supported by relevant sales information adds value.

This study is generally motivated by the evidence that seventy five percent of the world's poor live in rural areas and their main source of livelihood is agriculture. The rate of growth of the economy via the agricultural sector is estimated to be twice as much faster in reducing poverty when compared with growth in other sectors [7]. Africa has high rates of poverty, hunger and food shortages due to poor conservation techniques and post harvest losses. Most African farmers focus on subsistence agriculture and they suffer from weak productivity yet the continent has most of the arable land. The continent suffers from poor food chains from farm to storage, transport, processing and marketing. Transforming agriculture in Africa faces challenges like poor financing, poor investment, lack of innovation and incentives to farmers. It is generally accepted that developing industrial agri-business raises productivity and economic growth [8]. Agriculture, in Africa, has suffered from neglect by governments and the donor community. The sector holds considerable potential to take the rural populace out of the poverty trap by increased productivity and farm incomes. Agriculture dominates the rural economy as such increased productivity can be a key driver for inclusive growth in African communities. Inclusive growth is achieved by changing smallholder farmers into market oriented value chains that provide products to local, regional and global markets. The focus should be on creating a favourable environment for investment in agriculture as well as supporting infrastructure. This is against the background that rural farmers have experienced market failure resulting in lack of access to funding which left them in a poverty trap. Countries face a tradeoff between giving subsidies to increase access to finance and the cost of its provision [9, 10]. Agriculture plays an important role within SADC member states as a source of subsistence, employment and income. The region has experienced low yields and growth rates in agriculture production in recent years. This is against the background of high poverty incidences and low growth rates in the region. It is evident that coming up with credible policies that aim at improving economic growth and reducing poverty levels is critical. The expectation is that member states benefit from cooperation in formulating sustainable policies focused on improving agricultural output. Within the region reducing poverty and improving economic growth as well as food production is still a challenge. This may be partly explained by the over dependency on erratic rainfall patterns and lack of other key inputs. However, the type of policies formulated is critical, over and above other factors like availability of infrastructure, technology, finance and education, in improving agricultural production [11].

In the case of Botswana [12, 13] annual growth rates in national output have declined from 7.5% during the period 1980 − 1990 to around 3.8% in 2015. So far government initiatives like Integrated Support for Arable Agricultural Production (ISPAAD), introduced in 2008, have failed to improve agricultural productivity [14] so as to complement growth initiatives. ISPAAD aimed to address challenges in the arable sector, of poor technology adoption by farmers and low productivity in the sub sector. The agricultural sector has suffered due to policy inconsistencies. The performance of the agricultural sector has remained below 5% in recent years which is unsustainable leading to a decline in farm incomes, UNDP [15]. There still remain opportunities to diversify the

economy and increase agricultural productivity to reduce poverty levels in the rural Botswana through increased economic growth. The problem of agriculture to fail to contribute effectively to economic growth is resolved using two different and complementary approaches being enhancing productivity and increasing value addition of agriculture. This study argues that success of agriculture productivity in enhancing economic growth is underpinned by both country specific as well as regional factors. The failure by farmers to add value to their products causes them to fail to get the most out of their products and to attract consumers. Failure to add value can be attributed to lack of infrastructure, lack of training and policies supporting such initiatives. It is important to delineate the factors driving agricultural productivity and how it will subsequently drive economic growth in the context of a country. Evidence [16-20] in literature is not conclusive with one group of economists suggesting a positive connection between agriculture and industrialization while others [21-24] suggest a negative link between the two. There is no agreement on the direction of causality between growth and agricultural productivity [23, 25].

The main questions are whether or not productivity in agriculture granger causes economic growth and vice versa, and what are the key drivers of agricultural productivity? The study answers the questions, in the context of Botswana, by testing the short and long term connection between economic growth and agricultural productivity and by establishing the key determinants of productivity. The results from this study show that there is unidirectional causality moving from agricultural productivity to economic growth. Thus in the case of Botswana the study supports agricultural led growth. The study, further, shows that agricultural productivity is mainly driven by the provision of adequate infrastructure and investment in farming machinery. However, access to credit by the private sector retards productivity levels in the agricultural sector. The rest of the study is organized as follows: section two puts the study into context by explaining agricultural productivity and economic growth in Botswana, section three reviews related literature on agricultural productivity, economic growth and related factors, section four explains the data and methodology employed in this study, section five presents the main findings and section six concludes and gives policy recommendations.

2. ECONOMIC GROWTH AND AGRICULTURE PERFORMANCE IN BOTSWANA

Botswana became independent from Britain in 1966, the time at which the economy was not performing well and heavily dependent on agriculture. The economy grew by an average 7% per annum from 1967 to 1997 which saw the country moving to middle income. The average rate of growth was 6.1% between 1966 and 1991. The growth of the economy has been driven by sound macroeconomic management and accountability by the government. The government came up with successive national development policies which have driven economic growth and development [26]. Evidence [12, 15, 27] shows that annual growth declined over the years: 1980 – 1990 (7.5%), 1990-2000 (3.2%) and 2000-2008 (3.8%) and growth rate remained more or less the same thereafter (see Figure 1). The agricultural sector has continued to register low yields worsening poverty among the rural folk. Per capital income stood at US$9,400 in 2012 making the country to be ranked number four in Africa [28].
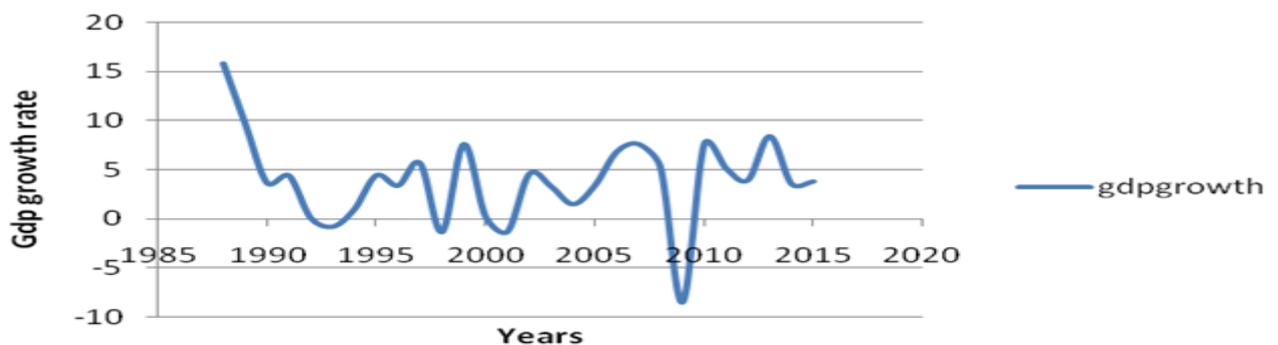

Figure-1. Botswana gdprowth (1988-2015)

Source: World Bank [29]

The agricultural sector composes both crops and livestock production and it is dominated by traditional farming [15]. Agriculture contributed slightly above forty percent of the country's gross domestic product (GDP) and it was a source of livelihood. This is true even now where nearly three quarters of the country's rural populace relies on rain-fed agriculture. However, evidence suggests that around 2008 agriculture contributed around less than two percent of GDP. This is worse than its 3% contribution in the 2000/1 and 5% in the early 1990s crop season. However the beef industry is still contributing significantly to GDP [15, 30]. The fall in the contribution of agriculture to economic growth has been explained as the high growth in other economic sectors between 1974 and 2011. The agricultural sector's performance has continued to fall in Botswana and it has become unsustainable and incomes in the sector have fallen. Figure 2 shows that agricultural productivity has remained stagnant over the years, around 700 United States Dollars, since 1980. After 2010 it is showing signs of decline which is likely to cause poor contribution of agriculture to economic performance.
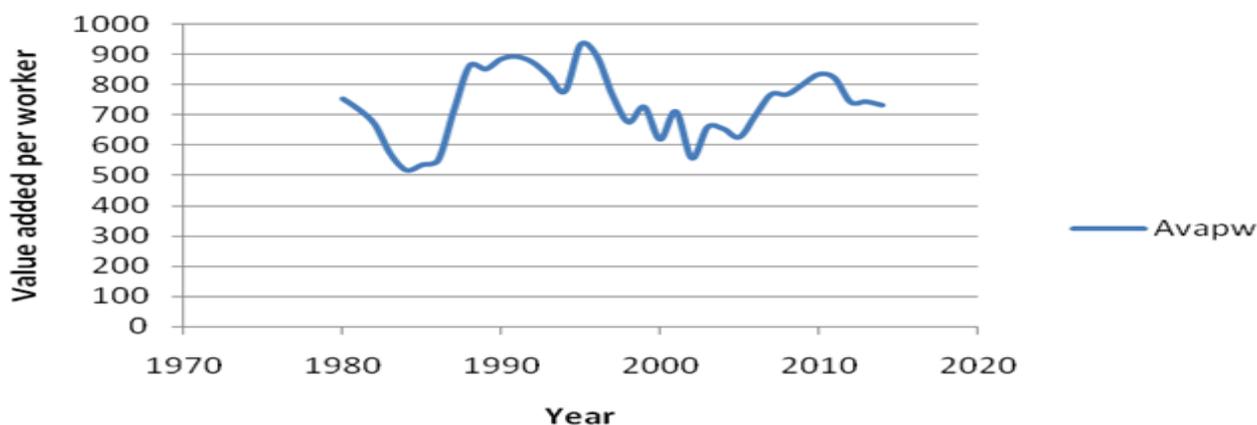

Figure-2. Value added per worker

Source: World Bank [29]

Crop production has not been doing well while livestock production has performed better. Evidence shows that access to infrastructure by farmers is still a challenge. For example access to roads, electricity, telecommunication, water for irrigation, grain storage, markets, sanitation, water for domestic use and water for livestock is limited to 45%, 17%, 22%, 43%, 39%, 52%, 54%, 66% and 64% of the farmers respectively [31]. This may have contributed to slowness in the growth supply chains linked to agriculture like food processing and manufacturing. According to the UNDP [15] report crop production is facing challenges like erratic rainfall patterns, limited access to markets, skills shortage, poor marketing facilities and failure to use technology. Technological advancement has been made in dairy and horticultural sectors in which the later relies on irrigation. Similarly, Matambo [27] noted that agriculture experienced problems like recurring droughts and lack of access to markets. In addition to the rainfall challenges agriculture has continued to experience low yields which is likely to trap many rural dwellers in deep poverty.

The economy is currently heavily dependent on diamonds, which is a non renewable resource, for growth. The government has come up with initiatives to diversify the economy and enhance the contribution of agriculture to growth. The government introduced two programs supporting arable agricultural sector in the mid 1980s: the Arable Lands Development Program (ALDP) and the Accelerated Rainfed Arable Programme (ARAP). Evidence Seleka [32] shows that cultivated area, output and yields rose by 27%, 120% and 74% respectively as result of implementation of the later policy. ARAP was effective in improving rural livelihoods and increasing food security but the programme was found to be unsustainable from the government's point of view. In 2002 the government came up with the National Master Plan for Arable Agricultural and Dairy Development (NAMPAADD) which aimed among other things to transform traditional to commercial farming activity. It aimed to improve crop yields

17

and productivity and to create viable business opportunities for farmers [33]. In 2008 the government came up with Integrated Support for Arable Agricultural Production to improve agricultural productivity. The program aims to provide free inputs and equipment to farmers and finance at low interest rates. However the program has failed to improve yields and productivity levels in agriculture [14]. This could have been as a result of erratic rainfall which calls for the government to make important considerations to revive agriculture. However, there are still opportunities for growth in agriculture as the government is seeking to mobilize resources to diversify the economy. Agriculture provides this avenue for diversification with potential contribution to economic growth, employment and poverty reduction. Meaningful diversification of the economy can be achieved by supporting agro-based projects. Agriculture has potential to create a new platform for exports and to bring meaningful industrial activity among the rural populace [34]. Agriculture in Botswana [27] is labour intensive absorbing much of the unskilled labour force. It has potential to be part of the global value chains and gain access to prime international markets. There is potential to increase food security through increased investment in irrigation and related equipment. The government is still finalizing the designing of the pipeline from the Zambezi River to carry water for irrigation for the horticultural sector. This project is expected to increase the number of commercial farmers and create more jobs.

3. REVIEW OF RELATED LITERATURE

3.1. Conceptual Framework

Theories of growth been developed by earlier economists like Adam Smith, David Ricardo and Thomas Malthus who became known as the classical growth theories. Their framework was similar in which the production function showed the output depends on stock of capital, land or natural resources and labour force (Y = F(K, L, N)). They also agreed that technological progress is dependent on the rate of capital accumulation which results when a firm makes profit [35, 36]. Neo classical economists, like Harrod and Domar, show that the savings rate and the rate of technical progress are useful in explaining growth. Their main argument is that growth is increased when the savings rate rises and/or when the capital output ratio has been reduced. The main shortfall is the assumption that there is no technical change and the economy is closed [37, 38]. Similarly, Solow [39] assumes that labour is exogenously determined, no depreciation of capital stock, labour and capital cannot be substituted, and that unemployment is temporary and there is no need focus on it. Technological progress only exists when the amount of knowledge increases over time. The model has been criticized because it fails to incorporate the effectiveness of labour and the inclusion of technology is not justified. It says that output is a function of capital, labour and knowledge or effectiveness of labour.

Endogenous growth theorists [40, 41] allow technological advances to influence output due to externality or spillover effects that arise from knowledge generation. Spillover effects give rise to increasing returns to scale within the production function. Rebelo [42] who is also an endogenous growth theorist, supports the idea that output depends on technology and capital. This is known as the AK technology where there are constant returns to scale due to acquiring capital (physical, human, knowledge). Growth is, therefore, explained by investment in human capital, innovation and knowledge. The theory primarily shows that long run economic growth depends on policy measures which affect research and development, education and infrastructure development. Romer [40] argues that the production of goods depends not only on the private knowledge but on the aggregate stock of knowledge. Thus endogenous growth theories show that economic growth increases with more subsidies on human capital from the government. In this case the production function framework explains the link between economic growth and investment. The endogenous growth model [41, 43] shows that any changes to infrastructure have an effect of increasing the steady-state level of output. Hence other variables like infrastructure, farming machinery and access to credit can be included in the production function [44]. Following Echevarria [45] and Lorde, et al.

[46] the Cobb –Douglas function, with agricultural productivity as the dependent variable, can be specified as follows:

$$Y_t = A_t K_t^{\alpha} mech_t^{\beta} Infr_t^{\gamma} dcpriv_t^{\upsilon} \tag{1}$$

Where agricultural productivity (Y_t), depends on the level of capital (K), farming machinery (mech), access to credit (dcpriv) and infrastructure ($Infr$), elasticities are given by α, β, γ, v and they add up to 1. K is composed of human (H) and physical capital (K), A is technology. Equation (1) can be further developed to incorporate technology. It is assumed that accumulation of total capital (physical and human) induces the accumulation of technology as follows:

$$A_t = B(K_t H_t)^c$$ and 0<c<1, B is a constant in the final model.

The production function will be as follows:

$$Y_t = B(K_t H_t)^{\alpha+c} mech_t^{\beta} Infr_t^{\gamma} dcpriv_t^{v} \tag{2}$$

The log linear model will be given as:

$$\log Y_t = B + (\alpha + c)\log K_t + (\alpha + c)\log H_t + \beta \log mech_t + \gamma \log Infr_t + v \log dcpriv_t \tag{3}$$

3.2. Empirical Review

The share of the agricultural sector in Gross Domestic Product (GDP) differs across countries. There is still disagreement on the level of value creation for agriculture and non-agriculture sectors in the economy. It is argued that richer nations have predominantly large non-agricultural sectors than poor ones. Earlier economists [16, 17] argue that agriculture expansion is a precondition for growth as well as industrialization. They argue that an increase in agricultural productivity frees some labour into other key sectors like manufacturing. As farming sector incomes rise there will be an increase in demand for products from the manufacturing sector. This suggests a positive link between agricultural productivity and economic growth. On the other hand some earlier economists [21, 47] suggest a negative connection between agriculture and economic growth. They argue that countries with low productivity in agriculture have managed to industrialize at a faster rate. This study reviews recent studies on productivity, value addition and economic growth as a way of streamlining the previous findings on agricultural productivity, economic growth and infrastructural development.

3.2.1. Agricultural Productivity and Economic Growth

Producers of agricultural products have the task of assessing the potential of customers buying their products ahead of those for competitors. The products produced in the agricultural sector are essentially the same and business is driven by price. This means those who control the market enjoy less costs and push for high volumes. Value addition is another important factor which may drive current and future incomes for farmers. It is against this background that a further review has been on studies linking value addition and economic growth as follows:

The demand by consumers for better quality products, safety, organic and processed products is on the rise. Such changes create opportunities for farmers and suppliers of agricultural products to change their commodities into products that are in high demand. This gives rise to value chains which are organized between producers, traders, service providers and processor with the aim to enhance value of their activities. They take advantage of synergistic effects as the value of the final products tends to be higher than the value of their individual products Asian Development Bank [48]. Ceylan and Ozkan [49] shows that the effect of agricultural income, as a result of value added, on growth is positive. Agriculture keeps its economic importance and that average per capita incomes

19

were found to be higher within the European Union members than for non members. Similarly, Anderson and Hanselka [50] argue that value added agriculture generates income that has a positive impact on economic growth. Agricultural producers earn less in value terms than food processors who sell branded products. Customers perceive value added products as more beneficial and they are ready to pay extra which makes the business more profitable and sustainable. Value addition is driven by factors like competition, increased consumer incomes, changing tastes and preferences. Different activities done by the business should create value like procurement of inputs, conversion of inputs into final products, marketing, supply chain logistics and customer service activities. Mabuwa [51] shows that value addition in agricultural products results in more integration in agro based businesses and foreign direct investment, increased capacity utilization, employment creation, more disposable income, increased demand for services, more government revenue and increased export earnings. Businesses would need to identify products and come up with activities that improve value to their products.

Productivity measures the increase in output which is not accounted for by the increase in production units. Total factor productivity happens when the ratio of output to inputs grows overtime. It contributes to the health of the economy and increased viability of the farming sector. An increase in productivity also translates into an increase in income for farmers in the short run. Oyakhilomen and Zibah [18] using time series data and ARDL bounds testing approach, showed that agricultural production is significant in influencing economic growth. This is despite the rise in poverty which needs more investment in agriculture and putting in place pro poor policies to reduce poverty in rural areas. Similarly, previous studies [19, 20] found that agriculture acts as an engine for economic growth in the short term. These studies support increasing public and private expenditure and channel resources towards research and development of infrastructure. They also show that former food net exporters have been adversely affected by changing global weather patterns and they are now net food importers.

However, Diao [22] asserts that the agricultural sector is important for economic growth considering its size in the economy. Economic transformation results from broad based development in agriculture. Continuous expansion in land increases the risk of environmental degradation as the quality of land deteriorates due to over farming and low usage of fertilizer. The contribution of agriculture to economic growth was found to be invisible which causes the former's role to be underestimated. According to Los and Gardebroek [23] agriculture executes different roles during the different stages of economic development. Economic development is driven by food production in low income countries while in high income countries growth is driven by the movement of labour away from agricultural activities to other critical sectors. This suggests that agriculture contributes to growth in developing than in developed economies. A recent study by Rillo and Sombilla [52] provide evidence that enhancement in productivity is not an end in itself but it is a way in which development is achieved. Productivity increases incomes for small scale farmers but the livelihoods of the poor are improved when economic growth becomes inclusive. The failure to make growth inclusive results in agriculture being marginalized which causes productivity gains to be lost. Thus agriculture sector reforms are effective when supported with credible policies and improvements in other sectors like education and health. However, Huang and Luh [53] argue that there is a threshold for the impact of education on agricultural productivity. Similarly, Mashindano, et al. [54] asserts that economic growth has not been influenced by agriculture but it was driven by service and industry sectors. The agriculture sector has suffered from low growth rates, low utilization of fertilizer and improved seed types and poor mechanization.

Evidence suggests that the direction of causality between growth and productivity is not definite. Los and Gardebroek [23] show that there is bidirectional causality between agricultural production and economic development. However, Oyimbo and Rekwot [25] show that there is unidirectional causality from agricultural productivity to economic growth and unidirectional causality from inflation to agricultural productivity. Similarly, Odetola and Etumnu [55] found that agriculture sector contributed more to Nigeria's economic growth and that agricultural growth granger causes economic growth. Crop production contributed more to the growth in the

agriculture sector. Again, Kohansal, et al. [56] found that there is a long run relationship between agricultural value added and economic growth. Value addition, among other variables, had a positive effect on economic growth but the former's effect on growth was negligible. Evidence [57] shows that value added of agriculture is positively influenced by other factors like labour, capital stock and total factor productivity of labour and capital.

3.2.2. Agricultural Productivity and Infrastructure Development

Infrastructure development is another source of productivity in agriculture. The challenge is that most of the lower income countries suffer from poor infrastructure in telecommunication, road network and energy. Governments fail to prioritize the provision of such infrastructure as an intervention strategy to increase productivity, which adversely affects attainment of the millennium development goals [58]. It is against this background that this study reviews several studies on the impact of infrastructure development on productivity. Felloni, et al. [59] using data for 83 countries and 30 provinces in China show that the density of roads and the availability of electricity, proxies for infrastructure, had a positive effect on production and productivity in agriculture. This suggests that access to quality infrastructure is vital for improved agricultural production. Similarly, Goswami and Chatterjee [60] show that composite infrastructure index, fertilizer and high yielding varieties have a positive effect on productivity. The study further shows that electrified villages along with fertilizer and high yielding varieties have a positive effect on productivity. Again, Ashok and Balasubramanian [61] show that investment in rural infrastructure like irrigation, rural markets and roads enhance the level of productivity. An increase in investment in rural infrastructure helps secure livelihoods as the economic environment changes. Adepoju and Salman [62] show that improvements in soil practices and extension services had a positive effect on productivity. This confirms results by Segun, et al. [63] who showed that poor infrastructure have a negative effect on farming productivity levels. On the other hand [64] show that electrification makes it possible for farmers in areas with erratic rainfall patterns to irrigate leading to higher productivity. Similarly, Llanto [65] suggests that inadequate infrastructure acts as a constraint to economic growth and productivity. Rural infrastructure increases productivity which in turn supports growth initiatives in rural areas, increases farm income and opportunities. As productivity rises, food prices fall which acts as a spillover effect to urban and rural communities. Electricity and roads are both significant determinants of productivity and growth. Access to electricity generates more income earning opportunities for farming and rural communities. Again, Li and Liu [66] suggest that transportation played a significant role in increasing productivity. It was ahead of factors like education infrastructure, electricity and water supply. On the other hand other studies [67, 68] show that farmers participating in adult education programmes have high productivity that those who do not participate.

3.2.3. Other Determinants of Agricultural Productivity

The challenges facing Africa economies are that of food insecurity, hunger, poverty and economic competitiveness. These can be addressed by increasing agricultural productivity which is driven mainly by supporting infrastructure and other factors like human capital, credit markets and research [69]. A study by Oni, et al. [70] examined the trends in and drivers of agricultural productivity using Nigerian data and analysis was done using graphical and econometric methods to determine drivers over time. Findings show that agricultural productivity was driven mainly by female family labour but women farmers had limited access to extension services. Small scale farms were found to be efficient while large scale farms were less productive due to constraints in accessing finance and yields for certain crops differed across regions as explained by different climatic conditions. Bhattarai and Narayanamoorthy [71] show that there is no significant growth in agriculture productivity when the level of all inputs use and their costs are taken together. The marginal impact of irrigation on growth of productivity of all inputs is found to be positive. According to Diao [22] productivity of crop production is driven by intensive use of inputs and high yields are increased by better land management and farming practices.

Productivity constraints come in the form of failure to apply modern tools, inputs and lack of knowledge. Labour may act as a constraint when promoting intensive farming practices. Productivity also grows by promoting new activities and exploring additional market opportunities that increase value addition of agricultural production. Rizov, et al. [72] argue that farming subsidies have both positive and negative impact on farm productivity depending on the nature of reforms put in place by the government. In the case of Latin America and Caribbean countries productivity has been driven by improvements in efficiency and introduction of new technologies. Land abundant countries exhibited higher productivity than those who are constrained. Productivity is boosted by policies that are applied fairly to all agricultural sectors and policies that remove distortions in price and production. It has potential to reduce poverty but its effect depends on the method used to measuring it Ludena [73]. Underinvestment in agricultural machinery leads to low crop yields. This can manifest in the form of few farming machinery, like combine harvesters and tractors, per hectare. The more machinery becomes old then the more is the level of underinvestment which raises food security concerns. The rural poor and farming communities experience lack of access to funding which delays the process of farm mechanization [74].

4. METHODOLOGY AND DATA

The study tests the connection between agricultural productivity and economic growth and examines the factors that are important in explaining agricultural productivity in Botswana. Annual time series data was obtained from World Bank [29] covering the period 1980-2014. The study employed six variables: Agricultural productivity (Avapw) was measured as the value added per worker. Value added includes the output of the agricultural sector less value of intermediate inputs. Agriculture comprises value added from forestry, hunting and fishing as well as cultivation of crops and livestock production; Infrastructure was represented by two variables: Electricity power consumption per capita (epc) was represented by the total kilowatt hours consumed during the year divided by the population and total length of roads maintained by the central government (trl); physical capital is represented by the gross fixed capital formation (gfcf) includes improvements on land (fences, ditches, drains), purchases of plant and machinery and construction of roads and railway networks; human capital (ter) is measured as the total percentage of the population in a particular age group enrolled in a tertiary education institution after successfully completing secondary education; investment in machinery (mech) was defined as agricultural machinery, like tractors, employed per 100 square kilometers of arable land; access to credit (dcpriv) was defined as financial resources provided to the private sector by depository corporations in the form of loans, purchases of non-equity securities, trade credit and other accounts receivable; economic growth (gdgn) was defined as the total national output after subtracting total valued added in agriculture at market prices based on constant United States Dollars. Other variables like trade openness (tot) and flows of foreign direct investment (fdi) were used as control variables in the causality model.

4.1. Model Specification

The study tests the existence of both short and a long run relationship among variables. Short relationship was determined using the method by Granger [75] to test the causality between economic growth and agricultural productivity. Variables may be integrated of order one, or I (1), and their interrelationship is examined by taking first differences and then including their differences in a vector autoregression (VAR) model. But this gives problems where the variables are found to be integrated because a VAR would not capture long run movements in variables. This long run relationship among variables was adequately captured using a vector error correction model (VECM) which deals well with weaknesses of the granger causality approach. The VECM improves the arguments around granger causality by making use of an error term to capture the connection between cointegrated variables. The error term, where there are two variables, is represented by the residual from the cointegrating regression, of the series on the other variables in levels. It is an explanation of the movement away

from long run equilibrium. The model has multiple variables, resulting in a vector of error correction terms, whose length equals the number of cointegrating vectors among the series [76]. It is possible for variables to move away from equilibrium which can be easily corrected using by adjustment parameters which have an influence in the short run. Firstly a simplified VECM can be explained using a two variable case as follows [77, 78].

A two I(1) series is assumed which is made up of x and y to be cointegrated and there exist unique α_0 and

α_1 such that $u_t \equiv y_t - \alpha_0 - \alpha_1 x_t$ is I(0). The VECM model can be expressed, where y and x is the dependent variable and regressor respectively, as:

$$\Delta y_t = \beta_0 + \beta_1 \Delta x_t + \lambda u_{t-1} + \varepsilon_t = \beta_0 + \beta_1 \Delta x_t + \lambda(y_{t-1} - \alpha_0 - \alpha_1 x_{t-1}) + \varepsilon_t \tag{4}$$

The terms in (4) are taken as being I(0) where the cointegrating vectors (α) are consistently estimated. The magnitude by which y is out of the long term equilibrium is represented by the term u_{t-1}. The amount of correction, happening in period t, for the disequilibrium in period t-1 is denoted by λ and it is expected to be negative. Equation (4) can be extended so that variables x and y evolve jointly over time as a VAR system. The two variables may indicate that there is one contegrating relationship between them. Assuming a one lagged difference in the equation it's possible to have a bivariate equation of the following form:

$$\Delta y_t = \beta_{y0} + \beta_{yy1}\Delta y_{t-1} + \beta_{yx1}\Delta x_{t-1} + \lambda_y(y_{t-1} - \alpha_0 - \alpha_1 x_{t-1}) + v_t^y$$

$$\Delta x_t = \beta_{x0} + \beta_{xy1}\Delta y_{t-1} + \beta_{xx1}\Delta x_{t-1} + \lambda_x(y_{t-1} - \alpha_0 - \alpha_1 x_{t-1}) + v_t^x \tag{5}$$

The terms in equation (5) are considered to be I(0) if variables are cointegrated where $y_t - \alpha_0 - \alpha_1 x_t$ is stationary. In the same way λ still represents the error correction coefficients which capture the response of each variable to the level of movement away from long term equilibrium in the previous period (t-1). For example if x_{t-1} is above its long run equilibrium value in relation to y_{t-1}, then $\lambda_x < 0$. This should result in a positive error correction term which is given in brackets in a system of equations (4) thus y will take a downward trend in the current period (t). The model employed has more than two variables and so it is worthwhile to provide a generalized VEC model with several variables. First one can consider a VAR with p lags given as

$$y_t = v + A_1 y_{t-1} + A_2 y_{t-2} + \ldots\ldots\ldots\ldots\ldots + A_p y_{t-p} + \varepsilon_t \tag{6}$$

Where: y_t is a vector of K x 1 vector of variables, v is a K x 1 vector of parameters, $A_1 \ldots A_p$ are K x K matrices of parameters, and the disturbance or error term is a K x 1 vector of disturbances with a mean of zero. Equation 6 can be written as a VECM in the following form:

$$\Delta y_t = v + \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{7}$$

Where $\Pi = \sum_{j=1}^{j=p} A_j - I_k$ and $\Gamma_i = -\sum_{j=i+1}^{j=p} A_j$. The other variables are as defined in (6) above.

Stata 12 was used to estimate the VEC model as follows. Firstly the number of lags is specified to include in the system of equations using the method by Tsay [79]. Secondly tests for cointegration in the variables are done

using the method by Johansen [77]. Lastly, the VEC model was fitted with parameters in the cointegrating equations (β), adjustment parameters (α) and short run coefficients. The general form of the model for agricultural productivity is as follows:

$$\text{Avapw} = f(\text{dcpri, gfcf, mech, epc, trl, ter}) \qquad (8)$$

The study employed a log linear model of the following form:

$$\log Avapw_t = \beta_0 + \beta_1 \log dcpri_t + \beta_2 \log gfcf_t + \beta_3 \log mech_t + \beta_4 \log epc_t + \beta_t \log ter_t + \beta_t \log trl_t + \varepsilon_t \quad (9)$$

Where β_0 a constant and β s are coefficients and ε_t is an error term.

5. RESULTS AND DISCUSSION

5.1. Descriptive Statistics and Preliminary Analysis

When dealing with panel data it is necessary to test for integration and results in Table 1 shows that three variables (loggfcf, logmech, logfdi) were stationary at levels or they show a covariance stationary process. The remaining three variables were stationary after first differencing or they are said to be integrated of order one. Estimations were done at the level in which a variable was found to be stationary.

Table-1. Unit root tests

Variable	Statistic	p-value	Order of Integration
logAvapw	-5.837	0.0000	I(1)
Loggdpn	-4.540	0.0002	I(1)
Logdcpriv	-4.621	0.0000	I(1)
Loggfcf	-3.316	0.0142	I(0)
Logmech	-2.950	0.0398	I(0)
Logepc	-5.543	0.0000	I(1)
Logter	-3.619	0.0054	I(1)
Logtrl	-5.983	0.0000	I(1)
Logtot	-7.807	0.000	I(1)
Logfdi	-4.525	0.0002	I(0)

Source: Author's own computation from Stata

Testing the variables for multicollinearity was done using the method explained in Williams [80] in stata. Results (Table 2) show that the variables were lowly correlated and so there was no problem of multicollinearity in the variables.

Table-2. Tests for multicollinearity

	logAvapw	Loggfcf	logtrl	logepc	logdcpriv	logmech	logter
logAvapw	1.0000						
loggfcf	-0.4680	1.0000					
logtrl	0.2642	0.1775	1.0000				
logepc	0.0991	-0.0658	-0.1311	1.0000			
logdcpriv	-0.1831	0.4185	0.0785	0.2273	1.0000		
logmech	0.2645	-0.0083	-0.3024	-0.0167	0.3424	1.0000	
logter	0.0367	-0.0528	-0.5111	0.2231	-0.1121	-0.1754	1.0000

Source: Author's own computation from Stata

5.2. Tests for Heteroskedasticity

The Breusch –Pagan/ Cook-Weisberg was employed to detect the presence of any linear form of heteroskedasticity [81]. This was done by first running the regression and making the estat hottest command in stata. The null hypothesis was that there is constant variance and the alternative is that there is heteroskedasticity.

Results gave a chi2(1) equal to 1.03 (which is small) and p-value of 0.3105 suggesting that there is not enough evidence to reject the null hypothesis. This means that heteroskedasticity was not a problem in the variables.

Table 3 presents results for the optimal lag length obtained using the method contained in VECM model. The study used three lags, as indicated by an asterisk (*), which have been chosen using sequential Likelihood-Ratio (LR), Hannan-Quinn Information Criterion (HQIC) and Schwarz Bayesian Information Criterion (SBIC) method.

Table-3. Selection order criteria

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-584.584				32.00	39.4389	39.5435	39.7659
1	-532.154	104.86	49	0.000	28.00	39.2103	40.047	41.8259
2	-469.349	125.61	49	0.000	20.00	38.2899	39.8588	43.1941
3	-351.395	235.91*	49	0.000	17.00*	33.693*	35.9941*	40.8858*
4	3126.58	6956	49	0.000	0.087	-194.906	-191.872	-185.424

Source: Author's own computation from Stata

The study used the method by Johansen, vecrank, to tests for the existence of a long run relationship. The method helps to test for the null hypothesis of no cointegration which is rejected when the log likelihood of the unconstrained model which includes the cointegration equations is significantly different from the log likelihood of the constrained model which excludes the cointegrating equations. Results in Table 4 fail to reject the null hypothesis of at most one cointegrating equation. The study, therefore, uses two cointegrating equations as indicated by the trace statistic.

Table-4. Johansen tests for cointegration

Maximum rank	parms	LL	eigenvalue	trace statistic	1% Critical value
0	78	-537.76205		128.0525	103.18
1	89	-516.34031	0.74894	85.2091	76.07
2	98	-498.20032	0.68973	48.9291*	54.46
3	105	-486.43554	0.53187	25.3995	35.65
4	110	-478.897	0.38514	10.3224	20.04
5	113	-475.62303	0.19041	3.7745	6.65
6	114	-473.73577	0.11464		

Source: Author's own computation from Stata

5.3. Results from Vector Error Correction Model

Overall the results (Table 5) show that the model fits well since the coefficients in the cointegrating equation and the adjustment parameters are statistically significant. Estimates in Table 5 have correct signs and they show that there is rapid adjustment towards equilibrium. The coefficient of physical capital (gfcf) is positive which shows that it is above its equilibrium level. The coefficient for the adjustment parameter is negative and significant which shows that when the level of gfcf is above its equilibrium level it will quickly fall back to equilibrium towards the level of other variables. Similarly when access to finance and infrastructure variables are below their equilibrium level (coefficients are negative) they will move back to equilibrium towards the level of agricultural productivity since the adjustment parameter is positive and significant.

The discussions on the results on the long run model (Table 5) are as follows:

The long term model shows that growth in agricultural productivity in Botswana is mainly driven by expansion in infrastructure (epc and trl) and physical capital (gfcf). The infrastructure in Botswana is mainly provided by the government by improving electricity distribution which increases consumption levels and by maintaining and upgrading the road network. This suggests that as government makes improvement in the electricity distribution network and supply of energy, the level of agricultural productivity goes up.

Table-5. The Vector Error Correction Model

Variable	Coefficient	p-value	Adjustment parameter	p-value
logAvapw	1	-	0.153	0.282
Loggfcf	2.045	0.000*	-0.6222	0.002*
Logdcpriv	-1.833	0.000*	0.3405	0.061**
Logmech	-0.965	0.149	0.0943	0.757
Logepc	6.870	0.000*	-0.1887	0.045*
Logtrl	1.845	0.000*	-0.1613	0.035*
Logter	0.0223	0.908	-0.1375	0.105
Constant	-2.8411			

*significant at 5% ** Significant at 10%

Provision of better transport networks like roads and railway lines encourage farmers to produce more agricultural output which immediately results in increased economic growth. The study shows that maintenance of roads is one of the ways in which the government's diversification efforts can be sustained in the agricultural sector. Findings, in this study, are consistent with those in previous studies [60, 62, 65] which show that provision and access to infrastructure promotes productivity which in turn boosts farm income and opportunities. They are also consistent with findings by Felloni, et al. [59] which show that improvement in the usage of electricity has a positive impact on productivity in agriculture. This study show, over the long term, that as the government invests in power production by upgrading power generating projects realizing more output per worker becomes possible. Thus improvements on land (fences, ditches, drains), purchases of plant and machinery and construction of roads and railway networks improves food security. However, human capital and farming mechanization were insignificant. Surprisingly the study finds that financial resources advanced to the private sector by financial institutions in the form of loans, purchases of non-equity securities, trade credit and other accounts receivable crowds out resources that would otherwise have been utilized by farmers. These results are not consistent with those by Gajigo and Lukoma [69] who showed that access to credit drives agricultural productivity. Results show that monies advanced to the private sector are not productive in the agricultural sector and this has key implications for policy makers. Results on causality, Table 6, show that agricultural productivity has a short run connection with economic growth. The two variables confirm the existence of a unidirectional causal relationship from agricultural productivity to growth. Our results are consistent with previous studies [25, 55] which show the presence of unidirectional causality from agricultural productivity to economic growth. This explains the potential contribution of agricultural productivity to economic growth in Botswana. This means an increase in agricultural productivity will result in high growth in the short term. The other important finding is that both physical and human capital granger causes agricultural productivity. These results are important for policy making in the short to medium term.

Table-6. Granger Causality Wald Tests

Equation	Excluded	Chi2	d.f.	Prob>chi2
D_loggdpn	d.lfdi	2.3473	3	0.504
D_loggdpn	d.lter	5.4711	3	0.140
D_loggdpn	d.gfcf	5.3265	3	0.149
D_loggdpn	d.ltot	1.1753	3	0.759
D_loggdpn	d.ldcpriv	1.7266	3	0.631
D_loggdpn	d.logAvapw	9.3426	3	0.025*
D_loggdpn	All	32.49	3	0.019*
D_logAvapw	d.loggdpn	0.6077	3	0.895
D_logAvapw	d.lfdi	8.0981	3	0.044*
D_logAvapw	d.lter	8.6564	3	0.034*
D_logAvapw	d.lgfcf	7.0774	3	0.069**
D_logAvapw	d.ltot	7.2323	3	0.065**
D_logAvapw	d.ldcpriv	7.7838	3	0.051**
D_logAvapw	All	37.381	3	0.005*

*Significant at 5% and **Significant at 10%

6. CONCLUSIONS AND POLICY IMPLICATIONS

The study sought to find whether or not productivity in agriculture granger causes economic growth & vice versa and to establish the key drivers of agricultural productivity in Botswana in the long term. The study finds that there is unidirectional causality flowing from agricultural productivity to economic growth. The study further shows that agricultural productivity is mainly driven by the provision of adequate infrastructure and physical capital. Factors like human capital and farming mechanization were insignificant while improved access to credit by the private sector retards agricultural productivity. Results suggest that improvement in agricultural productivity in the long term will have positive short term effects on economic growth. Thus government efforts to diversify the economy through agro-based initiatives can pay dividends in the form of sustainable growth in the short term. This requires government intervention in the form of improving fencing which keeps away animals, provision of ditches and drains to improve soil productivity by getting rid of unwanted moisture. The government can also intervene by putting in place good roads and upgrading the already existing ones which increases access to markets by farmers. The ease with which farmers access product markets through provision of good transport networks reduces transport costs and hence increases farming incomes which subsequently contributes to national income. This increases the level of utilization of land by farmers. The government needs to encourage usage of electricity by reducing rates charged per kilowatt hour and improving supply of electrical power. This means the government should improve the power generation plants and increase production capacity to guarantee continuous flow of electrical energy to the farming community. Thus a more targeted approach is desirable in which the government supports farmers in places that are not prone to drought but those with good quality soil and hence potential for increasing farming output. Using a targeted approach helps in advancing finances specifically to the farming communities and not the private sector in general. This improves the chances for access to credit to improve farming output.

Future research work can focus on how agricultural productivity and agrobased industrialization can be enhanced through improving value chains in regions like SADC. This focus can be on trade, level of competition and integration. There is need to promote agro linked industrialization by developing infrastructure, human capital, strengthening institutions and improving access to investment opportunities for farmers. Agriculture can be used as a way of reducing inequality among youths, women and rural populace.

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