SOURCES AND DETERMINANTS OF AGRICULTURAL OUTPUT AND PRODUCTIVITY GROWTH IN NIGERIA: 1960–2015

By

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CERTIFICATION

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DEDICATION

This thesis is dedicated to God Almighty for His grace, mercies and enablement to successfully complete the program, His name be praised for ever.

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ABSTRACT

Nigeria's agricultural productivity and output growth have been a challenge to efficient distribution of scarce farm resources over the years, due to population pressure on land. Thus, Agricultural production has moved into marginal lands, characterised by poor output. Though, previous studies have focused mainly on agricultural productivity, however, paucity of information exists in the area of agricultural output and productivity growth over the years. Hence, sources and determinants of agricultural output and productivity growth in Nigeria from 1960 to 2015 were investigated.

Secondary data, sourced from Food and Agriculture Organisation statistics covering 1960 to 2015 were used to determine output and productivity growth. Agricultural land, agricultural labour, fertiliser (as proxy for all chemical inputs used), number of tractors in agriculture, Agricultural Gross Domestic Product (AGDP), index of trade openness and trade ratio were variables used in the study. Augmented Dickey-Fuller test was used to determine stationarity of variables. Data were analysed using descriptive statistics, exponential trend model, stochastic production function, inefficiency model, agricultural output/productivity decomposition and multiple regression model at $\alpha_{0.05}$

Inputs used for the period were 32,615.1±3,627.9 hectares (land), 12,423.2±7,705.2 man-days (labour) 319,684.7±300,285.0 kg (fertiliser), 13,201.3±9,830.3 (tractor), with a corresponding 389.760.0±225,907.2 (naira) for AGDP. Declining productivity was observed from 1961 to 1998 with Total Factor Productivity (TFP) of 0.43±0.03. Constant productivity was observed from 1999 to 2001 with a TFP of 0.97±0.01, while increasing productivity was observed from 2002 to 2015 with TFP of 1.14±0.03. Growth rates of agricultural variables were 3.5% (AGDP), 10.2% (fertiliser), 7.1% (tractors), 3.6% (land) and 0.03% (labour). The contribution of inputs to AGDP growth were 48.8%, 33.9%, 17.1% and 0.1% for fertiliser, tractors, land and labour, respectively. The estimated input parameters (β) value of the response of output to input used were fertiliser (0.2376), land (0.2234), labour (0.2032), and tractor (0.1681), they positively determines AGDP. The sum of these parameter was 0.8145, indicating decreasing returns to scale. Technical Efficiency (TE) of AGDP was 0.8246, while Technical Inefficiency (TI) of AGDP was

0.1754. Factors influencing TI were inflation (-0.5874), fertiliser price (-0.2311), trade openness (-0.2163), trade ratio (-0.3520) and time (-0.5634), indicating inefficiency reduction. Input growth (0.52), technical change (1.56), technical efficiency change (0.85) and allocative efficiency change (0.76) positively determined AGDP growth, while scale effect (-0.92) and price adjustment (-0.06) negatively determined AGDP growth. The growth rate of AGDP was 3.52%, with input growth, TFP and residual contributing 14.8%, 62.8% and 22.4%, respectively. Trade openness (0.3042) and time (0.2576) positively influenced productivity growth, while macro-economic stability (-0.2459), fertiliser price (-0.2326) and tractor price (-0.2274) negatively affected productivity growth.

Input growth and productivity were the main sources of agricultural output growth from 1960-2015. Technical change, technical efficiency change, and allocative efficiency change were other sources of agricultural output and productivity growth in Nigeria. Fertiliser, labour, land, tractor and time positively influenced agricultural output while trade openness, number of tractor, agricultural land, labour and time enhanced productivity in Nigeria.

Keywords: Technical efficiency, Technical change, Total factor productivity, Stochastic production function, Output decomposition.

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Nigerian agricultural sector in the 1960s, was known to be the most significant sector in the economy. This was due to its contributions to domestic production, employment generation, as well as its earnings international trading (Adedeji *et al*., 2014, Daramola, 2014). It is significant in terms of food supply and how it is connected to the other sector of the economy (NBS 2014; Daramola, 2014). According to NBS (2014), the agricultural sector is considered important because it contributed about 42.1% of Gross Domestic Product (GDP) to the economy. In the 1960s, Agricultural sector provides food, raw materials for industries, has positive relations to job creation, national income and chances for marketing industrial products. It possessed the capacity to reduce poverty and improve health conditions of the people (Adedeji *et al.,* 2014). Nigeria had food sufficiency record in the 1960s. The neglect of the sector lead to dependence on food imports (Ekpo and Umoh, 2010). In spite of this, the sector remains the cornerstone of the economy (Akanmidu, 2015).

Nigeria as an agricultural nation is blessed with an ecosystem containing about 12 million freshwater resources, arable land of about 68 million hectares and different ecological zones. These endowments allow for fisheries, crops, livestock and forestry products to thrive (Arokoyo, 2012). According to Al-Hassan (2012), in the 1960s, the Agricultural sector produced major agricultural products such as rubber, palm oil, cotton, groundnuts, cotton and cocoa for export. Then, it contributed well above 60% of Nigeria's GDP sector share of the GDP (Aigbokhan, 2001). Post 1960s, the sector's output experienced fluctuations and steady deterioration in its contributions to GDP (Al-hazzan, 2013, CBN, 2014).The sector's contributions to the GDP was 28% in 1985, 32% in 1988 and 31% in 1989. It contributed 37% in 1990 and 24% in 1992 (CBN, 2014). The sector contributed

37% in 1994, 32% in 1996 and 40% in 1998. The contribution of the GDP were 37% and 31% in 2002 and 2006, respectively. In 2012, it was 23.91% in 2013 and 22.90% in 2014 (NBS 2016). In 2017, the agricultural sector contributed 20.85% and 21.91% in 2019 (World Bank, 2020). The decline experienced in the agricultural sector, was due to heavy dependence on crude oil since its advent in the early 1970s. The main foreign exchange earnings in Nigeria came from petroleum (Oni *et al.,* 2009). In 2000, more than 98% of Nigeria's national income emanated from the oil and gas sub-sector (Odularu, 2009). The Nigerian economy relied so much on the oil sector. The subsector accounted for about 95% of the foreign exchange earnings and for about 65% of the national budget. This dependence on the oil sector for its revenue made the government to formulate policies in favour of the oil sector (CBN, 2003).

The neglect of the agricultural sector caused rural dwellers to migrate to the urban area to look for jobs. This action downgraded most farming activities to the bearest minimum as many farm adolescents and able-bodied men abandoned their farms (Raheem *et al.,* 2014). The oil boom lead to marginalization of the agricultural sector. The sector received reduced annual budgetary allocations (Egbuna *et al.,* 2013). The allocations were contrary to Food and Agriculture Organisation (FAO) recommendations as they were often inadequate to put the sector on sustainable growth (Okoro and Ujah, 2009). The budgetary allocations did not reach the 10% of the annual budget recommended for agriculture as stipulated in the Maputo declaration (Ochigbo, 2012). Unfortunately, various administration could not achieve any outstanding success. Thus many projects and programs were affected in the sector (Iganiga and Unemhili, 2011). The total spending on agriculture, as percentages of total spending, was 4.57% from 1986 to 1993, 4.51% from 1994 to 1998 and 1.12% from 2006 to 2010 (CBN, 2014). The budgetary allocations was 1.6% for agriculture in 2016, 0.9% in 2015, 1.4% in 2014, 1.7% in 2013, 1.6% in 2012 and 1.8% in 2011 (Daily Trust, 2017). The agricultural sector was inadequately funded. This therefore led to fluctuations in the sector's GDP growth and contribution to the economy, even in the recent times. It stood at 4.2% in 2002, 7.4% in 2007, 3.72% in 2015 and 4.11% in 2016 (NBS, 2016). In 2017, it was 25% and 22% in 2020 (NBS 2020).

Despite the earning capacity of the oil sector for more than three decades, the agricultural sector remains the most essential sector of the Nigerian economy (Emeka, 2007). It still engages close to 67% (two-third) of the employed population (Nwafor *et al.,* 2011). It contributes meaningfully to the GDP, and its influence to non-oil earnings is also very large (CIA, 2013, Sekunmade, 2009). In 2013, the contribution of the agricultural sector to GDP was 22%, the crude oil contributed 14%. Telecommunication contributed 9% while the manufacturing sector contributed 7% (US Department of State, 2014). In 2014, the agricultural sector contributed 20.2%, mining and quarrying contributed 10.9%, while manufacturing contributed 9.8% to the GDP (Adedipe, 2015). In 2016, the sector contributed 24.18 % which is greater than the contributions of the manufacturing and oil sector combined (CBN 2016). The instability in the crude oil market, coupled with fluctuations in its price globally has led to uncertainties about the prospect of the oil sector in generating the necessary revenue for the country (NBS, 2014). Hence, there is the need to enhance the agricultural sectors' output growth and productivity as a means of diversifying the economy. According to Alabi (2005) agricultural productivity performance is crucial as it improves the well-being of the citizens. However, the decline in output experienced were due to reduction in productivity due to poor resource base decline in soil productivity and production practices that are inefficient among others (Tanko *et al.,* 2006). The overall deterioration in the sectors' productivity has led to its being unable to meet food demand, resulting to continuous increase in food prices, rising food shortages and high food importation (Onyenweaku and Nwaru, 2005).

Intensification of agriculture had long been noticed to be a fundamental way out for the agricultural sector. This can only be achieved by replacing current extensification methods, with a more intensive arrangements. The agricultural sector needs to adjust its total factor productivity as this is identified to be the main source of output growth rather encouraging inputs growth, as the latter option might not be sustainable in the long-run. According to Rahji and Adewumi (2008) and UNDP (2009) in recent times, growth in agricultural output has come mainly from the expansion of land area cultivated. Hence, agricultural production has moved into marginal land due to the expansion. As a result, the potential for output increases from land is diminishing with overall productivity known to be low and decreasing (Daramola, 2014). The sector has long suffered from labour out-migration of able-bodied men. The farming population is ageing. The overall effect is a sector that is characterized by low labour productivity. Capital input in form of machineries is low, while tractorisation or farm mechanisation had been hampered by land fragmentation (Kienzle and Sims, 2015).

However, the level of inputs used determines the output in agricultural production. Hence, the response of output to inputs over the years becomes critical in understanding the output- input relationship. Output can be increased in two ways, one is increased through increased availability of inputs and better technologies. Increasing input-use may not be a feasible alternative, due to the down-turn in the economy. Intensive use of the available inputs may be the alternatives. Hence, if the productivity of the factors is low, output increases are likely to be low. Agricultural output growth is derived from agricultural output while productivity growth is derived from agricultural productivity. Higher productivities were expected to translate into higher output and output growth. By extension higher productivity growths is the precursor for higher output and higher growth, ceteris paribus.

Agricultural output and productivity growth have leverage effect on the rest of the economy. Hence, the sector should be the focus of researchers and policy makers. According to Saikia (2014) productivity growth in agriculture is both a necessary and sufficient condition for the development of the sector and the economy at large. It is a necessary condition as it enables the sector to avoid falling into the Ricardo's trap of diminishing returns (to which it is prone). It is a sufficient condition as it increases output by reducing the cost of production. In this context, the sources of output and productivity growth require empirical investigation in the Nigeria agriculture. Hence determining the output and TFP growths and decomposing them is of research importance within the context of the Nigerian agriculture as the input use levels and growth in these inputs are necessary parameters to understand the production structure in the sector.

1.2 Statement of the Research Problem

Agriculture sector is a dynamic sector in the Nigerian economy (Daramola, 2014). The various agro-ecological zones allow for the production of wide-range of agricultural products. Despite the rich agricultural resources of the economy, the sector's growth rate is very low. This is coupled with low productivity. Farming systems in most cases are small-scaled and predominantly subsistence. The sector depends on the vagaries of the weather. It is almost entirely rain-fed and susceptible to climate change and variability. About a million hectares are currently irrigated from a total of 30.5 million arable hectares of land in Nigeria. According to FMARD (2011), the low productivity of inputs used by Nigerian farmers is largely due to the low use of intermediate inputs like fertiliser, tractors, improved seeds and irrigation system and inefficiency in resource use. Increasing farm production is the major challenge faced by Nigerian agriculture. The call to go back to the land itself is a problem due to labour out-migration from the sector. There is lack of new entrants into the sector. Improvement in the quality and productivity of the residual farm labour becomes a developmental problem. The main challenge of how to rescue the sector and to secure its future is to substitute the extensive systems with a more intensive system. There is the need to work toward achieving growth in output from factor productivity improvement instead of the unsustainable extensive strategy.

In Nigeria, the annual food demand is greater than 3.5%, while its agriculture has a 2.5 % growth rate (Daramola, 2014). The country thus has high food demand-supply gap (Daramola, 2014). The deficit has to be bridged to offset the population growth rate of about 2.83% per annum (Daramola, 2014). The sector has to produce more food to prevent dependence on importation. To achieve this, the agricultural sector output, its output growth and total factor productivity growth must be enhanced.

Total factor productivity as a source of output growth can be improved by improving the efficiency by which available inputs and technology are used in production. To improve efficiency in the use of available resources and technology both local and improved, the output, productivity output, productivity growth and total factor productivity must be ascertained for policy formulation for the sector. The baseline information that is required needs to be generated through research. The research gap relate to examining the cumulative effects of the different policies enacted in the sector. It also relates to investigating the fluctuations impacted on the performance of the sector by the policies and to analyse the production structure of the sector. This is in order to understand the change that have taken place in the sector since independence in 1960. The research need is to provide a structural handle from the results as a basis for policy formulation in the sector. This is expected to provide a sound basis for how the changes could be used to move the sector forward, to meet both the current and future need of the people. The production structure and efficiencies could lead the way to improvements in the performance of the sector.

1.3 Research Questions

The research questions that call for empirical validation are:

What are the trends in the key variables relevant to this study?

What is the effect of input growth on output growth in agriculture?

What is the relationship between total factor productivity and output growth in agriculture?

What are the factors influencing technical inefficiency in the sector?

What are the sources of output growth in agriculture?

What are the sources of total factor productivity growth in agriculture?

What is the production structure in the agricultural sector?

1.4 Objectives of the study

The general objective of this study is to determine the sources of agricultural output and productivity growth in Nigeria from 1960-2015 and sub-periods of 1961-1970, 1971-1980, 1981- 1990, 1991-2000, 2001- 2010, 2011-2015 as a basis for policy formulation.

Specific objectives are to:

Profile the trends and growth rates in the key variables

Determine the response of agricultural output to the inputs in the agricultural sector

Identify the factors influencing technical inefficiency in the sector

Profile the TFP indices on year by year as a basis for determining the trends

Examine the production structure of the sector in terms of the TFP indices

Identify the determinants of TFPG in Nigerian agriculture.

Decompose the output and TFP growth into their components as sources of growth

Make recommendations based on findings from the study.

1.5 Justification of the Study

Nigerian agricultural sector has been known for its crucial role which is fundamental to general growth. The economic slowdown deserves extraordinary consideration for its revival. Therefore, Growth in the sector's productivity is seen as vital to the process of development, Saikia (2014). Major challenge recorded in the sector is that most farming system are peasant in nature, technological level is low, resulting to a productivity growth that is poor, declined earnings from exports, food insecurity, low capital formation, and meager rural development. Increased inputs source, like land and rural labour movement off farm are dwindling (Jin *et al.,* 2007). The scenario tends to imply that increasing output may not feasibly be as a result of increasing inputs, because more of the inputs of labour and land are allocated for other purposes that are not agricultural. Due to the limitation that can soon be experienced in the enlargement of cultivable areas and intensification in the input used, it is advisable to move towards a point where growth in productivity is improved instead of stressing the use of increased inputs. To achieved and sustained this, technological breakthrough and efficient use of resource must be increased in the sector, while the quality of inputs used are not compromised. The instant resolution can emanate from production efficiency rise. Therefore, it is crucial to evaluate the utilization of the current resources and recognize how the efficiency of Nigeria agricultural production can be improved, given the resource limitations. In research and policy arena, the dynamic role played by efficiency gains to increase agricultural output has been extensively acknowledged, thus, significant effort has been dedicated to quantifying and investigating productive efficiency. This has become issues in many empirical and theoretical works for some years, particularly, since Farrell's (1957) seminal work.

Therefore to generate high output and growth in the sector, focus has to shift increasingly towards means to increase productivity and/or intensification. The decomposition of same will indicate the sources of growth in the sector, and provide a structural handle for effective policy formulation for the sector. Similarly, estimating total factor productivity has potential of providing insights to productivity-increasing variables as the different sources of productivity gains can be identified and used as the basis for policy guides and formulation. Formulation of appropriate long-term strategies for agricultural growth and development can only then become possible. Achieving food self-sufficiency requires keeping the level of productivity high. Subsequently, output growth and TFPG will not arise mainly from inputs mobilization, but will entail raising the productivity level of the inputs. The research gap relates to investigating whether there has been variations in the production structure of the sector over decades since independence. The challenge is to recognize the nature of change, and to know how the changes can be used to move the sector forward to meet the needs of the future. Hence, other sources and their contributions to growth and productivity increases require identification and empirical quantification.

At the macro level, there is scarcity of research on productivity growth in Nigeria. Looking at the policy side, decomposing output growth and productivity in Nigeria agriculture is important as it will provide useful statistics to indicate the advancement of agricultural growth through productivity gains.

This study is justified based on being an attempt at providing empirical information relevant to solving the problems identified and in isolating the sources of output and productivity growth. Approach frequently used is cross-sectional primary data-based analysis. Although, both were evident in literature for growth and productivity studies. Time-series data/analysis used in this study is unique. According to this researcher, this is a pioneering effort/attempt within the Nigerian agricultural sector.

1.6 Organisation of the report

The report is divided into five chapters. Chapter two presents literature review, theoretical/ conceptual framework and the analytical review of the study. Chapter three presents the methodology used for the study. These include the study area, analytical tools adopted, and measurement of variables. In chapter four, empirical results are discussed and chapter five concludes the report with summary, conclusions, recommendation and suggestion for further studies.

CHAPTER TWO

LITERATURE AND METHODOLOGICAL REVIEW ON CONCEPT

2.1 Agricultural Productivity Growth

Agricultural productivity can be said to mean efficiency of production (Shafi, 1984). It is usually computed in a production process as the proportion of output to inputs used (Singh and Dhillion 2000, Dharmasiri, 2012). These are referred to as partial measures of productivity.

Growth is simply an increase in number, size, power and intensity over time. To therefore calculate a simple growth rate, the trend equations can be used. Agricultural growth rate can be referred to as an increase or decrease in the resultant outputs to inputs ratio over a time period. Agricultural productivity growth is the amount of growth in output that does not come from growth in inputs. Products from agriculture can be measured either in weight (kilograms, tons million / metric tons) or in volume (litres). Therefore, the problem that often arise is knowing the best way of combining diverse agricultural products.

The total worth of agricultural product, minus value of all inputs within the sector is known as the aggregate output. Usually, it is measured in monetary units.

2.1.1 Total Factor Productivity

Total Factor Productivity (TFP) was used to correct the inadequacies of partial measures of productivity. TFP refers to an index ratio of output to an index of inputs at a particular time (Singh and Dhillion, 2000). Index of output from agriculture is the sum of all produce constituents, index of agricultural inputs is the weighted value of all conventional inputs (Alston, *et al.,* 2009). The weights attached to inputs are factor share derived from parameters of Cobb-Douglas production function involving the inputs. Growth in TFP (Solow residual) is the technological progress that is achieved in production from alterations in commercial infrastructure, development of human capital or capital research and Development (R&D), extension services and policies from government (Ahearn *et al.* 1998;

Mozumdar. 2012). TFP change can also be as a result of error of measurement. This happens when inputs are not used at all or are wrongly measured.

2.1.2 Measuring Agricultural Productivity

Growth model have been used to isolate the impact of inputs used on growth in output. They have also been used to isolate output growth that was achieved that is not as a result of increase in inputs. In the literature, three economic models have been used to measure productivity, these are; Non-parametric approaches, parametric approaches, index numbers or productivity growth accounting techniques. These approaches are characterised by different data requirements. They also have merits and demerits.

2.1.2.1 Index Numbers or Growth Accounting Techniques

According to Diewert (1976, 1981) technique implies the collection of detailed accounts of the inputs and the output. The data are then aggregated into input index and output index, these indices are used to calculate the TFP index. In the 1950's and 1960's, the index number technique was used to estimate partial measures of growth. In the 1990's it was renewed to growth accounting approach.

2.1.2.2 Parametric Approach

This approach entails the estimation of the production technology or the technology of production. There are two ways of doing this based on the duality theory in production. The first is the primal approach which involves the estimation of a production function. The second is the dual approach which involves the estimation of the cost function (Antle and Capalbo, 1988). This production function approach allows for measuring the impact of each input on the output. The cost function approach indicates the influence of the prices of the inputs and output on the cost of production (Capalbo and Vo, 1988).

2.1.2.3 The Non-parametric Approaches

The non-parametric approach is a linear programming based technique that is used in estimating TFP (Chavas and Cox, 1992).

2.1.2.4 Strengths and Weaknesses of the methods

The methods have characterised strength and weaknesses. The index numbers were simple to calculate, but the approaches impose strong assumptions about technologies on the analysis. Index number cannot be statistically derived. Their reliability cannot be evaluated using statistical methods. It cannot identify sources of growth. The good thing about the approach is that irrespective of the numbers of observations, the technique can easily be applied. The parametric approach is statistical in nature. It involve the use of econometrics. Calculating confidence interval, testing of hypothesis and testing for dependability of the model are possible. It can also be used to measure the effect of additional inputs on total output. There is a limit to the number of observations it can accommodate.

Barro, (1999) envisaged the problem of simultaneity, measurement error as well as time variation, when changes in TFP are estimated directly through the parametric.

The non-parametric method does not impose assumptions on the production technology. It is also not data intensive. The major deficiency of this approach is that the models under it are not statistical in nature, so testing or validating them statistically could be difficult (Antle and Capalbo, 1988).

2.1.3 Factors Affecting Agricultural Productivity

Some factors that affect productivity which are mostly beyond farmer's control include: weather, which is referred to as unusual climate pattern. They include, lengthy wet period, drought, late or early rains and other vagaries of weather that may affect productivity by destroying farm output. A capable farmer with adequate capacity can improve the soil condition. Soil production capacity can be improved using various methods. These methods includes adding nutrients to the soil, pest control, the use of fence, biological and chemical control and crop rotation.

Mechanization of farm can affect productivity. Larger farm land can be covered, labour requirement may be reduced through the use of farm machines.

The supply-demand condition for farm produce may encourage farmers to improve on their productivity in the cobwebism tradition of cashing in on a favourable condition (Nerlove, 1958).

The adoption and use of innovations as recommend is a major route by which productivity in agriculture can be enhanced.

2.1.4 Factors Affecting Productivity Growth

Human and social capital are elements that can assist on how other factors affect the utilization of farm inputs.

Human Capital means the experience, knowledge and abilities acquired by farmers over a long period of time on the job. Education, training and extension are major factors affecting performance of farmers. They also affect their acceptance and use of technology. These consequently affect the use of their resources and productivity (Nehru and Dhaveshwar 1994).

Social capital formation among farmers enhances cooperation among them. It leads to self-help principle and togetherness in their daily life. It encourages coming together to work and support one another and it’s expected to enhance their productivity.

2.1.4.1 Research and Technology Transfer

Research outcomes in terms of biological, chemical and mechanical innovations and adequate transfer to farmers have the potentials to improve their productivity. Although, these often do not lead to adoption. Sometimes, non-adoption of a particular technology might be as a result of developing inappropriate technology. Inappropriate because it fails to meet the needs of agricultural producers (Chavas and Cox, 1992).

2.1.4.2.Technological Change

Technological change is known to determine productivity growth (Antle and Capalbo, 1988). This means alterations in the process of production that emanates from newly acquired scientific knowledge, innovation usage, technical and management skills. Its effect is to shift upward the production frontier. This results in the productivity of output using the same input level (Alston, Norton and Pardey, 1995)

2.1.4.3. Technical Progress

The adoption of innovations enhances workers' output. The improvement in output results in higher productivity. This result in labour-saving that may lead to a capital intensive economy. The Nigerian situation typifies agricultural production done with crude implements or traditional technology, such that technical progress is very low (Daramola, 2014).

2.1.4.4. Natural Resources

Natural resources are known to be major factors in food production and food supply. When natural resources are degraded, their production capability and future use are jeopadised (Andersen and Lorch, 1998). By estimation, several hectares of permanent pastures, agricultural land, forest and woodland were degraded by means of deforestation, overgrazing and unsuitable agricultural practices (Oldeman, 1992). This leads to supply bottlenecks for most of the natural resources degraded.

2.1.4.5. Political Stability and Conflict

Political situation is an aspect of the governance that enhances or hinders agricultural production. Nehru and Dhareshwar (1994) found that economies that involved in wars and price changing policies resulting in political instability had worst economies. They opined that political stability and initial endowments are the variables that are highly connected with growth and productivity.

2.1.4.6. Public Investment and Policy

Agricultural production is greatly affected by unstable public policies, unfavourable budget decisions in terms of poor infrastructures. There is the need for adequate budgetary allocation, public investment in physical and institutional infrastructures. Irrigation facilities and road networks are also needed. This is because infrastructures plays important role in the growth and development of any nation. It goes a long way in enhancing the productivity of all sector in the economy. Infrastructure provisions through public investment and sound policy formulation is expected to have a profound effect on agricultural production and productivity.

2.1.4.7. Quality of Labour Force

The availability of quality labour force is a precursor of high productivity in an economy. The presence of skill labour in the economy tend to result in enhanced productivity in the economy. This is expected to result in the efficient use of resources that will lead to higher output enhanced by the productivity of the efficient workers. Lack of skilled labour in an economy is expected to produce opposite results.

2.1.4.8. Capital Intensity

The economy may require more capital than labour in production. This implies a capital intensive system. Capital intensity may have to increase in order to enhance productivity in the economy.

2.1.4.9. Availability of Raw Materials

Local production of raw materials is a necessary condition for industrial development. It is known that to achieve a long term high rate of productivity, countries most not depend raw material for their industries and most especially in the agricultural sector.

2.1.4.10. Inadequate Funding of Research and Development (R&D)

Funding in research and development (R&D) has witnessed shortfalls in the past. That is, despites its position as a major means through which productivity in the agricultural sector can be increased (Comin, 2004). This is reflected in the poor performance of the research institutes in Nigeria (Idachaba, 2000, Hall and Mairesse, 1995; Dillin.-Hansen *et al.,* 1999).

2.1.4.11. Socio-Economic Factor

Productivity hinges on the prevailing socio-economic setup within an economy. Even when technical know-how is supplied in abundance and there are more than enough raw materials, without an improvement in the existing political, economic and social institutions, no meaningful productivity gain can be achieved.

2.1.5 Other Factors Affecting Productivity Growth

Other factors that can affect productivity includes public goods and human capital, provision of infrastructure, provision of extension service, agricultural research and education (Mankiw *et al.,* 1992; Griliches, 1963; Solow, 1957 and Nelson, 1964; 1981). Also, timely policy reforms associated with agricultural production is a key factor for productivity growth (Auraujo *et al.,* 1997; McMillan *et al.* 1989; Lachaal, 1994; Wiens, 1983 and Lin, 1992). Research is expected to lead to increase in standard of awareness, either by simplifying current learning or producing innovative technology that will result in productivity enhancement.

2.1.5.1. Agricultural Research and Extension

The importance of extension and research in agricultural growth cannot be overemphasized. According to Rosegrant and Evenson (1992) output growth in South Asia, was found to be as a result of public research. About 25% of growth was accounted for by extension with a rate of returns of 63 and 52 % for research and extension respectively.

Fan (1996) found that during the 1980s and 1990s, China had a rapid growth in agricultural output, institutional and market reform that was supported by public investment in research and development (R&D). The conclusion is that, enhanced agricultural research is expected to enhance output growth. It is also expected to improve level of returns to agricultural research and lead to a higher productivity.

2.1.5.2. Policy Reform and Prices

Policy reform is seen as vital vehicle for agricultural gains, especially in countries where there is strong governmental agricultural intervention. However, to remove market distortion and allow market signals to be the main focus for establishing such reforms, e.g.

the structural adjustment programmes in Nigeria. The reform system in China in the 1970s was an example of policy reform which connected productivity with material rewards. The policy brought about increased incentives to producers and subsequently increases yields of major crops.

Kalirajan, McMillan, Whalley and Zhu (1996) reported that 61% increase in Chinese agricultural sector and 32 % increase between 1978 and 1984. It was found to be partly as a result of the response of producers to price reform (Kalirajan, *et al.,* 1996).

Although, policy reform is known to influence productivity and output growth in agriculture. However, long-term productivity gains can be achieved through agricultural research, technical change, human capital investment and infrastructure provision (Kalirajan, *et al.,* 1996).

2.1.5.3. International Trade

In theory, international trade is seen as a means of improvement in transportation and communication technology. Trade openness is seen as being strongly associated with rapid economic growths. All nations engaged in such trade are expected to experience rapid growth. The rapid post-war growth of Japan, South Korea and Taiwan is often cited as due to international trade. The low growth rate of inward looking countries, such as China and India was attributed to the close-door policy of trade. Most African countries engaged in international trade since 1900s, yet they have not registered any significant or rapid economic growth as against the expectation. However, the macro-economic, financing and lending policy in most African countries like Nigeria could be responsible for the outcome experienced.

2.1.6 Productivity versus Efficiency

Efficiency is not same thing as productivity. But, they are often used interchangeably. However, they are not precisely the same thing. This is because productivity improvement can be achieved in two ways (Coelli, 1995).

It can be improving the state of technology. This approach is referred to as technological change, which represents an increasing movement in the production frontier. Alternatively, it can be by implementing procedures like improving farmers' education, which ensures efficient use of existing technology and resources. This indicates that the farmers are moving towards the existing frontier. So productivity is not precisely the same as efficiency (Coelli, 1995).

2.1.7.1 Total Factor Productivity (TFP) versus Total Factor Productivity Growth (TFPG)

Production Function Approach (PFA)

Total factor productivity is defined as growth in output that is not explained by index of input growth. In most cases, change in technology is usually known to be responsible for such growth.

Total Factor Productivity is used to measure the total growth in output for every component of input used. As a result, TFP level is determined by how efficient the inputs are employed in production. Apart from improvements in the techniques of production, quality of inputs used and management practices increase the degree of efficiency in resource utilization which results in TFP.

2.1.7.2. Total Factor Productivity Growth

Total Factor Productivity Growth simply implies technical progress, these represents shift in the production or the cost function over time.

Another way of estimating total factor productivity growth is in terms of the differences between changes in total cost and the weighted changes in total input prices. The TFPG measure from the production function is equal and opposite in sign to the TFPG measure from the cost function. Thus, TFPG captures changes in efficiency in addition to pure technical change as a result of shifts in the production or cost function (Chambers and Quiggin, 1988).

2.2 Methodological Framework/Issues

Output growth over time is usually ascribed to growth in inputs and/or advancement in total factor productivity. As a result, to measure the sources of output growth, the contribution of total factor productivity is always estimated as a residual. This is done after the growth accounted for by the inputs might have been determined. The contribution of total factor productivity is interpreted as emanating from technical progress. This interpretation implies an assumption that improvement in productivity arises only from technical progress. This assumption is valid only if farmers operate on their production frontiers. That is, they are producing the maximum possible output or they are realizing the full potential of their production technology. This can only be achieved when farmers follow the best practice methods. Operating on the frontier is commonly referred to as achieving total technical efficiency (TE = 1).

Most studies on agriculture in Nigeria (Oni *et al.,* 2009) and agriculture in general (Battese, 1992; Bravo-Ureta and Pinheiro, 1993) applied the stochastic frontier methodology and found some level of technical inefficiencies (TE < 1).

The contention of this study and as observed by Kalirajan *et al*., (1996) is that since farmers operate below the frontier, technical progress cannot be the only source of total factor productivity growth. Hence, a significant increase in total factor productivity under this circumstance can be realized by improving the method of application of the given technology. This study intended to explore the possibility of correcting this anomaly in the literature. As breaking down total factor productivity growth into its components of technological progress and changes in technical efficiency would provide more information on the status of the production technology applied by the farmers. The study was about to correct the erroneous impression. The major reasons for breakdown the TFP is to know whether there is stagnation in technical progress over time or whether a given technology has been used exhaustively to realise its full potential (Kalirajan *et al.*1996).

The result obtained from decomposing the TFP is important from the policy point of view. This is because without using the existing technology to its full potential, embarking or introducing new technologies would not lead to any meaningful gains.

Many studies have identified the sources of output growth in agriculture using stochastic production frontier approach, e.g. Kalirajan, Obwona and Zhao, (1996) and Kalirajan and Shand (1997). These studies found that technical change (shift in the production frontier), size effect (changes in input use or growth that involves movements along the production frontier; changes in technical efficiency (movement towards or away from the production frontier) were sources of output growth.

Nihimizi and Page (1982) introduced a theoretical framework in which constant returns to scale in production technology was assumed. They also assumed that producers are perfectly allocative efficient. The framework assumes implicitly that technical change and change in technical efficiency are the only source of attaining TFP. This assumption contradicts the decomposition framework adopted by the other studies as scale effect and allocative efficiency were conspicuously omitted in their studies. But, returns to scale (increasing or decreasing) and allocative efficiency are known to be important sources of TFP growth. This is because scale economies fuel output growth in the absence of technical change. So also improvements in technical efficiency so far as input use increases enhances output growth. Diseconomies of scale in agricultural production slows down output growth under similar circumstances. It must be noted that the omission of scale effect in the decomposition of TFP growth is possible only when constant returns to scale is assumed (Lovell, 1996). This observation presupposes that their study was silent on increasing and decreasing returns to scale. However, since the range of scale economies is not known a *priori,* it seems appropriate to proceed by statistically testing the hypothesis of constant returns to scale in their study. The required and necessary test was not carried out. This observation raises issues on the empirical validity of their results. This is so because if the constant returns to scale (CRS) hypothesis is rejected, the scale effect is present and should be taken into account in the subsequent analysis. This is because the relative contribution of the scale effect to output growth depends on both the magnitude of scale economies and the rate of input growth. This study reframed from imposing the constant returns to scale restriction. The expectation is for either increasing or decreasing returns to scale. Hence this study is different from the other studies that used the stochastic production frontier approach to break down output growth in a distinctive way. This is because the study uses input-oriented Farell-type measure of technical efficiency. The other studies used the output- oriented, Timmer-type measure of technical efficiency. The use of input-oriented measure becomes necessary in order to integrate properly the approaches of Bauer’s (1990); Bravo-Ureta and Rieger’s (1991) approaches to the decomposition framework.

The approach in this study is based on the estimation of a self-dual production frontier function with its corresponding dual cost frontier function. Bravo-Ureta and Rieger's

(1991) used the production functions result to derive the cost frontier. Although, the cost frontier function that was analytically derived from the production function was not presented by them and Karagiannis and Tzourvelekas (2001), this study included the result of the cost function as part of its methodology in line with Taylor *et al.*, (1986), and Fan, (1991).

2.2.1 Literature Review on Previous Studies

It is noted that existing literature on technical efficiency change (TEC) and technical change (TC), on TFP without any consideration for scale efficiency change (SEC) on TFP growth were considered (Bruemmer *et al.*, 2006).

Bruemmer *et al.,* (2006) obtained negative SEC growth in the study. This result confirmed and is consistent with the criticism of land fragmentation in agriculture.

Fleisher and Liu (1992) decomposed TFP growth into SEC, TEC and TC in their study with the possible effect of scale efficiency considered.

Lovell, (1996) used a panel data set to decompose TFP into five effects they included the effect of scale economies in the analysis, while Kim and Han (2001), decomposed TFP and TFPG into four effects in their study of the Korean manufacturing industry.

Karagiannis and Tzouvelekas (2001) used the concept of duality theory and they disaggregated productivity into its components within a cost frontier function framework.

Ahmad and Bravo-Ureta (1995) used Vermont dairy farm data for the 1971-1984 period in their study. They found that size effect had 56% of the dairy output growth. Technical progress effect accounted for 41% of the growth and the remaining 3% was attributed to improvement in technical efficiency.

(Tauer, 1998) worked on the productivity of 70 dairy farms, the results indicated that technical efficiency decreases slightly, while the dairy farms' productivity increased by 2.6% annually, due to the gains in technical progress.

Bravo-Ureta and Rieger (1991) Kalaitzandonakis (1994), Piesse, *et al.,* (1996); and Karagiannis and Tzouvelekas (2001), also applied the stochastic frontier production function approach to decompose productivity growth in their studies.

Kuroda (1995), found in his study that Japanese output during the 1956-1990 period was mainly due to the effects of scale economies and technological progress.

Tauer (1993) found that the types of business organization, the accounting system of Dairy farms Herd Improvement Association (DHIA) membership had influence on the farmers' allocative efficiency, while number of cows affected their technical efficiency.

Piesse *et al*., (1996) in a comparative study of private sector farms and co-operative farm found ownership effect on efficiency, their findings indicated that the private sector farm had more growth in their productivity and were more technically efficient. The cooperative farms were found to be more productive as a result of their small farm size. Fan (1991) and Kalirajan *et al.,* (1996) highlighted the fact that institutional reform, rural industrialization, changes in relative grain prices, and natural disasters such as floods and drought also have significant influences on Chinese provincial agriculture and could affect any other agriculture.

Fulginiti and Perrin (1993) found that if price intervention were eliminated in the developing countries, agricultural productivity could increase on average by about one fourth of its current level.

2.2.2 Total Factor Productivity (TFP) Growth

TFP is the increase in output that is not accounted for by increased in inputs in the production process. It is the efficiency gains from using resources efficiently by applying best practices from existing production technology.

Conceptually, from the production frontier perspective, the growth in TFP can be disintegrated into its components. These components are; Technical efficiency change, Scale effects and Technological change.

Scale effects refer to an equivalent rise in output from an equivalent rise in all inputs used. Increasing economies of scale suggests that additional output in production requires less than proportionate rise in input use.

The technological change relates to technological progress. It mean more than advances in physical technologies. It connotes general understanding about innovation that lead to better planning and decision making in production. Improvement in the degree of technical efficiency refer to efficient use of the available resources and under best practice.

Stewart (2006) opined that the efficiency contribution obtained in the Canadian agricultural sector offers important perception about the impacts of different productivity growth policies in the sector. For instance, the productivity growth component of technical change points to the existence of development in technology and acceptance to advance productivity in the sector.

According to Stewart (2006) if a significant role is played by scale effect, then change in existing structure is the main driver of the sectors' growth in productivity. Therefore, policy design to speed up structural change possibly would boost productivity growth.

2.3 Empirical Review of Studies/Issues

2.3.1 Empirical Review on Agricultural Productivity

McMillan, Whalley and Zhu, (1989) used the growth accounting method in their study of Chinese agriculture for the period 1978–1984. The study revealed that reform in the sector brought about motivations that increased productivity by almost 78%. Zhao, (2004) in his own study used Solow's growth model to investigate dynamically, the Chinese agricultural productivity over the period 1979 - 2000. The result showed that technological progress had a 2.3% growth rate in the period while technological improvement contributed about 32% to output growth.

Zhen, Jiao and Li (2006) examined rural system reform effects on agricultural growth using country-level dataset from 1978 to 2004. The result showed that from 1989 to 1995, agricultural growth was 40% while government support stimulated another rise of about 35.8%. The study also confirmed that state-assisted agricultural policies and rural tax policy were the main driving force of agricultural productivity growth between 1996 and 2002.

Xu (1999) investigated agricultural productivity in China using CES production functions for the period 1979 to 1996. The result indicated that in the entire reform period, average annual growth recorded for TFP was 2.3%.

Fan, (2000) investigated the effect of allocative efficiency improvements, technical efficiency and technological change on Chinese agriculture from 1980 to 1993 using frontier shadow cost function approach. The result revealed that from 1980 to 1984, there was a significant increase in technical efficiency by 8.5% to 1985, a very small improvement was recorded for technical efficiency, for the period investigated, little allocative efficiency was recorded. From 1980 to 1984, rate of technical change showed annual growth of about 13.3%. Technological change according to the study could be a major future source of agricultural growth.

2.3.2 Empirical Review on Trend Analysis for Agricultural Output and Inputs

Kumar *et al.,* (2004) studied movement in TFP of marine and aquaculture sector in India. The result indicated a 4.4% annual growth of TFP indices for aquaculture, which accounted for two third of growth of output in the economy, driven by technology. The fish sub-sector recorded a 2.0% annual growth.

Ball (1985) compared the operation of U.S and U.S department of agriculture (USDA), using Tornqvist-Theil indexing. The result revealed that an annual growth of about 1.75% in total factor productivity (TFP) instead of the 1.70% gotten by USDA, 1.99% as average output growth rate, while input growth was 0.24%. Hence, 88% of output growth was achieved from increase in productivity while the remaining 12 per cent was from inputs growth. The estimated growth in output and input, according to USDA's estimates were 1.83% and 0.13%, respectively.

Capalbo, (1988) used indexing method in the U.S to investigate how increasing/decreasing returns to scale and technical change affect growth in TFP. The indexing method was used to construct TFP and econometric method was used to estimate translog function which was later used to decompose TFP growth. Output variable used in the study was quantity index of crops and livestock, while price index of labor, land and materials were used as input variables. The results showed a steady TFP growth with phases of volatility. 1.56% annual average TFP growth was obtained for the period 1950-1982. The estimated U.S study further revealed that 89% of the output growth was from technical change, while the remaining 11% was from the rate of growth in total inputs.

McCunn and Huffman (2000), considered the contribution of private and public research and development (R&D) to convergence. Törnqvist-Theil quantity indexes and econometric models were used for input and output, respectively. Result indicated that deregulation of interest rate and genetic engineering improvements for both animals and of plants made the period significant. There was no agricultural TFP level convergence throughout the states of U.S. Although, there are signs of convergence (single TFP level) at different zones and subsectors, but not persistent in all states. Rates of convergence recorded was 1.7%. The annual aggregate for sectors were 0.3% and 2.1% for livestock and crop, respectively.

Acquaye *et al.,* (2003) worked on agricultural productivity growth, using 48 US States from 1949 to 1991. The study followed the Divisa indexing procedures. The study used 58 types of inputs and 55 types of output to compare among Paasch, Laspeyres, Tornqvist-Theil and Fisher's Ideal indices to identify the most suitable index. The result revealed that similarity was found in the data by Fisher's ideal and the Tornqvist-Theil indices. The later was selected as the appropriate tool for the study. The rate of growth in input was deducted from that of output, in order to determine the multifactor growth rate. The results confirmed that agricultural productivity growth in the U.S, in percentage was 1.90%. The output growth contributed 1.71% while 0.19% was the annual contribution of input. All the States documented same productivity growth. Appalachian, Southeast and Delta regions experienced the maximum regional productivity growth rates whereas Corn Belt and Southern Plains regions had minimum growth rates.

Pfeiffer (2003) studied growth in agricultural productivity. The study at investigational and identified the characteristics that often lead to negative agricultural growth in developing countries. Bolivia, Colombia, Ecuador, Peru and Venezuela were used for the study. The study adopted econometric and non-parametric options. A Malmquist productivity index and stochastic frontier production function were used in productivity change measurement. Time trend variables based on time series data and parametric production function methods were used to evaluate technological change rate. Output was the total value of agricultural production. Labour, land, fertilisers, tractors and livestock were used as the inputs.

According to Hayami and Ruttan (1985). The analysis indicated that despite the different techniques used in the study, the result obtained were stable. A 1.52% TFP growth rate per annum was obtained. This was similar to the growth rate for the developed countries. The growth rate of 2.11% and 1.08% were recorded for Ecuador and Venezuela, respectively.

Technical progress was found to be the driver for agricultural productivity growth, while efficiency increase had a minor effect.

Agricultural TFP growth was estimated by Coelli and Rao (2003) using Malquist index and Data Envelopment Analysis, they also estimated agricultural productivity in their study for the period 1980-2000. The study constructed a piece-wise linear production frontier. The aim was to investigate outputs of crop and livestock for 185 agricultural commodities. Variable input used were livestock (pigs, cattle, goats, sheep and sheep-equivalent of buffaloes) labor, fertilizer, land, area under irrigation and total number of tractors used. The results revealed annually that 1.2%, 0.9% and 2.1 % growth rates were achieved by technical change, efficiency change and TFP growth, respectively. Highest TFP growth of 2.9% was displayed by Asia, followed by efficiency change, which contributed 1.9 % to TFP growth. A minimum growth rate of 0.6 % was posted by South America. The study also recorded a period of productivity setback characterised by a negative productivity trend and technological regression. This happened between 1980 and 2000. It was also noted that Africa and Asia region recorded least average technical efficiency scores in 1980 but attained maximum mean technical efficiency in the entire period of the study.

Stewart *et al.,* (2009) investigated reasons for discrepancies between the Canadian provinces TFP growth. The study used three Prairie Provinces data to construct the TFP, Superlative indexing method and econometric methods were used. Translog cost function was used to breakdown productivity growth. The study used crops (potatoes, hay, oats, sun flowers, wheat, mixed grains, grain crops, sugar beets, beans, dry peas and grain corn, dry peas, sugar beets, dry peas, canary, grain corn, and lentils) and livestock (dairy, cattle, poultry and swine) as dependent variables. The explanatory variables were grouped into four categories; these are; labour (remunerated and voluntary labour), capital (which include livestock inventory, equipment and machinery), materials (feed, veterinary fees, fuel, irrigation, fertilizer, pesticides, artificial insemination, electricity, seed, and other sundry expenses). Land and buildings (summer fallow, pastures, cropped land, and buildings).

The result showed that Prairie agriculture had robust productivity growth rate of 1.56% during the period 1940-2004. The annual growth rate was 1.56 %. Growth in

Productivity was 2.43%. This constituted 64% of output growth. Productivity growth rate between 1980 and 2004 was found to be high at 1.80% per annum. The annual output growth during same period remained 2.38%. In all, 76% of output growth was ascribed to productivity growth. For the three Prairie Provinces; the highest productivity growth was attained in Manitoba. This was followed by Saskatchewan, while Alberta had the least productivity growth. The study also revealed that crop growth at 2.85% was higher than that of the livestock at 1.56%. Also, the contributions of technical change to crop productivity growth in Manitoba was 80.4%, Saskatchewan had 84.5%, and Alberta had 94.7%. Scale effect's contribution to crops productivity growth was 16.9%, in Manitoba, 16.5% in Saskatchewan, and 4.9% Alberta. The Scale effects' contributions to livestock was 62.4% in Saskatchewan and 51.0% in Alberta. Productivity growth obtained from livestock for Manitoba comprised primarily of technical change. This was 53.2%, while 36.0% was for scale effect.

O'Donnell, (2010) used Data Envelopment Analysis procedure to estimate and decompose multiplicatively complete Hicks-Moorsteen TFP index. This method was used so as to understand the reasons for changes in TFP. The study used crops and animals as output variables and labor, land, tractors, livestock, and fertilizer as input. The mean technical change rate of 1.0% was obtained. This was, less than the 1.1% documented by Coelli and Rao (2005). In the 1970s, Nepal recorded the highest TFP, Zimbabwe and Nepal recorded the highest in the 1980s, Thailand and Nepal had the highest in the 1990s.

Agricultural productivity in U.S, New Zealand and Australia responded to variations in agricultural terms of trade (TT). The assumption was that by increasing TT, technically efficient optimizing firms can be encouraged to increase their operations. The study submitted that increases in tax rates, elimination of input subsidies, reduction in the levels of output price support and other policies affecting deterioration in the agricultural TT and enhancing TT can improve productivity. Fuglie, (2010) measured output growth using Törnqvist-Theil index and econometric methods. Output index as measured by Food and Agricultural Organisation was used as output of livestock and crop. Input used were divided into five groups – agricultural land, farm machinery, fertiliser, livestock, and farm labour. The results indicated no decline in agricultural productivity. The study found TFP growth speed up and input growth slow down, this were found to basically counterbalance one another.

2.3.3 Empirical Review on Total Factor Productivity Growth

Individuals and corporate bodies have used both parametric and non-parametric methodology for many industries to estimate total factor productivity. The studies use the methodologies to compare economies and segments like the services, industrial and exchange sectors. The subsequent section looked at criticism of empirical studies in which the parametric approach was used to estimate total factor productivity.

2.3.3.1 TFP Growth by Parametric Approach

Many researcher have used the parametric approach to measure TFP growth, most of them follows the approach developed by Aigner *et al.,* (1977). The unobserved error terms representing statistical noise and efficiency were assumed to be under this regression based approach. The approach allows for the use of maximum likelihood by assuming specific distributions for the error term. Parametric frontier approach has been used in diverse segment to estimate total factor productivity. Those used for manufacturing include: Aigner *et al.,* (1977); Diaz and Sanchez (2008); Tsao (1985); Mahadevan (2001); Leung (1997); Mahadevan, (2002) and Rahmah and Fung (2002), applied it in the manufacturing industry. (Wu, 2000) also used same approach in the APEC countries.

Diaz and Sanchez (2008) used stochastic frontier production function to investigate how small and medium scale firms perform in Spanish industry for the period 1995- 2001. The study focused mainly on technical inefficiency and its determinants. A low level of efficiency was noticed in large farms when compared with small and medium scale farms. Also, under economic hardship, small firms simply pull out of the market. Firms under investigation are likely to be effective if the following are controlled: the share of market, capital strength, foreign shareholders, quantity of short-term labour over the fixed labours, and lawful status of firms.

Hashim and Basri (2004) used parametric approach to study the TPP growth in manufacturing subdivision in Malaysia between 1990 and 2000. The result revealed that some of the industries recorded very low total factor productivity growth. Industries like the chemical, textile, rubber, petroleum and wood recorded positive growth. Furthermore, other industries except chemical, paper and petroleum industries recorded efficiency change as the major source for TFP growth. Technological progress was highest in Petroleum industry. Electrical industry had highest efficiency change while food industry had the lowest.

Rahmah and Fung, (2002) employed stochastic function analysis to estimate the influence of total factor productivity (TFP) growth in six industrial companies from 1981 to 1994. The study found that change in technical efficiency declined in the small size firms but improved for medium size firms. For both firms, technical change was positive. The study finally revealed that there was a relatively high TFP growth for medium than for small scaled firms.

Mahadevan (2002) used parametric technique approach on food, textile, Chemical and fabricated metal industries in South Korea between 1980 and 1994. The results indicated that productivity drove four of the companies' output growth. The study indicated that export oriented industries had higher TFP growth. The Food and Textile industries had technical efficiency change, Chemical and fabricated metal industries had positive technical efficiency change.

Mahadevan, (2001) used Stochastic Function approach to estimate total factor productivity in Malaysian manufacturing industry for the period 1981-1996. The period of study was divided into three sub-period. The first was from 1981 to 1984. The second was from 1987 to 1990 and the third was from 1991 to 1996. The result showed that the TFP growth in the last two sub-periods was negative. The main reason for the fall of TFP growth in the second sub-period was as a result of negative contributions of efficiency change to TFP (Mahadevon, 2001).

Leung, (1997) investigated the manufacturing industry in Singapore. The study used parametric approach to estimate growth in TFP. The study cover the period 1983-1993. The result revealed that TFP growth was about 2 to 3% annually in the study period. The study further established that the fast change experienced by the economy of Singapore was due to input growth.

Tsao, (1985) in his study estimated total factor productivity in Singapore using 28 manufacturing industries over the period 1970-1979. The results indicated that TFP growth of 0.08% was obtained for the manufacturing sector. All the other industries showed negative TFP growth. The study identified that high proportion of foreign capital, low level of industrial capability, policy of low wage by Government and entrance of unskilled overseas labour in Singapore were the reasons suggested for the low TFP growth.

Wu, (2000) estimated total factor productivity using Stochastic Frontier Method to study seven developed and nine developing APEC countries. A positive TFP growth was recorded for the countries investigated. The developed countries recorded better performance. The study submitted that the main factor for improved TFP growth in almost all the countries was technical progress. The result indicated that size of managerial efficiency was very small but positive.

2.3.3.2 TFP Growth by Non Parametric Approach

The non-parametric approach has been used in many studies to estimate TFP growth. Data Envelopment Analysis method has been extensively used.

Charnes *et al.,* (1978) worked on existing frontier concept initiated by Farrell (1957) to calculate TFP growth in his study.

Nkamleu, (2004) analysed the studies in which DEA method was used in African during the period 1970-2001. The study revealed that the main constraint to achieving higher level of productivity was technical change in sub-Saharan Africa. It revealed that the driving force of productivity growth in the Maghred countries was the technological change while institutional factors and agro-ecological factors were important contributing factors for agricultural productivity growth, generally.

Agricultural productivity growth structure was investigated by Belloumi and Matoussi, (2009) using the non-parametric approach. The result indicated that on the average, 1% rise of annual growth rate was achieved in agricultural productivity growth. Technical change was the main growth source recorded.

Deliktas and Candemir, (2007) examined the performance of agricultural enterprise productivity between 1999 and 2003 in Turkey. The result showed that on the average, there was technical progress. Technical efficiency was enhanced by about 1.5%. The study also revealed that the major determinants of production efficiency were geographic locations of enterprises, irrigation rate and tractor (proxy for existing technology).

Basti and Akin, (2008) studied the productivity of non-financial firms from 2003 to 2007. They employed non-parametric (DEA) approach to compare national and international owned firms operating in Turkey. The productivity of the firm was broken down into its components. The study showed a significant difference in the productivity of the domestic and foreign owned firms. The recorded that average productivity deteriorated throughout for the groups except for the year 2006.

Wadud (2008) estimated Productivity Growth in Malaysia using the industrial sector for the period 1983-1999. The study used non parametric DEA-Malmquist Productivity Index to compute technical efficiency change, technical change and TFP growth. The study found productivity improvement in 76 industries out of the 114 industries investigated. The improvement ranges between 0.1% and 7.8% during the study period. It was also discovered that 95 companies recorded technological progress while 53 companies improved based on efficiency change. The study indicated that in the mid-1990, low productivity growth was experienced due mainly to deterioration in technical efficiency. The study revealed that Glass products and Glass industries, coal and chemical industries and the Petroleum industries had high TFP growth that was connected to technological progress and efficiency improvement.

Kong and Tongzon, (2006) used DEA method to compare sectors with respect to productivity growth in Singapore. The approach was adopted because of inconsistences in input prices and lack of uniform characteristics in the sector. The study used ten sectors. It investigated TFP growth from 1980 to 2000. The investigation projected that receipt of new skills, knowledge and technology were necessary for each sector. Besides, higher efficiency in resource utilisation and administration may result in improvement in competitiveness of the sectors.

Jajri and Ismail (2006) examined technical change, TFP growth and efficiency change in the Malaysian manufacturing sector for the period 1985-2000. The study used a nonparametric DEA method to estimate Malmquist productivity index. Inputs used were capital and labour while value added was the output used. The result showed that TFP growth improved with efficiency change as the major source. Besides, technological change equally showed growing trend. While in food, wood, chemical and iron products, high efficiency change was noted. Technological progress was found to be greater than the efficiency change for food and wood industries. The analysis indicated no progressive relationship amongst efficiency, capital intensity, TFP growth and technical change.

Using Chinese manufacturing industry data for the period 1990-1997, Fu (2005) employed Malmquist productivity index to estimate total factor productivity. The TFP was later decomposed. The result showed no significant productivity gains in the industry. This was ascribed primarily to exports in the changing economy of China.

Donglan (2005) used the Malmquist productivity index to analyse TFP growth in the industrial sector of China between 1993 and 2002. Findings showed that TFP grew by 2.4%, technical change by 2.4% and efficiency change by 0.3%. Technological progress was the main source of productivity growth.

Shao and Shu (2003) investigated 14 *Organisation for Economic Cooperative and Development* (OECD) countries, they used the non-parametric approach to examine the productivity growth of Information Technology (IT) in the industries of the countries. Results shows that 10 countries progressed. In the 10 countries, technological progress was the most important source of growth, the 10 country became more technically efficient in the period. The study also revealed that scale effect led to productivity growth in Italy and Finland.

Malmquist Productivity Index approach was used by Mahadevan (2002b) to estimate in the manufacturing sector of Malaysia for the period 1981 to 1996. The study showed that 0.8% TFP growth was recorded. The results from various sectors indicated that most industries experienced a progressive TFP growth. This was sourced from technical efficiency change, which also benefited the total factor productivity.

Mahadevan (2002c), evaluated TFP growth, using both parametric and non-parametric techniques. The result showed that using both methods amounted to different results, but it however indicated a declining TFP growth after 1990 due to the decline in the contribution of technical change.

Fare *et al.,* (2001) investigated the effect of reform on productivity performance in New Zealand and Australia in manufacturing sector from 1986 to 1996, using Malmquist

Productivity Index, further decomposition was made, to see other source of TFP in connection with the performance for the concerned economies. According to the findings, technical change effect on TFP change in New Zealand was higher than that of the efficiency change, while low capital intensity was responsible for a lesser TFP in Australia.

Fare, *et al*. (2001) carried out a research in Taiwan over the period 1978-1992, they used sixteen manufacturing sectors. The study employed Malmquist Productivity Index. TFP was decomposed in order to identify the sources of its growth. Technical change was decomposed to input and output bias. Result indicated that the manufacturing sectors' productivity increased by 2.89% annually. Scale efficiency change led to slight increases in productivity, while technical progress was achieved mainly to development activities, improved research and progressive policies.

Chandran and Pandiyan (2008), examined the technical change, total factor productivity and technical efficiency in the service industries in Malaysia from 1987 to 1992. The results asserted that on the average, total factor productivity led to a positive and progressive increase of about 1.8%., and that the TFP growth was due to technical efficiency. Technical change was found to be weakening productivity growth.

Angelidis and Lyroudi (2006) researched into 100 banks in Italy, the Malmquist Productivity Index was used for 2001 and 2002 to calculate changes in productivity. Nominal values of output and inputs in natural logarithm were used. Bank size and performance relationship were measured using rank correlation. The results showed that both variables were inversely related, but were not significant.

2.3.4 Empirical Review on Determinants of Total Factor Productivity Growth

Many empirical study have been carried out at OECD and developing countries. Wang and Tsai (2003), investigated the determinants of TFP growth using Taiwanese firms. The result showed that R&D investment is a major determinant of TFP growth. A positive correlation was found between R&D investment and TFP growth.

Lichtenberg and Siegel, (1991), Hall and Mairesse (1995) in French firms and Dilling-Hansen *et al.,* 1999) in Danish manufacturing firms obtained similar results.

Comin, (2004) looked at the influence of Research & Development on TFP growth. The U.S., the world's foremost country in R&D was used for the study shows very low percentage of TFP growth ascribed to R&D. This result is contrary to most findings that asserted that R&D is the chief source of long-term growth.

Jones and Williams (1998) used panel data in their analysis. The result showed that R&D almost completely lose its influence on TFP growth.

Mayer, (2001) used two components of literature in relation to productivity growth. The first is trade, as a carrier of knowledge. It sees imports as an avenue of bringing in overseas technology into local production and which subsequently influenced TFP positively. The second component stressed that human capital performs the dual role of being the facilitator of technology adoption from abroad and the creator of appropriate local technology.

2.3.5 Theoretical and Conceptual Framework

2.3.5.1 Theoretical Framework

Theoretically this study is partly based on the duality theory. The most essential development in the theory of production and cost is Shepherd's (1953, 1970) finding of a twin relationship between the production and cost function (Chambers and Quiggin, 1998). Agricultural production is full of uncertainties. Hence, in view of this, and because of economic problems connected with altering it, have provided the arguments for its special nature and its preferential treatment in the economy. Similar agreement pervaded the analytical rational of agricultural economists. Due to the stochastic in nature of agricultural production, its production differs from other non- stochastic production. Regularly, it assumes that common ideas based on economic theory is no longer applicable. This was more obvious in the mix-up over the presence of cost functions for stochastic technologies (Chambers and Quiggin, 1998).

Chambers and Quiggin (1998), opined that with a closed and non-empty input set, a production function can generate a well behaved cost function. The latter is a twin to the former, showing convex of inputs and free disposability of inputs. Therefore, this study is centered on usage of self-dual production frontier functions. Within the frameworks by

Bauer (1990) and Bravo-Ureta and Rieger (1991), output growth is decomposed by depending on the econometric valuation of a self-dual production frontier. Adopting generalized Cobb Douglas frontier production function (Fan, 1991), allows for use of input biased technical change, returns to scale variables, substitution elasticities and time-varying production (Karagiannis and Tzouvelekas, 2001). Statistically, it allowed carrying out tests of hypothesis on rates of technical change and constant returns to scale.

Precisely, the following broad stochastic production frontier function is considered:

$Q_{ii} = f_{jii}$t;α) exp (V$_{ii}$ − u$_{it}$) (1)

Where

Q* is the maximum output that can be produced. It is also the observed output adjusted for the statistical noise.

Kjit is the ratio of observed inputs Xiit and Xjit at Q*it.

~ (*) = functional form,

Qit = ith farm output in time t,

xjit = quantity of jth input ,

α = vector of parameters estimated

ei_f = Vir – Uit composite statistical noise,

V_i defines normally and symmetric dispersed error term not quantified by farmers.

Uit is non-negative, one-sided, error term indicating stochastic underperformance of ith farm output as a results of technical inefficiency.

Uir is the output-oriented technical efficiency.

The Uit and Vit are expected to be independently distributed from one another

The input-oriented technical efficiency is obtained by calculating the technically efficient input bundle/ vectoe X^T. This is obtained by doing two things, one is to combine the estimated SFPF and the observe factor ratios X_I / X_j for J ≠ 1. Two is to solve the system of equation in (2) together or as one system.

$Q_{it} = f(*) - U_{it}$ (2)

$$Q_{it}^* = Q_{it} - U_{it}$$

$$Q_{it}^* = Q_{it} - V_{it}$$

$$\frac{X_{1i}}{X_{jit}} \equiv K_{jit}\, ; j > 1$$

Where

$Q^*{}_{it}$ = is the maximum output that can be produced.

Q = output produced by ith farm

X = inputs used and

kjit = proportion of observed inputs Xiij and Xjit at Q*.

Then,

$$T = \frac{W^I X^T}{W^I\, X}$$

In conclusion, evaluating farm- specific input allocative inefficiency are acquired using Farrell's, (1957) formula.

2.3.5.2 The Self-Dual Production Frontier Functions

2.3.5.2.1 Production Frontier Function Model

The production frontier function is approximated by the generalized Cobb-Douglas procedure (Fan, 1991). This is a translog specification less the cross terms. It is separable-in inputs translog production frontier function (Fan, 1991),

$$f(.) = \alpha_0 + \sum_{j=i}^{m} \alpha_j\, lnX_{jit} + \alpha_t t + \frac{1}{2}\alpha_{tt} t^2 + \sum\nolimits_{j=i}^{m} \alpha_{jt}\, lnX_{jit} t + V_{it} - U_{it} \qquad (3)$$

2.3.5.3 The Technical Inefficiency Model

The inefficiency model is made up of the SFPF and the inefficiency equation. These equations were estimated simultaneously. The first one captures the response of the output to the production factors. The second equation was used to isolate inefficiencies factor.

Battese and Coelli, (1995) represented the inefficiency model as a linear function. The inefficiency equation is a function of selected socio- economic explanatory variables. The two equations are

$$Q_i t = f(X_i t, t; \alpha) + V_{it} - U_{it}$$

$$U_{it} = \delta_0 + \sum_{m=1}^{m} \delta m Z mit + W_{it} \quad (4)$$

2.3.5.4 The Cost Frontier Function Model

Supposing all regularity conditions hold for the production function, a closed-form solution of the cost minimization problem yields the following (dual) cost frontier function

$$l_n C_u = \beta + \beta_Q In Q_{it} + \Sigma_{j=i}^{m} \beta_j In w_{jit} + \beta_t t + \beta_{tt} t^2 + \sum_{j=I}^{m} \beta_{jt} in w_{jit} t \quad . \quad (5)$$

The variables used in the stochastic cost frontier function are derived from SFPF. These are the frontier output (Q*) and the prices of the inputs W_1 for X_1, W_2 for X_2, W_3 for X_3 and W_4 for X_4. Hence, the SFCF has six explanatory variables as against five in the SFPF.

2.3.5.5 Calculation of the Input Prices for the Cost Function.

Price of land (W_1) = Rural consumer price index as a proxy

Price of Labour (W_2) = $\frac{Agricultural\ wage\ in\ time\ t}{Total\ Mandays\ in\ time\ t}$

Price of a tractor (W_3) = $\frac{\text{Value of tractors } in\ time\ t}{\text{Number of tractors } in\ time\ t}$

Price of fertilizer (W_4) = $\frac{\text{Value of fertilizers used } in\ time\ t}{\text{Quantity of fertilizer used } in\ time\ t}$

Most essential variable in primary production is land. Yet there is strictly no discernable market for agricultural land. As a result, the rural consumer price index (CPI) is used as the general price level for the area and a proxy for the price of agricultural land in this study. This is done because rural agriculture is the major dominant contributor to agricultural GDP. It is also done because Nigerian agriculture is strictly rural. The information to be used in calculating the prices of the other inputs were obtained in the FAOSTAT data sets.

The time variables are also added in this case. Hence, if the SFCF has eleven explanatory variables, the SFPF must have ten.

2.3.5.5.1. Relationship between SFPF and SFCF Parametres

The relationships between the parameters of the SFPF and SFCF are presented below

$\boldsymbol{B} = 1/\beta^2{}_Q\, (1/\beta_k + \beta_{kt}t) - \Sigma_{j=2}^{m} In(\beta_j + \beta_{jt}t/\beta_k - \beta_0\, for k \neq j,$

$\beta_j = \alpha_j\beta_Q$

$\beta_Q = 1/\sum_{j=I}^{m}(\alpha_j + \alpha_{ji}t),$

$\beta_{jt} = \alpha_{ji}\beta_Q,$

$\beta_t = \alpha_t\, \beta_Q,$

$\beta_{tt} = \alpha_{tt}\, \beta_Q$ and

$\beta_0 = \beta_Q In\alpha_o$

From the equations above, the parameters of the SFCF are thus derived from those of the SFPF

2.3.5.5.2 Production Efficiency Measures and Output Decomposition

The starting or point of departure is the concept of cost efficiency within this setting.

In this regards, economic efficiency is:

E(Q,w,x,t) = C(Q,w,t)/C = W'X?(Q,w,t)/w'x (4)

(Bauer, 1990; Lovell 1996),

Where

O < E (Q,w,x,t) ≤ 1, C (Q,w;t) is a well-defined cost frontier function, C = cost observed, Q = quantity of output, W = input price vector, t = time index, used as proxy for technical change, X^E is the cost-minimization economic efficient input bundle. The Shephards' Lemma is used to obtain the efficient input vector X^E and x is the observed input vector.

E (Q,w, x,t) is independent of factor prices scaling and has a cost interpretation in the sense that

1–E (Q,w, x,t) indicates the proportion reduction in cost associated with the removal of all inefficiencies (Kopp, 1981).

In addition,

E (Q,w, x, r) = T(Q, x,t) • A (Q,w, x,t) (Farrell 1957),

Where

T (Q,x,t) = w'x^T/w'x = input-oriented measure of technical efficiency.

O < T(Q,x,t) ≤ 1, A(Q,w,xt) = w' E(Q,w,t)/w'xT = input Allocative efficiency with O < A(Q,w,xJ) ≤ 1, and

X^T = technical efficient input vector.

Moreover, T (Q,x,t) and A(Q,w,x t) are both independent of factor prices scaling (Kopp, 1981)

According to Bauer (1990) taking logarithms of both sides of E (Q,w, x,t) = C(Q,w;t)/C and completely differentiating with respect to time

results in:

$$E(Q,w,x,t) = \varepsilon^{CQ}(Q,w,t)Q + \sum_{j=I}^{m} s_j\,(Q,w,x,t)w_j + \dot{C}(q,w,t) - \dot{C}, \qquad (6)$$

Where

A dot over the variable or function indicate time rate of change

$$\varepsilon^{CQ}(Q,w,t) = \frac{\partial InC(Q,w,t)}{\partial InQ}, s_j(Q,w,t) = \frac{\partial InC(Q,w,t)}{\partial Inw_j}, and - \dot{C}(Q,w,t)$$

$$= \frac{\partial Inc(Q,w,t)}{\partial t}$$

$is\ the\ rate\ of cost$ diminution.

However, taking logarithm of C = w'x and totally differentiating with respect to t yields:

$$\dot{C} = \sum_{j=i}^{m} s_j \dot{x}_j + \sum_{j=i}^{m} (s_j wj)\dot{w}_j \qquad (7)$$

Substituting (7) into (6)

$$\left(TFP = \dot{Q} - \sum_{j=I}^{m} s_j\,\dot{x}_j\right) \qquad (8)$$

$and\ using\ the\ relation$

$$\dot{E}(Q,w,x,t) = \dot{T}(Q,x,t) + \dot{A}(Q,w,x,t)$$

(9

Results in the output growth decomposition model.

2.3.5.6 Output Growth Decomposition Model

$$\dot{Q} = \sum_{j=I}^{m} s_j \dot{x}_j + [1 - \varepsilon^{CQ}(Q,w,t)]\dot{Q} - \dot{C}(Q,w,t) + T(Q,\dot{x},t) + A(Q,\dot{w},x,t) + \sum_{j=I}^{m}[s_j - s_j(Q,w,t)]\dot{w}_j$$

(10)

Equation (10) is the output growth decomposition association as established by Bauer (1990)

The first part explains effect of input growth (size effect) on variations achieved in output over time. This implies that if an input is very important, more of it will be used in the production process

Second term deals with the impact of scale economies (scale effect) on output growth. The term disappears, as ε^{CQ} (Q,w,t) = 1, in constant returns to scale (CRS). However, it becomes positive if it is greater than 1, indicating increasing RTS and negative, if less than one indicating decreasing RTS.

The third part talk about the dual-rate of technical change which is identified as cost diminution, this remains positive when technical change is progressive.

The fourth and fifth expressions in (10) tend to be positive as input allocative and technical efficiency increase, it becomes negative when input allocative and technical efficiency decline over time. However, no acknowledged reasons for the increase or decrease of efficiencies at the same time, (Schmidt and Lovell, 1980).

The most important thing in the analysis of output growth decomposition is the rate at which efficiency changes over time. The efficiency gained itself does not matter much even when efficiency is achieved at low level. Output gains can still be attained by improving either input allocative efficiency or technical efficiency or both efficiencies. Price adjustment effect is the last part in (10). This part is closely connected to describing TFP. This is because the TFP is centered on perceived quantities of output and input. The effect is as good as zero if there is no input allocative inefficiency. If there is input allocative inefficiency, the extent of the effect is inversely associated with efficiency in input allocative efficiency.

2.3.5.7 Total Factor Productivity Growth Decomposition

$$T\dot{F}P = \dot{Q} - \sum_{j=I}^{m} s_j \, \dot{x}_j$$

Note that from the Divisa index equation above, by making Q the subject gives

$$\dot{Q} = \sum_{j=I}^{m} s_j \, \dot{x}_j + T\dot{F}P \qquad (11)$$

Hence,

$$T\dot{F}P = [1 - \varepsilon^{CQ}(Q, w, t)]\dot{Q} - \dot{C}(Q, w, t) + \dot{T}(Q, x, t) + \dot{A}(Q, w, x, t) + \sum_{j=I}^{m} [s_j - s_j(Q, w, t)]\dot{w}_j \qquad (12)$$

This implies that TFP growth can be disintegrated into five constituents. This is obtained when the input growth is subtracted from the output growth equation (10).

The right-hand side (RHS) of equation 6a, b and c are essential for attaining the quantitative measures of some of the components in (3)

2.3.5.8 Input Growth Rate Model

The aggregate output growth rate is equal to the sum input growth rate and total factor productivity, as below

$$\dot{Q} = \sum_{j=1}^{m} \mathrm{Sj}\dot{X}_J + T\dot{F}P$$

But

$$\dot{Q} - T\dot{F}P = \sum_{j=1}^{m} Sj\dot{X}_J$$

Following Limam and Miller, 2004; Fulginiti, *et al.,* 2004, the equation is specified as

$$\dot{Q} - T\dot{F}P = C + S_1 X_1 + S_2 X_2 + S_3 X_3 + S_4 X_4 + V_I \qquad (13)$$

Equation 13 is the estimating equation. In this, $\dot{Q}$- $T\dot{F}P$ is regressed on the growth rates of inputs to get the coefficients (Sj`s); which are understood as factor shares while the constant (C) in the equation accounts for omitted variables. These comprised of the physical variables such as institutions and political instability and climatic conditions

2.3.5.9 Estimation of TFP Indices

TFP is the ratio of the aggregate output index to aggregate input index. The input index is constructed as a linear of inputs using the production function approach. Following (Wen, 1993), the TFP index is written as stated in 2.3.5.9 as

$$\text{TFPI} = \frac{100 \text{ x GVAO}}{\text{a x labour} + \beta \text{ x land} + \gamma \text{ x capital} + \Theta \text{ x fertilizer}} \qquad (14)$$

Where;

Gross Value of Agricultural Output (GVAO) in the numerator represents output index. The linear sum of weighted inputs of capital, agricultural labour, land and capital, weighted by factor shares in the denominator represents the input index. α, β, γ and Θ are production elasticities for labour, land, capital and fertilizer as weights.

2.3.5.10 Estimation of the Factor Shares or Inputs Weights for the TFPI

GVAO are often termed as the value of agricultural production in studies on agriculture. GVAO is the sum total of the value of productions from crop, fishery, forestry and livestock.

Tripathi (2008), used constant returns to scale (CRS) to estimate Cobb-Douglas production function.

According to Peterson (2000) the production elasticities equals to the factor shares and sum to one under CRS and profit maximization (Nevertheless, it provides other ways by which input weight can be derived, on which precise time series of factor prices were unobtainable.

The limitation enforced on the model does not allow the data set to "speak". The focus of this study is that the data set should be allowed to assert itself. In this case, the resulting returns to scale could be either growing or falling. The current study thus adopt (Tripathi, 2008) methodology. It uses GVAO as dependent variable and agricultural land, agricultural labour, fertiliser and capital (tractors) as explanatory variables.

2.3.5.11 Estimation Problems in obtaining the Factor Shares for the TFP Indices.

The use of time series data in estimating agricultural production function were in most time faced with complications like;

High correlation may exists between the explanatory variables, leading to unreliable results, when ordinary least square (OLS) are used with multicollinearity variables.

When annual national data were used, the available degree of freedom are limited, thus the numbers of variable that can effectively be included in the model is reduced.

Accuracy and quality of data used are considered uncertain, particularly on agricultural labour inputs and land.

The Cobb Douglas function, for example, will because certain structure was imposed on the production process, assumes a substitution that is unitary elasticity in nature between any two inputs

Finally, since the number of inputs allocated to agricultural production are part of farmers' decisions, endogeneity of the X variables problem may arise from the estimation.

Consequently, the approach to estimating production function estimation were as follows. The restricting variables number reduces the problem of multicollinearity associated with OLS.

To deal with multicollinearities, it is importance to look at the shortcomings of other approaches like principal components or ridge regression analysis. The latter introduces an arbitrary numerical alteration to the data, while in the former, estimator mixes the original coefficients in the model, and thus, to interpret becomes difficult. This therefore makes both approach to be biased (Greene, 1993).

The use of OLS in non-stationary data will result in getting spurious regression results, obtained. R^2 will be high, Durbin-Watson statistics will be low and the value of t-statistic will be significant, to suggest a major association between dependent and explanatory variable, even when not totally related in the real sense.

Conventionally, logarithm form has been used to express variables used in explaining factors responsible for TFP. This is same in time series analysis as there is first differencing of variables. As long as the series are integrated of order 1, expressing the variables in logarithms ensures that OLS method and stationary data series can directly and safely be used (Hendry, 1995).

2.3.6: R^2 and Durbin- Watson Test

R^2 and Durbin- Watson statistic (d) are used to test for spurious effect in estimated model (Granger and Newbold, 1974)

If $R^2 > d$, OLS estimated equation is suspected to suffers spurious effect

If $R^2 < d$, then it does not suffer from the spurious regression phenomenon.

Non-stationary data produces spurious regression results which may be misleading. Therefore, it is important to establish the stationarity of data to be used. This was carried out by using the Augmented Dickey-Fuller (ADF) unit root test. The decision rule is that the ADF test statistic value must be greater than Mackinnon's critical value of 5% in absolute value. Given the unit root properties of the variables, the study proceed to carry out other analysis.

2.4. Conceptual Framework

The conceptual framework borrows from the output growth decomposition analysis. The key variables inherent in the decomposition process are synthesized into the schematic diagram that is as presented. The linkages are thereafter explained within the available information in the literature.

2.4.1 Conceptual framework – Explanation

Output growth can be divided into growth in inputs and TFP. This observation is responsible for, the circular arrows linking the three variables.

Between input and output growth, growth is the bi-directional inputs (land, labour, capital, fertilizers, and tractors). They are responsible for both input growth and output growth.

Output growth is affected by size effect, technical change and improvement in both TE and AE. Output growth has components, hence it can be decomposed and sources of its growth can be identified. Both SFPF and SFCF are to be used. Translog for production and double-log for cost function. The determinants of output growth shall be identified using a linear function.

TFP = Output growth – Input growth.

But TFP is said to be identically equal to technical progress. The assumption here is that TE = 1

However, in agriculture generally, TE is less than one (TE<1). Therefore, under this situation, TFP has other components apart from technical progress.

For this reason, other sources of increases in TFP can be identified. Also, the determinants of TFP can be identified. Similarly, TFP can be decomposed using Double log (DL) model and its determinants by linear model.

Scale effect and AE in one box and improvement in TE and changes in TE in another box are said to affect TFP. This is responsible for the arrows from the two boxes linking them to TFP.

Arising from the fact that TE<1, size effect, technical progress improvement in TE and technical inefficiency are linked. Some variables can be generated and examined. In essence, this results in the estimation of the inefficiency model in production. This implies a single estimation technique or simultaneous estimation of SFPF and SFCF. The inefficiency model links back to the translog SFPF and Double-log SFCF.

TFPG is derivable from the TFP and vice versa. Issues relating to TFPG are returns to scale in production, changes in AE and scale effect, economies and diseconomies of scale as long as TE<1.

Hence, TFPG has its components. TFPG can be decomposed and its sources of growth and determinants can be identified. The decomposition model is DL while the determinants model is linear. In this way, the key variables, relevant issues and the models involved in the study are all linked conceptually.

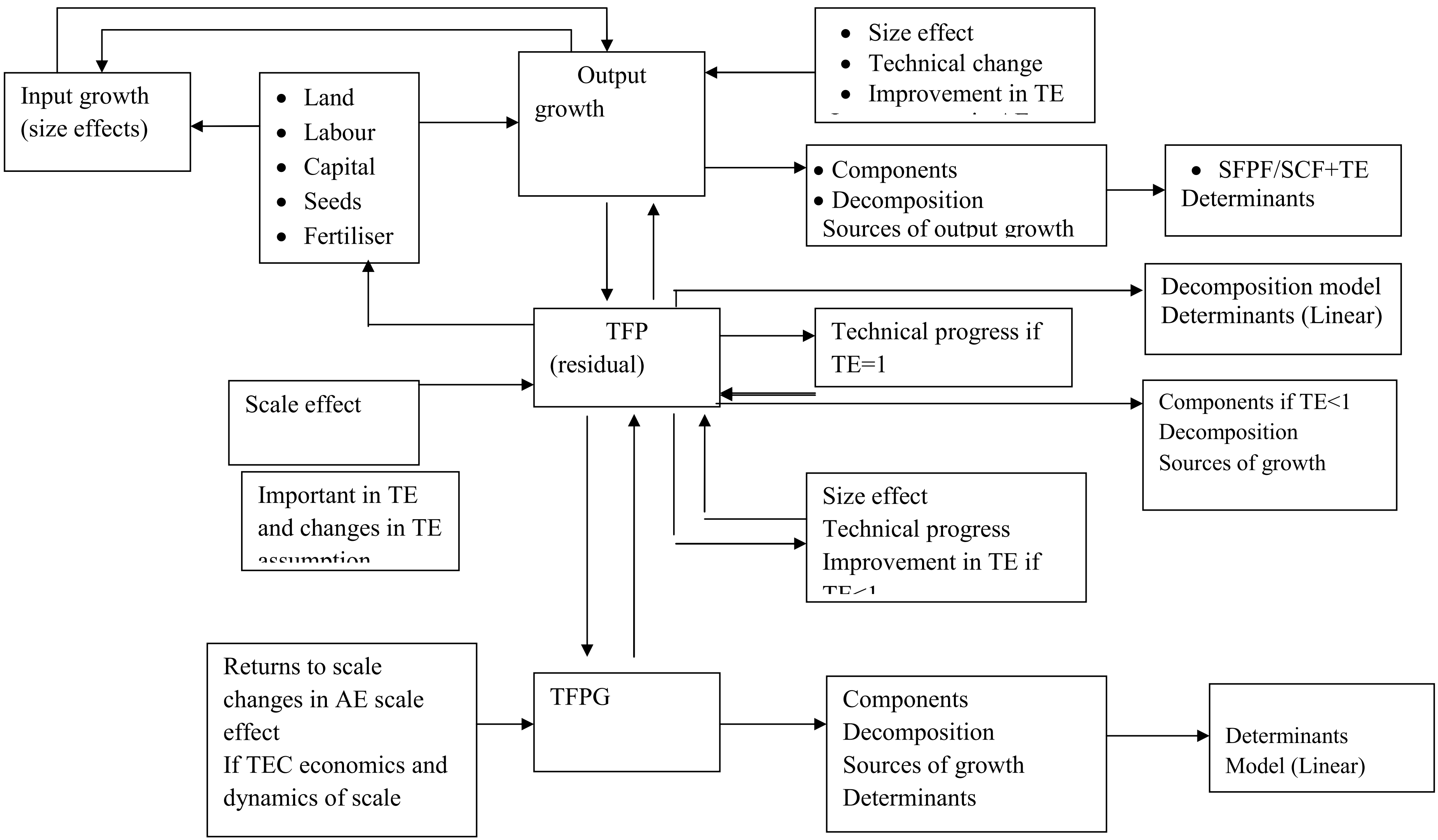

Fig. 1: Conceptual framework of Output Growth Decomposition and its links to TFP and TFPG in Agriculture (Author,

CHAPTER THREE

METHODOLOGY

3.1 Area of Study

The study area for this research work was the Federal Republic of Nigeria, as shown in the map presented.

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Fig 2 Map of Nigeria

Nigeria has land area of 923,769 square kilometers. This is made up of 909,890 square kilometers of land area and 13,879 square kilometers of water area, It is situated between 3°and 14° East Longitude and 4° and 14° North Latitude. The longest distance from East to West is about 767 kilometers, and from North to South 1,605 kilometers. The country is bordered on the west by the Republics of Benin and Niger; on the east by the Republic of Cameroon; on the north by Niger and Chad Republics and on the south by the Gulf of Guinea. The coastal area of Nigeria is a belt of mangrove swamplands that passes through a network of streams and rivers and the great Niger Delta. Outside these is the continuous belts of tropical rain forests which breaks into woodlands with hilly ranges. The undulating plateau and rises from an average of 609.6 metres to 1,828.8 metres eastwards. The northern part of the country is covered with grassland, scattered with trees and shrubs and terminated to the Sahel savannah of the semi-arid north-east. The river Niger which has its source from the East of Sierra Leone and enters Nigeria through the North West, receives river Benue, which also has its source from the republic of Cameroun at Lokoja and then flows into the Atlantic Ocean. The tributaries of river Niger are Sokoto, Kaduna and Anambra Rivers while River Benue receives Katsina-Ala and Gongola Rivers.

3.1.1 Climate

Nigeria is characterised by tropical climate with raining and dry season's variables. This depends on the particular location. The southeast could be hot and wet most of the year but in the southwest and farther inland, it is mostly dry. The savanna climate is marked with wet and dry seasons, that prevails the north and west, while a steppe climate with little precipitation is found in the far north. The length of the raining season drops from south to north. In the south, raining season lasts from March to November, while in the far north it lasts from mid-May to September. In the South and around August, a little interruption occurs in rains, the result is a very short period of dry season, which is called "August break." During this period, the Southeast experience heavier precipitation of more than 120 inches (3,000 mm) of rain a year, when compared to what the Southwest receives, 70 inches (1,800 mm). Progressively, as one moves away from the coast towards the North, rainfall decreases. That is not more than 20 inches (500 mm) in a year. In the South, temperature and humidity are constant year round, while it varied considerably in the North. Vegetation patterns run in broad East-west belts, parallel to the Equator. Mangrove and freshwater swamps are seen along the coast of the Nigerdelta. This give way to dense tropical rainforests. The north is characterised by tropical grassland. In the far north is the savanna characterized by scattered stunted trees and short grasses, while in the Lake-chad area, the semi desert exists.

3.1.2 Rainfall

In Nigeria, the mean annual precipitation from 1960 to 2016 was between 1,165.0mm and 1160.10mm in 1991-2020 period. In Nigeria, annual rainfall has decreased significantly by 3.5 mm per month per decade from 1960-2006. This decrease ranged between 3000mm in the coast inland to less than 500mm in the Sahel of the north-east. In the South, the wet season starts from March and ends in October while in the north, the season starts in May and ends in September. Throughout the year, temperature are mostly moderate except for few months that is characterised by dry cold of the north-east wind. The raining season is characterized by high wind, with heavy but dispersed storm that marks the beginning of the season. Most Northern area experience peak of rain in August, as air from the Atlantic covers the entire country.

3.1.3 Temperature

The southern Nigerian had experience increase in mean temperature than the northern part during the period of 1961-1990. The average maximum temperatures have increased in Nigeria with a maximum temperatures of between 31-33° C. From 1960-2016, The mean annual temperature stood at 26.9°C, while between 1991 to 2020 it was 27.26°C. Annually, the number of hot days and hot nights had increased from 1960-2003. Indicating that cold days and cold nights have decreased in the same period. Nigeria generally experiences high temperatures throughout, with pronounced variations across the nation, it is usually very high, in the dry season. This is because the dry season records the highest temperature. It rains reasonably during the raining season, although highest sometimes during the wet season. Temperatures differs in the seaside, the northeast specifically recorded greater extremes. Temperature get to its highest peak before rains begins and fell to its lowest level during harmmattan from December to February.

3.2 Data Sources

Data used covers the period 1960 to 2015. That is fifty- five (55) years. The secondary data were sourced from Food and Agriculture Organisation statistics (FAOSTAT) data sets. The data sets contain the relevant variables needed for the analysis carried out. Agricultural domestic product, labour utilised, land cultivated, wage, fertiliser consumed, number of tractors, input prices and inflation rate were variables used. While the index of trade openness and trade ratio were generated.

3.3 Methods of Data Analysis

3.3.1 Descriptive Statistics of Data;

The descriptive statistics are used to identify key variables of agricultural production in Nigeria. The Parameters of interest in the summary statistics are the mean, standard deviation, coefficient of variation, minimum and maximum values of variables

3.3.2 Exponential Trend Equations

The exponential trend equation shows the growth rates of the variable over the sub-periods and the entire period.

The exponential form of the equation is specified as

- $V = b_0 (b_1)^t$

Where;

v = any variable

t = time variable

The log-linearized form is the estimating equation and is expressed as

$$\text{In } V = \text{In}b_0 + t\text{In}b_1$$

Growth Rate

From the estimated exponential trend equations, the annual compound growth rate (r) is calculated as

$$r = \text{antilog}(b_1) - 1$$

For the five variables output, fertilizer, labour, land and tractors, equations were estimated for the sub-periods and the entire period 1960-2015 to generate the growth rates for the variables.

3.3.3: Production Frontier Function

Generalized Cobb-Douglas form was used to represent the function. This is presented as a translog specification but without interacted terms. Hence it is a strongly separable functions in terms of the inputs (Fan, 1991),

$$f(.) = \alpha_0 + \sum_{j=i}^{m} \alpha_j \; lnX_{jit} + \alpha_t t + \frac{1}{2}\alpha_{tt} t^2 + \sum_{j=i}^{m} \alpha_{jt} \; lnX_{jit} t$$

(1)

This is estimated on its own as single equation.

3.3.3.1 Variables under consideration from Previous Studies

Agricultural GDP, Land, Labour, Capital stock, Fertilizer, seed, herbicides, and Tractors were generally used. However, the selection of variables for this study is based on the works by Gerdin (2002) who used the output in prices and assumed a constant return to scale at 1982 constant prices, intermediate output in prices, labour in number adjusted for average hours worked. He then used perpetual inventory and investment analysis to calculate the value for capital stock.

(Li *et al.*, 2008) used agricultural GDP as output, plus physical capital, labour, human capital, but no land. (Ali *et al.*, 2009) used agricultural GDP as output, land, labour, capital, fertiliser and pesticides. Jorgenson and Gollop, (1992) used agricultural GDP as output, labour, capital, energy materials, but no land. (Odhiambo *et al.*, 2004) used agricultural GDP, land, labour, capital, fertiliser as his variables. Tripathi, (2008) used land, labour, and capital.

There is no theoretical way of deciding how many inputs should be included in a production function. However, the recourse to previous/similar studies and economic theories can lead to a meaningful selection of the relevant factors for any particular study. This route is followed in selecting the variables for the models in this study.

Q = Output represented by agricultural GDP (million Naira)

X_1 = fertiliser (million metric ton/million kg.),

X_2 = labour ('000 man days),

X_3 = land ('000 hectares),

X_4 = capital (Tractors) (number in '00 and '000)

t. = time variable.

3.3.3.2. Description of the Variables

Fertiliser: fertiliser used represent the total number of chemical used (Mundlak *et al*., 1997). Countries are known to using different quantity and types of chemical inputs. Previous studies like that of (Hayami and Ruttan, 1971; Rao *et al.,* 2003) the quantity of nitrogen (N), potassium (P_2O_2) and phosphate (K_2O) used were stated in thousands tons, and used to measure total commercial fertilisers input used.

Labour refers to all economic active people in agriculture every year and at every nation. It may also include such people who are involved in or searching for employment in agriculture, in any of the areas of agriculture like forestry, fishing, either as a proprietor, salaried worker, own-account worker or unpaid worker. Since it is often difficult to get information on the accurate number of farm workforce and total hours put to work per day, the best option is to use the economically active population in agriculture an alternative of labour input into the sector.

Agricultural land refers to the total arable land cultivated, which include land used as temporary meadows for mowing or pasture, temporarily fallow lands, temporary crops, or land under permanent crops such as coffee, cocoa and land under pastures, that is land used for planting herbaceous forage crops. It is however observed that there is no more land or very little land for agricultural purpose, this is because available land suffers from such constraints such as high incidence of pest and diseases, low fertility, ecological fragility and so on. This hinders land productivity and thus required high input and managerial skill for them to perform.

Tractors: represent the total numbers of operational tractors in the agricultural sector

3.3.4 The Technical Inefficiency Model

The Inefficiency model is made up of the SFPF equation (1) and the inefficiency equation (2). These equations were estimated simultaneously. The first one captures the response of the output to the production factors. The second one was used for inefficiency determinants.

Battese and Coelli (1995) recommended that in stochastic production frontier model, the technical inefficiency effect, Uit, is expressed as a function of farm-specific socio-economic variables.

$$f(.) = \alpha_0 + \sum_{j=i}^{m} \alpha_j \ lnX_{jit} + \alpha_t t + \frac{1}{2}\alpha_{tt} t^2 + \sum_{j=i}^{m} \alpha_{jt} \ lnX_{jit} t (1)$$

The inefficiency model is a linear function of the variables. This technical inefficiency effects are expected to be independent, a non-negative, and truncate at zero of normal distribution with unknown variance and mean.

Specifically,

$$U_{it=} \ \delta_0 + \sum_{m=i}^{m} \delta_m Z_{mit} + W_{it} \qquad (2)$$

Where

Z_1 = Inflation,

Z_2 = Fertilizer price (₦),

Z_3 = Trade ratio (index),

Z_4 = Agricultural openness (index),

Z_5 = Labour wage (₦),

Z_6 foreign exchange rate (₦) and

$Z_{7=}$ Time. (Number)

The inefficiency variables selected in the model were based on information in literature reviewed. Hence, the variables constitute the basis for experimentation with the model. It is thus hypothesized that those variables significantly affects the dependent variable. The dependent variable is exp μ.

3.3.5. The Cost Frontier Function Model

A closed-form solution of the cost minimization problem subject to (1) yields the following cost frontier function:

$$\text{In } C_u = \boldsymbol{B} + \beta_Q InQ_{it} + \Sigma_{j=i}^{m} \beta_j Inw_{jit} + \beta_t t + \beta_{tt} t^2 + \Sigma_{j=I}^{m} \beta_{jt} \, inw_{jit} t \qquad (3)$$

The variables used in the cost frontier function are derived from the SFPF. These are the frontier output (Q*) and the prices of the inputs w_1 for X_1, w_2 for X_2 ,w_3 for X_3 and w_4 for X_4. Hence, the SFCF has six explanatory variables as against five for the SFPF. (See section 2.3.5.5)

3.3.6 Estimation of TFP

TFP is the ratio of the aggregate output index to aggregate input index. The input index is constructed as a linear of inputs using the production function approach. Following (Wen, 1993), the TFP index is written as: (see section 2.3.5.9)

$$\text{TFPI} = \frac{100 \text{ x GVAO}}{\text{a x labour} + \beta \text{ x land} + \gamma \text{ x capital } \theta \text{ fertilizer}}$$

Where;

Gross Value of Agricultural Output (GVAO) in the numerator represents output index. The linear sum of weighted inputs of capital, agricultural labour, land and capital, weighted by factor shares in the denominator represents the input index. α, β, γ and Θ are production elasticities for labour, land, and capital as weights.

3.3.7 Input Growth Rate Model

The rate of growth of output is equal to the addition of the rate of growth of input and total factor productivity.as shown.

$$Q = \frac{Q_{t-}Q^{t-1}}{Q^{t-1}}$$

But

$$\dot{Q} - T\dot{F}P = \sum_{j=1}^{m} Sj\dot{X}J \quad (4)$$

The specification for the equation is as below (Fulginiti *et al.,* 2004; Limam and Miller, 2004),

$$\dot{Q} - T\dot{F}\dot{P} = C + S1\dot{X}1 + S2\dot{X}2 + S3\dot{X}3 + S4\dot{X}4 + vi \quad (5)$$

Equation (5) is the estimating equation .In this, $\dot{Q}$- $T\dot{F}P$ is regressed on the growth rates of inputs to obtain the coefficients (Sj`s); which are interpreted as factor shares while the constant (C) in the equation accounts for omitted variables. Xij is already defined.

3.3.8. Output Decomposition Model

$$\acute{Q} = \sum_{j=i}^{m} S_j\dot{X}_j + [1 - \varepsilon^{CQ}(Q, w, t)]\dot{Q} - \dot{C}(Q, w, t) + \dot{T}(Q, w, t) + \dot{A}(Q, w, t) + \sum_{j=i}^{m} [S_j - S_j(Q, w, t)]\dot{W}J$$

(6)

3.3.9 Total Factor Productivity (TFP) Decomposition Model

$$T\dot{F}P = [1 - \varepsilon^{CQ}(Q, w, t)]\dot{Q} - C(Q, \dot{w}, t) + \dot{T}(Q, w, t) + A(Q, w, \dot{t}) + \sum_{J=\iota}^{m} [S_J - S_j(Q, w, t)]\dot{W}_j \quad (7)$$

3.4 Total Factor Productivity Growth (TFPG) Model

TFPG involves changes in efficiency and pure technical change. This indicates shifts in the production function (Saika, 2014).The TFP and the TFPG are derived from the production function. TFPG comprised of technical efficiency change, technical progress and a scale economies effect (Kumbhakar and Lovell, 2000).

3.4.1 TFPG Equation

TFPG measures are mainly used to compare productivity gains overtime on year by year basis. However, the yearly exact values vary. Therefore, TFPG measures productivity trends in relation to sometime Saikia (2014), Akinlo, (2005); Alabi (2005) and Ghose and Bhattacharyya (2011)

The functional form of the model is

$$TFPG = f(Y_1, Y_2, Y_3, Y_4, \ldots, Y_8).$$

The estimating equation is specified as

$$\ln TFPG = \ln\theta + \theta_1 \ln Y_1 + \theta_2 \ln Y_2 + \theta_3 \ln Y_3 + \theta_4 \ln Y_4 \ \ldots \ \theta_8 \ln Y_8$$

The dependent variable is **TFPG.**The explanatory variables are

Y_1 = Macroeconomic stability

Y_2 = Agricultural Trade ratio

Y_3 = Price of Fertilizer

Y_4 = Number of Tractors

Y_5 = Land area

Y_6 = Fertilizer quantity

Y_7 = Price of Tractor, and

Y_8 = Price (Wage) of Labour.

3.4.2 Variables in the TFPG Model

Description of the variables and selection of the variables were based on previous studies.

3.4.2.1 Terms of trade

Terms of trade refers to the value ratio of export to the value ratio of the import. Export of agricultural commodities exposes producers to competition which are universal in nature and subsequently encourages efficient production. Also, importation of agricultural commodities are signs of a challenging agricultural sector. Increasing terms of trade lessens inefficiency and subsequently enhances TFPG. Reduction in inefficiency and increase in TFPG can only be achieved when terms of trade increases, it means that a rise in the export unit value by implication, improves TFP.

3.4.2.2. Openness

Openness positively impacted on the growth of any nation. This is due to increased productivity of the country. A more open economies develops quickly through a better and direct linkage to larger markets and the entire world, advanced technologies and importation of imported intermediate goods that enhances TFP growth (Miller and Upadhay, (2000); Akinlo, (2005); Khan, (2005). According to literature, trade openness can be proxied as export and import as a percentage of GDP, export plus import to GDP ratio, ratio of export to GDP (Miller and Upadhay, (2002), Khan, (2005); Akinlo, (2005), Njikman *et al.,* (2006); Nachega and Fontaine, (2006). It is calculated as the sum of agricultural exports and imports as per cent of agricultural GDP, as was used by this study. The risk that is often associated with opening of an economy is when policies that has to do with financial/lending policies and macro-economics are not properly put in place.

3.4.2.3. Inflation

Theorists and policymakers have conflicting views when investigating the influence of inflation on growth and productivity. Akinlo, (2005) found that inflation is an indicator for macroeconomic stability. Studies have used inflation to capture the stability in the economy. They found that inflation is an essential player for TFP growth. These studies further found that the effect of inflation may sometimes be positive or negative on TFP. The effect is positive, if it add to the economic growth by generating employment, and negative if prices are unstable, if it creates economic uncertainty and investments are discouraged. Capital flight are inspired by inflation which in turn affects investment and TFP growth unfavorably.

Economist in the past limit their studies to the role inputs like water, labour and land in explaining productivity growth. The prices of land and labour are not included in the model time because the markets for those inputs are not well defined or developed. These variables have little or nothing to contribute to the policy sphere.

3.5. Limitation to study

The GDP of the agricultural sector is made up of the monetary values of the crop, livestock, fisheries and forestry sub-sectors. As an aggregate variable, it becomes difficult to be able to highlight any of the subsector in the subsequent analysis. In addition to this observation and for ease of analysis the crop sub-sector contributes the lion's share of the GDP. The other sub-sectors are thus subsumed in the crop sub-sector as usually done in literature. The current study is patterned along the line of some previous studies. These previous studies include Ahmed and Bravo-ureta (1995), Fan (1996), Kalirajan *et al.,* (1996), Kalirajan and Shand (1997) and Kalirajan and Tzouvelekas (2001). This account for the selection of the independent variable in the production function.

The time series characteristics of the data set were not examined. This will lead to differencing the variables that will lead to co-integration, VAR error correction mechanism analysis. These analytical tools cannot be combined with the stochastic frontier methodology. To confirm the acceptability of using the level time series data, the R^2 versus Durbin-Watson statistics were used. Co-integration and error correction model methodology can be applied separately by further studies. To use them here would complicate the focus of this study. The basis for comparing the results of this study with other studies in this genre would be lost if the TFPG model is modified with lagged variables. In addition to this, the number of variables may double or triple inclusion of one or two lag-period. This would complicate the interpretation of the parameters. Hence, instatenous response of the independent variable to the dependent variable as done in all other studies constitute a limitation to this study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter is made up of five sections. The first section discusses the descriptive statistics for the variables used in the study as contained in Tables 4.1, 4.2 and 4.3. The second section covers the result of the ordinary stochastic frontier production function, (Table 4.4) and the inefficiency model, (Table 4.5) consisting of the stochastic frontier production function and the inefficiency equation. In the third section, TFP indices are discussed with the result presented in Tables 4.6, 4.7.1, 4.7.2, 4.7.3, 4.8.1, 4.8.2 and 4.8.3. Section four covers the result of the estimated TFPG model and its determinants. (Tables 4.9, 4.9.1 and 4.10). Section five presents the input and output decomposition results. (Tables 4.11, 4.12, 4.12.3 and 4.12.2)

Table 4.1: The Descriptive Statistics of the Key Variables in the Analysis

Variables	Mean	Standard Dev.	Coeff. of Variation	Minimum	Maximum
Output	389.760.0	225,907.2	57.96	150,383.9	787,989.7
Fertilizer	319,684.7	300,285.0	93.93	1,394	118,058.5
Labour	12,423.24	7,705.19	62.02	12,289	12,583
Land	32,615.11	3,626.91	11.12	28,800	40,500
Tractors	13,201.34	9,830.38	74.47	500	30,000

Source: Data Analysis, 2018

NB**:** Variable measurements see section 3.3.3.1.

Descriptive Statistics of the Key Variables in the Analysis

Table 4.1 is descriptive statistics of the variables used in the study. The emphasis here is on the coefficients of variation (C.V). The C.V. measures the relative dispersion in the observations (variables). The C.V values range between 11.12% and 93.93%. All the C.V values are less than 100%. This finding implies that the means of the variables are representative of the data. Hence, the majority of the observations for particular variables cluster around the means of the variables. As a means of profiling the key variables of agricultural production in Nigeria, the statistical distribution of the variable is okay, reasonable and meaningful statistically for subsequent analysis.

Table 4.2: Growth Rates of Key Variables for the Sub-periods and Entire Period

Variables	**1960-69**	**1970-79**	**1980-89**	**1990-99**	**2000-09**	**2010-15**	**Average 1960-2015**	**2015**
Output	3.59	2.04	6.27	4.72	3.05	2.60	3.71	3.46
Fertilizer	30.00	36.48	13.59	15.53	9.71	21.80	21.19	10.16
Labour	0.09	0.05	0.01	0.06	0.04	0.06	0.05	0.03
Land	0.32	0.17	0.58	0.12	2.33	5.62	1.52	3.57
Tractors	20.66	11.43	5.26	3.44	3.26	2.22	7.71	7.07
TOTAL	51.07	48.13	19.44	19.15	15.34	29.70	30.47	20.83

Source: Data Analysis, 2018

4.2: Growth Rates of Key Variables for the Sub-periods and Entire Period

Table 4.2 contains growth rates of variables. The exponential trend equations were estimated to get the growth rates in this section. The growth rate of fertilizer started at a high rate of 30% in the 60s. This increased to 36.48% in the 70s. It decreased in the 80s and increased slightly in the 90s. It decreased below the values of the 90s of 15.53% to 9.71% during 2000-2009 sub-period. By the 2010-2015 sub-period, it increased to 21.80. The trend in the rates is one of oscillating fluctuation of up and down. Over the entire period, the growth rate stood at 10.16%. The only sub-period that is lower than this at 9.71 is the 2000-2009 sub period value. The growth rates of the 60s, 70s, 80s, 90s and 2010-2015 were greater than for the entire period. Surprisingly, it was 21.80% for the period 2010-2015. This study agrees with the findings of Fuglie and Rada, (2013) Henao and Baanante, (2006). They found that fertilizer application rates fluctuate and later declined suddenly in countries like Nigeria after removing subsidies in the early1990s, also for the entire sub Saharan African (SSA) region. According to them, the rate of fertilizer usage were inadequate to tolerate uninterrupted cropping. But the study negates the findings of

Adedeji *et al.,* (2014), who reported that is an increase in the trend of fertilizer usage, due to awareness on part of the people.

Labour growth rates ranges between 0.01 and 0.09 over the sub-periods and a growth rate of 0.03 during the period for which the study was carried out. In all these, only 80s had a lower growth rate than the entire period. Generally, all the growth rates are less than 1%. The agricultural labour had grown at a very low rate. This could be ascribed to out-migration of workers from the sector in search for better job. This study is not in line with Adedeji *et al., (*2014), their study found a positive trend of labour use, meaning more people have been involved in agriculture overtime. The growth rates of land as factor of production in the agricultural sector were very small less than one in the 60s, 70s and 90s. It was about 0.6 in the 80s. By the sub-period 2000-2009, it reached a high of 2.33 and peaked at 5.62 during the 2010-2015 sub-period. The growth rate for the entire period was 3.57.

The growth rates of tractors decreased consistently over the sub-periods from a high of 20.66 in the 60s to a low of 2.22 in 2010-2015. The growth rate in the number of tractors stood at 7.07% in the entire period. The result agrees with the findings of Nkamleu, (2011) the result revealed that the use of capitals, like tools, farm machinery and structures, were very small in SSA. According to him, for each 1,000 Ha of crop area reaped, less than one tractor is used.

Overall, all the sub-periods averages were higher than the entire period growth rate except for land. The sub-periods growth rates average for land was 1.52 while the growth rate for the entire period was 3.57

Table 4.3: Percentage Contributions of the Input factor shares to the Output over the Sub-Periods and Entire Period (output assumed to be 100)

Variables	60-69	70-79	80-89	90-99	00-09	10-15	60-2015
Output	100	100	100	100	100	100	100
Fertilizer	58.74	75.80	69.91	81.10	63.30	73.40	48.78
Labour	0.18	0.10	0.51	0.31	0.26	0.20	0.14
Land	0.63	0.35	2.98	0.63	15.19	18.92	17.14
Tractors	40.45	23.75	27.06	17.96	21.25	7.48	33.94
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Data Analysis, 2018

4.3; Percentage Contributions of the Inputs to the Output over the Sub-Periods and the Entire Period,

Table 4.3 shows that by ranking, the percentage contributions of fertilizer to output growth were the highest. These were followed by those of tractors, land and labour in that order. The same trend is observed for the entire period for the inputs. This study agrees with the findings of Nkamleu (2011) who studied the impact of inputs on output growth in agriculture, the study showed that fertilizer contributed highest percentage (51%), followed by land and labour ranked third to total agricultural output growth. the study further revealed that if the pattern of land contribution persist, available lands for agriculture will all be put to use in less than two centuries. Odhiambo *et al.,* (2004) in Kenya and Mehdi (2011) also had similar results. Tables 4.1, 4.2 and 4.3 thus present the profile in descriptive statistics of the key variables. In this way, the first objective of the study is met. The results indicate factor shares contribution to output in percentage since output is assumed to be 100, as is usually done in the literature see Nkamleu (2011). The values for the inputs in table 4.2 are added. This stood at 51.07, each input in the column is divided by 51.07 and multiply by 100 to obtain the percentage factor shares contributions presented in table 4.3. Alternatively, the factor share fractions can be multiplied by the output 3.59 for the column. The alternative method will lead to the same result if converted to percentage.

Table 4.4: Response of output to inputs used in agricultural production in Nigeria: The Estimated Stochastic Frontier Production Function

Variables	Parameters	Standard Error	t-values
In X_1 Fertilizer	0.2376***	0.0679	3.4993
In X_2 Labour	0.2032**	0.0818	2.4841
In X_3 Land	0.2234***	0.0815	2.7411
In X_4 Tractor	0.1681**	0.0786	2.1387
In X_5 Fertime	0.0166*	0.0095	1.7474
In X_6 Labortime	-0.0568	0.0430	1.3209
In X_7 Landtime	-0.0624	0.0403	1.5484
In X_8 Tractime	0.0592	0.0496	1.1936
X_9 Time	0.1718***	0.0675	2.5452
X_{10} $^1/_2$ time^2	-0.0426**	0.0197	2.1624
K Constant	1.8467	0.9036	2.0437

Source: Data Analysis, 2018

** 5%,

γ (TE) = 0.8246

(1-γ) = 0.1754

Log –likelihood 109.4327

σ_u = 0.3522

σ_u^2 = 0.1241

F-value = 232.3812

σ_v = 0.1627

σ_v^2 = 0.0265

σ = 0.3880

σ^2 = 0.1505

λ = 2.1647

Wald χ^2 = 653.

4.4 Response of output to inputs used in agricultural production in Nigeria

Table 4.4 contains the results of the output to inputs used in agricultural production in Nigeria. The estimated input coefficients are positively signed with the expected magnitude. They were all less than unity. That is they are greater than zero but less than one. This result is in line with Xu and Jeffrey (1998), Karagiannis and Tzouvelekas (2001) and Rahji (2003).

The estimated variance of the one-sided error term ($\sigma_u^{\ 2}$) is 0.1241. The estimated variance of the statistical noise ($\sigma_v^{\ 2}$) stood at 0.0265. The logarithm of the likelihood function of 109.4327and the lambda (λ) value of 2.1647 specifies a satisfactory good fit for the quasi-translog specification. Fertilizer contributes more to the output overtime than all the other inputs. Its coefficient is 0.2376 and significant. Fert-time is the only variable that is significant of all the interacted term. Time variable is positive and significant. The output responded positively to time. However, time-squared is negative and significant. The production function models used in this study and the results obtained are in line with those of Ali *et al.,* (2009), Odhiambo *et al.,* (2004) and Triphati, (2008).

In summary, all the inputs responded positively to output over-time. This finding indicated that output expansion relies on increases in these factors. So future output expansion based on these factors may not be feasible as they have reached their limits in use. If however, this is possible, it cannot be sustainable over-time. The major finding here that helps in meeting the second objective of this study is that all the key inputs respond positively and significantly to the output. Increases in the inputs will amount to increases in the output realised. The output-oriented technical efficiency (γ) of the sector is 0.8246. This confirms findings by other studies (see Oni et al 2009) that generally agricultural sectors are characterized by technical inefficiency which is 0.1754 in this case. The sector is thus about 83% technically efficient and 17% technically inefficient. By these results, the second objective is achieved.

Table 4.5: The Inefficiency Model for the Nigerian Agricultural Sector 1960-2015

Variables	Parameters	Standard Error	t-values
In X_1 Fertilizer	0.2433***	0.0932	2.6105
In X_2 Labour	0.1852***	0.0733	2.5266
In X_3 Land	0.2314**	0.0945	2.4487
In X_4 Tractors	0.1546**	0.0724	2.1354
In X_5 Fertime	0.0274*	0.0146	1.8767
In X_6 Labortime	-0.0315	0.0254	1.2402
In X_7 Landtime	-0.0432	0.0408	1.0588
In X_8 Tractime	-0.0346	0.0245	1.4123
X_9 Time	0.0837***	0.0331	2.5287
$X_{10}\,{}^1/_2$ time^2	-0.0213**	0.0099	2.1515
K (Constant)	1.2355	0.4986	2.4779
Inefficiency Model			
Z_1 Inflation (cpi)	-0.5874***	0.2312	2.5407
Z_2 Fertilizer Price	-0.2311**	0.1026	2.2524
Z_3 Trade Ratio	-0.3520***	0.1078	3.2653
Z_4 Agric Openness	-0.2163**	0.1065	2.0310
Z_5 Labour Wage	0.2358	0.1583	1.4895
Z_6 Foreign Exchange	0.1242	0.0931	1.3341
Z_7 Time	-0.5634**	0.0026	2.1669
K (constant)	3.7269	1.7154	2.1726

Source: Data Analysis 2018

** 5%

$\Upsilon = 0.9458$

TE = 0.8246

RTS = 0.8145

$\sigma u = 2.2101$

$\sigma u^2 = 4.8844$

$\sigma v = 0.5291$

$\sigma v^2 = 0.2799$

$\sigma = 2.2725$

$\sigma^2 = 5.1643$,

$\lambda = 4.1771$

4.5 Estimated Parameters of the Inefficiency Model

Table 4.5 presents the estimated parameters of the inefficiency model. This model consists of two sections. One is SFPF. The other is the inefficiency equation. The two parts are to be taken as one since the models are estimated simultaneously. The (σu^2) equals 4.8844 while the statistical noise (σv^2) is 0.2799. The logarithm of the likelihood function and the lambda (λ) value of 4.1771 indicate a satisfactory good fit for the quasi-trans-log specification in this study.

All the inputs are positive, less than one as reported by Xu and Jeffrey (1998), Karagiannis and Tzouvelekas (2001) and Rahji (2003) and significant at 5%. The contributions of the inputs to the output are similar to the ordinary SFPF used as the response function to meet the second objective. The sum of the coefficients is 0.8145. This confirms a decreasing returns to scale in production. This result is consistent with that of Xu and Jeffery (1998) at 1.244 scale effect, and that obtained by Karagiannes and Tzouvelekas (2001) with RTS of0.8143 and scale effect of 1.228, all indicating returns to scale in agricultural production. The result is at variance with Rahji (2003). This result is at variance with Rahji, (2003) with scale effect 0.8868 and RTS 1.277. The result are based on the fact that the scale effect is the reciprocal of RTS and vice versa. The gamma (Υ) of 0.9458 is not the technical efficiency in this instance. It measures the goodness to fit of the inefficiency model for both equations. Here, it must be as close to one as possible. The estimated first order parameter (α_{ij}) have the anticipated positive sign and magnitude that is between zero and one. This analysis applies to the production function of the inefficiency model and the analytically derived cost function. The coefficient of the output of the cost function is 1.261 in the study. This indicates return to scale (RTS) of less than one at (0.8868). The production function is typified by decreasing return to scale (0.804). This result of 1.26 is consistent with that of Xu and Jeffrey (1998) at 1.244 scale effect and that obtained by Karagiannis and Tzouvelekas (2001) with RTS of 0.8143 and scale effect of 1. 228. All indicating decreasing return to scale in production. However, this result is at variance with Rahji (2003), with scale effect of 1.27 and RTS of 0.8868. These results are based on the fact that the scale effect is the reciprocal of RTS and vice versa.

4.5.1 The Determinants of Technical Inefficiency

The inefficiency equation tries to identify the determinants or factors influencing technical inefficiency in production. It must be noted here that parameters with negative signs are inefficiency reducing. The variables Z_1, Z_2, Z_3, and Z_4, are negatively significant to the inefficiency level. Hence, increases in these variables amounted to decrease in the level of inefficiency. The influence of time is also significant and inefficiency reducing. In addition to this, parameters with positive signs are inefficiency enhancing. The variable Z_5 and Z_6 are thus inefficiency increasing. By this result, the third objective of this study is met. The inefficiency model constitutes the main model of interest in this section. This is because its SFPF part is the basis for deriving the SFCF as stated in the analytical tools section. This is also because some of the parameter estimates of the SFCF are to be used in the output and TFP decomposition procedure.

Table 4.5.1: Summary of the Determinants of Output Growth

No	Variables	Effects
1	Fertilizer	Positive
2	Labour	Positive
3	Land	Positive
4	Tractor	Positive
5	Fertime	Positive
6	Time	Positive
7	$^1/_2$ time^2	Negative

Source: Data Analysis, 2018.

Table 4.5. Summary of the Determinants of Output Growth

Table 4.5.1 is derived from table 4.5. It displays factors determining output growth in the Nigerian agriculture. Fertilizer, labour, land and tractor were positive and affect output growth over time. The half time squared variable though significant, but negatively affected output growth.

4.5.2 Analytically Derived Stochastic Frontier Cost Function (SFCF)

The analytically derived SFCF is presented as:

In Cit = 2.4789+1.26InQit + 0.3066In Wit + 0.2334InW2t + 0.2916In W3t + 0.1948InW4t + 0.1055t + 0.0268t2 + 0.0345lnW_1tt + 0.0317 lnW_2tt – 0.0544 lnW_3tt – 0.0436 lnW_4tt

Of empirical importance is the parameter of the output in the derived cost frontier. This is equal to 1.261. This term is the scale effect. The singular effect of this indicates relatively, the contribution of scale economies on output growth. This result is a reciprocal of the return to scale of the production function analysis. i.e. 0.8143= 1.261 and vice versa. It indicated decreasing return to scale in production. This finding is in line with Rahji (2003) with scale effect 1.27, Karagiannes and Tzouvelekas (2001), with scale effect of 1.22 and Xu and Jeffery (1998) at 1.244. From the output decomposition equation (6) the term [1- ε^{cQ}(Q,w,t)]$\dot{Q}$. Measures the relative contributions of scale economies on output growth. This is known as scale effect. Three outcomes are possible with this term depending on the return to scale in production.

If ε^{cQ}(Q,w,t).= 1, the production process is characterized by CRS and the scale effect disappeares as the term [1- ε^{cQ}(Q,w,t)]$\dot{Q}$becomes zero. This term is equal to dlnC(Q,w,t)/dlnQ.

Where

lnCit ≡ lnC(Q,w,t) and the same as the analytically derived SFCF

If ε^{cQ}(Q,w,t).< 1, the scale effect [1- ε^{cQ}(Q,w,t)]$\dot{Q}$ is positive signifying that the production system is characterized by increasing returns to scale. However If ε^{cQ}(Q,w,t)> 1 scale effect [1- ε^{cQ}(Q,w,t)]$\dot{Q}$is negative. Hence, production had a decreasing returns to scale.

In this study, $[1-\varepsilon^{cQ}(Q,w,t)]\dot{Q}$= 1.26 is more than one. This makes the scale effect to be negative. Hence, decreasing returns to scale is evident in production. The RTS obtained from the SFPF is 0.8145. This is greater than one confirming the finding from the scale effect analysis of the derived SFCF. These results contributed to attaining the third objective of this study.

The average input-oriented production efficiency measures are presented in this section. The average input-oriented technical efficiency for this model stood at 0.74 (74%). The average technical inefficiency is 0.26 (26%). This indicates that output level may not be affected even if the inputs are reduced by 26%. The sector is about 74% technically efficient and 26% technically inefficient. This supports the general finding that the agricultural sector is characterized by technical inefficiency (bee Oni *et al.,* 2009)
The average allocative efficiency is calculated to be 0.65. The average allocative inefficiency is 0.35. The sector is thus 65% allocative efficient and 35% allocative inefficient. The average economic efficiency equal 0.48. The mean economic inefficiency is thus equal to 0.52. This indicates the percentage reduction in cost that is linked with the elimination of all inefficiencies (Kopp, 1981). The input-oriented measures of production efficiency used in this study, have the useful interpretation that one minus any of the measures is the proportion by which costs could be lowered/reduced if that form of inefficiency were eliminated in production

Table 4.6: Total Factor Productivity (TFP) Indices 1961-2015

Obs(yr)	61-71	72-82	83-93	94-04	05-2015
1	0.26	0.33	0.28	0.73	1.22
2	0.27	0.34	0.30	0.79	1.16
3	0.29	0.37	0.31	0.84	0.95
4	0.30	0.37	0.33	0.89	1.20
5	0.33	0.32	0.33	0.92	0.95
6	0.33	0.32	0.39	0.97	1.21
7	0.36	0.30	0.43	0.98	1.20
8	0.36	0.29	0.47	0.96	1.26
9	0.41	0.31	0.56	1.02	1.24
10	0.46	0.30	0.62	1.03	1.20
11	0.41	0.29	0.66	1.17	1.16
Total	**3.78**	**3.54**	**4.68**	**10.3**	**12.75**
Average	**0.34**	**0.32**	**0.43**	**0.94**	**1.16**
Min	**0.26**	**0.29**	**0.28**	**0.73**	**0.95**
Max	**0.46**	**0.37**	**0.66**	**1.17**	**1.26**
Range	**0.20**	**0.58**	**0.38**	**0.44**	**0.31**

Source: Data Analysis, 2018

4.6 Total Factor Productivity (TFP) Indices

Table 4.6 contains the TFP indices calculated for each year in the data set. The focus here is thus on the yearly productivity from 1960 to 2015. The means of the indices for sub-periods are calculated. If the mean for a particular sub-period is less than one, the sub-period is regarded as having decreasing productivity. If the mean for a sub-period is greater than one, then the sub-period enjoyed increasing productivity. But if, however, the mean is equal to one, then the production process in that sub-period has constant productivity.

The sub-periods 1961-1971, 1972-1982, 1983-1993 and 1994-2004 all have mean TFP less than one. This means that productivity was decreasing during the sub-period. However, the sub-period, 2005-2015 indicated that productivity was increasing during the sub-period as the mean of TFP is greater than one. This finding implies that for over four decades, the agricultural sector experienced decreasing productivity over the years. This results is in line with Wen (1993); Nkamleu, (2004), Njikam *et al.,* (2006), Nachega and Thomson, (2006) and Belloum and Matoussi (2009);

4.7.1: Profiling the TFP Results (1961 to 1998)

Year	TFP
1961	0.26
1962	0.27
1963	0.29
1964	0.30
1965	0.33
1966	0.33
1967	0.36
1968	0.36
1969	0.41
1970	0.46
1971	0.41
1972	0.33
1973	0.34
1974	0.37
1975	0.37
1976	0.32
1977	0.31
1978	0.30
1979	0.29
1980	0.31
1981	0.30
1982	0.29
1983	0.28
1984	0.30
1985	0.31
1986	0.33
1987	0.33
1988	0.39
1989	0.43
1990	0.47
1991	0.56
1992	0.62
1993	0.66
1994	0.73
1995	0.79
1996	0.84
1997	0.89
1998	0.92
Total	**16.17**
Average	**0.829231**
Min	**0.26**
Max	**0.92**
Range	**0.66**

Table 4.7.2: Profiling the TFP Results (1999 to 2001)

Year	TFP
1999	0.97
2000	0.98
2001	0.96
Total	0.97
Average	0.96
Min	
Max	0.98
Range	0.02

Source: Data Analysis, 2018

Table 4.7.3: Profiling the TFP Results (2002-2015)

Year	TFP
2002	1.02
2003	1.03
2004	1.17
2005	1.22
2006	1.16
2007	0.95
2008	1.20
2009	0.95
2010	1.21
2011	1.2
2012	1.26
2013	1.24
2014	1.2
2015	1.16
Total	**15.97**
Average	**1.140714**
Min	**0.95**
Max	**1.17**
Range	**0.22**

Source: Data Analysis, 2018

4.8. Profiling Total Factor Productivity

Tables 4.7.1; 4.7.2 and 4.7.3 are derived from Table 4.6 by rearranging the sub-periods to 1961-1998, 1999-2001 and 2002-2015. The period 1961-1998 gave a mean of 0.83 meaning productivity was decreasing. However, there is no particular trend for the decrease. At best it has a fluctuating distribution. But while the period 1961-1982 was in no particular order the period 1983-1998 overlapping to 2006 showed an increasing trend. The sub-period 1999-2001 by approximation gives 0.97 approximate to a mean of 1. The implication is that for this very short period of 3 years, productivity can be deemed to be constant. The period 2002-2015 with a mean of about 1.4 indicated that productivity was increasing. The production structure of the sector has thus been classified into three periods of decreasing (1961-1998), constant (1999-2001) and increasing (2002-2015) productivity growth

Table 4.8.1: Profiling TFP Results (1961 to 1982)

Year	TFP
1961	0.26
1962	0.27
1963	0.29
1964	0.30
1965	0.33
1966	0.33
1967	0.36
1968	0.36
1969	0.41
1970	0.46
1971	0.41
1972	0.33
1973	0.34
1974	0.37
1975	0.37
1976	0.32
1977	0.32
1978	0.30
1979	0.29
1980	0.31
1981	0.30
1982	0.29
Sum	**7.32**
Average	**0.33**
Min	**0.26**
Max	**0.46**
Range	**0.20**

Source: Data Analysis, 20

Table 4. 8. 2: Profiling TFP Results (1983 to 2005)

Year	TFP
1983	0.28
1984	0.3
1985	0.31
1986	0.33
1987	0.33
1988	0.39
1989	0.43
1990	0.47
1991	0.56
1992	0.62
1993	0.66
1994	0.73
1995	0.79
1996	0.84
1997	0.89
1998	0.92
1999	0.97
2000	0.98
2001	0.96
2002	1.02
2003	1.03
2004	1.17
2005	1.22
Sum	**16.20**
Average	**0.70**
Min	**0.28**
Max	**1.22**
Range	**0.94**

Source: Data Analysis, 2018

Table 4. 8. 3: Profiling TFP Results (2006 to 2015)

Year	TFP
2006	1.16
2007	0.95
2008	1.20
2009	0.95
2010	1.21
2011	1.20
2012	1.26
2013	1.24
2014	1.20
2015	1.16
Sum	**11.53**
Average	**1.153**
Min	**10.45**
Max	**1.26**
Range	**0.31**

Source; Data Analysis 2018

4.8.1. Profiling Total Factor Productivity

Table 4.8.1, 4.8.2 and 4.8.3 is derived from table 4.6 with the following sub-periods 1961-1982, 1983-2005 and 2006-2015. The first sub-period 1961-1982 indicated period/time of fluctuating trend and a mean of 0.34 indicating productivity growth was decreasing. The second sub-period 1983-2005 shows a period of an increasing trend in the TFP indices. Yet the mean is about 0.70 also indicating a decreasing trend in productivity growth. The third sub-period of 2006-2015 shows a fluctuating trend with a mean of about 1.2. This indicated that productivity was increasing. Despite these results, the mean for the entire period of 1961-2015 is about 0.72. This indicates that productivity growth was decreasing over the entire period. In this way, the profiling of TPF indices was attained and the fourth objective of the study met.

These results for the TFP are consistent with the findings by Wen (1998), Tripathi (2008). This assertion relates to Tables 4.6, 4.7.1, 4.7.2, 4.7.3, 4. 8, 4,8.2 and 4.8.3. The results all indicates increasing or decreasing or constant total factor productivity.

Table 4.9: Determinants of Total Factor Productivity Growth in the Nigerian Agriculture.

Variables	Parameters	Standard Error	t-value
Trade openness (Y_1)	0.3042***	0.1099	2.7680
Macroeconomic Stability (Y_2)	-0.2453**	0.1067	2.2986
Fertilizer Quatity (Y_3)	0.1162	0.1054	1.1025
Price of Fertilizer (Y_4)	-0.2326**	0.1095	2.1242
Number of Tractors (Y_5)	0.1354	0.0892	1.5179
Price of Tractors (Y_6)	-0.2294**	0.0937	2.4482
Agric Land (Y_7)	0.2014	0.1625	1.2394
Labour Man-days (Y_8)	0.1215	0.0807	1.5056
Time (Y_9)	0.2576***	0.0912	2.8246
Constant K	3.4661	1.4315	2.4073

Source: Data Analysis 2018

** Significant at 5%

$R^2 = 0.6835$

DW = 1.0342

F = 64.6534

4.9. Determinants of Total Factor Productivity Growth in Nigerian Agriculture.

Table 4.9 contains the results of the estimated TFPG equation. The equation was estimated using the STATA software. The Durbin Watson (DW) indicates the lack of spurious relationship, because the D W statistic of 1.0342 is greater than the R^2 of 0.6835. Only about 68% of the variation in the dependent variable was explained by the explanatory variables. The alternative hypothesis was accepted for the model.

The parameter of the agricultural trade openness is positive and significant at 1% level. The finding indicated that an increase in the variable lead to increases in TFPG in the sector. That is as trade openness grows, the TFP growth will equally grow. This is as a result from pressure that might have risen based on competition from international based market demand and economies of scale benefits. this often arises when production changes from dependence on local market to satisfying export market, such firms is bound to go into a large scale production, thereby the volume of production will increase to enjoy production at a reduced cost. Not only these, it will also encourage the application of superior technology and capable manpower, and by so doing, improvement in efficiency and productivity will be attained, that will lower production cost per unit. This result agrees with the result of Jajri (2007). The finding is also consistence with that of Edwards (1998), he finds robust and positive results of openness on TFP growth. The finding also supports Miller and Upadhyay (2000). They find that greater openness benefits TFP growth.

The macroeconomic stability variable that is proxies by inflation rate has a negative and a coefficient that is significant at 5% level. This finding implies that higher values of the variable tend to lead to a reduction in the TFPG.

Fertilizer quantity and number of tractors are positive but insignificant in the model. The non-significance of the fertilizer can attributable to its low level of usage that is often below the recommended level. The positive coefficient of fertilizer agrees with the findings of Ghose and Bhattacharyya (2011).

Tractor usage is equally hampered by land fragmentation and the small-holder nature of agricultural production in the sector. Both the parameters of the price of fertiliser and the price of tractors were negative and significant at 5% level. This may be because both inputs were imported and their prices externally determined. Hence, as prices of these inputs increases, TFPG reduces in the sector. The country has no control over these prices

In addition to these findings, agricultural land and labour were also positive but insignificant. The quality of land in terms of fertility and the use of marginal lands may be contributory factors to this result. The quality of labour is equally suspected as the literacy level, technology acceptance, the rate use are assumed to be low. The time variable is positive and significant these could be due to policy reforms, technical of investment in the sector over the years.

Table 4.9.1; Summary of the Determinants of Total Factor Productivity Growth

No	Variables	Effects
1	Trade openness	Positive
	Macro-economic Stability	Negative
3	Fertilizer Quality	Positive
4	Price of fertilizer	Negative
5	Number of tractor	Positive
6	Price of tractor	Negative
7	Agric. Land	Positive
8	Labour	Positive
9	Time	Positive

Source: Data Analysis, 2018

Table 4.9.1 Determinants of Total Factor Productivity Growth

Table 4.9.1 is derived from table 4.9. It revealed that the macro-economic stability variable proxied by inflation, price of fertilizer and price of the tractor negatively affected total factor productivity growth, while trade openness, number of tractors, agricultural land, labour and time positively affect total factor productivity growth

Table 4.10: Contributions of Factors and Productivity to Agricultural Growth in Nigeria: 1960-2015

Item	1961-1971	1972-1982	1983-1993	1994-2004	2004-2015	1961-2015
Output growth	3.80 **(100.0)**	-0.04 **(100.0)**	9.6 **(100.0)**	3.20 **(100.0)**	0.68 **(100.0)**	3.52 **(100.0)**
Growth due to factor inputs	-0.47 **(-7.79)**	1.21 **(29.0)**	-2.59 **(-32.8)**	2.28 **(-31.6)**	1.53 **(41.2)**	0.52 **(14.8)**
Growth due to TFP change	5.5 **(91.2)**	2.00 **(48.0)**	9.5 **(120.4)**	3.9 **(54.1)**	1.20 **(32.4)**	2.21 **(62.8)**
Growth due to unaccounted factors	1.00 **(16.61)**	0.97 **(23.0)**	0.98 **(12.4)**	1.03 **(14.3)**	0.98 **(26.4)**	0.70 **(22.4)**
Total	**6.032**	**4.18**	**7.89**	**7.21**	**3.71**	**3.52**

Source: Data Analysis, 2018

NB:

Average	Sub periods Average	Entire period
Output Growth	3.45	3.52
Input Growth	0.39	0.52
Growth due to TFP	3.62	2.21
Residual	0.99	1.00

4.10. Contribution of Factor and Productivity to Agricultural Growth

Table 4.10 shows the factor and productivity contributions to agricultural growth as generated from the Input Growth equations. The average contributions of the different components of the model are aligned in terms of their magnitudes over the sub-periods and with the value for the entire period.

The study revealed that the production structure had varying degrees of fluctuations in the contributions of the components to output growth in the sub-periods. The output growth itself was not stable.

Factor inputs contributed the highest only in 2005-2015 at 41.2% for the sub-period and only 14.8% overall. It recorded negative contribution in 1961-1971, 1983-1993 and 1994-2004 at -7.79%, -32.8% and -31.6% respectively

Growth in TFP contributed the highest in 1961-1971, 1983-1993 and 1994-2004. It contributed 91.0%, 48%, 120.0% and 54.1%, respectively for the four sub-periods and 32.4% in the last sub-period. Overall, it contributed 62.8% over the entire period. The production structure tends to imply that most of the increases or growth in output emanated from changes in the TFP.

The effect of the unaccounted for inputs overall at 0.79 or 22.4% is minimal or small. It ranges between 12% and 26%, and 22.4% overall. For the entire period, TFP has the highest contribution of 2.21 or 62.8%. This is followed by unaccounted for inputs with 0.79 or 22.4% and lastly by factor growth of 0.52 or 14.8% contribution to output growth. Increases in the factor inputs are necessary as dependence on TFP in the face of dwindling factor input may not be sustainable. More so, since numerous factors such as input-output prices, technological innovation institutions, infrastructures, policy initiative, etc. are the factors responsible for growth in inputs (Kumar *et al.,* 2008).

The results are consistent with the findings of Tauer (1998), Fleisher and Lin (1992), Ahmed and Bravo-ureta (1992), Koroda (1995), Bruemmer *et al.,*(2006),

Table 4.11: Breakdown of Factor Input Growth Using the Factor Shares of the Input Growth Equations

Item	1961-1971	1972-1982	1983-1993	1994-2004	2005-2015	1961-2015
Factor input	-0.47	1.21	-2.59	2.28	1.53	0.52
Fertilizer	-0.01	0.01	0.02	-0.01	0.02	0.01
	(2.13)	(0.83)	(-0.77)	(0.44)	(1.31)	(1.92)
Land	-0.02	0.28	-1.22	-0.04	-0.07	0.01
	(4.26)	(23.14)	(47.10)	(-1.35)	(-4.58)	(1.92)
Labour	-0.45	0.89	-1.38	2.33	1.58	0.51
	(95.75)	(73.55)	(53.28)	(102.19)	(103.27)	(98.08)
Tractor	-0.01	0.03	-0.002	-0.001	0.002	-0.01
	(-2.13)	(2.48)	(-0.08)	(-0.04)	(0.13)	(-1.92)
Total	-0.47	1.21	-2.58	2.28	1.53	0.52

Source: Data Analysis, 2018

4.11;Factor Input Growth and Factor Shares

Table 4.11 indicates that though fertilizer, land and labour have a negative share of the factor input growth, they have contributed positively to the growth in the factor input at 2.13%, 4.26% and 95.75%, respectively in the 1961-1972 sub-period. This finding agrees with Adedeji *et al.,* 2014). The results tend to indicate that labour and land are the major contributors to factor input growth in the sector. These two inputs came first and second in ranking over the sub-periods and overall in terms of percentage contributions. This findings tallies with Nkamleu (2011) persistent rise in agricultural land use in Africa has been observed from about 1.06 billion ha in 1961 to about 1.15 billion ha today, meaning the increase is more than 10%. Strangely, land use rate since 1980 were higher and seems to accelerate. There is a need to improve the contributions by fertilizer and tractors as inputs into the sector. In the current setting, fertilizer tends to have a slight edge over tractors. Overall, there is a need for policy measures that will result in improvement in the contribution of factor inputs to agricultural output in the sector.

Table 4.12: Decomposition of Agricultural Output and TFP Growth in Nigeria 1960-2015

Variable	Contribution	Percent (%)	Estimates	%
Output Growth	-		**3.52**	**100.0**
Aggregate Input Growth	-		**0.52**	**14.80**
Input				
Fertilizer	0.01	1.92		
Labour	0.01	1.92		
Land	0.51	98.08		
Tractors	-0.01	-1.92		
	0.52	**100.0**		
TFP Growth Items			**2.21**	**62.80**
Scale Effect	-0.92	-41.63		
Technical Change	1.56	70.59		
Autonomous	-	-		
2.41				
Biased -0.85	-	-		
1.56	-	-		
Technical Efficiency Change	0.85	38.46		
Allocative Efficiency Change	0.78	35.29		
Price Adjustment Effect	-0.06	-2.72		
	2.21	**100.0**		
Residual (Unexplained)	**-**	**-**	**0.79**	**22.4**
Total	-	-	**3.52**	**100.0**

Source: Data Analysis, 2018

4.12 Decomposition of Output and TFP Growth

Table 4.12 presents findings from output and TFP growth decomposition that is done in conjunction with the derived SFCF. An annual compound growth rate of 3.52 is obtained for output growth over the 1960-2015 period. The growth rates of the other items/components are added and their contribution to output growth calculated from the values obtained. Aggregate input growth with a growth rate of 0.52 contributed 14.8% of the output growth. The results suggest that TFP with a growth rate of 2.21 contributed 62.8% of the output growth. This finding indicates that TFP contributed more to output growth than the aggregate input growth. This finding contradicts the finding of Busari *et al.,* (2005) and Nkamleu (2011), but in line with Fulginiti *et al.,* (2004).

The scale effect which measures the relative contribution of scale economics is – 0.92 and has 41.63%. The scale effect being negative implies that the sector demonstrated diminishing returns to scale as the total input improved over time. Technical change rate or the increase in the cost of production per unit time has a growth rate of 1.56 or 70.59%. Averagely, output growth rate was slowed down by diseconomies of scale with about 35.29% and TFP by about 41.63%. However, if constant returns to scale is assumed, such figure will be omitted in the production process. By such a wrong assumption, there would be an over-estimation of TFP and output growth. The average annual rate of technical change is 1.56. This accounted for 70.59% of the TFP growth. This finding supported the result of Jin, *et al.,* (2010) who documented that the magnitude of TFP is determined by changes both in the efficiency and technical change. The study is also in line with the findings of Ruttan (2002) and O'Donnell (2012), who discovered that Technical change is the main component pulling TFP upward. The study is consistent with Capalbo (1988) in his U.S study, he found out that 89% of output growth was from technical change while inputs contributed 11%. The growth rate of technical efficiency at 0.85 contributed 38.46% to the output growth. Hence, technical efficiency has enhanced output and TFP growth.

The Allocative efficiency is positive so has also enhanced output growth. However, their relative impact on the growth of output hinge on their change rate gradually as time passes, rather than their entire magnitude. The relative contribution of the input-oriented technical efficiency of 38.46%, this is more than that of input allocative efficiency on the output of 35.29%. By merging their effect, it is noticed that enhancements in efficiency account for 73.75% of output growth annually. Efforts should be made to improve both TE and AE for increased output growth.

Price adjustment effect negatively affected output and TFP growth. Averagely, price adjustment effect at -0.06 represents about 2.72% of output change. Unexplained output at 0.79 implies that 22.4% observed output growth remained as residual.

Table 4.12.1: Sources of Output Growth

No	Items	Contribution	Percentage contribution	Effects
1	Input growth	0.52	19.05	Positive
2	Scale effects	-0.92	-33.70	Negative
3	Technical change	1.56	57.14	Positive
4	TE Change	0.85	31.14	Positive
5	AE Change	0.78	28.57	Positive
6	Price Adjustment	-0.06	- 2.20	Negative
	Total	**2.73**	**100.00**	

Source: Data Analysis, 2018

4.12.1: Sources of Output Growth

Table 4.12.1 is derived from table 4.12, the results indicate the six components of output growth,

The table revealed that input growth, technical efficiency change, technical change and allocative efficiency change contributed positively to total output growth, while scale effects and price adjustment contributed negatively to output growth

Table 4.12.2: **Sources of Total Factor Productivity Growth**

No	TFP Growth Item	Contribution	Percentage Contribution	Effects
1	Scale effect	-0.92	-41.63	Negative
2	Technical Change	1.56	70.59	Positive
3	Technical Efficiency Change	0.85	38.46	Positive
4	Allocative Efficiency Change	0.78	35.29	Positive
5	Price Adjustment Effect	-0.06	-2.72	Negative
	Total	2.21	100.00	-

Source: Data Analysis, 2018

4.12.2: Sources of Total Factor Productivity Growth

Table 4.12.2 is derived from Table 4.12, the results indicated that of the five components of TFP, three of the components have a positive effect while the remaining two components negatively affected TFP. In summary, output growth has been disintegrated into input growth, scale economies, technical change, technical efficiency, Allocative efficiency and a price adjustment effect. Reliant on the econometric approximation of a self-dual production frontier. It follows that the components of TFP are price adjustment effects, technical efficiency, technical changes, scale economies, and allocative efficiency. Based on these analyses and results, the fifth objective of this study is attained.

Basically, one of the objective is to find out the key factors contributing to growth in Nigerian agriculture. The research studied the effect of fertilizer, land, labour and tractors on growth in agricultural (GDP /agricultural output). This is so in that the sector in question is prime to the Nigerian economy. This is also because several studies in recent time have recognized the importance of size effect, improvement in technical change and technical efficiency on output growth (Karagiannis and Tzouvelekas, 2001) using SFP approach.

In Nigeria and this study, the results show that labour and land played a very important role in increasing agricultural output growth over time. However, agricultural-land increase, resulting from inadequate land may not be a reliable means of future rise in output. It should be noted, therefore, that any future increase in agriculture must come from growth of productivity in agriculture.

The interpretation of TFP being shift in production function can only be true if farmers are technically efficient and realize full potential of available technology. But farmers are known to be technically inefficient, because they differ in their ability to use different technological knowledge. Hence, TFP growth may not have come from technical progress only.

As a result, productivity change may come from two components – technical progress and efficiency change. Decomposing TFP is imperative because it offers a valuable indicator to show how agricultural development can actually be progressive through productivity improvements in agriculture. Productivity is the foundation of agricultural development. Hence, high productivity is the necessary condition for agricultural modernization of a country. Thus, the analyses of the origins of productivity and how to increase productivity are issues of importance to academic and government. Three things are possible when the efficiency of resource usage is correctly measured. One, the driving force behind agricultural growth can be confirmed. Two, the benefits of agricultural development can be properly evaluated. Three, the provision of appropriate long-term strategies/policies of agricultural development becomes possible.

Total factor productivity growth rate equals the rate of change in total output index minus rate of change in total input index. Its decomposition also reveal the contributions it has on the real growth of agricultural outputs and the addition to the increase in factor inputs. This residual is attributed to certain possible reasons. These include progress of knowledge in technology and management, the effect of scale economies, market structure fluctuations and industrial organization, quality of inputs improvement and so on.

To achieve self-sufficiency in agriculture, Nigeria needs improvements in labour, chemical, biological and mechanical inputs. Nigerian agriculture is characterized by low productivity. To achieve self-sufficiency in agriculture, Nigeria needs to keep its productivity high.

Hence, future output growth cannot be based on mobilizing inputs. It will require rising productivity. This means improvement in technological change, technical efficiency or Scale economies is necessary. The literature record is more in favour of technological change. This is because of major concern is on productivity increases especially if they are to come through technical efficiency or scale economies. Therefore, improvement of agricultural productivity is expected to be in an overriding position to development practitioners, policymakers and researchers in Nigeria.

CHAPTER FIVE

5.1 SUMMARY CONCLUSION AND RECOMENDATIONS

Agricultural output and productivity growth are known to have positive influence on the entire economy. Such growth has emanated mainly from area expansion as against intensification, productivity increase of other inputs or the use of intermediate inputs. The potential for continued growth increases from land is diminishing as production is moving into marginal land. Nigerian agriculture is known to be characterized by low land productivity. Hence, other sources and their contributions to growth and productivity increases require identification and empirical quantification. The objective of this study is to identify and quantify the sources of output and productivity growth and their determinants in Nigerian agriculture as a basis for policy formulation. Descriptive statistics, Trend analysis, TFP and TFPG indexes, Translog stochastic growth models, and growth and productivity decomposition models were used in analysing the data.

Summary of Major Findings

The C.V values range between 11.12% and 93.93%. All the C.V values are less than 100%. This finding implies that the means of the variables are representative of the data. Hence, the majority of the observations for particular variables cluster around the means of the variables. As a means of profiling the key variables of agricultural production in Nigeria, the statistical distribution of the variable is okay reasonable and meaningful statistically for subsequent analysis.

The trend in the rates of the fertiliser was of oscillating fluctuation up and down. Over the entire period, the growth rate stood at 10.16%, the only sub-period that is lower than this is the 2000-2009 sub-period, with 9.71%. The growth rates of the 60s, 70s, 80s, 90s and 2010-2015 were greater than for the entire period. Surprisingly, it was 21.80% for the period 2010-2015

The growth rates of labour range between 0.01 and 0.09 over the sub-periods and a growth rate of 0.03 for the period of study. In all these, only 80s had a lower growth rate than the entire period. Generally, all the growth rates are less than 1%. The growth rates of land were very small less than one in the 60s, 70s and 90s. It was about 0.6 in the 80s. By the sub-period 2000-2009, it reached a high of 2.33 and peaked at 5.62 during the 2010-2015 sub-period. The growth rate in the entire period was 3.57

Tractors' growth rate decreased consistently over the sub-periods from a high of 20.66 in the 60s to a low of 2.22 in 2010-2015. The growth rate in the number of tractors stood at 7.07% in the whole period. Generally, all the sub-periods averages were higher than the entire period growth rate except for land. The sub-periods growth rates average for land was 1.52 while growth rate for the entire period was 3.57%. The finding indicates that by ranking the percentage fertilizer has highest contribution towards output growth. These were followed by those of tractors, land and labour in that order. The trend was same in the entire period for inputs.

The estimated parameters from the output response function have the predicted positive sign and magnitude. These are all less than unity. i.e greater than zero but less than one.

Fertilizer contributes more to the output overtime than all the other inputs. Its coefficient is 0.2376 and it's significant at 1%. This is followed by land with a coefficient of 0.2234 and also significant at 1%. Labour with a coefficient of 0.2032 ranks third while tractors with 0.1631 came last. Both are significant at 5%. The summation of these coefficients is 0.8273. This indicates decreasing returns to scale overtime by the inputs. Of the interacted terms only the labour-time variable is significant at 10%. The time variable is positive and significant at 1%. The output responded positively to time. However, time-squared significant at 5% but negative. The major finding here that helps in meeting the second objective of this study is that all the key inputs respond positively and significantly to the output. Increases in the inputs that will bring about increases in the output. The output-oriented technical efficiency of the sector is found to be 0.8246. This confirms findings by other studies that generally agricultural sectors are characterized by technical inefficiency which is 0.1754 in this case. The sector is thus about 83% technically efficient and 17% technically inefficient of the variable tends to lead to a reduction in the TFPG.

The quantity of fertiliser quantity and number of tractors were positive but insignificant in the model. The case for fertilizer is attributable to its low level of usage that is often below the recommended level. Tractor usage is equally hampered by land fragmentation and the small-holder nature of agricultural production in the sector. Both the parameters of the price of fertilizer and the price of tractors are observed to be negative and significant at 5% level. The time variable is positive and significant at 1%.

5.2 Conclusion

This study was designed to determine the sources of output and productivity growth in the Nigerian agriculture from 1960-2015 and sub-periods of 1961-1970, 1971- 1980, 1981-1990, 1991-2000, 2001- 2010, 2011-2015 as a basis for policy formulation

Conclusively, trade openness and time factor significantly affected agricultural TFPG in the long-run. The results also indicated that openness of agricultural economy was significant and positively linked with TFPG. The analysis also concluded that inflation rate, price of fertilizer and price of tractors have a significant negative influence on agricultural TFPG in Nigeria.

In general, results indicated that policies that will ensure macroeconomic stability and encourage or facilitate agricultural openness in the economy be embraced, because it will lead to a higher agricultural productivity growth in Nigeria.

However, results of this study is as presented and discussed. Hopefully, findings from the study will be of value to students/researchers embarking on a similar study and to policymakers in particular and the society in general

5.3 Contributions to Knowledge

The major contributions of this study to knowledge were;

Agricultural output witnesses a decreasing return to scale (0.8273) overtime by the inputs.

Major contributor to output increase in Nigeria agriculture in the entire period were Fertilizer (48.78) and tractors (33.94).

Source of Output growth were input growth (0.52), technical change (1.56), technical efficiency change (0.85) and allocative efficiency change (0.78).

Source of total factor productivity were technical change (1.56), Technical Efficiency Change (0.85) and Allocative efficiency change (0.78).

Trade openness (0.3042) and time factor (0.2576) have significant positive effect on TFPG of agriculture in the long-run. While inflation rate (-0.2453), price of fertilizer (-0.2326) and price of tractors (-0.2294) have significant negative effect on TFPG of agriculture in Nigeria.

5.4 Policy Recommendations

Based on the findings of this study, the following recommendations were suggested.

It is recommended that policy that will bring down prices of marketable inputs (fertilizer and tractor) be encouraged, so that farmers can buy more and enhance output growth.

It is recommended that policy that will encourage a reduction in inflation and fertiliser price to be considered

It is recommended that production of fertiliser be developed domestically.

It is recommended that policy that will increase trade ratio and agricultural openness, as well as the policy on technical progress in terms of capital investment (tractor), be put in place.

It is recommended that policy that will improve the contributions of fertilizer and tractors as inputs into the sector be encouraged.

5.4 Suggestions for Future Research

Main message of this study is that future research should focus on how agricultural output and productivity can be increased/sustained to meet food security challenges and attain self-sufficiency. Rigorous studies on the possible effects of the global, climatic, or agronomic factor on the productivity growth deserve acute attention. To sum up, this study opens up various directions for further research. The insights presented in this paper will serve as a reliable guide for such studies.

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Appendix

Figure 1: Analysis of Objectives

Objective	**Meaning**	**Data Required**	**Analytical Tool**
1.To profile the key variables of agricultural production	Observe the statistical distribution of each variable over-time	Time series data on each variable over the period to be considered	Descriptive statistics , Exponential trend equation, Coefficient of variation
2.To determine the response of output (agric GDP) to the inputs.	To capture the contribution of each input to output and the order and magnitude of their contribution.	Time series data on output (GDP) and the key inputs	Stochastic frontier production function, (SFPF) only...Multiple regression analysis
3.To identify the factors influencing technical inefficiency in the sector	Technical inefficiency exists in production. This objective is designed to identify those factors that affect inefficiency positively or negatively.	Time series data on the output and selected factors that are suggested in the literature as likely variables that influence technical inefficiency	The inefficiency effect model SFPF and SFCF.to be estimated simultaneously. Single-stage regression
4.To examine the changes in production structure of the sector	Difference in output growth rate and TFP growth rate will run against input growth rates	Time series data on relevant factors	Linear model. Multiple regression
5.To decompose output growth into its components	This is to identify and determine the size of the variables as sources of output growth. Input growth technical, change scale effect, technical efficiency, allocative. efficiency and price adjustment	Time series data on output inputs, prices of the inputs and total factor productivity	Output Decomposition econometric and statistical analyses with the SFPF and the derived SFCF. SFCF parameters are needed for the analyses.

6.To profile TFP in the sector over the sub and entire periods	TFP will be run against selected factors The interest will be on the significant factors	Information on TFP and time series data on the selected factors	Descriptive Statistics
7.To determine the factors influencing TFPG in the sector	TPPG will be regressed against selected variables. To identity the significant factors.	Information on TFPG time series data and the selected and variables.	Double log model multiple regression analysis

Fig. 3: Growth Rates of Key Variables over Sub periods and Entire period

Year	Output	Fertilizer	Land	Labour	Tractor
1960-69	3.59 0.9255 99.9796 7.9900	30.00 0.9586 185.2316 13.6100	0.32 0.9315 108.7679 10.4292	0.09 0.3068 3.5412 1.8818	20.66 0.9455 141.4625 11.8938
1970-79	2.04 0.3978 5.2852 2.2990	36.48 0.9248 98.4624 9.9228	0.17 0.8463 44.0552 6.6374	0.05 0.9057 76.8272 8.7651	11.43 0.9808 409.1272 20.2269
1980-89	6.27 0.8987 70.9341 8.4222	13.59 0.7135 19.9223 4.4634	0.58 0.9823 443.4784 21.0589	0.01 0.4787 7.3453 2.7102	5.26 0.9958 1887.749 43.4482
1990-99	4.72 0.9333 111.9642 10.5813	15.53 0.7970 31.4140 5.6048	0.12 0.0288 0.2368 0.4866	0.06 0.9430 132.3315 11.5035	3.44 0.9983 4783.12 69.1601
2000-09	3.05 0.6006 12.0292 3.4683	9.71 0.3856 5.0207 2.2407	2.33 0.7503 24.0375 4.9028	0.04 0.3222 3.8020 1.9499	3.26 0.9776 384.55 18.6695
2010-15	2.60 0.5489 4.8567 2.2061	21.80 0.6113 6.2902 2.5080		0.06 0.5747 5.4040 2.3247	2.22 0.8607 24.7126 4.9712
Average	3.71	21.19	1.52	0.05	7.71
1960-2015	3.46 0.9046 511.8543 22.6242	10.16 0.6192 87.8101 9.3707	0.75 0.7354 150.0523 12.2469	0.03 0.5951 79.3592 8.9084	7.07 0.8580 326.152 18.0597

Source: Data Analysis, 2017.
NB:
The First figure is the growth rate (r)
The second value is the R^2 for the Trend equations
The third number is the F value for the equation and
The fourth value is the t-value for the estimated parameter of the equation

Trend Equation

The functional form of the equation is

$TE = f(t)$;

Where

TE is technical efficiency and t is time variable

Exponential form of the equation is

$TE = b_0 (b_1)^t$

$\text{In } TE = \text{Inb}_0 + t\text{Inb}_1$

Growth Rate

Annual compound growth rate(r) is calculated as

$r = \text{antilog } (b_1) - 1$

NB: A similar analysis was carried out for AE the allocatiive efficiency

Technical change

Technical change = autonomous part + biased part

The functional form of the TC (technical change) equation is specified as

$TC = f(t)$

Linear Equation

$TC = B + bt$

B = autonomous part

b = biased part

NB; TVC for each year represents the TC for the year