Impact of Agricultural R&D on Sectoral Economic Growth

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Authors' contributions

This work was carried out in collaboration between both authors. Author LO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NM managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Public and private investment in agricultural research and development (R&D) creates preconditions for the implementation of more advanced and better technologies. It enables the introduction of new production processes and products which can result in higher earnings and potential sectoral economic growth in Agriculture. Despite the fact that accelerated agricultural research and development is a catalyst for the beginning of the long-run economic activity, its importance is not widely investigated at regional levels. The East Africa economies have defined strategies that view innovation as an essential element in stimulating growth and job creation. The goal of this study is to establish the role of agricultural R&D in fostering sectoral economic growth of East Africa states. The data used in this research were panel data of the East Africa Countries for the period from 2001 to 2015. The result showed that agricultural sector R&D is important factor in explaining sectoral economic growth in East Africa. Therefore, only innovation through increasing Agricultural R&D expenditure and strengthening institutions can sufficiently drive sustainable sectoral output growth and development in East Africa economies. Thus, East Africa nations need to strengthen and build their agricultural research and development capacity while aligning of policies and procedures of research organizations to achieve sustainable sectoral economic growth.

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1. INTRODUCTION

The past four-decade has been one of agro-defeatism. The promises that agricultural development seem to hold did not materialize. This defeatism seemed to coincide with pessimism about East Africa's success. Especially for East Africa countries, the hope was that economic growth and innovation would be brought about by agricultural development through accelerated research and development. After the triumph of the green revolution in the Asia continent, the hope was that a similar agricultural vision would transform African states. But this hope never materialized, agricultural productivity did not increase much in East Africa and worse, the negative effects of the green revolution in Asia became more apparent, such as pesticide overuse and subsequent pollution. Also in Asia, the yield increases tapered off [1].

The skeptics put forward several arguments why agriculture is no longer an engine of growth. For instance, the liberalization of the 1990s and greater openness to trade have lead to a reduction in the economic potential of the rural sector. The natural resource base on which agriculture is founded has been deteriorating and getting poor each day. Thus attaining increased agricultural productivity growth is becoming a nightmare for Africa economies. However, since the beginning of the new century, there seems to be a renewed interest in agriculture [1]. Most governments and organizations that still focused on agriculture were put under pressure to focus more on reducing poverty, besides increasing agricultural productivity through increased spending on agricultural research and development [2].

According to neoclassical theory, knowledge is regarded as an exogenous variable that, together with a country's input goods, labour and capital, affects agricultural productivity. In endogenous growth theory, on the other hand, investments in agricultural Research and Development (R&D) that provide new knowledge are seen as an important factor that explains growth and increased productivity [3]. This theory regards new technology not only as an exogenously produced input good that the economy utilises but new technology can also be created within the production set up.

According to endogenous theory, accelerated investment in agricultural R&D can achieve long-run output growth and increasing return to scale. This is possible since increased R&D translates to increased innovation, technology, and knowledge. The replication of the previous production does not, therefore, have to bear the burden of any R&D costs [2].

Agriculture is the engine of economic growth and the cornerstone of poverty eradication in East Africa countries [4]. Approximately 78 percent rely on agriculture as their primary source of livelihood. The sector also accounts for 40 percent of GDP in the East Africa states and almost 65% of its total export earnings besides the provision of 88% of the food needed in this region. R&D has made it possible for farmers to aid nature in making specific soils more productive through the discovery of chemical fertilizers and soil management; has led to the discovery of crop and animal diseases, there preventive and curative measures; the use of mechanised power and machinery of the farm and seed technology where crops are designed to withstand harsh weather conditions such as drought and flooding [5].

More agricultural investment in science and technology is being carried in Africa, in an effort to increase agricultural productivity and innovation [4]. The government spending allocation across Africa reflects state budget priorities. In the continent, the major spending budgets are on education, health and, security sectors. This explains why Asia has the best and high-quality human capital in comparison to other regions. The security and agricultural sector ranks below the education sector in Asia [6].

For the Agricultural sector, the declining productivity in East Africa countries can be attributed to low agricultural R&D government spending especially in infrastructure, research, and extension which culminates in low factor productivity growth [5,2].

Despite agricultural R&D being carried out by these public and private agricultural research institutions in East Africa, the sector is still being reported to be facing the challenges of low productivity and hence reducing productivity and slowing sectoral economic growth. In addition, information on the effect of R&D on the agricultural sector in East Africa is lacking and hence the motivation for this study is to establish the effect of R&D on the agricultural sector growth in East Africa.

2. LITERATURE REVIEW

Neoclassical model was advanced by Solow–Swan in 1956 as an exogenous growth theory [7,8]. It is an econometric production function of long-term output growth founded within the framework of the neoclassical school of thought. It tries to explain long-run sectoral economic growth by looking at capital accumulation, labor or population growth, and increases in Agricultural productivity [7,8]. Agricultural Productivity is enhanced by financing the investments that the private Sector would not supply in sufficient quantities due to various market failures like inadequate research and development infrastructure, road projects, and education and health services, which could directly providing private sector productivity. Insufficient supply of some basic public services that are crucial to providing basic conditions for entrepreneur activity and long-term investment; and financing its own activities in general that minimizes distortions to private Sector savings and investment decision and to sectoral economic activities in general [9]. It is on this basis that increased spending on agricultural R&D can impact sectoral economic growth by affecting capital and labor accumulation as well as the assimilation of technological progress reflected in total factor productivity growth [3,10]. Conversely, since the theory assumes that the long-run growth rate is bound by the population growth and the rate of technological progress, which is viewed to be exogenous, the impact of R&D agricultural expenditure on sectoral growth through production factors is considered to be the only channel of East Africa sectoral economic growth [11]. Further, Romer's hypothesis postulates that with innovation and new technology the price of goods and services will become less costly. On the other hand, Grossman and Helpman [12] together with Aghion and Howitt [13] developed a hypothesis where innovation improves the quality of existing varieties of capital goods.

The majority of the past empirical studies reviewed focused on the aggregate economy however research and development expenditures are allocated to each sector and therefore this study focused on sectoral economic growth that was omitted in the previous empirical studies.

3. RESEARCH METHODOLOGY

This study used a historical research design. This research design was the most appropriate as it captures the impact and trend of study variables over time [10]. This study was carried out in the five East African economies (Burundi, Kenya, Rwanda, Uganda, and Tanzania), which were selected mainly based on the availability of key data for the period under consideration. This study was carried out in the East Africa region. Since the five East Africa countries have been spending a substantial amount of budget on agricultural research and development in order to grow productivity and spur agricultural output and general economic growth. Further, from previous empirical studies, few studies have focused on sectoral growth in East Africa. The panel data covered the period between 2001 and 2015. The choice of the study period was informed by the availability of panel data and also to provide sufficient econometrics degree of freedom.

The agricultural research and development panel data was collected from the specific country statistical abstracts, economic survey reports and agricultural science and technology indicators reports. In addition, agricultural output growth panel data was collected from the member countries' economic survey reports, statistical abstracts, and world development indicators reports.

3.1 Panel Econometric Analysis

Descriptive and econometric analyses were employed to analyse the panel data, all in an effort to investigate the relationship between increased public spending on agricultural research and development and agricultural output growth. The Panel data was estimated using the panel Ordinary Least Squares (OLS) technique and balanced random effect estimation technique. To establish whether to employ a fixed-effects model or random-effects model, the study conducted Hausman Test which was developed by Hausman [14].

The basic regression equation that was used to investigate the relationship between R&D and agricultural sector growth was therefore of the type:

$$\ln y_{i,t} = \beta_0 + \beta_1 \ln ra_{i,t-1} + \beta_2 \ln ro_{i,t-1} + \beta_3 \ln rk_{i,t-1} + \beta_4 \ln rl_{i,t-1} + \beta_5 \ln ak_{i,t-1} + \beta_6 \ln al_{i,t-1} + \varepsilon_{i,t}$$

Where;

$y_{i,t}$ –is the dependent variable i.e. Agricultural sector economic growth.
$ra_{i,t}$ is the R&D in the agricultural sector.

ro_{it} is the R&D in other sectors apart from the agricultural sector.

$rk_{i,t}$ is the interaction of agricultural R&D and agricultural capital.

$rl_{i,t}$ is the interaction of agricultural R&D and agricultural labour.

$ak_{i,t}$ represents agricultural capital.

$al_{i,t}$ represents agricultural labour.

$\varepsilon_{i,t}$ is the error term.

The subscript i and t represent country and time period respectively and the data set consisted of a panel of five countries. Expenditures on R&D in the agricultural sector and research and development in other sectors were used as a proxy for research and development while agricultural capital and agricultural labour were used as control variables since they also influence agricultural sector growth.

3.2 Panel Unit Root Analysis

If a study variable contains a unit root, then it is non-stationary and if not, then it is stationary. Presence of a unit root can also cause problems in regression results involving econometrics models. Macroeconomic time series data are generally characterised by a stochastic trend which can be removed by differencing. This study adopted Levin-Lin-Chu (LLC, [15]) unit root analysis to verify the presence of unit root and in order to reduce chances of spurious findings [16]. Panel Co integration refers to the long-run linear movement of two variables that are stationary after differencing. A residual based co integration test is conducted to check whether the variables have got long-run relationship or not (Pedroni, 1999). For this to happen, however, estimation of cointegrating relationship requires that all time series variables in the model to be integrated order of one.

In order to provide an intuitive analysis of the results generated from this research, several post estimation diagnostic tests were analysed. Heteroskedasticity, serial correlation, and cross-sectional dependence were tested for the above econometric models before estimation and corrected accordingly.

4. RESULTS AND DISCUSSION

4.1 Panel Unit Root Test

Accordingly, Levin-Lin-Chu (LLC, [15]) technique was conducted at level and at first difference and the result is reported in Table 1. The results reveal that all the variables are stationary at level except agricultural research and development variable. However, agricultural research and development variable become stationary after the first difference implying that the variable is integrated of order one, I (1).

Cointegration refers to the long run linear relationship of two variables that are stationary after differencing and have to be integrated of the same order. However, dependent variable (agricultural economic growth) was found to be stationary at level, conducting cointegration test was impossible because the dependent variable and the independent variables were now not integrated of the same order.

From the Hausman test result, the p-value is greater than 0.05(0.28) which means that the difference is not statistically significant and so the null hypothesis of the preferred model being random-effects model was not rejected. So the random effects regression model was used to analyse the relationship between the dependent variable and the independent variables and the result represented in Table 2.

From the econometrics model findings, the coefficient of agricultural research and development R&D spending is 0.9. This means that a one percent increase in agricultural R&D expenditure leads to a 0.9% increase in agricultural output (growth). Since the p-value (0.03) is less than 0.05, it means that the coefficient is statistically significant at a 5% level. The coefficient is positive and this conforms to economic theory. The endogenous growth theory concludes that R&D leads to an increase in the stock of knowledge which in turn has got spill-over effects hence leads to economic growth.

Table 1. LLC panel unit root test results

Variables in Logs	Levin-Lin-Chu at level		Order	LLC at First difference		Order
	t value	P value		t value	P value	
ln y	-4.6993***	0.0000	I(0)	_	_	_
lnra	-1.8285	0.0517	I(1)	-5.5125	0.0000	I(0)
lnro	-3.6391***	0.0002	I(0)	_	_	_

*** one percent level of significance, **five percent level of significance*

Table 2. Random regression results

Random variable	Coefficient	Std. error	Z Statistic	P Value
lnra	0.8533**	0.3969	2.15	0.032
lnro	0.3160***	0.1232	2.56	0.010
lnrl	-0.9728**	0.4537	-2.14	0.032
lnrk	0.1216**	0.0576	2.11	0.035
lnal	0.1613***	0.0595	2.71	0.007
cons	0.2975	0.6071	0.49	0.627
Goodness of fit test	Adjusted R^2 = 0.57			
Breusch Pagan LM test	p-value = 0.19			
Modified Wald test	p-value = 0.45			
Pesaran CD analysis	p-value = 0.12			

*** one percent level of significance, **five percent level of significance

The significant and positive result can be attributed due to increased budget on agricultural research and development which leads to an increase in innovation, technology and, knowledge on crop protection and resistance which help in averting crop failures in the event of a drought, increasing soil fertility hence high yield and output, use of high quality machines in agriculture which made the production process to go faster hence high-quality and quantity of products within a short period of time. Advanced technology and machines include tractors for tilling the land, machines for planting and harvesting, and machines for milking. Advanced agricultural technology also provided solutions to livestock and crop diseases in African economies. This technology stimulates agricultural output through increased animal and crop productivity. Once agricultural research and development have been done by a particular research institution or an individual and a new product or service is invented, spill-over effects of the new knowledge occur and this leads to increased agricultural productivity. As stipulated in neo-classical economic theory with proper diffusion of knowledge and technology generated through agricultural R&D, the economy is likely to experience positive output growth. The finding by Pardy et al. [17] and Khaksar and Karbasi [18] were similar to the findings of this study.

From the result in Table 2, cross-sectional dependence, autocorrelation and heteroscedasticity were not a problem in this study. Also, the adjusted R^2 was 0.57 implying that about 60 percent of the variations of the dependent variable are jointly explained by the explanatory variables in the regression model. Therefore, it implies that the overall goodness of fit is satisfactory.

5. CONCLUSION

The positive and statistically significant relationship between agricultural R&D expenditure and agricultural sector growth could be because of the spill over effects of agricultural knowledge generated through agricultural R&D. Further, the positive and statistically significant effect of R&D expenditure on other sectors on the agricultural sector growth could be because of the spill over effects of R&D in general.

Research and development expenditure in agricultural sectors contributes positively to agricultural sector growth and the aggregate growth and because of that, budgetary allocations to R&D in all sectors should be increased by the governments of East Africa economies every financial year, more research scientists in all sectors should also be employed, trained and educated and also to have good remuneration and job security. In addition, the governments should also ensure that the knowledge generated through R&D in other sectors is disseminated to the public through publications in journal articles. Regions should put in efforts in developing new ideas but, at the same time, should create a proper climate for the development and implementation of new ideas through better policies and strengthening institutions.

6. AREAS OF FUTURE RESEARCH

However, there are some research limitations to this study, foremost, the available data where, in general, the data on the aggregate level are more complete as opposed to data on the regional level. Further disaggregation of data is

necessary so as to determine the effect of R&D on agricultural labour or capital and their influence on agricultural sector growth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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