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The Impact of National Innovation Systems on Agricultural Development Productivity Growth in Sierra Leone

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Abstract
Innovation has become an increasingly important subject in the field of economics. This paper examines the impact of National Innovation System on Agricultural Development Productivity Growth as a poverty alleviation tool towards the transformation of subsistence level of farming to commercialization in Sierra Leone since 2005 to 2014 inclusive. The Multiple Regression Model (MRM) OLS econometric techniques and Time series data analyses were used for the study to estimate the relationship between agricultural development productivity growth as a dependent variable and its potential macro elements as explanatory variables. Given the implication of national innovation systems on agricultural development productivity growth, it is imperative to investigate key impacts of innovation systems on agricultural productivity growth on the Sierra Leone Economy from 2005-2014 inclusive, using Augmented Dickey-Fuller (ADF) unit root test, Johansen's test of co-integration and the Error Correction Model. The Innovation has become an increasingly important subject in the field of economics. This paper presents the impact empirical results reveal that national innovation system has a significant positive functional relationship with agricultural development productivity growth in the long run. Therefore, the government should pursue policies in enhancing; funding more agricultural research development projects, establish strong patent laws and intellectual property laws so as to encourage enterprise to innovate and thus increase growth of output. Institutional context of any innovation should be adequately analyzed by policy makers as requisite to promote such innovation.Future research direction could be the nexus between the performance of the agricultural sector development and Economic growth in Sierra Leone.
Keywords: Agricultural Development Productivity Growth, Innovation, Sierra Leone, Research and Development.

Introduction

The integral condition for all social and economic growth of various developing countries is an activating sector brought by a substantial boost in agricultural productivity. Communique on agricultural production and food security revealed that food production has to step-up considerably to meet the food demand (Wikipedia, 1995, Amalu, 1998). Unsuccessfully, over the past decades, the agriculture sector is discouraging in terms of performance. Growth has been in degeneration in developing countries. Greater number of African countries has not so far met the benchmark for a blooming agricultural revolution. As a consequence, factor productivity in African agriculture drags far behind the rest of the world.

Before now, scientists confounded the above synopsis on the non-acceptance of recent agricultural technologies by rural farmers. Some scientists hammered that if African farmers with constrained resources had embraced some of the technological innovation developed by research in the past, renouncing food security and multiplying poverty would not be a leading catastrophe today. This failure has raised eye brows in the international development community about the significance of agriculture and poverty reduction. All rural households in Africa depend either directly or indirectly on agriculture. Agriculture is a fundamental poverty alleviation vehicle for sustainable human livelihood in developing economies of which Sierra Leone is not an exception.

In Sierra Leone, two-third of the sizing up six million people live in rural areas, where poverty and hardship are most severe. These people bank on agriculture for their bread and butter (Food and Agricultural Organization (FAO), 2010; International Fund for Agricultural Development (IFAD), 2007). This category accounts for 50% of Gross Domestic Product(GDP) of the country and 30% of its export proceeds(FAO,2013) and still remains the most important, providing employment of approximately 80% of the rural population. Therefore, the significance of agriculture to the national economy with respect to income and employment opportunities is evident.

The farming system in Sierra Leone is symbolized by conventional rain fed and low productivity techniques of production and is thus recumbent to the periodic natural catastrophe of drought, which leaves famine and bereavement in its wake. Farmers in Sierra Leone are rudimentary, meaning basically farmers use small holes and they cultivate small piece of land. Hence, the dying need to improve agricultural productivity and supply chain management from subsistence to commercialization through the acceptance and transformation of advance agricultural technologies and strategies techniques are probable. The country is richly blessed with endowed natural resources and cultivable land, but income distribution is uneven especially those in the rural

areas are approximated to live in absolute and abject poverty (United Nations Development Programme (UNDP, 2010).

In 1975, there was a scale down in the mining industry in terms of export and agriculture to a greater extent provided foreign exchange earnings in relative terms. Agriculture provided 44.1% of the total export in 1977. Due to world market depress in market prices for cocoa, coffee and oil palm products (Sierra Leone major export crops), agriculture contribution declined remarkably and was exclusively 25% in 1987, with coffee and cocoa each producing about 50% of the agricultural export proceeds. Sierra Leone was also importing large quantity of rice over this same period (1987) and exceeds export earnings with a net-trade balance deficit from the agricultural sector.

However, agricultural research and development (R&D) stopped in the 1990s due to the eleven (11) years devastating civil war that was declared at an end in 2002 disrupted with an increase decelerating ramification on agricultural productivity and finally put a slam on the brakes of its agricultural activities. Farmers and a handful number of researchers were killed by rebels and some fled out of the country causing a brain drain and depletion in agricultural human capital; research facilities and equipment were looted, vandalized and burnt down. Research Stations were abandoned as staff seek refuge in Freetown, the capital city of Sierra Leone (Asenso-Okyere et al. 2010).

Notwithstanding the significance of agriculture, Sierra Leone has been in shortage of food since 1970s. The average cereal yields are nothing to write home about. Examining the achievement of the Sierra Leone agriculture concedes that for the past 20 years it has been incapable to yield satisfactory quantity to feed the country's rapidly increase in population. Food aid is laudable and has been reckoning relative amount of the total food supply in the country. The country's potential for expanding agricultural production and productivity is very tremendous. The country has over 75% of arable land and only a small fraction of it is under cultivation.

Over the years, there have been widespread dissemination of innovations, such as high yielding and early maturing rice varieties that are also resistant to pests and diseases like BD 5, ROK 4, ROK 5, NERICAs, CP 4, Rohyb 6, ROK 10, ROK 23, WAR 1(WARDA, 1983), technologies in agricultural machinery such as tractors, power tillers and harvesters, supply chains for inputs such as fertilizers, seeds and pesticides, the development of land and water resources management, the increase of irrigation facilities to expand cropping cycles year round, agro processing, policy guide-lines for marketing, distribution and the encouragement of increased cultivation of food crops especially rice with farmer-based organizations (FBOs) and agricultural business centers (ABCs) ranging from small-scale to medium and large scale-farms.

All the successes of these interventions cannot be successfully evaluated in the absence of adequate, efficient, effective and timely information showing the level of adoption and areas needing intervention for improvement and needs assessment to boost and enhance sustainable agricultural productivity. The key parameter in reaching both small and large scale farmers with relevant agricultural technologies aiming at improving their knowledge, skills and attitude towards agricultural production, is innovation in agricultural technology transfer especially necessary training on managerial skills and financial management skills and techniques to effectively monitor and supervise their respective farming activities. It involves complex processes consisting of diverse structures, and relationship of inter-dependent factors and related variables, aimed at enhancing adoption of innovations. According to Blum (2005), most research efforts in technology creation in most developing countries are wasted due to their inadequate orientation to farmers' needs and utilization. A critical issue to the appropriateness of technologies is in developing them at local levels using skills and perception of the people who live in those rural communities (Platt, 1989). To avoid controversies in determining the right types of agricultural innovation technologies and methods suitable for communicating and disseminating to small scale farmers in enhancing adequate and sustainable agricultural practices, and improving on the lively-hood security of farmers in these mangrove regions, suggests that farmers should be reached with appropriate technologies that are economically viable and culturally acceptable (Sokoya, 1998).Therefore, efforts by the West African Agricultural Productivity Program (WAAPP) in making the Rokupr Agricultural Research Centre, the center of excellence for mangrove rice in the sub-region, clearly spelt out the ever rising need for taking inventory of available mangrove swamp rice technologies and their dissemination and adoption status. This will provide information for guiding policy research in initiating, designing, developing and disseminating mangrove swamp rice technologies that are productive, environmentally friendly and culturally acceptable for farmers'

Innovation is a diffusion process that benefits each and every one in society. It is a dynamic growth that focuses not only high but also low and middle income earners in society. Hence, it is the basis of economic development and there by gives a face lift for developing and least developed countries (LCDs).The commission for Africa (2005) and the UN millennium project (2005) pointed out the role of innovation in terms of creation and investment, and the use of new knowledge as an agent of economic transformation.

Innovation at national level is referred to as National Innovation System (NIS). It is that set of specific, institutions which collectively and independently provides to the development and diffusion of new technologies

and which bestows the frame work within which government formed tackle policies to network the innovation process.

Metcalfe (1995) defined it as a system of inter co-dependent institutions to constitute, store and transmit the expertise, know-how and relics which construe unique technologies.

According to Metcalfe (1995), the concept of nationality follows not only from the sphere of technology policy but from elements of shared culture and language which crunch the system together, and from the limelight of other policies, laws and regulations that condition the innovative environment. NIS approach offers a comprehensive, collaborative as well as integrated frame work for analyzing innovation process, the impact of science and technology actors and their interactions, emphasizing on wider stake holder participation, linkages and institution context of innovation processes.

Furthermore, NIS has influenced both the direction and the vigour of innovation activities in Sierra Leone. The inputs (science funding) outputs (publications and patents) assume a linear model of technological development.

The concept of NIS has played great emphasis on the role of institutions, in terms of norms, rules, laws and organizations. It has made improvement in terms of agricultural development and has strengthened research and development (R&D) and hence motivates activities in agricultural development.

Three agencies are involved in agricultural R&D in Sierra Leone. The Sierra Leone Agriculture Research Institute (SLARI) is under the Ministry of Agriculture, Forestry, and Food Security (MAFFS). MAFFS is the backbone of the country's agricultural research institute. It accounts for 75% of the total agricultural staff. The other two agencies are: the Institute of Marine Biology and Oceanography (IMBO) at the Fourahbay College University of Sierra Leone together with the School of Agriculture and Environmental Sciences at Njala University (NU) account for 25% of the country's agricultural R&D staff.

This paper contributes to the existing literature on the impact of agricultural innovations. To the best of our knowledge, this is the first paper to precisely and goes into detail in assessing the impact of national innovation systems on agricultural growth and development in the context of Sierra Leone. Previous studies have focused on strategy for research on sustainable agriculture.

The main aim of this paper is to examine and evaluate the impact of NIS as a poverty alleviation tool in agricultural development productivity growth towards the transformation of subsistence level of farming to commercialization in Sierra Leone in the period review.

The specific objectives of this paper are in four folds and hence to:

1. Examine the impact of NIS on agricultural development growth in Sierra Leone in the period 2005-2014,
2. Investigate if there is a significant relationship between NIS and agricultural development growth,
3. Examine if there is a relationship between growth variables and agricultural development growth.
4. Analyze the policy implication of agricultural development growth.

The rest of this paper is organized as follows. In section 2, we present the institutional background. Section 3, we present a basic literature review of the theoretical and empirical literature followed in section 4 by data collection and research methodology. In section 5, we present the conceptual frame work, and in section6, we provide recommendations and conclusions.

2. INSTITUTIONAL BACKGROUND

This chapter examines the state of the country ranging from the country profile, the description of National innovation systems, the role of government in sustaining Agricultural development growth and donor support to the agriculture sector.

2. 1 Country Profile

Sierra Leone is located on the west coast of Africa, with its capital city-Freetown. It is a British colonized country which gained independent in April; 1961and bordered by Guinea to the north and extended to northeast, Liberia to the southeast, and the Atlantic Ocean to the west. The country has a total area of 71,740 kilometres (27,699 squares miles), divided into a land area of 71,620 kilometres (27,653 square miles) and water of 120 kilometres (46 square miles). (Christopher Fyfe, 1967)

Its population is estimated 6 million (2011) with an average annual growth rate of 2.1 percent. About two-thirds of the population lives in rural areas and 70 percent live below the poverty line with severe poverty and 60 percent of the youth are non-school going. Unemployment rate stand at a high percentage.

2.2 Description of the National Innovation systems in Sierra Leone

The key components of the national innovation system (NIS) for enhancing economic opportunities and wealth of any nation are Research Institutes and Universities. These components develop new ideas and knowledge that are transformed to the market by the industry. In Sierra Leone, the NIS is in an infant stage and is less developed

by order. The technological and institutional properties required for modern economic growth were not developed in the system. Linkages, interactions and learning mechanisms are among component actors are notably weak.

2.3 The Role of Government in sustaining Agricultural development productivity growth for Poverty Reduction.

The current government has a passion for agriculture and shows commitment towards it: "a two-pronged vision of promoting food security and poverty alleviation through the commercialization of agriculture" and there by making the sector "the engine of growth and development of Sierra Leone". Agriculture, fisheries and industries are sectors where innovation, science and technology hold greater promise for the comprehensive transformation of the country. With abundant supply of water resources and a vast arable land, the country is forging ahead in terms of development and industrial growth championed by agriculture.

Hence, there is a great potential to expand the acreage land especially the inland valley swamps and provide farmers with training on the agricultural practices so as to increase their yields.

In consultation with its main partners, the Government of Sierra Leone (GOSL) has initiated the National Sustainable Agriculture Plan (NSADP) nationwide NSADP main goal is to push agriculture and make it the pivot for socio-economic growth and development in promoting the private sector/farmer based organization (FBOs) through commercial agriculture. As a way of encouraging small farmers on dissipation of professional and fiscal assets, GOSL in its own wisdom has registered the Smallholder Commercialization Programme (SCP) having the possibilities of accomplishing immense food security and wealth generation for the defenseless population in the short and medium term plan. GOSL has scrutinized many policies to support agriculture like the Decentralization policy. The Local Government Act (2004) has been approved into law and thereby expedites the relocation of power to local communities and chiefdoms, and intensifies dispensation distribution to small farmers through dissolution of technical and financial resources. The Youth Agriculture Farm Scheme has also been established by the GOSL to promote employment for the young population.

2.4 Donor support to the development of the Agricultural sector and National innovation systems in Sierra Leone.

Sierra Leone is a donor driven country as 40% of its capital expenditure is from foreign aid. The donor partners play active role in supporting the policies and implementation of MAFFS. Donor partners together with some non-governmental organizations (NGOs) recently embarked on conducting research in areas like participatory research, extension and farmer fields, rehabilitation of feeder roads capacity building and improving productivity through input supply. Donor partners like World Bank (WB), European Union (EU), African Development Bank (ADB), Islamic Development Bank (IDB), World Food Programme (WFP), International Fund for Agricultural Development (IFAD), Japanese International Cooperation Agency (JICA), Irish Aid and the Italian Cooperation, Governments of China, Germany and Nigeria are the key players in financing the ongoing projects in the country. A handful number of NGOs including Action Contre le Faim, ACDI/VOCA, Africare, BRAC, Care, Concern, COOPI, Catholic Relief Services, Christian Aid, Heifer International, OFID, Oxfam, World Vision as well as UN agencies, including FAO, ILO, UNDP, UNICEF, UNEP, WHO are also partners of development in the country. The Mano River Union, ECOWAS, and Comite permanent inter Etat de lute contre la secheresse (CILSS) are sub-regional organisations that are also supportive in terms of inputs on food security issues.

3. LITERATURE REVIEW

3.1 Theoretical Analysis

Computable general equilibrium (CGE) models typically use data on the production structure in reckoning how an economy reciprocates to a shock or change in policy. The CGE model at many country levels (Coxhead and Warr 1991, De Franco and Godoy 1993, Datt and Ravallion 1996) exhibits the multiplier effects of agricultural growth in other sectors of the economy.

Hussain et al. (2002) affirmed that achieving higher income for farmers is the most direct contribution of agricultural growth. The effects of general equilibrium in bridging agricultural and general economic growth have been modelled with an increase in degrees of worldliness. Nonetheless, no universally endorsed model has materialized despite the fact that empirical evidence supports the results (Hussain et al.2002, Thirtle et al. 2002).

According to World Bank (2007), Lesotho a large tradable sector with a small economy experiences less multipliers in terms of agriculture growth than Tanzania, Cameroon and Nigeria which are larger economies with a great share of non-tradable goods and services. Theoretical analysis of agriculture on economic growth centers on the economics of structural change. Structural change is a complicated anomaly and can affect structural attributes. Labour quota decisions (part-time versus full-time) along with farm size; number of farms; investment decisions and substitution of capital for labour.

Farm size and number of farms are interwoven and influenced directly by the substitution of capital

labour. A decrease in the number of farms and upholding the amount of utilized land will lead to a reduction of physical farm size by the same amount. Similarly, an increase in the amount of capital invested will increase the economic dimension of farms provided all other factors are kept constant.

The theoretical analysis laid emphasis on the role of agriculture policy especially direct payments that regard evaluation. Absolutely, agricultural support policies are the engine of structural change (OECD, 2011).They influence production incentives as well as farm incentives and hence affect labour use. However, the issue of how agricultural programmes influence farm structure is still not universally accepted in terms of theoretical models. Some researchers support the notion that farm commodity programmes activate farm structural change and reduce farm numbers while other schools of thoughts are on the contrary.

In economics, structural change is defined as " a complex phenomenon, not only because economic growth brings about complementary changes in various aspects of the economy such as the organization of industry and the sector compositions of employment and output, though the growth process in turn is influenced by these changes" (Kiminori,2008).

Never the less, a wide range of theories examine structural change on the factors of production (land, labour and capital) used in the farm (Lobley et al, Allan Butler 2010).

The Neoclassical model of structural change emphasizes on the relationship between efficiency return to scale and farm size. It centers on the assumption of whether returns to scale in production can explicitly combine farm size and economic efficiency. Farm size growth has definite impact on the competitiveness of the farm and there by authorizes to reach economies of size, and in turn, reduce production costs. Farm size may provide competition if technical innovation is in favour of large farms. This is because some recent technologies (example, mechanical) are acceptable only in farms performing large scale of production (Glauben et al, 2006).Although the intermediate cost function is L-shaped in the process of farm incorporation on the exit of farms from the sector, there is a wide range of farm sizes where it is approximately constant.

However, researcher like Boehlje (1992) in his review of the four alternate models focuses on the human capital, the financial, the sociological and the institutional model in

1. Human Capital Model: this model is based on the hypothesis that administrative capacity is demanding to underlying cost and production alliance of any firm and that it can be a permanent factor and is generally diversified across firms. Consequently, the availability of such managerial input influences the ability to channel information and to assess and gadget new technologies (Boehlje, 1992).

2. Financial Model: this model explores the possibility that the decision regarding the amount of durable and non-durable inputs used in firming activities is not just a function of relative factor prices but also of the expected relative capital gains or losses (Boehlje, 1992).

3. Sociological Model: this refers to the common category of family farms. The family life cycle classify this model into three (3) main stages: the entry or establishment stage; the growth and survival stage; the exit or disinvestment stage. The model explains why important decisions are normally subjected to renegotiation. This supports the apprehension for restricted resource mobility in agriculture and for the adjustment of land, capital and farm labour tends to take place for several years (Maria S. Bowman and David Zilberman, 2001).

4. Institutional Model: this model according to Behlje (1992) is the structure-conduct-performance paradigm of industrial organization and its variants.

Hubbard (1997), a researcher in New Institutional Economics stresses the role of transaction costs in determining behaviour within and between organizations. The theory of the firm examines the nature of the firm and assesses the apprehension behind its existence, structure, behaviour and connections.

A body theory named Transaction Cost Economics (TCE) has been used to consider the transaction as the basic unit of analysis and embrace several transactions apart from the "cost of using the price mechanism" Coase (1937). TEC critically turns on two attributes of the contracting process-the bahavioural assumptions of bounded rationality and opportunism (Williamson, 1987).

Bounded rationality: behavior of human agents is limited by the information they possess and inclusive epitomizing is not a pragmatic solution. Under this condition, "the cost of planting, adapting, and monitoring transactions needs expressly to be considered".

Opportunism: According to Williamson (1987, page 3). Opportunism "is a condition of self-interest seeking with guile" that implies an incomplete or distorted disclosure of information and is responsible for the well-known condition of information asymmetry between economic agents. These two assumptions distinguish TEC theory from neoclassical models.

3.2 Empirical Studies

There has been a large body of empirical studies on agricultural research and development without any significant impact on the socio- economic status of Sierra Leone. Based on the above theoretical justification, few empirical studies captured the impact of national innovation systems on agricultural development growth. Over the period of time, the studies have focused on indicators of agricultural development growth in the form of

foreign direct investment (FDI), the private sector, farmers, government expenditure, R&D, intellectual property rights (IPRs) and literacy.

Anil K. Bhargava (2014) conducted a study on investigating whether an increase in opportunity cost of agriculture labor incentivizes farm owners to adopt labor-saving agricultural technology in India. He used regression discontinuity design and new Indian agricultural census data. He finds a shift of roughly 20 percentage points away from labor-intensive technologies towards labor ones. The short-run result indicates that the rural poor's incomes are increasing, village infrastructure is improving and agriculture wages are going up.

Idowu Ayodedi Adetunji (2013) in his paper examined the relationship between FDI and Agricultural sector in Nigeria using vector auto regression model. The results from his study show the existence of a positive significant relationship between FDI and labour generation. However, there is no significant relationship between FDI and output of the agricultural sector. Kausar Yasmeen, Dr. Ezotollah Abbasian and Dr. Tanveer Hussain (2012) investigated the impact of educated farmers on agricultural productivity in India. The primary data of 330 house hold were collected from the rural areas of Telsil Mailsi in India. They use OLS model and found out that education is positively correlated with the product that boost up the farmers income.

Dwi Susanto, C. Parr Rosson, and Rafael Costa (2012) studied structural reforms and agricultural export performance: an empirical analysis. The study employed gravity model of panel data. Results from their study indicate an upward trend of structural reforms on agricultural growth. They concluded by suggesting that reduced tariffs in trade reforms enhance agricultural trade and less government intervention in the agricultural sector will boost agricultural production and hence facilitate the trend towards export.

Arega D. Alene (2010) examined the impact of total output growth in African agriculture under simultaneous and subsequent technology border line over the period 1970-2004. The paper used an established regression model and a polynomial lag structure for agriculture R&D expenditures. Results from his findings show that African agricultural productivity grew at a higher rate of 1.8 percent. Furthermore, R&D, Technical process, reforms in trade and weather have significant effects on productivity in African agriculture.

4. Methodology and Data Sources

4.1. Data

This study implements a quantitative approach that aims to investigate the impact of NIS on agricultural development productivity growth in Sierra Leone using secondary data set collected from the World Bank Data Base for the period 2005-2014 inclusive. The research findings of this study if implemented will improve income and better standard of living for sustainable human livelihood of the nation as a whole.

4.2. Methodology

The Ordinary Least Square (OLS) econometric technique was used as an estimate for the model. The model was chosen based on the fact that OLS is best suited analysis that involves testing the nature of economic relationship in testing specific hypothesis (Guajarati 2004). Variables of the properties of the time series were tested in the process. The methodology connects an econometric model in which the key macroeconomic elements of NIS on agricultural development growth in Sierra Leone were investigated. In this study, multiple linear regression model was used to estimate the relationship between agricultural development growth and its potential macroeconomic elements. Thus the model is adopted to take the following specification:

$$Y = F(EX, LR, FDI, RD, IPR) \quad (1)$$

From (1) the econometric form of the model can be written as

$$Y_t = \beta_0 + \beta_1 EX_t + \beta_2 LR_t + \beta_3 FDI_t + \beta_4 RD_t + \beta_5 IPR_t + \varepsilon_t \quad (2)$$

In order to measure the degree of responsiveness of agricultural development growth, model (2) is estimated in natural logarithm form using the equation.

$$LogY_t = \beta_0 + \beta_1 \log EX_t + \beta_2 logLR_t + \beta_3 logFDI_t + \beta_4 logRD_t + \beta_5 logIPR_t + \varepsilon_t \quad (3)$$

From equation 3
Y = Agricultural Development Growth
EX = Export to GDP
LR = Literacy Rate for Labour Force
FDI = Foreign Direct Investment to GDP
RD = Research and Development to GDP
IPR = Intellectual Property Right proxied as total number of patents granted to R&D.
ε = Stochastic Error term and
t = Time Trend
β_0 is a constant and β_1- β_5 are coefficient parameters to be estimated. The a priori expectation signs of the

parameters are $\beta 1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 > 0$ i.e. all the independent variables are expected to have positive impact on the dependent variable.

4.3. Model Estimation Procedure

It is a standard practice for every effective research that requires the use of econometric technique to highlight the significance of investigating the data generating process that are fundamental to the variables before estimating the parameters and carrying out various hypothesis testing. This procedure is meant to avoid the problem of spurious regression results. It commences with the test for stationary using the Augmented Dickey-Fuller (ADF) unit root test. This is achieved with the aid of the following equations:

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{i=1}^{n} \alpha \Delta Y_{i?} + \varepsilon_t \quad (4)$$

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \sum_{n=1}^{n} \alpha \Delta Y_{i?} + \delta_t + \varepsilon_t \quad (5)$$

Equation (4) contains and intercept and no trend, while equation (5) contains intercept and time trend α_0 are constants, α_1 are coefficients of autoregressive process. Where t is time trend, Y_t is the variable under investigation, n is the number of lags and ε_t are error terms. The null hypothesis is that the variable is non-stationery as against alternative hypothesis that the variable is stationery. If the absolute value of the ADF test statistic is greater than the critical values, we reject the null hypothesis of non-stationary and conclude that the variable is stationery. On the other hand, if the absolute value of the ADF is less than the critical values (in absolute terms), we fail to reject the null hypothesis and conclude that the variable is non-stationary.

4.4. Co-Integration Test Analysis

Given that the variables are assumed to be stationary-integrated of the same order, the co-integration analysis will be appropriate to estimate the long-run Agricultural Development Growth function since the theory assert that non-stationary time series are co-integrated if their linear combination is stationary. The co-integration tests involve testing for the presence of long-run equilibrium relationship between the variables of the same order of integration through the formulation of co-integration equation(s). The maximum likelihood test method recommended by Johansen and Juselius (1988, 1990) is used. The co-integration requires the error term in the long-run relation to be stationary. Exclusively, given that Y_t is a vector of n number of stochastic variables, it follows that there exist a K-lag vector auto-regression with Gaussian errors of the following structure where Johansen and Juselius methodology adopt its initial point in the vector auto regression (VAR) of order k specified by:

$$Y_t = \delta + \beta_1 Y_{t-1} + \ldots + \alpha_k Y_{t-k} + w_t \quad (6)$$

Where Y_t denotes an (nx1) column vector of k-variables that are integrated of order one, and w_t denotes a vector of white noise residuals. In error correction model (ECM), equation (6) can be written as:

$$\Delta Y_t = ? + \prod_{t-1} + \sum_{i=1}^{k-1} \Delta \varepsilon_{t-1} + \quad (7)$$

$$\prod = \sum_{i=1}^{k} \Gamma_i \quad \text{and} \quad \Gamma_i = -\sum_{j=i+1}^{k} \alpha_j$$

Where Δ is the difference operator, Y_t is an nx1 column vector of k-variables, δ is a constant, ε_t is an error term, Γ_1 denotes the long-run coefficient matrix and $\prod$ denotes the short-run coefficient matrix. They both show the impact in the long-run and short-run respectively. Thus the significant issue is to determine the number of co-integrating vectors. Johansen and Juselius (1988, 1990) suggested the use of two statistical tests which are the trace test (λ_{trace}) and the maximum eigen value test (λ_{max}). These two tests are estimated with the aid of the following equations:

$$\lambda_{trace}(r) = -T \sum_{j=i+1}^{n} ln(1 - \hat{\lambda}_i) \quad (8)$$

$$\lambda_{max}(r, r+1) = -T ln\left(1 - \hat{\lambda}_{r+1}\right) \quad (9)$$

Where
λ_{trace} test the null hypothesis r = 0 against the alternative of r > 0
T = number of usable observations

λ_i = Eigen values or estimated characteristics root
λ_{max} test the null hypothesis r = 0 against the alternative of r =1
If the null hypothesis of no co-integrating vector is rejected, it indicates that there is a long-run relationship among the variables in the model.
The error correction model is also estimated given the equation:

$$\Delta X_t = \gamma_0 + \gamma_1 \Delta Y_t + \lambda V_{t-1} + \varepsilon_t \quad (10)$$

Substituting equation (3) into equation (10) to reflect the short run dynamics gives:

$$\Delta LogY_t = \beta_0 + \sum_{i-1}^{q} \beta_1 \Delta logEX_{t-j} + \sum_{i-1}^{q} \beta_2 \Delta logLR_{t-j} + \sum_{i-1}^{q} \beta_3 \Delta logFDI_{t-j} + \sum_{i-1}^{q} \beta_4 \Delta logRD_{t-j} + \sum_{i-1}^{q} \beta_5 \Delta logIPR_{t-j} + \lambda ECM_{t-1} + \varepsilon_t \quad (11)$$

5. Presentation and Analysis of the Results

Based on the above methodology, the following results are obtained
Table 1: Unit root test result from the Augmented Dickey –Fuller unit root test

Variable	Level/ΔLevel	Calculated ADF	ADF critical value	Included in test equation	Inference
Log Y	Level	-1.041983	-3.259808	Intercept & trend	Non-Stationary
	ΔLevel	-4.246503	-2.821666**		Stationary
LogEX	Level	-2.296679	-3.320969	Intercept & trend	Non-Stationary
	ΔLevel	-4.107833	-1.983877**		Stationary
LogLR	Level	-4.211504	-4.582648	Intercept	Non-Stationary
	ΔLevel	-85.28389	-4.582648***		Stationary
LogFDI	Level	-0.996656	-2.771129	Intercept	Non-Stationary
	ΔLevel	-3.041319	-2.801384*		Stationary
LogRD	Level	-0.857153	-4.107833	Intercept & trend	Non-Stationary
	ΔLevel	-3.320969	-1.721193**		Stationary
LogIPR	Level	-2.672431	-4.246503	Intercept & trend	Non-Stationary
	ΔLevel	-14.14843	-4.246503**		Stationary

Note: ***, ** and * indicates that the variable is stationary at the 1 %, 5% and 10% level of significance respectively.

Result from the unit root test reveals that all the variables are non-stationary at their levels but became stationary after first differencing. Therefore, the concept of co-integration is necessary.

5.1. Optimal Lag Selection

Before proceeding with the Johansen's test of co-integration and the Error Correction Model (ECM) estimation, the optimal lag selection criteria was employed to determine the lag length to be used in carrying out the estimation. In table (2) the lag order selection criteria for sequential modified likelihood ratio (LR), final prediction error (FPE), akaike information criterion (AIC), schwarz information criterion (SC), and hannan-quinn information criterion (HQ) suggested the selection of an optimal lag of 1. Thus a maximum of lag one has been chosen.
Table 2: VAR Lag Order Selection Criteria

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-41.81578	NA	4.255428	9.959063	10.02480	9.817193
1	74.27176	128.9862*	2.40e-10*	-13.83817*	-13.57520*	-14.40565*
* indicates lag order selected by the criterion						
LR: sequential modified LR test statistic (each test at 5% level)						
FPE: Final prediction error						
AIC: Akaike information criterion						
SC: Schwarz information criterion						
HQ: Hannan-Quinn information criterion						

Source: E-views output

5.2. Co-integration Test Results

Here the Johansen's co-integration test was used to check whether the variables are co-integrated or not. Both the trace statistics λ_{trace} and the maximum Eigen statistics λ_{max} were used and the results are presented in table 3 and 4 below.

Series: LogY LogEX LogLR LogFDI LogRD LogIPR
Lags interval: 1 to 1

Table: 3 Unrestricted Co-integration Rank Test Result (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.863592	112.7426	95.75366	0.0020
At most 1 *	0.589192	54.97168	69.81889	0.4202
At most 2	0.346581	29.17244	47.85613	0.7601
At most 3	0.235933	16.83187	29.79707	0.6525
At most 4	0.169422	9.027977	15.49471	0.3628
At most 5	0.118099	3.644592	3.841466	0.0562
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: E-views output

Table: 4 Unrestricted Co-integration Rank Test Result (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.863592	57.77096	40.07757	0.0002
At most 1	0.589192	25.79924	33.87687	0.3331
At most 2	0.346581	12.34056	27.58434	09181
At most 3	0.235933	7.803895	21.13162	0.9153
At most 4	0.169422	5.383386	14.26460	0.6929
At most 5	0.118099	3.644592	3.841466	0.0562
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: E-views output

The values of both the trace statistics (112.7426) and the Max-Eigen statistic (57.77096) are greater than their critical values at 5% significant level of (95.75366) and (40.07757) respectively and their corresponding probability values are less than 5%, which implies that we reject the null hypothesis of no co-integrating relationship at the 5% significant level for none. Moreover, whiles we reject the null hypothesis of no co-integrating relationship at the 5% significant level for none, we fail to reject the null hypothesis of At most one co-integrating relationship at the 5% significant level; since both the trace statistics (54.97168) and Max-Eigen test statistic (25.79924) are less than their critical values at 5% significant levels of (69.81889) and (33.87687) respectively. However, the co-integration test result shows the existence of long-run relationship among agricultural development growth, export, literacy rate, foreign direct investment, research and development and intellectual property right. The result of the long-run relationship is presented in table 5 below.

Table 5: Result of the long run agricultural development growth model

Dependent Variable LogY				
Independent Variables	Coefficient	Standard error	t-statistics	Inference
LogEX	13.63085	1.76196	7.7362	Significant
LogLR	0.133608	0.05030	2.6562	Significant
LogFDI	0.05203	0.01927	2.7001	Significant
LogRD	5.68502	1.55547	3.6549	Significant
LogIPR	-0.442950	0.16074	-2.7557	Significant
Constant	11.30782	…….	…….	…….

Source: computed by author from E-views output

Results from the long run agricultural development growth model reveal that export has a direct relationship with agricultural development growth in the case of Sierra Leone. The coefficient was found to be positive and significant, suggesting that a 1% increase in export will lead to 13.63 percent increase in agricultural

development growth in the long run. The degree of responsiveness of agricultural development growth with respect to export is 13.63. This finding is in accordance with the study of Dwi Susana, C.Parr Rosson and Rafael Costa (2012).

Similarly, literacy rate for labor force has a direct relationship with agricultural development growth. The coefficient was also found to be positive and significant. This suggests a 1% increase in literacy rate for labor force will increase agricultural development growth by approximately 0.134 percent on average in the long run. The degree of responsiveness of agricultural development growth with respect to literacy rate for labor force is 0.134. Similar result was also found in India by Yasmeen and Dr. Ezotollah Abasian (2012).

Foreign Direct Investment was also found to have a direct relationship with agricultural development growth in Sierra Leone. The coefficient is positive and significant, suggesting that a 1% increase in foreign direct investment will also increase agricultural development growth by approximately 0.052 on average in the long run. The degree of responsiveness of agricultural development growth with respect to foreign direct investment is 0.052. Unlike this finding for Sierra Leone, Idowu Ayodedi Adetunji (2013) found no significant relationship between FDI and output of the agricultural sector in Nigeria.

Research and Development (R&D) was also found to have a direct relationship with agricultural development growth in Sierra Leone. The coefficient is positive and significant, suggesting that a 1% increase in research and development will as well increase agricultural development growth by approximately 5.685 on average in the long run. The degree of responsiveness of agricultural development growth with respect to research and development is 0.052. This finding is consistent with theories. Similar result was also found by Arega D. Alena (2010) that R&D, technical process, reforms in trade and weather have significant effect on productivity in African agriculture.

For intellectual property right, in has an inverse relationship with agricultural development growth in Sierra Leone. The coefficient was found to be negative and significant, suggesting that an increase in intellectual property rights by 1% will leads to approximately 0.443 fall in agricultural development growth on average in the long run. The degree of responsiveness of agricultural development growth with respect to intellectual property right is -0.443.

5.3. Short run dynamics (ECM)

The existence of long run relationship among the I(1) variables suggests the estimation of the short run dynamic model. The short-run error-correction model (ECM) is an autoregressive distributed lag model for the stationary forms of agricultural development growth, export, literacy rate for labor force, foreign direct investment, research and development (R&D) and intellectual property rights. It is estimated using OLS. The error correction mechanism is employed to examine the short-run and long-run behavior of agricultural development growth in relation to its explanatory variables. This equation incorporates the short run adjustment mechanism into the model. In the previous section, it was evident that there exists a unique co-integrating relationship between agricultural development growth and export, literacy rate for labor force, foreign direct investment, research and development (R&D) and intellectual property rights. Nevertheless, in the short run, there may be disequilibrium and the error correction model is therefore employed to eliminate deviation from the long run equilibrium. The most important thing in the short run result is the speed of adjustment term. The results of the short run dynamic model are reported in table 6.

Table 6: Result of the short run dynamics model (ECM). Dependent variable D(LogY)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.164750	0.098093	-1.679526	0.2351
D(LOGEX)	-0.214641	0.047415	-4.526831	0.0455
D(LOGLR)	9.206688	4.293324	2.144419	0.1652
D(LOGFDI)	0.022440	0.006046	3.711293	0.0655
D(LOGRD)	0.658079	0.204618	3.216138	0.0846
D(LOGIPR)	0.008096	0.002570	3.150211	0.0877
ECM(-1)	-0.622103	0.206808	-3.008119	0.0074
R-squared	0.966930	Mean dependent var		0.015240
Adjusted R-squared	0.867719	S.D. dependent var		0.022176
S.E. of regression	0.008065	Akaike info criterion		-6.750999
Sum squared resid	0.000130	Schwarz criterion		-6.597602
Log likelihood	37.37949	Hannan-Quinn criter.		-7.082028
F-statistic	9.746242	Durbin-Watson stat		2.101412
Prob(F-statistic)	0.005966			

Source: E-views output

The coefficient of the error correction term indicates the speed of adjustment in eliminating deviation from the long run equilibrium. The coefficient has the expected negative sign (-0.622) and it is statistically significant. The significance of the coefficient further confirms the existence of the long run relationship between agricultural development growth and the independent variables under consideration. The magnitude of the coefficient implies that approximately 62.2% of the disequilibrium in the previous year's shock adjusts back to long run equilibrium in the current year. The error correction term (ECM) was also found to be stationary. Results from the short run relationships are in support of results from the long run relationships except for export and intellectual property rights.

The adjusted R- squared value is 0.867719, implying that approximately 87% of the variation in the agricultural development growth is explained by the independent variables, which is an indication of a very good fit. The Durbin-Watson statistic is greater than 2 suggesting that there is no first order autocorrelation which implies that the regression has economic meaning. The overall equation is statistically significant as shown by the probability value of the F-statistic (0.005966).

5.4. Diagnostics test

Diagnostic tests were also conducted to examine the robustness of the model used. The results are presented in table 7.

Table 7: Diagnostic tests

Test	**Type**	**Null Hypothesis**	**Statistic**	Probability	**Inference**
Serial Correlation	Breusch-Godfrey L.M	No serially correlated errors	F-statistics = 0.022418	Prob. Chi-Square = 0.6569	Fail to reject Ho
Normality	Jarque-Bera	Errors are normally distributed	Jarque-Bera Statistics = 2.375095	Probability = 0.304968	Fail to reject Ho
Heteroskedasticity	Breush-Pagan-Godfrey	Homoscedasticity	F-statistics = 0.306959	Prob. Chi-Square = 0.6342	Fail to reject Ho
ARCH	F-Statistic	ARCH effect does not characterize model's errors	F-statistics = 0.736928	Prob. Chi-Square = 0.3495	Fail to reject Ho
Functional Form Misspecification	Ramsey RESET	Model is correctly specified	F-statistics = 2.211028	Probability = 0.3769	Fail to reject Ho

Source: computed by author using the software

The diagnostic test suggests good fit of the model. The model does not suffer from the problems of non-normality of the errors, serially correlated errors, ARCH effect, heteroskedasticity and functional form misspecification which can be seen from all the probability values greater than 5%.

6. Conclusion

National innovation system is an open system comprising of many actors and their interactions. In Sierra Leone, science and technology has received considerable attention as the engine for the exponential growth of the agricultural sector. Despite the fact that knowledge is increasing, the micro innovative strength and stake holders' participation are more or less developed**.** This research demonstrated a positive impact of NIS on agricultural development growth in Sierra Leone. This paper has clearly shown that NIS creativity and innovation is a key vehicle to promote, stimulate and revamp agricultural productivity growth towards the transformation of subsistence level of farming to commercialization with advance techniques, strategies and efficient supply chain management for a better standard of living and sustainable human livelihood in Sierra Leone. The empirical and econometric analysis performed in this paper showed that there is existence of long run functional relationship between agricultural development productivity growth as a development variable on one side, export, literacy rate, FDI, R&D and intellectual property rights as explanatory variables on the other side. Furthermore, results from the short run relationship are in support with the long run relationship except for export and intellectual property rights.

This failure of interaction between export and intellectual property rights can be investigated to further this work.

The study therefore concludes that the NIS concept should be explored to evolve a unique agricultural development growth system capable of neutralizing the challenges in the agriculture sector.

6.1 Policy Recommendations

The application of national innovation systems to agriculture is gaining momentum and is rapidly becoming

popular and gaining favour among policy makers and planners**.**

The linkage established by this study is of particular importance given the strong relationship between NIS and agricultural development productivity growth. Nevertheless, it demonstrate leading policy connotation for extension transmission. Primarily, government and policy makers should boost and reinforce intensive researches in sectors, sub-sectors of importance, relating to any form of investigative process to perceive the potency, lapses, alternative direction for policies and programmes that could foster and strengthen the innovation system.

The innovative performance of the economy is characterized by actors in the agricultural research, education, and extension and farmers system as equal partners.

Government should enhance the following:

i. Pay attention in allocation of resources;
ii. Establish strong patent laws and intellectual property laws to encourage enterprise to do innovation;
iii. Review and adopt macroeconomic policies like lowering taxes and subsidies to both subsistence and mechanized farmers to encourage innovation;
iv. Have well organized planning process for farming activities capturing short-run, medium-term and long-run period with strategic focus;
v. Promote projects that imitate innovation and creativity like developing solar energy;
vi. Funding more agricultural research development;
vii. Building more roads and irrigation systems
viii. Government in collaboration with international partners should Provide more continual support to farmers in terms of access of financial facility such as credit, savings, remittances and transfer services especially to farmers in rural areas to facilitate their farming activities
ix. Building more agricultural infrastructures like storage facilities, Agricultural Business Centers (ABCs) and ready market place for agricultural businesses.
x. Continual Educational training programmers for farmers especially in the area of new advance agricultural techniques, managerial and financial management skills to prepare their readiness in taken ownership and responsibility of effective and efficient monitoring and supervision of their agricultural activities for sustainable agricultural development productivity growth.

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