

**Drivers and Sustainability of
Agricultural Growth in Nigeria**

**Eric Eboh,
Moses Oduh
and Oliver Ujah**





AIAE RESEARCH PAPER 8

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Abbreviations and Acronyms

ADF	Augmented Dickey-Fuller
AGDP	Agricultural Gross Domestic Product
AGSF	Agricultural Guarantee Scheme Fund
CBN	Central Bank of Nigeria
CPI	Consumer Price Index
DMO	Debt Management Office
ECM	Error Correction Model
FAO	Food and Agricultural Organization
GA	Growth Accounting
GCA	Government Capital Expenditure
GDP	Gross Domestic Product
GNI	Gross National Income
LCU	Local Currency Unit
MFBS	Micro- Finance Banks
NEXR	Nominal Exchange Rate
TFP	Total Factor Productivity
TSFP	Total Social Factor Productivity
UK	United Kingdom
UNCTAD	United Nations Conference on Trade and Development
US	United States
WB-GDF	World Bank Global Development Fund



About AIAE Research Paper Series

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Executive Summary

This paper evaluates the factors that drive Nigeria's agricultural growth with an intent to inform and stimulate appropriate policy responses for growth sustainability. Using hypothesized traditional factor inputs, the study estimated a global agricultural production function for Nigeria based on Cobb-Douglas model, assuming Hicks-neutral technological progress. Also, the study estimated an econometric model of total factor productivity (TFP) based on 'Solow Residual'. The data covered a 40-year period from 1970 to 2009. The total factor productivity model distinctively incorporated market-related and policy-level factors that potentially affect agricultural productivity growth. The TFP analysis was extended to cover total social factor productivity (TSFP) in order to analyse growth sustainability.

The analysis shows that Nigerian agricultural sector is characterised by increasing return to scale, which implies that farmers are operating at the low end of the production function. This underscores the huge potential to raise agricultural output through increased use of more efficient inputs, rather than by mere expansion of cultivated land. The relatively more important factors that influence Nigeria's agricultural value added include rainfall, technology (efficiency parameter) and fertiliser use; and land area is the least important factor.

Capital expenditure on agriculture, price of agricultural commodities, per capita income and investment rate in agriculture, human capital and access to credit are positive influences on total factor productivity. On the other hand, agricultural trade (openness), environmental degradation and agricultural output variability have negative influences. Among the strongest positive influences are human capital in agriculture, price of agricultural commodities, per capita income (reflecting aggregate demand) and access to credit. Government spending on agriculture and investment rate in agriculture are the weakest positive influences in terms of magnitude and time lag of impacts.

Total social factor productivity, which reflects sustainability of growth, is characterised by a negative and unstable outlook over time, meaning that growth rate in agriculture might not be sustainable in the longer term. This is not unexpected, considering the poor quality of the growth milieu. The growth of aggregate output is less than proportionate to the growth of aggregate inputs, a situation that can be linked with the predominantly labour-intensive and or land-expanding character of agricultural growth. Labour productivity (in terms of output per man day) has tended to stagnate and land expansion is not the sustainable pathway for agricultural growth. Implicit in the analysis is the huge potential for boosting agricultural growth through irrigated agriculture. The estimated potential contribution of irrigation to growth of total factor productivity exceeds the combined effects of all the



included production factors, less rainfall and technology (efficiency parameter). The huge potential role of irrigation in accelerated and sustainable agricultural growth poses critical challenge for public policy to harness the vast water resources across the country.

Overall, the study shows that Nigerian agricultural output growth is directly related to the growth of factor input, but, the negative outlook of the trend of TFP implies that growth might not indeed be sustainable. The low capital-labour ratio further underscores the agricultural growth sustainability concerns. The negative outlook of TSFP reflects the adverse environmental externalities and the unsustainable trends associated with continuous expansion of cultivated lands to compensate for 'constrained yield increases' and meet additional demand for agricultural output. The growth sustainability risk is more aptly substantiated by the fact that while the average nominal growth rate of agricultural value added is estimated at 20.2%, the average growth rate of TFP is estimated at 9%. This confirms the pieces of evidence that Nigeria's agricultural growth has been accounted for largely by growth in agricultural value added, much more than growth in productivity.

Tackling the empirical growth sustainability challenges and setting the agricultural sector on the path of transformative growth calls for different layers and forms of capacity building. Capacity building at the farm level is crucial for improving crop, soil and water management, enhance the demand for and use of better and more efficient production inputs and increasing the financial absorptive capacity of farmers. Tied to the farm-level capacity building is the need to strengthen public agricultural sector institutions for effective and efficient delivery of agricultural financial services, agricultural extension and education, agro-inputs, irrigation water and market development. The strengthening of public agricultural sector institutions will however, make better sense if it addresses economic externalities and mitigates market failures rather than supplant decision-making by private economic agents or distort markets.



1.0 Introduction

Theoretical postulations and country experiences in developing regions underscore the crucial role of agricultural growth for poverty reduction. Growth originating in agriculture could be up to four times as effective in reducing poverty as growth originating outside of the agricultural sector (World Bank, 2007)¹. Agriculture and poverty are closely linked. Most of the poor live and work in the agricultural sector and low agricultural productivity and incomes prevent the movement out of poverty.

Over the past decades, higher incomes from agriculture and access to cheaper food have helped hundreds of millions of people to move beyond the US\$1 per day poverty line. For example, China, Vietnam, Brazil and Thailand have experienced significant agricultural growth over the last three decades with corresponding decline in poverty. In particular, estimates indicate that Vietnam and China took 40% of their population out of poverty in 10 years, on the back of aggressive agricultural investment and growth. In China, poverty dropped from 33% to 17% between 1990 and 2001 and in India, from 42% to 35%.

In Nigeria, economic growth has largely been accounted for by resilient agricultural growth. According to the Nigeria Vision 2020 First Implementation Plan for the period 2010-2013, the agricultural sector contributed 73% of GDP growth over the period 1999-2009. With real growth averaging about 7% per annum from 2004-2008, and value added to the tune of 42% of the Gross Domestic Product (GDP) within the same period, the agricultural sector in Nigeria clearly stands out as the most dominant and leading component of economic growth².

Agricultural growth is associated with performance in four constituent sub-sectors: crops, livestock, fisheries and forestry. The crop sub-sector had on average the largest share of growth, followed by livestock, forestry and the fishery sector which grew substantially in the post-1974 period. Currently, the crops subsector contribute up to 85% of the agriculture GDP, while livestock contributes about 10%, fisheries about 4%, and forestry about 1%. On a comparative basis, the share of the crop sector declined up to the early 1980s while the performance of fisheries steadily improved over the past 50 years. Nevertheless, the crops subsector overall remains the dominant agricultural economy of Nigeria. Accordingly, the growth performance of the agriculture sector has been largely driven by the performance of the crop sub-sector.

¹ The World Development Report 2008: Agriculture for Development (World Bank, 2007).

² Figures computed from CBN Annual Report and Financial Statements (2008).



While the agricultural sector may have in recent years contributed significantly to improved growth performance in Nigeria, its actual contribution appears to be much short of overall potential. The quality of agricultural growth remains questionable considering the ample evidence of low productivity, poor economic competitiveness and weak linkages to other sectors (Oni and others, 2009; Nkonya and others, 2010; Eboh, 2011). Moreover, evidence shows that the increase in agricultural output has been accounted for by expansion in cultivated land rather than increase in productivity (Eboh and others, 2006; UNDP, 2009). This growth pattern (mainly driven by land expansion) is not transformative but nominal in nature and merely additive.

In contrast, transformative growth³ occurs when increases in agricultural output are driven by structural and 'real' improvements in production functions and economic competitiveness of the agricultural value chains. Such desirable growth patterns can be brought about by improved use of more resource-efficient production inputs (improved seeds, fertilisers, agrochemicals, water, etc.) coupled with the right institutional conditions (product market, agricultural extension, agricultural credit) and efficient infrastructure. Growth of agricultural productivity and farm incomes are prerequisites for structural transformation. Increase in farm incomes pushes up demand for non-farm products, and in turn stimulates the growth of small and medium enterprises (UNECA, 2005; Timmer and Akkus, 2008).

Under the circumstances in Nigeria whereby agricultural growth is accounted for mostly by land expansion, there are lingering doubts about the longer-term sustainability of current growth records. In order to clarify the doubts and put the concerns in proper perspective, there is need for empirical research that inquires into the kind of growth being experienced, the drivers of growth and prospects for sustainability. Against this backdrop, this study examines the drivers and sustainability of agricultural growth in Nigeria. The study describes and explains agricultural growth drivers and the factors implicated in the observed kinds and patterns of growth. Better understanding of the range and interactions of constraining influences on agricultural growth will help to inform and stimulate more appropriate agricultural policies into the future.

2.0 Review of Literature

2.1 Growth Theory

³ Two pioneering models worthy of note in discussing the structural transformation of societies are the Lewis-Ranis-Fei (LRF) models of economic development and the neoclassical two sector model. See Lewis (1954) and Fei and Ranis (1961).



Solow's theory of economic growth provides a useful framework for analysing growth drivers. According to Spence (2009), Solow's theory relates to explanation of the sources (determinants) of growth in the supply (production) side of an economy. It starts with the idea of production functions, namely, that the quantity of output (Q) in any sector is a function of the amounts and qualities of inputs or factors of production. These typically are land and natural resources (R), labour (L) and physical capital, such as buildings and machines (K):

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

The theory postulates that with detailed data for an economy's sub-sectors, it should then be possible to 'explain' the growth of output by the growth in quantities and qualities of inputs. Any residual is attributed to 'technological change', that is, shift in the production function not due to factor inputs. Solow's results challenged economists who thus far had seen savings and capital accumulation as the main determinants of economic growth. As he succinctly summarized in his Nobel lecture:

The main result of that 1957 exercise was startling. Gross output per hour of work in the US economy doubled between 1909 and 1949; and some seven-eighths of that increase could be attributed to 'technical change in the broadest sense' and only the remaining eighth could be attributed to conventional increase in capital intensity (Solow, 1987).

Over the past 50 years, much work was done to set out the conditions of steady growth with aggregate supply and demand in balance, and to examine ways in which technology and knowledge were 'embodied' in capital or in labour (people). These approaches, however, mainly took the primary explanatory variables of growth – the rate of technological change and the rate of savings – as being exogenous and largely unexplained.

Since the 1980s, efforts to explain technological change have culminated in 'endogenous' growth theory (Romer, 1990). Two of the key factors underlying technical change, not surprisingly, are 'education' and 'research and development', with the latter subsequently broadened to 'innovation'. In summary, the growth theory of the past 50 years brought attention back to technology, ideas and knowledge, and thus, to the capabilities of people, in the form of education and innovation.

Spence (2009) indicates that there are many factors that influence economic growth, and this number increases as the view is expanded from economic growth (GDP per capita) to include equitable growth and individual well-being. The factors cover a wide range of conditions including



savings and investment, technological change, innovation systems, human development, economic efficiency, trade and exports, infrastructure and services, governance and security.

2.2 Previous Studies and their Methodologies

Several studies have been undertaken in Nigeria and elsewhere to assess agricultural productivity and its drivers. The empirical literature includes: Nkonya *et al.* (2010), Oni *et al.* (2009), Diao *et al.* (2009), Benin *et al.* (2008) and Nkamleu (2007). These studies generally examined output and/or productivity growth in relation to some factors/determinants in different countries.

For example, Nkamleu (2007) investigated the sources and determinants of agricultural growth, covering the last three decades. The analysis employs the broader framework of empirical growth literature and recent developments in Total Factor Productivity (TFP) measurement to search for fundamental determinants of growth in African agriculture. One main contribution/finding is the quantification of the contribution of the productivity growth and the contribution of different inputs such as land, labour, tractor and fertilizer in agricultural growth. Growth accounting highlights the fact that factor accumulation rather than TFP accounts for a large share of agricultural output growth and that fertilizer has been the most statistically important physical-input contributor to agricultural growth. The study also highlights the extent to which agricultural growth contributors vary in different country contexts.

O'Connell and Ndulu (2000) show that there is increasing volume of empirical research on the factors affecting economic growth in both developed and developing countries. Most of the research is inspired by the 'endogenous growth theory', which emphasizes the role of technological progress, innovation and human resource development in the growth process (Downes, 2001).

Several theoretical models have been used to explain economic growth. The point of departure for most theoretical models used to explain economic growth is the production function approach pioneered by Solow in 1957 who specified a neoclassical model of economic growth, where physical inputs such as labour and exogenous technology influence the level of output. Recent literature is centred on whether the differences in physical and intangible capital observed for different countries can account for the difference in income between countries. This has led researchers to examine the main sources of growth for different countries and regions of the world.

In this regard, this study investigates the drivers and sustainability of agricultural growth in Nigeria. The essence of the study is to analyse the growth of Nigerian agriculture of the past 4 decades in order to determine the quality of growth and relative influence of the growth determinants. The



problematic is approached by estimating how much agricultural growth is associated with quantitative increase in different physical inputs and how much is due to total factor productivity (TFP), institutional change and other identified factors.

3.0 Study Methodology

3.1 Conceptual framework

Growth in the neoclassical framework stems from two sources: factor accumulation and productivity (TFP) growth.

Productivity (TFP)

Total factor productivity is a neoclassical concept. TFP is an attempt to measure productivity taking into account all factors of production, thus, the underlying assumption that labour is not the only input (classical Ricardian labour theory of value). TFP is a notion linked to the aggregate production function. Productivity, per se, is a technical concept which refers to a ratio of output to input, a measure of efficiency. With respect to a single input (i.e., partial productivity), typically labour (Q/L), the notion of productivity is simple. However, when more than one input is involved (e.g. labour and capital), there arises the question about how to weight each factor (Felipe, 1997).

Productivity is defined as output per unit of input, while productivity growth aims at capturing output growth not accounted for by growth in inputs. The concept of total factor productivity (TFP) credited to the seminal work of Solow (1957), “technical change and aggregated production function” is an important common index for analyzing the sources of economic growth.

The logic of TFP analysis is the need to split economic or sector growth into two components. One is the component due to increases in the amount of factors used – traditional production function. Thus, TFP is the component which cannot be accounted for by observable changes in production factors. The unexplained part of growth in the sector is then taken to represent increases in productivity, which implies getting more output from the same amount of inputs.

Productivity can be defined and measured in absolute or relative terms. However, an absolute definition of productivity is not very useful. The term is much more useful when conceptualized in a relative sense or as productivity factor (Encyclopedia of Management, 2010). Productivity is useful as a relative measure of output compared to the input (or resources) measured across time or against common entities. As output increases for a level of input, or as the amount of input



decreases for a constant level of output, an increase in productivity occurs. Therefore, a "productivity measure" describes how well the resources of an organization are being used to produce output.

There are three global measures of productivity – partial, multi and total factor productivity. Partial productivity considers ratio of total output to a single input. Multifactor productivity utilizes more than a single factor, that is, the ratio of total output to a subset of inputs. Total factor productivity (TFP) measures the combined effects of all the resources (labor, capital, raw material, energy, etc.). This is the working definition adopted for this study and constitutes the object of econometric analysis.

Productivity (TFP) Growth

Growth refers to increase in the amount of output over time. Most studies on drivers of growth in Nigeria focused on productivity (yield). The emphasis in the current study is that productivity is part of growth but not growth in itself. This conceptual clarification is necessary because of empirical situations whereby factor productivity decreased while agricultural growth subsisted. Fuglie and others (2007) cited the case of the United States where after 1980 there was decrease in volumes of capital, land, labor, chemical, and energy inputs to agriculture, but agricultural output still grew. Therefore, productivity is a necessary factor for growth but not sufficient to be used as a measure of growth. Growth encompasses productivity and includes factors for a sustainable growth.

The variables to address the methodological questions of agriculture growth drivers are selected to include demand and supply factors as well as policy factors. The supply-side focus on the production function variables such as factor inputs (land, labour, and capital, fertilizer, agro chemicals, irrigation and rainfall), while demand and policy related factors include aggregate demand for agricultural products, income related factor (income elasticity), size of market, foreign income, exchange rate, public agricultural expenditure on agriculture, infrastructural development, and trade policy-related factors.



3.2 Theoretical insights on analytical approach

Existing studies in Nigeria focused on the yield-based determinants of productivity. Oni and others (2009) examines the trends and drivers of agriculture productivity in Nigeria. But, because factor inputs could decline without affecting agricultural value added in the economy (as was the case in US after 1980⁴), there is the need to look beyond increase in output when modeling growth in agriculture. This underscores the approach of this study in modeling factors that affect growth through productivity transmission and those that affect agricultural growth rate.

To measure productivity when there are multiple factor inputs, the literature provides three alternative techniques. They include (i) growth accounting or index number approach, (ii) non-parametric and (iii) econometric approach.

Growth accounting (GA) decomposes growth into components associated with increase in factor inputs – usually land, labour and capital, and those accounted for by unobservable changes in factor inputs. TFP index is then calculated by compiling detailed accounts of inputs and outputs, aggregating them into input and output indices. The problem with this approach among other problems highlighted in Zepeda (2001) is the fact that growth accounting methods were unable to demonstrate much of a link between the amount of physical capital formation and output growth.

The non-parametric approach is similar to (GA), but it is estimated by using linear programming. It is sometimes cited as alternative to GA and can be used to identify input-output combination that defines production frontier, and can use either micro- or macro-level data. It is credited to be flexible since it does not make any assumption about the technology that generates agricultural output, Zepeda (2001). But, like a typical non-parametric technique, it has an inherent limitation of not being able to identify determinants of production within a testable hypothesis.

The study adopted an approach based on the traditional Solow residual growth model by econometrically estimating a global production function of agriculture value added. The use of econometric method makes up for the deficiencies in alternative approaches and gives room for validation of estimation results. The approach is criticised on two grounds: (i) that it requires more robust data than the other approaches and (ii) that the number of observations may not be available to permit its use. Moreover, it faces the usual challenge of general econometric approach like

⁴Fuglie, K. O.; MacDonald, J.M. and Ball, E. (2007). "Productivity Growth in US Agriculture". *Economic Brief*, No. 9, United States Department of Agriculture (USDA).



measurement error and time variation. In spite of these downsides, the approach is considered appropriate because these problems are surmountable. On data challenges, there is sufficient observation of more than 40 years data from various data agencies, and the use of de-trending (unit root analysis) to ensure data integration will overcome time variation problems. Equally, the required input factors to estimate the production function are readily available within the time frame of study. In this circumstance and for the purpose of overcoming the problems of nonparametric testing, econometric framework is preferred to growth accounting and non-parametric techniques.

3.2.1 Analytical tools and procedures

The study estimated a model of traditional determinants of agriculture valued added. These are land area, labour, machinery and tractors, fertilizer efficiency use, irrigation and rainfall, agro chemicals (pesticides, insecticides, and disinfectants. Based on the estimated production function, the total factor productivity (TFP) and TFP growth in agriculture are extracted and analysed.

Two steps are used in modelling sources of growth – decomposing sources of growth into supply and demand side factors. The supply side factors are factors that influence agricultural production, while the demand side are the factors that affect growth in agricultural sector not accounted for by increasing input factors (TFP) – market factors, policy factors, and environmental factors.

Estimating drivers of growth – factor input segment

For specifying production function in the agriculture sector, the literature provides a proven menu of determinants of agricultural output in developing economies. The factors include land expansion, labour, capital stock (machinery and tractors), fertilizer consumption, irrigation, rainfall, and agrochemicals. These variables in the model are defined as follows.

Aggregate output: Aggregate output (Y) is defined as the value added of agriculture (including livestock, crops, and fishery) at current market prices. The data is collected from United Nations online statistics resources, 2011.

Labour: Labour (YLB) in agriculture sector is defined as the total active population in agriculture. Some studies recommend the use of flow of labour (labour intensity) defined as the log of the ratio of persons (male and female) economically active in agriculture to agricultural land, but because this will obscure the contribution of livestock and water resources, the study used the raw data on labour force in agriculture.



Agricultural Land: Land (YLD) is a very important factor in modelling determinants of agricultural output, but to account for agriculture land expansion agricultural land is defined as the percentage of total land. Both data were obtained from FAO online data resources.

Capital stock: This is the monetary value of machinery and tractors, including milking machines, soil preparation equipment/machines and crop harvesters used in agriculture (YMK).

Fertilizer input: The available fertilizers in Nigeria include nitrogen, phosphates, and potash in (kg). In place of quantum of fertilizer used by farmers, we constructed index of fertilizer use recovery in agriculture per crop unit (YFK). This is defined as efficiency of fertilizer application per unit of crop yield in kilogram per hectare. The method of calculating the index is already stated in case (2). Data used for the construction of the index are from FAO online database.

Agrochemicals: This is aggregated market value of pesticides, insecticides, and disinfectants (YAK). Data was collected from FAO data in US Dollars and was converted to local currency unit (LCU) using applied exchange rate⁵.

Irrigation: Irrigation is captured as irrigation intensity defined as irrigated land per total crop area.

The term (A) is used to capture technology, a time dependent factor measured as trend.

3.2.2 The Model

The model is specified as Hicks-neutral Cobb-Douglas (CD) production function.

$$Y = Af(YMK^{\alpha}YFK^{\beta}YRK^{\gamma}YIK^{\delta}YLB^{\pi}YLD^{\delta}) + e \quad (1)$$

where:

Y = agricultural value added

A = efficiency parameter

YMK = value of physical capital (machinery and agro chemicals)

YFK = Fertilizer use efficiency

YRK = average annual rainfall

⁵ Prevailing exchange rate from 1970-2009



YIK = percentage of crop land area irrigated

YLB = economically active agricultural labour force (excluding child labour and 65⁺)

YLD = agricultural land area as percent of total land area

Instead of using the amount of fertilizer consumption, the study employed the efficiency perspective in terms of the use of fertilizer per unit of crop yield. Fertilizer efficiency use (YFK) is calculated as total crop yield in kilogram per hectare divided by total fertilizer consumption in kilogram per hectare. It is calculated as:

$$YFK = \left(\frac{\text{yield}}{\text{fertilizer consumption}} \right) kg \tag{2}$$

Estimating equation (1) with OLS will require logarithm transformation of form:

$$\ln Y = \ln(A) + \alpha(\ln(YMK)) + \beta(\ln(YFK)) + \lambda(\ln(YRK)) + (1 - \lambda) \ln(YRK^2) + \theta(\ln(YIK)) + \pi(\ln(YLB)) + \delta(\ln(YLD)) + e \tag{3}$$

From case (3) rain fall is modelled as a quadratic function to account for the turning point of rain fall intensity that is necessary and sufficient for agricultural production. This is because evidences from empirical research in Nigeria alluded to the fact that excessive rain fall hinders agricultural output, hence the need to accommodate that effect.

This is further simplified as:

$$y = a + \alpha(ymk) + \beta(yfk) + \lambda(yrk) + (1 - \lambda)yrk^2 + \theta(yik) + \pi(ylb) + \delta(yld) + v \tag{4}$$

Case (4) is the logarithm of case (3) which defines input factors that accounts for increase in agricultural productivity over time, the parameters $(\alpha; \beta; \lambda; \pi; \theta; \text{ and } \delta)$ are weights of each factor in agricultural value added, referred to as input prices; while (α) can be interpreted as a measure of TFP.

Estimating the total factor productivity (TFP) and TFP growth rate



TFP represent the rate of transformation of the total input (production factors) into total output (Y) specified in equation (1). For simplicity, let (YN) be expressed as a vector of all the input factors, while (a) defines a vector of factor input prices. TFP is then calculated as the ratio of output and weighted input factors – weighted with corresponding input factors estimated in case (4).

$$TFP=Y/[YN]^a \quad (5)$$

Case (5) could as well be expressed in log form so that:

$$\ln TFP = \ln Y - \alpha(\ln YMK) - \beta(\ln YFK) - \lambda(\ln YRK) - \kappa(\ln YIK) - \pi(\ln YLB) - \delta(\ln YLD) \quad (6)$$

$$tfp = y - \alpha(ymk) - \beta(yfk) - \lambda(yrk) - \kappa(yik) - \pi(ylb) - \delta(yld) \quad (7)$$

From equation (7) we can derive the concept of Total Factor Productivity Growth (TFP growth). This can be measured by taking the log difference of TFP as:

$$TFP_{growth} = (\Delta tfp) * 100 \quad (8)$$

Case (8) can as well be re-expressed by Letting (gy) denote the growth rate of aggregate agricultural value added, $(gymk)$ the growth rate of aggregate physical capital (machinery and agro chemical), $(gyfk)$, growth rate of fertilizer efficiency use, $(gyrk)$ growth rate of rainfall intensity, $(gyld)$ growth rate of agricultural farm area per unit of total land area, $(gyik)$ growth rate of land area irrigated and $(gylb)$ the growth rate of labor force, while the parameters are as earlier defined.

The TFP growth rate could be computed as:

$$TFP_{growth} = gy - (\alpha * gymk + \beta * gyfk + \lambda * gyrk + \kappa * yik + \pi * gylb + \delta * gyld) \quad (9)$$

Where (g) is defined in continuous time space as:

$$(g) = \Delta \ln (.) \quad (10)$$



3.2.3. Determinants of TFP – demand side factors

Factors that drive growth in agriculture other than the input factors include market- and policy-related factors such as international prices of agricultural commodities⁶, domestic income, exchange rate, degree of trade restriction, government capital expenditure on agriculture, rate of investment flow to agriculture, and farmers' access to domestic credit. The factors are broadly categorised into 'market' factors (domestic and external); and 'non-market' or 'policy-level' factors.

Market factors: These factors have vital influence on growth in agriculture because they are concerned with agriculture pricing, and subsequently income that are received by farmers. They are largely influenced by domestic and global demand and supply as well as by multilateral and bilateral trade arrangements. We expect that market share of agriculture will be influenced by prices of agricultural products, aggregate income, total output of agricultural sector (agricultural production less wastages and own consumption), investment flow to the sector, farmers access to domestic credit, and trade barriers to control for multilateral and bilateral arrangements (international trading environment).

Market-related factors are further grouped into domestic and external factors. the 'domestic market' factors include national income, to control for domestic demand, and rate of flow of investment in the sector; while the 'external market' factors include international prices of agricultural commodities to control for international demand and exchange rate.

Non-market factors: These are policy induced factors that augment or diminish growth factors. They include government expenditure on agriculture, infrastructural development, human capital investment and trade policies that promote competition or protect the domestic economy.

Domestic market factors

Income elasticity and poverty: In developing economies, like Nigeria, expenditure on basic food items constitutes more than two-thirds of the total monthly household expenditure. This is evident from the weight attached to consumer price index basket. Food items constitute about 63.76 per cent of the CPI basket (CBN, 2009); this shows that as income rises or as poverty level decreases the demand for food falls. This will also have effect on their preferences for high quality agricultural

⁶ Prices of agricultural products is defined as average producer prices of agricultural commodities (livestock meat, crops, etc) per ton in local currency unit, the naira.



product which if not provided locally could bring about high demand for imported agricultural products. This opinion was also expressed concerning the developing countries generally by (Paul, 2006) that in developing countries where incomes are rising rapidly, consumer preferences typically trend toward higher quality foods, with more value added services in what they purchase, and more livestock products (such as meat and dairy) in their diets. Therefore, income elasticity of demand and poverty are very important factors that could influence growth in the sector. The *a priori* relationship between poverty and income elasticity is negative. As income improves (reduction in absolute poverty) the share of agricultural demand (food items) in total demand decreases.

Investment rate in agriculture: Investment rate in agriculture is defined as total investment in agriculture per unit of Nigeria Agricultural Gross Domestic Product (AGDP). That is, the component of total paid-up capital (by foreigners and indigenes) in agriculture divided by agricultural GDP at current market prices. It measures both foreign and indigenous companies' participation in agricultural sector, a measure of the likelihood effect of technological transfer to the sector.

Access to credit: Total credit to agricultural sector comprises loans and advances from Deposit Money Banks (DMBs), and Micro-Finance Banks (MFBs) and Agricultural Guarantee Scheme Fund (ACGF) to the agricultural sector. Access to credit is then calculated as the total value of loans and advances to the sector.

External market factors

Foreign income and export demand: The volume of agricultural exports is determined by income of the importing countries and exchange rate. Over the years, barriers to trade, especially non-tariff barriers have bedevilled the export of agricultural products from developing countries. It is expected that there would be a direct relationship between export demand of Nigeria agricultural products and growth in the sector.

Exchange rate: Exchange rate is another market-related factor that could drive growth via export demand transmission. A rise in exchange rate (exchange rate depreciation) could have positive impact on agricultural growth through increased export demand for Nigeria's agricultural products.

Policy-level factors

The 'non-market' factors or 'policy-related' factors are defined here to include government capital expenditure on agriculture; domestic trade barriers on importation of agriculture commodities



defined as the degree of openness to imports of agricultural products into Nigeria; and human capital development.

Infrastructural factors: The future ability of the agriculture sector to service existing markets and exploit new market opportunities will depend critically on the capacity of Nigeria's infrastructure to handle future volume growth. Infrastructure of key importance includes transport, ports, telecommunications, energy, and irrigation facilities. Though, these factors are critical to growth, generally the relative importance of various infrastructures differs considerably. For example, investment in irrigation infrastructure and market infrastructure are particularly important to agriculture. The maintenance of irrigation infrastructure and efficient use of irrigation water are vital to maintaining the contribution of irrigated agriculture to growth.

Public spending: The government fosters agricultural growth through provision of infrastructure and public investment in agricultural sector. In Nigeria, available data from the CBN's Statistical Bulletin show an un-sustained increase in public capital spending on agriculture. It is instructive to find the effect of public spending (investment) on agriculture in fostering growth of the sector. The relation of public spending and agricultural growth is expected to be positive.

Agricultural trade barriers: Trade in agricultural commodities is vital in explaining the impact of trade policy on agricultural output. The total market demand for agricultural output is the aggregation of domestic and foreign demand. Therefore, trade liberalization that favours the exports of Nigerian agricultural products by protecting domestic output agriculture should be a potential growth driver. Though, there is an argument that favours the exposing of the commodities to international competition, the argument that seeks to protect the domestic agriculture rests upon the premise that agriculture in the developed economies are highly subsidized, unlike that of the developing economies. We computed trade barrier to reflect trade flow in agricultural products, that is, (agricultural export + agricultural import) divided by agricultural GDP. By implication, the lower the ratio, the higher the protection of domestic agriculture.

Human capital: The inclusion of human capital in the analysis of drivers of growth is highly controversial. Some consider it a production input factor while others see it as indirect factor either augmenting labour or capital. Mankiw and others (1992) advocates that the inclusion of human capital as direct production factor is questionable on both theoretical and empirical grounds, and considers it as total productivity factor rather than direct input factor, else it will have a negative impact on output. The current study adopts the same line of argument following an empirical



production function suggesting that human capital has negative impact on agricultural value added. As a result, it was included as TFP growth determinant.

The proxy variable for human capital is the share of active agricultural labour force of secondary school pupils⁷. Completion of basic primary education should have given a more global coverage to proxy for human capital in agriculture, considering high level of illiteracy among the Nigerian farming populace. The absence of reliable and up-to-date data compelled the use of an indirect measure of primary school completion, that is, secondary school enrollment ratio. The secondary school enrollment presupposes that the persons must have finished the basic primary school before he or she can enroll for secondary education.

3.2.4 Sustainability of agricultural sector –total social factor productivity (TSFP)

The concept of TFP is expanded to include Total Social Factor Productivity which measures sustainability. This is achieved by including market and non-market factors in defining determinants of TFP. In TFP analysis, a sustainable system has a non-negative trend in total factor productivity over the period under consideration, while a negative trend shows an unsustainable system. A sustainable agricultural sector growth indicates that output is increasing at least as fast as input, while an unsustainable system is an indication that the quality of the resource base is being degraded.

This is measured as:

$$(TFP_{growth}) = \gamma \Delta \ln(PRICE) + \rho \Delta \ln(OPEN) + \tau \Delta \ln(GCA) + \omega \Delta \ln(INCOME) + \theta \Delta \ln(ACCESS) + \varphi \Delta \ln(INRA) + \theta \Delta \ln(HMK) + \partial \Delta \ln ENV + \mu \quad (11)$$

Where:

PRICE = price index of agricultural commodities (crops, vegetable, and livestock)

GCA = government capital expenditure in agriculture

PCI = per capita national income

NEXR = nominal exchange rate

⁷ This is computed by dividing the entire population into agriculture and non-agriculture labour force. The percentage of active agricultural labour is used to multiply the agricultural labour force share of the primary school pupils, annually.

INRA = investment rate in agriculture (investment in agriculture as ratio agricultural GDP)

ACCESS = total credit to the agricultural sector

HMK = human capital (active agricultural population share of primary school pupils)

OPEN = agriculture trade policy (agric import + agric export/ agric GDP)

ENV = carbon dioxide damage percentage of GNI

4.0 Data requirements

4.1 Data availability, time frame and sources

The study employed time series data covering a 40-year period from 1970-2009. There are five sources of data: Central Bank of Nigeria (CBN), Food and Agricultural Organization (FAO), United Nations Statistical Database, UNCTAD and World Bank Global Development Finance (WB-GDF). Full description of the nature, sources and unit of measurement of the data used is in table 1.

Table 1: Summary of sources and unit of measurement of data used

AGRIC. VALUE ADDED DETERMINANTS	Unit of measure	Source	TOTAL FACTOR PRODUCTIVITY (TFP) DETERMINANTS	Unit of measure	Source
Agricultural value-added	NGN million	UNSTAT	Government expenditure on agricultural infrastructure	NGN million	CBN
Machinery and Agro chemicals	NGN million	FAO	International price of agricultural commodities	Index	UNCTAD
Agricultural labour force	Number	FAO	Per capita income	NGN	WB-GDF
Fertilizer consumption	Kg	FAO	Nominal exchange rate	NGN/USD	CBN
Land	Hectare	FAO	Investment in agriculture	NGN million	CBN
Average annual rainfall	Mm	CBN	Credit to farmers	NGN million	CBN
Irrigated land % of crop	Percent	FAO	Primary school pupils	Number	WB-GDF



land					
Yield	Kg/ha	FAO	Agricultural trade	NGN million	FAO
Efficiency parameter	Number	Authors	Adjusted saving: carbon dioxide damage percent of gross national income	Percent	WB-GDF
			Gross Domestic Product	NGN million	CBN

4.2 Data Processing

4.2.1 Unit root and Co-integration analysis

Two data related challenges are common when working with time series data: unit root problem and long term relationship among the variables. Unit root problem arises when data used for analysis are non-mean reverting. When this problem exists, information contained in the data is not reliable. It is also possible to have a situation where the variables have long run relationship in which case, the variables are tied together in the long run, a situation that will make impossible to separate their individual impact on each other. These two cases arose in the study and were handled using Augmented Dickey-Fuller (ADF) unit root test and the Granger residual approach for testing and correction of co-integrated variables. In line with Augmented Dickey-Fuller (ADF) unit root test and Granger residual approach to co-integration verification, the applied data were examined for integration and long-run relationship. While all the data used in the analysis except (TFP) growth are steady after the first difference, there is also evidence of long-run relationship between TFP growth rate and its explanatory variables. This is shown in table 3 where the residual of the TFP growth long-run is steady (stationary). This is a prerequisite for running an error correction (ECM) model as shown in table 5.

The results of the ADF test are given as follows (Table 2 and Table 3).

Table 2: Result of ADF of the variables in the production

Variables ($\Delta=0$)	Conclusions	Variables($\Delta=1$)	Value of ADF test	P-values	Conclusions
Log(Y)	unsteady	Δ Log(Y)	-3.915933**	0.0046	Steady
Log(YMK)	unsteady	Δ Log(YMK)	-3.846011**	0.0055	Steady
Log(YFK)	unsteady	Δ Log(YFK)	-5.473836**	0.0001	Steady
Log(YRK)	unsteady	Δ Log(YPK)	-7.942617**	0.0000	Steady
Log(YLB)	unsteady	Δ Log(YLB)	-10.94296**	0.0000	Steady
Log(YLD)	unsteady	Δ Log(YLD)	-4.949932**	0.0002	Steady
Log(YIK)	unsteady	Δ Log(YIK)	-5.370501**	0.0000	Steady

Note: Δ is the order of integration; ** significant responses at 0.01 probability level

Table 3: Result of ADF of the variables in TFP function

Variables ($\Delta=0$)	Conclusions	Variables($\Delta=1$)	Value of ADF test	P-values	Conclusions
(TFPgrowth)	Steady		-3.834756**	0.0057	
Log(PCI)	Unsteady	Δ Log(AGPCI)	-2.252756*	0.0252	Steady
Log(PRICE)	Unsteady	Δ Log(PRICE)	-5.226188**	0.0000	Steady
Log(ACCESS)	Unsteady	Δ Log(ACCESS)	-5.842121**	0.0000	Steady
Log(OPEN)	Unsteady	Δ Log(OPEN)	-4.778068**	0.0000	Steady
Log(NEXR)	Unsteady	Δ Log(NEXR)	-4.313805**	0.0001	Steady
Log(GCA)	Unsteady	Δ Log(GCA)	-4.871713**	0.0000	Steady
Log(INRA)	Unsteady	Δ Log(INRA)	-5.277484**	0.0001	Steady
Log(HMK)	Unsteady	Δ Log(HMK)	-7.306408**	0.0000	Steady
Log(ENV)	Unsteady	Δ Log(CO2)	-6.140346**	0.0000	Steady
(res)	Steady		-11.25625**	0.0000	

Note: Δ is the order of integration; * significant response at 0.05 probability level, ** significant responses at 0.01 probability level

Table 2 shows ADF unit root analysis of all the variables used in the production function. It shows that they are not integrated – they are unsteady. They only became stationary after the first difference satisfying the derivation of TFP growth in case (6) above. Note that growth rate is defined as log difference (Δ Log), meaning that the TFP is generated using the factor inputs in their steady form.

The ADF unit root test of TFP growth variables is in table 2. All the variables but the TFP growth index are not steady, they only became steady after the first difference. This satisfies the case in (11).

5.0 Results and Findings

5.1 Estimation of Production Input Factors

The results of the global production function estimation are given as follows:

Table 4: Estimated production function for Nigerian agriculture

Input Factors	Coefficient	Standard Error	t-Statistic	Probability
MACHINERY & AGRO.CHEM	0.249201	0.064458	3.866107	0.0005***
LABOUR	0.453610	0.091203	4.973618	0.0000***
FERT. USE EFFICIENCY	0.621470	0.034399	18.06652	0.0000***
LAND	0.226224	0.087795	2.576740	0.0145**
TECHNOLOGY(EFF.PAR)	0.908342	0.112956	8.041553	0.0000***
RAIN	2.022859	0.091063	22.21396	0.0000***
R-squared	0.994286	Mean dependent variable		25.56847
Adjusted R-squared	0.993445	S.D. dependent variable		2.599820
Standard Error of regression	0.210485	Akaike info criterion		-0.141327
Sum squared residual	1.506329	Schwarz criterion		0.112005
Log likelihood	8.826532	Durbin-Watson statistics		1.561422

Note*** significant responses at 0.01,** at 0.05 probability level

Table 5: Irrigation-inclusive Production

Input Factors	Coefficient	Standard Error	t-Statistic	Probability
MACHINERY & AGRO.CHEM	0.233079	0.063641	3.662382	0.0009***
LABOUR	0.577885	0.116595	4.956365	0.0000***
FERT. USE EFFICIENCY	0.560698	0.049838	11.25046	0.0000***
LAND	0.217158	0.085830	2.530082	0.0164**
TECHNOLOGY(EFF.PAR)	0.924936	0.110660	8.358335	0.0000***
RAIN	2.091083	0.097999	21.33780	0.0000***
IRRIGATION PER LAND AREA	1.738775	1.054181	1.649409	0.1086*



R-squared	0.994721	Mean dependent variable	25.56847
Adjusted R-squared	0.993761	S.D. dependent variable	2.599820
Standard Error of regression	0.205353	Akaike info criterion	-0.170545
Sum squared residual	1.391604	Schwarz criterion	0.125009
Log likelihood	10.41090	Durbin-Watson statistics	1.503576

Note*** significant responses at 0.01;** at 0.05; * at 0.1 probability level

Tables 4 and 5 show non-irrigation and irrigation-inclusive production functions. As shown in Table 4, rainfall (YRK), fertilizer use (YFK), labour (YLB) and land (YLD) are important factors in agricultural production in Nigeria. Rainfall is an important factor in agricultural yield, but its impact is disaggregated into positive and negative impact. Experience and empirical research show that though rain boosts crop performance, but beyond a particular point it may have adverse effects. To account for the negative impact we modelled rain as a quadratic function to account for the turning point of rainfall on crop yield. Our estimate shows that the net impact of rain on agricultural value added is about 1%. That is a 1% increase in annual rainfall increase agricultural production by 2.0%, but beyond a particular period it reduces output by 1% as shown in equation 13.

Total rainfall effect on agricultural productions is calculated as:

$$\lambda(\ln(YRK)) + (1 - \lambda) \ln(YRK^2) \quad (12)$$

$$\text{Where } \left[\frac{\Delta y}{\Delta YRK} \right] = \lambda = 2.02; \left[\frac{\Delta y}{\Delta YRK^2} \right] = (1 - \lambda) = -1.02 \quad (13)$$

Irrigation⁸ has a positive effect on production, but marginally at 10% level of significance. This marginal role of irrigation corroborates existing evidence about the poor state of irrigation in Nigeria. Agriculture in Nigeria is heavily rain-dependent and the potentials for irrigated farming are much under-harnessed. On the other hand, fertilizer use efficiency contributed about 0.62%, while land area contributes about 0.23%. Result of the potential contribution of irrigation is shown in table 5.

Active agricultural labour force contributed about 0.45%. The inclusion of human capital as input factor adds little or nothing to the explanatory power of the model and shows a negative relationship with agricultural value added. This supports the argument that human capital is an augmenting

⁸ Irrigation effect on production is excluded from table 4-1 since it is not statistically significant at 5%. In table 4-2 we however show the effect of irrigation as a potential driver of production if it is well harnessed.



factor to labour and physical capital. Its inclusion reduced labour and physical capital share of agricultural output, marginally. However, it proved to be a dominant factor in TFP growth which confirms the argument in literature that human capital is an indirect factor input that transmits through enhancement in the quality of labour. The impact of human capital on TFP growth is given in Table 5.

The summation of the production elasticity is approximately 4.48 which is greater than 1, which indicates that the agricultural sector is characterised by increasing returns to scale. The situation reflects low-input agriculture whereby farmers generally operate at the low ends of the production function. There is therefore, a compelling need for enhanced access to agricultural inputs to break away from the vicious cycle of low-input low-output agriculture. Also, the evidence that output per worker or output-labour ratio (0.45) is less than output-capital ratio (0.87) indicates preponderance of labour-intensive agriculture. This indicates a large scope for promoting the use of additional quantities capital inputs including improved seeds, irrigation water, agrochemicals and tractors.

5.2 Estimation of TFP and TFP growth rate

In order to compute TFP in agriculture, the estimated parameters (input prices or share of input factors in agriculture value added) in table 4 are substituted in case (5), while TFP growth is calculated as the growth rate difference between agriculture value added **and factor inputs multiplied by factor shares of respective inputs (estimated elasticities in table 5) as in equation (6).**

Furthermore, to determine the non-conventional factors that drive agricultural productivity in Nigeria, TFP⁹ growth was regressed on the non-conventional factors against the outcome in case (7). The results¹⁰ of the estimates are presented in Table 6.

⁹ Irrigation is excluded from the computation of TFP since it is not statistically relevant at 5% level of significance

¹⁰ A general comment on the estimates of elasticity under this model is that the estimate of elasticity is substantial rather than low. For example, 10% increase in prices will lead to 4.6% increase in TFP growth rate and 10% increase in access to credit will lead to 3.3 % increase in TFP growth rate. Also 10% increase in per-capita income will lead to 4.9% increase in TFP and 10 % increase in human capital will give 12% increase in TFP. One reason for these encouraging partial elasticity estimates is that most of these factors are currently under utilized. For example access to credit is low, human capital accumulation is low, private investment is low and even declining.

Table 6: TFP growth rate factors in agriculture

Variable	Coefficient	Std. Error	t-Statistic	Probability
CAP.EXPENDITURE AGRIC	0.048789	0.021118	2.310267	0.0323**
PRICE OF AGRIC.COMM	0.461044	0.161682	2.851554	0.0102**
PER CAPITA INCOME	0.494194	0.153538	3.218700	0.0045***
NOMINAL EXCH.RATE	0.378121	0.057434	6.583525	0.0000***
INV.RATE IN AGRIC	0.210262	0.080964	2.596978	0.0177**
ACCESS TO CREDIT	0.332162	0.089123	3.727006	0.0014***
HUMAN CAPITAL IN AGRIC	1.158635	0.199283	5.814026	0.0000***
AGRIC. TRADE POLICY	-0.081058	0.038314	-2.115626	0.0478**
ENV.DEGREDATION	-0.219139	0.080056	-2.737330	0.0131**
AGRIC.OUTPUT VARIABILITY	-0.022773	0.014178	-1.606245	0.1247*
CONSTANT	-0.107913	0.030755	-3.508778	0.0023***
LONG RUN ERROR ADJUSTMENT	-0.888896	0.075320	-11.80163	0.0000***
R-squared	0.917795	Mean dependent var	0.064380	
Adjusted R-squared	0.870203	S.D. dependent var	0.242804	
S.E. of regression	0.087476	Akaike info criterion	-1.750262	
Sum squared resid	0.145389	Schwarz criterion	-1.195170	
Log likelihood	39.12905	F-statistic	19.28450	
Durbin-Watson stat	1.941823	Prob(F-statistic)	0.000000	

Note*** significant responses at 0.01;** at 0.05; and * 0.1 probability level

5.3 Determinants¹¹ of agricultural TFP growth rate

The analysis of the determinants of agricultural TFP growth rate is conducted as follows:

Government capital expenditure in agriculture (GCA): Public sector remains the enabler of growth in Nigeria as it accounts for an estimated 0.05% of every 1% increase in infrastructural development in the sector. The positive relationship between public spending and agricultural productivity aligns with Alpuerto and others (2009). But, it is more likely that the aggregation of total public spending (capital and recurrent) in that study may have undermined the emphasis on agricultural infrastructure. When public spending is disaggregated into capital and recurrent expenditure, as adopted in the current study in table 5 it shows that a 1% increase in government capital expenditure adds about 0.05% to growth of agricultural total factor productivity. It is also interesting to observe that this impact takes a lag of about five years¹².

This is probably due to poor efficiency of government capital expenditures, poor levels of project management discipline and weak budgeting process. In table 8, we show summary of results extracted from tables 4-1 and 5 as well as the time lag of drivers of TFP growth rate in agriculture.

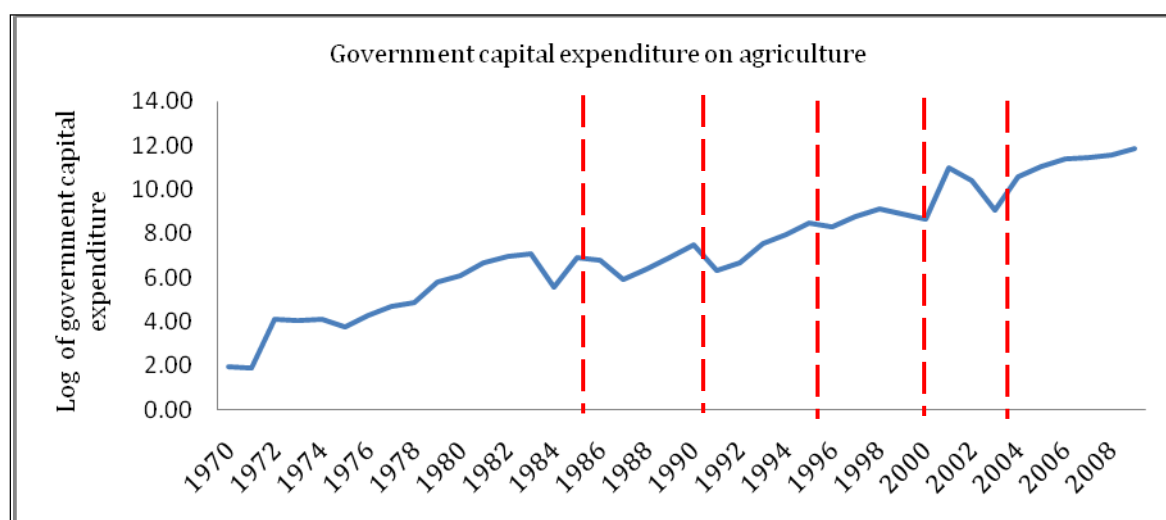


Figure 1: Expenditure path of government capital spending on agriculture

Source: Authors' derivation based on data from CBN

¹¹ For the lag length of each of the TFP determinants see table 8

¹² This long lag is probably due to poor efficiency of government capital expenditures, poor levels of project management discipline that characterise government spending and budgeting process such as high incidence of abandoned capital projects, overpricing or overvaluation of capital projects, etc.



Figure 1 shows that there is no systemic pattern in government capital spending on agriculture. It also revealed that there are only three regimes that have a fairly sustained pattern, the period between 1976 and 1984, 1991 and 1998, and between 2003 and 2010.

Prices of agricultural commodities (PRICE): Prices reflect market demand for agricultural commodities as well as what Jajri (2007) termed the extent of the productive capacity of the economy. His work on the determinants of TFP in Malaysia and indeed other studies in literature see demand changes as having a serious influence on TFP through the capacity utilization rates of machinery and equipment. The estimate in table 5 shows that the market demand share of the TFP growth rate is about 0.46%. This positive relationship has a serious policy implication for agricultural labour force. A continuous improvement in the prices of commodities will incentivise labour migration and boost agricultural employment.

Income per capita (INCOME): Per capita income (income) is an important determinant of TFP growth rate as shown in the estimates. It is the third most important factor (following price and human capital) to explain drivers of agriculture. A 1% increase in households' income increases TFP by about 0.49%. The low income elasticity of agricultural growth supports the conventional logic about the income inelastic nature of agricultural commodities, that is, increase in income produces less than proportionate demand for agricultural commodities.

Nominal Exchange Rate (NEXR): The result suggests that a rise in exchange rate (depreciation) increases the demand for Nigeria's agricultural commodities. The result shows that a 1% rise in exchange rate increases the export demand for Nigeria's agricultural commodity by 0.38%.

Private investment in agriculture (INRA): The analysis shows that investment in agriculture by both foreign and local investors is the eight biggest driver of the sector, though with a lag of seven years lag. For every 1% increase in investment rate, about 0.21% is added to agricultural total factor productivity. Figure 2 also substantiates our estimate to the effect that rate of investment in the sector is consistently declined from 1970 to 2009. This underscores the poor responsiveness of TFP to private investment.

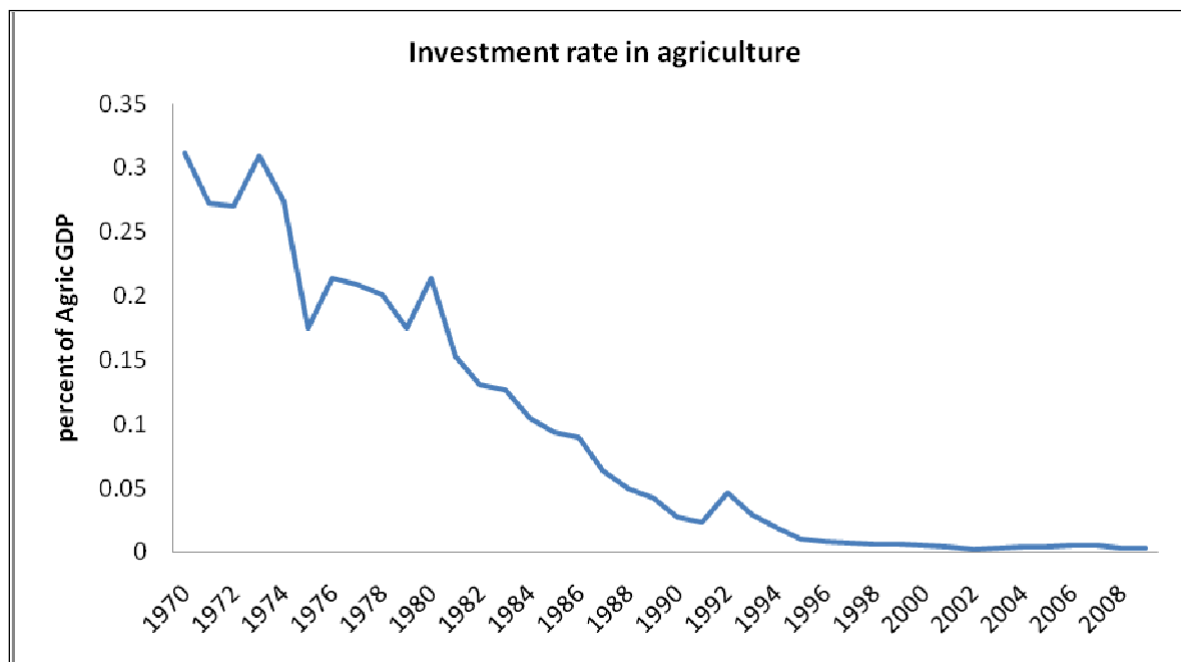


Figure 2: Trends in investment rate in agriculture, 1970-2009

Source: Computed based on data from CBN

There are two explanations of this long lag in transmission. As observed by Zepeda (2001), there tends to be fixity of agricultural assets. Accordingly, due to the fixity of agricultural assets and associated uncertainties, farmers are often reluctant to invest in equipment, land improvements or human capital. The second reason is the time lag of investment transmission. Investments take time to impact on productivity. Otherwise, the long lag in transmission could also be linked to the fact that the private investment is not in the critical growth-poles of agriculture.

Figure 2 sheds light upon the estimates from this analysis. The situation underscores the acute underinvestment in agriculture which could be linked to the lack of enabling economic environment for agriculture and agribusiness in Nigeria.

Farmers' access to domestic credit (ACCESS): The result shows that farmer's access to credit has a positive relationship with TFP, contributing about 0.33% to every 1% increase in TFP growth. This indicates that there is a large scope for improving agriculture growth through enhanced access to credit.



Human capital (HMK): The use of education to proxy the quality of labour in explaining TFP growth is an attempt to account for positive externalities of human capital formation. Human capital formation can have growth enhancing externalities through increased ability to use technology such as agricultural machinery and tractors, and better application of yield enhancing factors like fertilizer, improved crop seeds/livestock breeds and agrochemicals. The estimates as shown in Table 5 confirm that education externality, that is the quality of labour, is an important factor that explains TFP in the sector, accounting for about 1.16%. It also has a lag of six years, an indication of gestation period of transforming knowledge acquired into production factor.

Agricultural trade policy (OPEN): The degree of openness to the world economy is another important factor that could explain rapid TFP growth in agriculture. There are two theoretical arguments in favour of opening the domestic economy. One is the case for allocative-efficiency, and secondly on externalities associated with trade.

The analysis shows, for the Nigeria case, that trade restriction on imported agricultural tradable¹³ commodities accounted for about 0.08% of the agricultural TFP growth rate. Figures 3 and 4 also buttress the evidence that import restriction is associated with improved Nigeria's agricultural trade balance, while higher degree of openness reduced the trade balance within the period of study. Higher index shows less protection.

¹³ Instead of adopting the conventional method of defining trade openness (total trade as a ratio of total GDP), we used agricultural degree of openness. This is to accommodate only agricultural sector; and secondly to account for agricultural commodities that are tradable.

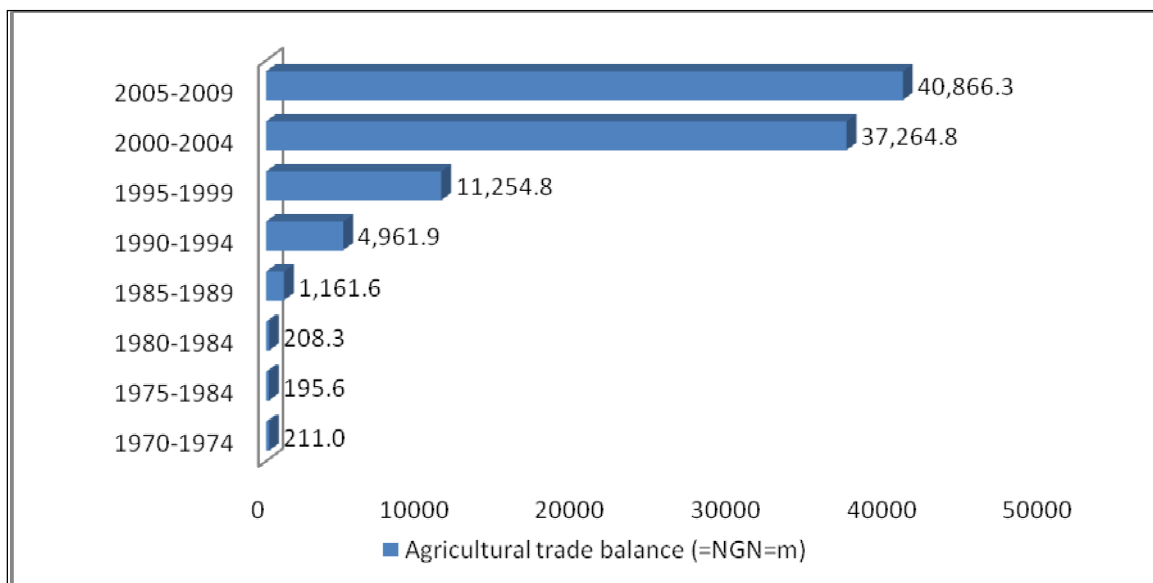


Figure 3: Average agricultural trade balance

Source: Authors’ derivation based on FAO online database, 2011

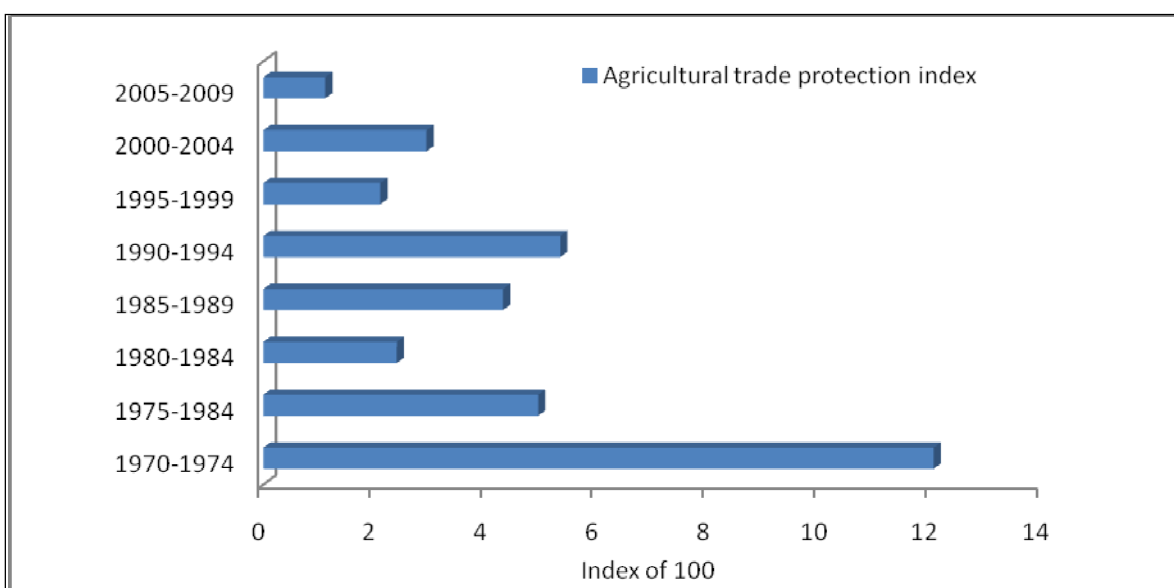


Figure 4: Average Nigeria’s agricultural trade protection index

Source: Computed by the Authors based on FAO online database, 2011



Environment degradation (ENV): The result shows that a 1.0 percent increase in carbon dioxide damage reduces TFP by 0.22 percent annually. This supports the argument by (Barnes, 2006) that sustainable growth, measured by TSFP, comprises a set of complex interactions between physical, natural and social conditions which cannot be adequately modelled or captured through a solely market-based instrument. In that study, the inclusion of negative externalities in TFP analysis decreases further the TFP growth in UK. The estimates from this analysis is consistent with Barnes (2006), implying a negative relationship between environmental factor and TFP growth rate.

Output variability: The result confirms the notion that output variability could hamper decisions to assess credit facilities irrespective of low cost of borrowing. The analysis shows that 1% increase in agricultural output volatility reduces TFP growth by 0.02%. Though not statically significant, it suggests that the uncertainty in the sector driven mainly by exogenous factors like weather conditions could negatively impact upon investment inflows and by extension TFP growth, as shown in figure 2. The impact of uncertainty on the sector is already discussed in Zepeda (2001).

5.3 ANALYSIS OF DRIVERS OF GROWTH

The study identifies two sets of factors, namely 'drivers of growth', and 'potential drivers of growth' (see Table 8). The drivers of growth are the factors that are currently contributing significantly to the sector, while potential drivers have the probability of being major drivers in future by the virtue of the magnitude of their parameter at 0.1% level of significance.

In constructing the index for the ranking, factors are decomposed into three categories. The 1st category is based on the weight of each variable/magnitude of policy parameter of each variable in output within group (production and TFP). The 2nd ranking is based on the policy relevance of policy parameters (statistical relevance) within group. The 3rd ranking is based on the total joint effects of both the parametric magnitude (share of factors) and statistical relevance (policy relevance). In ranking the policy parameters, the factor that has the highest weight¹⁴ (magnitude of parameter) is ranked 1, and others follows in that order, while in policy relevance ranking, three levels of statistical probability are used. That is, 0.01, 0.05, and 0.1 probability level. Factors with statistical probability of 0.01 are ranked 1, those with 0.05 are ranked 2, while 0.1 are ranked 3. The combined ranking is done by taking the average of the two ranks from which interval range are generated. The interval range starts from (1-2.5) as rank 1; (3-4.5) as rank 2; (5-6.5) as rank 3, and (7-8.5) as rank 4. The

¹⁴ For a parameter to be ranked it must be statistically relevant with a minimum of 0.05 percent probability



analysis is done by netting out rainfall¹⁵ which is exogenous supply shock, and as such, is not alterable by any policy change.

The ranking of all the variables is in Table 8 and shows that government capital expenditure ranked 9 in its contribution to growth, but is ranked the second most important policy variables to drive the sector.

Table 7: Ranking of relative contribution of agricultural factors of production

Variable	Magnitude of policy parameter	T-statistics	Probability	Ranking of policy parameter	Relevance of policy parameter (Statistical ranking)	Combined effect
				R1	R2	R3
Machinery and Agro chemicals	0.25	3.866107	0.0005	5	1	2
Labour	0.45	4.973618	0.0000	4	1	1
Fertilizer use efficiency	0.62	18.06652	0.0000	3	1	1
Land	0.23	2.576740	0.0145	6	2	2
Technology (efficiency parameter)	0.91	8.041553	0.0000	2	1	1
Rainfall	2.02	22.21396	0.0000	1	1	1
Irrigated land % of crop land	1.74	1.649409	0.1086			

Source: Calculated by the Authors based on regression estimates

¹⁵ The analysis of the importance rainfall made with respect to irrigation, so as to present the vintage position of irrigation in driving agriculture in future.

Table 8: Ranking of relative contribution of determinants of agricultural productivity

Variable	Magnitude of policy parameter	T-statistics	Probability	Ranking of policy parameter	Relevance of policy parameter (Statistical ranking)	Combined effect	Rank of length of policy transmission
				R1	R2	R3	R4
Government expenditure on agricultural infrastructure	0.05	2.310	0.03230	9	2	3	3
International price of agricultural commodities	0.46	2.852	0.01020	3	2	1	3
Per capita income	0.49	3.219	0.00450	2	1	1	2
Nominal exchange rate	0.38	6.584	0.00000	4	1	1	2
Investment rate in agriculture	0.21	2.597	0.01770	8	2	3	5
Access to credit	0.33	3.727	0.00140	5	1	2	1
Human capital	1.16	5.814	0.00000	1	1	1	4
Trade policy in agriculture	-0.08	-2.116	0.04780	7	2	2	1
Environmental damage	-0.22	-2.737	0.01310	6	2	3	2
Agriculture output variability (measure of uncertainty)	0.02	-1.606	0.12470				

Source: Calculated by the Authors based on regression estimates

Tables 7 and 8 show the ranking of growth drivers in agricultural sector based on the index already defined. The rankings are within group since it does not make sense to compare production factors

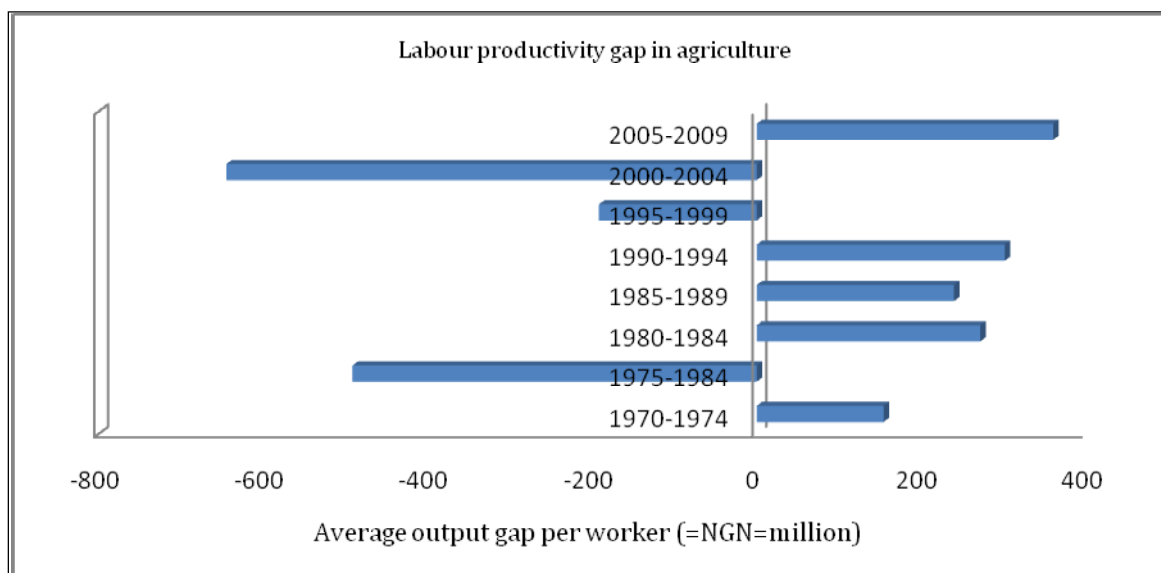


and TFP factors. Table 7 shows the rankings of determinants of agricultural output, while Table 8 shows the rankings of determinants of agricultural productivity.

Drivers of growth within groups¹⁶

Production- factors contributing to output growth: The combined effect of capital (excluding irrigation) is the most important variable that drives output, with fertilizer use efficiency accounting for a larger segment of the effect of material capital. The analysis shows that agrochemicals, fertilizer use efficiency and machinery are very vital. The share of capital is 0.21% more than labour share of output which points to the fact that capital-labour ratio is low. Labour is the second most import factor of production, but its contribution stagnated after the period from 1970-1984, as shown in Figures 5 and 6.

The stagnation of labour productivity is explained by the positive difference between actual labour productivity and potential labour productivity. Potential output per worker is generated by using Hordrick-Prescott (HP) filters. Land expansion is the next to labour, showing that land expansion is no longer an ideal framework to achieve growth of output. What is implied is that efficient capital-labour ratios are apparently driven by an augmentative factor - human capital. Irrigation which is another form of land-improving capital shows great potential of becoming a major driver of output in future. Its “potential” contribution to output is more than the joint contribution of other factors by about 0.29%.



¹⁶ The two groups of growth drivers are (i) production inputs and (ii) total factor productivity.

Figure 5: Productivity gap; Source: Calculated based on data from CBN and FAO

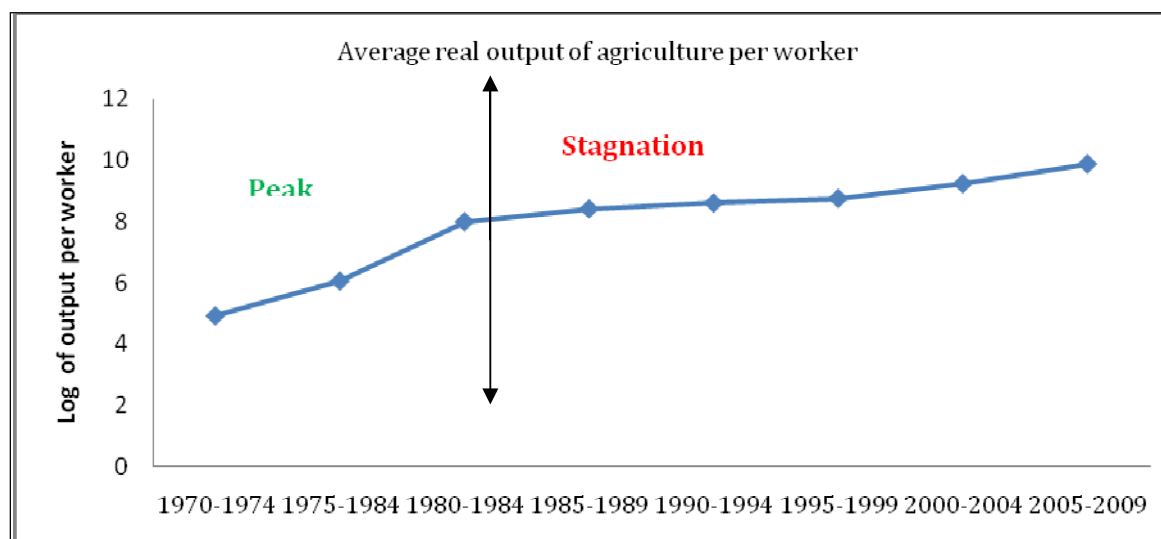


Figure 6: Average Labour productivity in agriculture; Source: Computed based on data from CBN and FAO

Total factor productivity – factors contribution to growth: Human capital also referred to as quality of labour is the main factor driving growth in the sector. Its contribution is almost twice the contribution of agricultural labour force. The impact of human capital on productivity is becoming increasingly important given the fact that evidence in figure 3 suggests that labour has been overstretched beyond its optimum¹⁷ productivity level. Apart from the periods - 1975-1984, 1995-1999 and 2000-2004, actual labour productivity surpassed its potential. The effect of this played out in the kind of trend witnessed in figure 6 whereby output per worker stagnated after the period from 1970-1980.

Two other important critical factors are market factors – price of agricultural commodities (income to farmers), and income of domestic consumers. They represent external and domestic demand drivers respectively. They have almost the same weight, with income of domestic consumers having a slight edge of about 0.03%.

Improvements in environment and investment rate are important policy variables that could spur growth of the sector. Investment in agriculture is very vital both as a form of technological transfer and augment to credit flow the sector. However, its contribution is hampered by uncertainties surrounding investment in the sector. The exclusion of agricultural output variability (volatility)

¹⁷ Output gap per worker is calculated as the difference between actual and potential output per worker. Potential output is generated with Hodrick-Prescott filters.

further improves its contribution to 0.25. It could be said therefore, that uncertainty in the sector reduces investment rate by 0.03 percent.

Finally, the contribution of the public sector investment in agricultural infrastructure is low. The situation might be due to the lack of systemic funding pattern of the sector and irregular expenditure pattern as shown in figure 1.

Drivers of growth – combined effect

The supply-side and demand-side drivers of growth in the agricultural sector are analysed for combined effects. The analysis gives the results as follows (Table 9).

Table 9: Summary of supply and demand drivers of growth in agricultural sector

Agricultural Value Added Determinants	% share of factor	Total Factor Productivity (TFP) Determinants	% share of factor	Lag Period of TFP determinants
Machinery and Agro chemicals	0.25	Government expenditure on agricultural infrastructure	0.05	(3 years) Long run
Labour	0.45	International price of agricultural commodities	0.46	(3 years) Long run
Fertilizer use efficiency	0.62	Per capita income	0.49	(2 years) Long run
Land	0.23	Nominal exchange rate	0.38	(2 years) Long run
Technology (efficiency parameter)	0.91	Investment rate in agriculture	0.21 ¹⁸	(8 years) Long run
Rainfall	2.02	Access to credit	0.33	Short run
Irrigated land % of crop land	1.74	Human capital	1.16	(6 years) Long run
Total share of capital:				
a.(excl. irrigation)	0.87	Trade policy in agriculture	(0.08)	Short run
b. (Incl. irrigation)	2.53			
Capital-Labour gap (measure of unbalance growth):				
(excl. irrigation)	0.42	Environmental damage	(0.22)	(3 years) Long run
(incl. Irrigation)	1.97			
Total factor elasticity:				
(excl. irrigation)	4.48	Agric output variability (measure of uncertainty)	0.02	(2 years) Long run
(incl. Irrigation)	6.34			
		Long run error correction	(0.89)	
		Constant term	(0.11)	

Source: Extracted from Authors' estimates in tables 4 and 5 and 4-2

¹⁸ If we do not control for volatility in agricultural output, share of investment rate increases to 0.25 percent. This shows that uncertainty discourages investment, not only in agriculture but in other sectors.

Table 9 summarises the two groups of drivers of growth (production and total factor productivity) as well as detailed information on the relationship among the production factors. There is also indication of the scale of operation and the gap between capital and labour input (unbalanced growth), suggesting that labour is over-used. The estimates mirror the importance of irrigation in agriculture. If one were to remove the restriction placed by ranking only the factors that are statistically significant, it is evidence that irrigation has the highest weight in driving production. Its 1.74% potential contribution is more than the contribution of all the production factors, setting aside rainfall and technological progress. This makes irrigation a vital factor.

The analysis of the average growth rate of agricultural value added and TFP over the period gives the estimates as follows (Table 10). Analysis was extended by decomposing the growth rate of agricultural value added into the component attributable to TFP growth and that attributable to factor inputs. The results are shown in Table 10, as follows.

Table 10: Average growth rate of agricultural value added and TFP (1971-2009)

Year	Average TFP growth rate	Average nominal growth rate of agricultural value added	Average real growth rate of agricultural value added
1971-1973	18.27	9.29	(1.84)
1974-1976	26.12	20.20	0.06
1977-1979	10.04	12.53	(1.26)
1980-1982	7.12	8.52	(0.26)
1983-1985	6.42	17.17	3.36
1986-1988	7.55	25.91	5.16
1989-1991	10.31	17.34	4.37
1992-1994	3.02	42.54	1.97
1995-1997	(-4.5)	33.48	3.95
1998-2000	0.39	7.47	4.03
2001-2003	7.57	37.04	18.17
2004-2006	2.75	16.47	6.69
2007-2009	21.93	14.56	6.26
Average annual growth rate	9.0	20.2	3.9

Source: Calculated by the Authors based on regression estimates



Table 10 shows that the average growth rate of TFP is approximately 9.0%, while the average nominal growth rate of agricultural value added is about 20.2% or average real growth rate of 3.9%. This implies that TFP growth rate accounts for 45% of the total growth rate in agricultural value added, while factor inputs accounts for 55%. Also, table 9 shows that if growth rates of production factors are kept constant, market and policy factors can drive it with an average growth rate of 9.0%.

Factors' contribution to growth and productivity: Using the criteria of 'magnitude' of policy parameter and 'relevance' of policy parameter, the study identified two outstanding factors - human capital and efficiency parameter.

Human capital stands out as the most important factor that influences productivity, while efficiency parameter drives production. These factors are not unexpected at least from both theoretical and experiential knowledge. Efficiency is associated with learning and advancement in on the job training. This confirms the endogenous growth theory of the Hick-neutral production function where efficiency parameter are labour and capital augmenting.

Apart from efficiency parameter, other factors that have equally significant policy implications are labour and fertilizer use efficiency. Land expansion and material capital (machinery and agro chemicals) jointly rank second. Per capita income, international prices of agricultural commodities and exchange rate are also jointly rank highest with human capital, but the magnitude of human capital policy parameter gave it edge over the aforementioned instrument variables.

5.4 Sustainability of growth in agriculture

The concept of TFP was analysed further to address the issue of total social factor productivity (TSFP). The inclusion of non-market factors, including environmental externalities (soil degradation) permits analysis from sustainability viewpoint. The analysis of TSFP is an appropriate concept that measures sustainable development because of the understanding that a non-negative trend in TFP growth implies that outputs are growing at least as inputs. Barnes (2006) shows that within the concept of sustainability, TFP growth allows economic and social benefits as well as an indication of greater efficiency of resources use, which ultimately improves environmental quality.

Sustainability can be gauged by examining the trend of TFP and TFP growth over the study period. The trend of TFP is shown as follows (Figure 7)

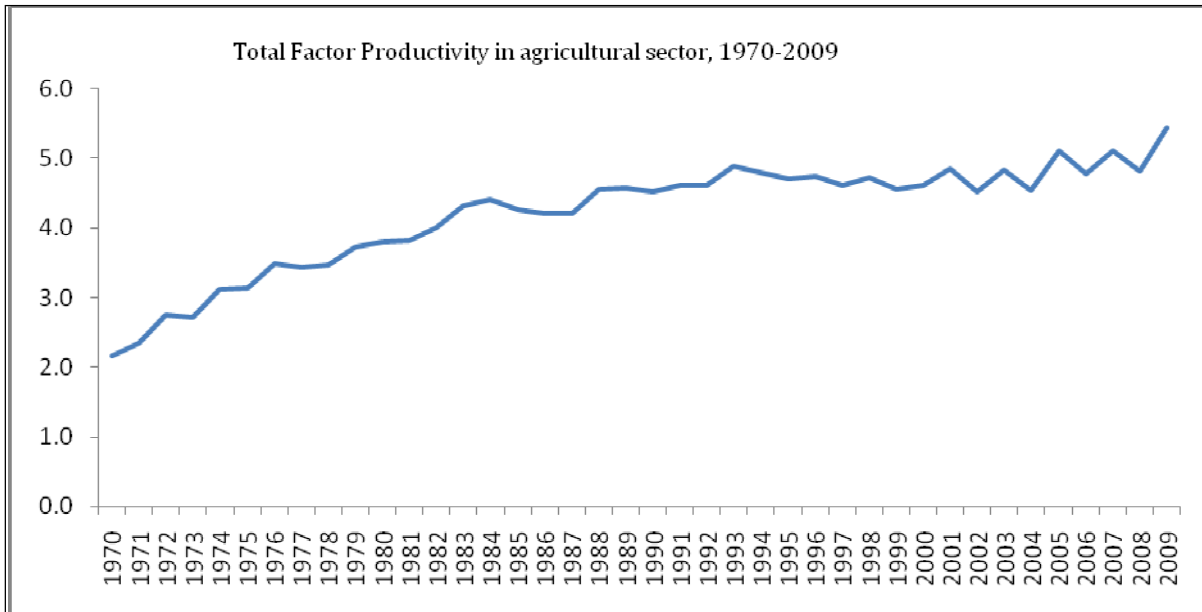


Figure 7: Trend in agricultural TFP 1970-2009

The trend in TFP, at least within the concept of TSFP shows that output is growing as much as input factors, but the trend in TFP growth raises concern about the sustainability on growth in agriculture. TFP in agriculture as shown in figure 7 is relatively stable which again proved TFP to be a stabilizing factor in economic growth.

On the other hand, the trend in TFP growth is shown in Figure 8 as follows.

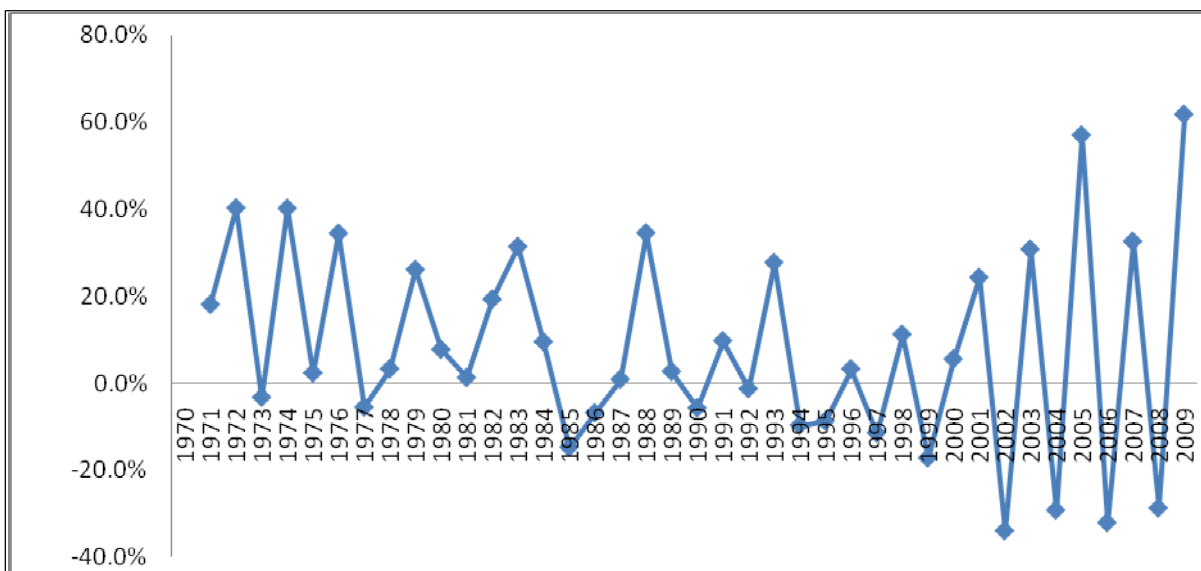


Figure 8: Trends in TFP growth rate of agriculture value added



The analysis shows that TSFP growth witnessed a negative large variation over time. This trend raises an important question about the sustainability of growth in agriculture. The growth rate of the sector shows that output is responding less than the growth in input, thereby giving rise to the negative trends in figure 8. The reason behind this is not far-fetched. The sector is a labour-intensive sector and persistent increase in labour input with a fixed land area with a minimal capital input generates decreasing marginal returns.

6.0 Conclusion and Policy Implications

The study examined factors that drive growth in the agricultural sector with the intent to inform and influence agricultural policies. The factors are decomposed into production-level (traditional production function variables) and policy-level factors (market and non-market variables). The methodology centred on two econometric models to estimate the production function and total factor productivity (TFP) respectively. The production function estimation followed the Cobb-Douglas model specified as Hicks-neutral technological progress, on assumption that technological progress is both capital and labour augmenting. The TFP model follows Solow Residual (SR) but with factor weights estimated econometrically.

The results of the global production function analysis has confirmed existing evidence that Nigerian agricultural sector is characterised by increasing return to scale, meaning that farmers are operating at the low end of the production function. This finding underscores the huge potential to raise agricultural output through increased use of more efficient inputs, rather than by mere expansion of cultivated land. Agricultural policies and measures to enhance increased applications of better and more efficient agricultural inputs are essential to break the lingering 'low-input low-output' cycle.

Within the framework of the estimated global production function, the relatively more important factors that influence Nigeria's agricultural value added include rainfall, technology (efficiency parameter) and fertiliser use. Land area is the least important factor. The finding that output-labour ratio is relatively lower than output-capital ratio indicates the preponderance of labour-intensive agriculture and underlines the large scope to increase output and productivity through the application of more capital inputs, rather than incremental amounts of labour.

The estimated model of global total factor productivity and its growth rate shows that capital expenditure on agriculture, price of agricultural commodities, per capita income and investment rate in agriculture, human capital and access to credit are positive influences. On the other hand, agricultural trade (openness), environmental degradation and agricultural output variability have



negative influences. Among the strongest positive influences are human capital in agriculture, price of agricultural commodities, per capita income (reflecting aggregate demand) and access to credit. Government spending on agriculture and investment rate in agriculture are the weakest positive influences in terms of magnitude and time lag of impacts.

The negative and unstable outlook of the trend of total social factor productivity calls attention to the salient fact that the growth rate in agriculture appears not sustainable in the longer term. This is not unexpected, considering the poor quality of the growth milieu. The growth of aggregate output is less than proportionate to the growth of aggregate inputs, a situation that can be linked with the predominantly labour-intensive and or land-expanding character of agricultural growth. Further evidence from the study shows that labour productivity (in terms of output per man day) has tended to stagnate and that land expansion is not a sustainable and stable pathway for agricultural growth. Implicit in the analysis is the huge potential for boosting agricultural growth through irrigated agriculture. The estimated potential contribution of irrigation to growth of total factor productivity exceeds the combined effects of all the included production factors, less rainfall and technology (efficiency parameter). The huge potential role of irrigation in accelerated and sustainable agricultural growth poses critical challenge for public policy to harness the vast water resources across the country.

Overall, the study has shown that Nigerian agricultural output growth is directly related to the growth of factor input, implying a positive TFP. But, the negative outlook of the trend of TFP shows that growth might not indeed be sustainable in the long run. The low capital-labour ratio further underscores the sustainability concerns about TFP growth. Also, the negative TSFP growth apparently underscores the adverse environmental externalities that have been associated with the kind of agricultural growth experienced in the country over the years. Continuous expansion of cultivated lands to compensate for 'constrained yield increases' and meet additional demand for agricultural output cannot be the sustainable trajectory for Nigeria's agricultural sector.

The sustainability risk to Nigerian agriculture is more aptly substantiated by the fact that while the average nominal growth rate of agricultural value added is estimated at 20.2%, the average growth rate of TFP is estimated at 9%. This confirms the pieces of evidence from the study which implies that the agricultural growth in Nigeria has been accounted for largely by growth rate in agricultural value added, much more than growth in productivity.

Tackling the empirical growth sustainability challenges and setting the agricultural sector for transformative growth call for interrelated policy and programmatic measures. Capacity building at



the farm level is crucial for improving crop, soil and water management, enhance the demand for and use of better and more efficient production inputs and increasing the financial absorptive capacity of farmers.

Tied to the farm level capacity building is the need to reinvent public agricultural sector institutions for effective and efficient delivery of agricultural financial services, agricultural extension and education, agro-inputs, irrigation water and market support/development. The institutional strengthening of public agricultural sector institutions will however make optimal sense if it is done within the overarching motivation to address economic externalities and influence, not supplant decision-making by private economic agents.



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