EFFECT OF RESEARCH AND DEVELOPMENT ON AGRICULTURAL SECTOR GROWTH IN THE EAST AFRICAN COMMUNITY (2000-2014)

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DECLARATION AND RECOMMENDATION

Declaration

This research thesis is my original work and to the best of my knowledge has not been presented for the award of any degree in any university or institution.

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Recommendation

This research thesis has been submitted for examination with our approval as university supervisors

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DEDICATION

This research thesis is dedicated to my parents Lucy Akoth Wanga and David Ouru.

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ABSTRACT

This study empirically examined the effect of research and development on agricultural sector growth in East African Community from the year 2000-2014. According to the endogenous growth theory, research and development leads to increase in the stock of knowledge which in turn has got spill over effects hence leads to economic growth. However, information on the effect of R&D on the agricultural sector in the EAC was lacking hence the study sought to bridge this knowledge gap. The objective of the study was to determine the effect of research and development on agricultural sector growth in the EAC. Historical design was employed while descriptive methods were used to show relevance of the information. Panel data analysis was used as it controls for country specific effects that makes the results gotten to be applicable to all the countries since the study involved five different countries. Random effects regression results showed that all explanatory variables had a positive relationship with the dependent variable significantly except the interaction of agricultural R&D and agricultural labour which had a negative relationship significantly and the recommendations are: That R&D to be allocated more funds; more research scientists and agricultural labourers to be employed, trained and motivated through better remuneration and good work environment; R&D based knowledge to be disseminated to the public through publications; firms to train agricultural labourers on how new technologies are being used and also to allocate them duties and responsibilities that match their skills and that agricultural capital costs be subsidised. The study has increased the stock of knowledge in addition to identifying other areas of future research. The results of this study may be of importance to agricultural policy makers in the government and in the private sectors. Future researchers may also gain from this study for comparison purposes. Future researchers can expand the period of a study similar to this and also study more countries; in addition, they should also focus on disaggregated R&D expenditures in other sectors. More studies should also be done on the effect of the interaction of agricultural R&D and agricultural capital on agricultural sector growth and also the effect of the interaction of agricultural R&D and agricultural labour on agricultural sector growth.

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ABBREVIATIONS/ACRONYMS

CNT	Centre National de Technologie Alimentaire
COSTECH	Commission for Science and Technology
DRD	Department of Research and Development
EAC	East African Community
GDP	Gross Domestic Product
ISAR	Rwanda Agricultural Research Institute
KALRO	Kenya Agricultural and Livestock Research Organization
NARO	National Agricultural Research Organization
NCST	National Council for Science and Technology
OECD	Organization for Economic Cooperation and Development
R&D	Research and Development
STI	Science, Technology and Innovation
UNCST	Uganda National Council for Science and Technology

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Research and development (R&D) is a general term for activities related to the enterprise or corporate or governmental innovation (Svensson, 2008). Research and development represents a large and rapidly growing effort in both industrialized and semi-industrialized nations. In 1997, the USA spent $151 billion on industrial R&D and $32 billion on military R&D. Similar ratios exist for economically advanced countries, such as Germany, France, the United Kingdom and Japan (Svensson, 2008). In order to compete in the international marketplace, rapidly industrialising countries such as Korea, Indonesia and Brazil have national policies in place for developing indigenous R&D (Svensson, 2008). Major countries not politically aligned with the western powers-notably Russia, China, and India, and to a certain extent, France and Israel have significant levels of R&D for defence purposes, in order to be technologically and logistically independent from western sources and to export arms to third world countries (Svensson, 2008). South Africa, Iraq, and North Korea spent inordinate amounts of their limited GNPs for military purposes in the 1990s. The reason for this increased emphasis on R&D is that it creates new or improved technology that in turn can be converted into a competitive advantage at the business, corporate, and national level (Svensson, 2008). While the process of technological innovation is complex and risky, the reward can be very high. If technology can be safeguarded as proprietary, and protected by patents, trade secrets, non disclosure agreements, etc, the technology becomes the exclusive property of the company and the value is much higher (Svensson, 2008).

In earlier neo-classical theory, knowledge is regarded as an exogenous variable that, together with a company's input goods, labour and capital, affects productivity (Solow and Swan, 1956). In endogenous growth theory, on the other hand, investments in R&D that provide new knowledge are seen as an important factor that explains growth and increased productivity (Romer, 1990). This theory regards new technology not only as an exogenously produced input good that the company utilises but new technology can also be created within the company. In endogenous growth theory, investments in R&D can provide long term growth and lead to rising returns to scale (Romer, 1990). This is because previous R&D investments that were made to generate specific knowledge do not need to be made again. The replication of previous production does not therefore have to bear the burden of any R&D costs.

Common capital goods such as machines and means of transport and even labour are products for which there is rivalry; they cannot be used at the same time for different purposes. Knowledge, however, is a product that is non-rivalry. This means that a company's use of the product (knowledge) does not diminish any other company's use of the product (Jones, 2004). However, knowledge is often, also non excludable. A company that has invested in R&D to acquire new knowledge may find it difficult to prevent other companies from using this new knowledge unless it is patented thus knowledge becomes "a public good". It is also highly unlikely that a company will itself have the expertise required to utilise all the knowledge generated by the R&D concerned (Svensson, 2008)). These factors explain how R&D can lead to spillovers to other companies and can lead to rising returns to scale which otherwise contradict the neo-classical theory.

The non-excludability of new knowledge and the occurrence of spillovers lead, as mentioned above, to a great risk that companies on a free market will invest too little in R&D. There are three ways of addressing the problem. First, intellectual property rights can protect the originators of new knowledge (Svensson, 2008). Patents are the most common instruments used here, but copyright and trademarks are also used. These exclude others from using the knowledge concerned. Secondly, the state can assume responsibility for the funding and production of new knowledge, with the aim of ensuring that the knowledge is then disseminated (Svensson, 2008). State universities and laboratories that conduct R&D are the foremost examples of this system. Sometimes the state just provides the funding and allows companies to perform the R&D. This is particularly effective if the private return is low and the social return high. Third, a contract can be drawn up between a party that produces the new knowledge and another party that is interested in it (Svensson, 2008). Contract research where the state funds companies that perform R&D in the defence industry is an example of this.

R&D that is performed by a company often leads to new and/or improved goods and services that the company then sells (Kim, 2011; Svensson, 2008). The company may not be able to utilise some of the results of its R&D and these may then be transferred through various channels (imitation, personnel who change jobs, licensing, cooperation between companies) to other companies (Svensson, 2008). Mansfield (1981) estimated that the cost of imitating a product is 65 percent of the original innovation costs. Performing R&D also leads to further training for the company's personnel. In addition, the company becomes better at absorbing knowledge that is generated at universities and other companies (Cohen and Levinthal, 1989; Geroski, 1995). This improves the ability of a company to utilise spillovers from other companies. Many observers, including (Callon, 1994) point out that knowledge generated as a result of R&D is not a public good that can be utilised by everyone. A certain form of education and training and the right networks are required to be able to understand and utilise new knowledge generated by others thus associated with a cost. Another characteristic of knowledge is that it cannot always be codified but is“tacit”, that is, the researchers or scientists know more than they can put into words (Rosenberg, 1990; Pavit, 1991). In general, this requires the participation of the researchers concerned if new research results are to be converted into innovations.

The East African Community is an intergovernmental organisation comprising five countries in the African Great Lakes region in Eastern Africa: Burundi, Kenya, Rwanda, Tanzania and Uganda. The organisation was originally founded in 1967, collapsed in 1977, and was officially revived on 7^{th} July 2000.All five of the East African community countries have shown their commitment through the formulation of relevant and the establishment of bodies in charge of higher education, science, technology and innovation (Tumushabe and Mugabe, 2012). There are bodies dedicated to higher education research, science and technology already in place in East Africa; the National Council for Science and Technology (NCST) in Kenya, the Commission for Science and Technology (COSTECH) in Tanzania, the National Council for Science and Technology (UNCST) in Uganda, the Ministry of Education in Rwanda and, the Ministry of Higher Education and Scientific Research in Burundi (Tumushabe and Mugabe, 2012). In addition, the EAC states allocates funds for R&D for example during the period 2000-2014, Burundi spent an average of 0.2% of its GDP on R&D, Kenya spent an average of 0.67% of its GDP on R&D, Uganda spent an average of 0.43% of its GDP on R&D, Tanzania spent an average of 0.36% of its GDP on R&D while Rwanda spent an average of 0.22% 0f its GDP on R&D (Tumushabe and Mugabe, 2012). These point to recognition of the role of higher education research, science and technology transfer in economic development in the East African Countries. All of these five countries that currently form the East African Community (EAC) are making an effort in the realisation of higher education research, innovations and technology-through the formulation of enabling policies.

EAC states have formulated policies to guide research and innovations and technology transfer, for example in Kenya, there is facilitation of acquisition of intellectual property rights by scientists; researchers and innovators, in Tanzania, there is the high level scientific research and technological trainings, motivation and retention programmes which include provision of attractive terms and conditions of service for scientists and technologists while in Rwanda, there is regular audit of research and knowledge transfer capacity to enable the quality and extent of research and knowledge transfer activity be properly assessed and in Uganda, there is support for local innovation and scientific excellence by funding national research priorities and providing infrastructure for technology generation and incubation and these if fully implemented, would see great accomplishments in higher-education research, science and technology activities, as well as increased collaborations with industry that would lead to the economic development of these nations (Tumushabe and Mugabe, 2012).

1.2 Statement of the Problem

Agriculture is the engine of economic growth and cornerstone of poverty reduction in the EAC states. Approximately 70% to 80% of the population rely on agriculture as their primary source of livelihood. The sector also accounts for 24% to 48% of GDP in the EAC and almost 60% of its total export earnings besides the provision of 90% of 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, their 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. The East African Community (EAC) partner states are committed to agricultural research and development through their established agricultural research institutions like Kenya Agricultural Research Organization in Kenya, National Agricultural Research Organization in Uganda, Department of Agricultural Research in Tanzania, Agricultural Research Institute in Rwanda and Centre National de Technologie Alimentaire in Burundi. Despite agricultural R&D being carried out by these agricultural research institutions in the EAC, the sector still faces the challenges of low funding, low productivity, poor farming techniques and lack of awareness by farmers on better farming methods. In addition, there is dearth of information on the effect of R&D on the agricultural sector growth in the EAC; it is the purpose for this study to provide insights into it.

1.3 Objectives of the Study

1.3.1 General Objective

The overall objective of this study was to assess the contribution of research and development to the agricultural sector in East African Community.

1.3.2 Specific Objectives

i. To determine the effects of agricultural R&D on agricultural sector growth in the EAC.

ii. To investigate the effect of R&D in other sectors on agricultural sector growth in the EAC.
iii. To examine the interactive effect of agricultural capital and agricultural R&D on agricultural sector growth in the EAC.
iv. To establish the interactive effect of agricultural labour and agricultural R&D on agricultural sector growth in the EAC.
v. To determine the effect of agricultural capital on agricultural sector growth in the EAC.
vi. To determine the effect of agricultural labour on agricultural sector growth in the EAC.

1.4 Research Hypotheses

i. Agricultural R&D has no effect on agricultural sector growth in the EAC
ii. Research and Development in other sectors has no effect on the agricultural sector growth in the EAC.
iii. Agricultural capital and agricultural R&D have no interactive effect on agricultural sector growth in EAC.
iv. Agricultural labour and agricultural R&D have no interactive effect on agricultural sector growth in EAC.
v. Agricultural capital has no effect on agricultural sector growth EAC.
vi. Agricultural labour has no effect on agricultural sector growth in EAC.

1.5 Significance of the Study

East African Community partner states are committed to the promotion and support of R&D through targeting expenditure of one per cent of their national GDPs on R&D, making research and development policies and also establishing research institutions. There have been mixed results on the effect of R&D on growth in other regions and economies and little is also known on R&D interaction with capital and labour. This study is therefore of importance to policy makers to come up with research and development policies that are relevant to the agricultural sector in the EAC. The study has also contributed to an increase in the stock of knowledge about agricultural R&D. In addition, other areas for future research have also been identified through this study. The study is also of importance to future researchers in the field of R&D because the findings can assist in making comparisons with the findings of their studies.

1.6 Scope of the Study

Research and development leads to increase in the stock of new knowledge which according the endogenous growth theory has got spillover effects which in turn leads to economic growth. The study covered East African Community states. The period of study was from the year 2000 to the year 2014. The period was chosen because it is within this period that data was readily available and it was also from the year 2000 that EAC was revived. EAC is also characterised by free movement of service workers across borders which is expected to be a source of efficiency, increased competitiveness and economic growth. In addition, the revival of the EAC also came with renewed emphasis on cooperation in STI.

1.7 Limitations of the Study

Only data on agricultural R&D and data on overall R&D could be easily accessed. This therefore made it impossible to determine the effect all specific sectors R&D on agricultural sector growth in the EAC. To overcome this challenge, agricultural R&D and aggregated R&D in other sectors (a part from the agricultural sector) were made specific objectives i and ii respectively. Aggregated R&D in other sectors was therefore to account for R&D other sectors that their specific data were lacking. In addition, one of the objectives (interactive agricultural R&D expenditure and agricultural capital) was dropped because of multicollinearity in the analysis process and this limited the objectives of this study. Literature on interaction of R&D and labour was also lacking and so there was no literature to make comparison with in the case of the interactive effect of agricultural R&D expenditure and agricultural labour on agricultural sector growth which was one of the objectives of this study. To address this problem, the relationship between interactive agricultural R&D and agricultural labour has been identified to be an area of future research to help reveal more information.

1.8 Definition of Terms

Agriculture: Advanced Learners Dictionary defines it as the art and science of growing plants and other crops and the raising of animals for food, other human needs, or economic gains.

Agricultural Capital: According to this study, it refers to fertilizers, livestock drugs and medicine, spares and maintenance of machinery, small implements, manufactured feeds, tractor services, transportation, raw materials, factories and infrastructure.

Agricultural labour: According to this study, it is defined as the population or work force that is engaged in agricultural activities mainly for livelihood.

Agricultural R&D: In the context of this study, it refers to innovative work/study undertaken to extend the frontiers of agricultural knowledge.

Agricultural Sector Growth: Based on this study, it refers to the output levels of the sector that deals with the art and science of growing plants and other crops and the raising of animals for food, other human needs, or economic gains.

Gross Domestic Product: This according to the Dictionary of Economics refers to the market value of all the goods and services produced by labour and property located in a region, usually a country within a given period of time usually one year.

Human Capital: According to Economics Dictionary, Human capital refers to the abilities, skills and knowledge of any individual that are acquired through investment in education and training that enhance potential income earning.

Knowledge: According to Advanced Learners' Dictionary, knowledge is a familiarity, awareness or understanding of someone or something, such as facts, information, descriptions, or skills which is acquired through experience or education by perceiving, discovering or learning. Knowledge can refer to a theoretical or practical understanding of a subject.

Panel Data: According to this study, it refers to cross-sectional time series data set in which the behaviour of entities such as states, companies and individuals are observed across time.

Research and Development: This according to World Bank is creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture and society, and the use of knowledge for new application. R&D covers basic research, applied research and experimental development.

Research and Development Expenditure: According to World Bank, it refers to current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new application.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

This chapter has reviews of some of the theories of R&D and summarizes the related results of the actual research that have been done by other scholars in the area of R&D or other areas related to R&D.

2.2 Theoretical Literature Review

2.2.1 The Arrow Model of Endogenous Growth

Arrow (1962) model regarded learning by doing as endogenous in the growth process. The theory hypothesised that at any moment of time, new capital goods incorporate all the knowledge then available based on accumulated experience, but once built, their productive deficiencies cannot be changed by subsequent learning. The theory showed that if the stock of labour is held constant, growth ultimately comes to a halt because socially very little is invested and produced. The argument by Arrow (1962) that learning by doing is endogenous in the growth process is true and this has been supported by Segura and Rodriguez (2004) who said that learning is a product of experience (doing) that takes place during activity, since it usually occurs through the attempt to solve a problem. Rotheli (1993) also supported this theory by saying that the observation by Arrow proved the capability of workers to improve their productivity by regularly repeating the same type of action. The increased productivity is achieved through practice, self perfection and minor innovations. However, Arrow (1962) model emphasized only on endogenous growth process based on an existing stock of knowledge but not a new stock of knowledge generated through R&D. Romer (1994) criticised this model by saying that for technical reasons, the fact that this model could lead to sustained endogenous growth was not emphasised.

2.2.2 Sheshinski Theory

Sheshinski (1967) theory emphasises the spill-over effects of increased knowledge through learning by doing as the source of knowledge. The theory says that the source of knowledge or learning by doing is each firm’s investment and an increase in a firm’s investment leads to a parallel increase in its level of knowledge. The theory also says that the knowledge of a firm is a public good which other firms can have at zero cost. Thus knowledge has a non-rival character which spills-over across all the firms in the economy. This stems from the fact that each firm operates under constant returns to scale and the economy as a whole is operating under increasing returns to scale. The argument by Sheshinski (1967) that increased knowledge through learning by doing has got spillover effects is true and Romer (1986) showed later that an equilibrium rate of technological advance can be determined in this case if the competitive framework can be retained. However, such a growth rate would typically not be Pareto optimal. In general, the competitive framework may not be valid if new ideas depend particularly on purposive R&D and if innovations spread only progressively to other producers. The theory also assumes that knowledge of a firm is a public good which other firms can have at a zero cost which in real sense is not true sometimes. Finally, the theory is not R&D based which caters for the creation of new knowledge.

2.2.3 Lucas Theory

Lucas (1988) theory says that investment on education leads to the production of human capital which is the crucial determinant in the growth process. He makes a distinction between the internal effects of human capital where the individual worker undergoing training becomes more productive, and external effects which spill over and increase the productivity of capital and of other workers in the economy. The theory says that it is investment in human capital rather than physical capital that have spill over effects that increase the level of technology and hence increasing the productivity of capital and workers in the economy. Lucas (1988) view that accumulation of human capital rather than physical capital is the source of economic growth because of the spillover effects of human capital is true and this has been supported by the approach of Benhabib and Spiegel (1994) who assumes that stock of human capital determines the ability of an economy to develop and assimilate technologies and thus produce economic growth. A criticism raised against the Lucas model is that intentionally accumulated nontrivial knowledge is neglected. According to Romer (1989), education yields primarily skills which are tied to human bodies and therefore rival. Non-rival knowledge that is passed on to future generations is viewed only as a by-product of production. In reality, non-rival knowledge is intentionally accumulated, scientific research and commercial development yield primarily ideas and designs that can be employed by workers but are not necessarily tied to them. In addition, Lucas model is human capital based and not R&D based.

2.2.4 King-Robson Theory

King-Robson (1989) theory emphasise learning by watching. The theory says that investment by a firm represent innovation to solve the problems it faces. If it is successful, the other firms will adapt the innovation to their own needs. Thus the externalities resulting from learning by watching are a key to economic growth. The theory says that innovation in one sector of the economy has the contagion or demonstration effect on the productivity of other sectors, thereby leading to economic growth. The theory concludes that multiple steady state growth paths exist even for economies having similar initial endowments and that policies that increase investment should be pursued. The emphasis of King-Robson (1989) that learning by watching leads to spillover effects of knowledge is true and this has been supported by Scott (1989) who said that ongoing production processes are seen as heritage from the past. Increases in production can be brought about by changing production processes and by changing existing economic arrangements, which requires investment outlays to be made. At the same time, every transformation implies problem solving from which people learn. However, learning by watching is not automatic as the theory almost inevitably suggests. In fact it depends on the organisation of industry and trade and the way firms take advantage of these opportunities. This was according to Porter (1990) who said that competitive advantage emerges from close working relationships between world class suppliers and the industry. Firms gain quick access to information, to new ideas and insights, and to supplier innovations. They have the opportunity to influence suppliers' technical efforts as well as serve as test sites for development work. The exchange of R&D results and joint problem solving leads to a faster and more efficient solution. Suppliers also tend to be conduits for transmitting information and innovations from firm to firm. Through this process, the pace of innovation within the entire national industry is accelerated. So lack of close working relationships may hinder learning by watching hence making it not to have spillover effects. In addition, King-Robson theory is not R&D based which caters for the creation of new knowledge but instead emphasizing on the spillover effects of an existing stock of knowledge.

2.2.5 The Romer Model of Endogenous Growth Theory

Romer (1990) model identifies a research sector specialising in the production of ideas and this involves human capital along with the existing stock of knowledge to produce ideas or new knowledge. The new knowledge enters into the production process in three ways. First, a new design is used in the intermediate goods sector for the production of a new intermediate input. Second, in the final sector, labour, human capital and available producer durables produce the final product. Third, a new design increases the total stock of knowledge which increases the productivity of human capital employed in the research sector. However the increase in the stock of knowledge due to a new design may be limited through patenting and lack of proper dissemination of knowledge. Romer's approach postulates innovation of new capital goods that make production of final goods less costly and this is true as it gets the support of Grossman and Helpman (1991) together with Aghion and Howitt (1992) who developed models where innovation improves the quality of existing varieties of capital goods. However, the shortcoming in Romer's (1990) model is that there is an infinite life for a R&D patent. This contradicts facts in real life, which are usually less than twenty years and so the spillover effects of new knowledge created through R&D is is not much affected by patents as they exist only for a while but even if patents can exist for long or forever, they even encourage more R&D activities which leads to more increased new knowledge which in turn spillsover and hence leading to growth. So with or without R&D patents, spillover effects of new knowledge generated through R&D will still take place.

2.3 Empirical Literature Review

Some researchers conducted research on the effect of R&D and other areas related to R&D on economic growth in different countries and regions. All of them have come up with different results hence they have been inconclusive.

According to Sessional paper of Kenya Vision 2030 (2012), new knowledge plays a central role in boosting wealth creation, social welfare and international competitiveness. In addition, the Sessional paper on policy framework for education, training and research (2004) recognises that R&D is a means of creating wealth and enhancing human development and is a critical component of higher education and training. It also plays a vital role in industrial transformation, economic growth, and poverty reduction. However, quality research requires sufficient funding, availability of highly trained research staff, adequate and appropriate facilities and equipment.

According to the Tanzania National Science and Technology Act (1986), COSTECH was established as the national institutional mechanism to mobilise funds for support and promotion of scientific research and technological development from both the government and other sources. The purpose of the Fund is to finance research or studies relating to the development of science and technology, the training of citizens of Tanzania and innovation projects. However, this council may exist but may fail to be effective in discharging its mandate.

The Uganda National Science, Technology and Innovation Policy (2009) supports basic, applied and development research for enriching the STI knowledge base and product development for enhancing indigenous knowledge and adaptation of imported knowledge through provision of adequate public funds for national research programs and financial incentives for researchers thus reducing brain drain. However, this may be done but may not be effective sometimes.

According to the Rwanda National Science, Technology and Innovation Policy (2006), the government of Rwanda decided to establish a national research fund to be administered by the National Commission on Science, Technology and Innovation. The policy states that the government shall allocate annually 0.5% of the total budget to the national research fund to be managed by NCSTI for R&D activities oriented towards the development goals of Rwanda. However, the government may fail to fulfil what has been stated in the policy.

According to Wu (2010) who studied provincial data in China on the effect of R&D on economic growth, he found that R&D has a positive effect on the regional innovation rate and that innovation has a positive effect on productivity and consequently economic growth in China. The finding of Wu (2010) is satisfactory as it conforms to endogenous growth theory. However, his finding was only applicable to China and so prompted the need to investigate how R&D influences growth in the EAC and specifically the agricultural sector growth since agriculture is a key sector in the EAC states with serious R&D investments.

Nunes *et al*. (2012) conducted a study to determine whether there are similar relationships terms of R&D intensity and growth between small and medium size enterprises with high technology and those which lack high technology in China. According to their findings, R&D intensity restricts the growth of enterprises with high technology at lower levels of intensity and encourages them to grow at higher levels. However, R&D intensity restricts the growth of enterprises without high technology regardless of the level of R&D. The finding of Nunes *et al*. (2012) is satisfactory and conforms to the endogenous growth theory of economic growth. However, it is important to note that their finding was only applicable to China and so prompted the need to find out how R&D influences growth in the EAC specifically the agricultural sector growth because the agricultural sector is a key sector in the EAC states.

In addition, Kim (2011) analysed the effect of R&D activities on economic growth in Korea by using R&D based Cobb-Douglas production function and the data for the period 1976-2009. According to his empirical findings, traditional production factors like labour and capital contributed to economic growth by approximately 65%. The contribution of R&D stocks on economic growth was approximately 35%. Detailed analysis showed that the contribution of private and public R&D stocks on economic growth is 16% and 19% respectively. The findings of Kim on how R&D contributed to economic growth are convincing as they coincide with the endogenous growth theory of economic growth. However, the findings are only relevant to Korea and as a result, there was need to investigate how R&D relates to growth in the EAC using which in this study is between R&D and agricultural sector growth.

Peng (2010) analysed the relationship between R&D expenditures and economic growth for China and concluded that increased R&D expenditure by 1% lead to an increase in the GDP of China by approximately 0.92%. The finding of Peng (2010) is right and satisfactory since it supports the endogenous growth theory of economic growth. However, increase in R&D expenditure may not necessarily lead to increase in economic growth in some situations and some countries or regions and so this led to the need to investigate the relationship between R&D and growth (agricultural sector growth) in the EAC so as to come up with policies that are relevant to the EAC.

According to Sadraoui *et al*. (2014), who analysed the causality between R&D collaboration and economic growth by using data of 32 industrialised and developed countries for the period 1970-2012, they found a strong causality between economic growth and R&D collaboration. On the contrary, the non-causality between R&D collaboration and economic growth couldn't be refused in several contexts. However, the results showed that if there is such a relationship, a Granger causality test with one or two variants cannot be defined easily. The findings of Sadraoui *et al*. (2014) are applicable because increased economic growth sometimes is the one that leads to increase in R&D and again, R&D sometimes may not necessarily lead to increased economic growth due to factors like improper dissemination of knowledge generated through R&D. However, Sadraoui et al. (2014) studied different countries that have different characteristics using Granger causality test which does not control for the specific characteristics of the different countries. To address such a problem, a panel data analysis that controls for the different countries' specific effects was used in this study. This therefore makes the results that are gotten to be applicable to all the countries that were studied because their specific characteristics have been controlled.

Altin and Kaya (2009) analysed the relationship between R&D expenditures and economic growth by using the data for Turkey for the period between 1990-2005 and found that there is no causal relationship between R&D expenditures and economic growth in the short term, but there is a causal relationship from R&D expenditures to economic growth in the long term. The finding of Altin and Kaya (2009) is true and satisfactory as it confirms what endogenous growth theory says that R&D leads to increase in the stock of knowledge which in turn has got spillover effects which leads to economic growth. However, their finding was only applicable for making policies in Turkey and so this prompted the need to investigate the relationship between R&D and growth, specifically agricultural sector growth in the EAC so as to come up with policies that are relevant to the agricultural sector in the EAC.

According to Korkmaz (2010) who analysed the relationship between R&D investments and economic growth with co integration method by using the data for the period 1980-2008, the finding was that there was co integration between both variables that affect each other in the long term. The finding of Korkmaz (2010) is relevant as it supports the endogenous growth theory that shows that there is a positive relationship between R&D and economic growth. However, the study of Korkmaz (2010) just investigated the relationship between R&D in general and economic growth in general. To bridge the knowledge gap that Korkmaz (2010) created, this study therefore concentrated on a specific sector (agricultural sector growth) as the dependent variable and again disaggregated R&D into agricultural R&D and R&D in other sectors in the EAC some of the explanatory variables.

Taban and Sengur (2013) analysed the relationship between R&D and economic growth by using the data for the period 1990-2012 in Turkey using co integration models. They reached to the conclusion that R&D expenditures affect economic growth positively in the long term. Their finding is right as it supports the endogenous growth theory which says that there is a positive relationship between R&D and economic growth. However, this result applies only to Turkey and to economic growth in general. This therefore led to the need to find out how R&D affects agricultural sector growth in the EAC states since this is now a sectoral based study. Gulmez and Yardimcioglu (2012) in their analysis on the relationship between R&D expenditures and economic growth in OECD countries by using data for the period 1990-2010 came to the conclusion that there is a significant interactive relationship between R&D expenditures and economic growth variants in the long term. Their finding is true as it supports the endogenous growth theory. However, their finding was only applicable to the OECD countries and not to other parts of the world. To come up with policies that are specifically relevant to the EAC, a study specifically for EAC was necessary hence led to this study.

Genc and Atasoy (2010) analysed the relationship between R&D expenditures and economic growth by using the data for the period 1997-2008 through the use of causality method. They found that there is a unilateral causality relationship from R&D expenditure to economic growth. The finding of Genc and Atasoy (2010) is satisfactory and is in line with the endogenous growth theory which emphasizes positive spillover effects of knowledge. However, their study was on general economic growth but did not investigate how R&D affect specific sectors as has been done in this study which has addressed the effect of R&D on the agricultural sector growth in the EAC.

Pardy *et al*. (2012) studied the effect of R&D in the agricultural sector in Asia and Pacific region for the period 1960-2009. They found that countries with larger agricultural economies are likely to invest more in agricultural R&D and those with smaller agricultural economies are likely to invest less in agricultural R&D simply because of congruent effect. They concluded that the intensity at which the Asia and Pacific region invests in agricultural R&D has grown much more modestly from 0.43 percent of agricultural GDP in 1960 to 0.52 in 2009. While this region has sustained growth in agricultural R&D spending at a comparatively rapid pace, averaging 5.1 percent per year since 1960, agricultural output has grown at reasonably rapid rate as well (3.71 percent per year). Thus the growth in spending on agricultural R&D has more than kept pace with the growth in the value of output, such that the region's research intensity has inched up over time and increasingly so after the mid -1990s. The findings of Pardy *et al*. (2012) are true as far as endogenous growth theory is concerned as it has proved endogenous growth theory right. However, the findings are only applicable to the agricultural sectors of Asia and Pacific regions and so to come up with results that are relevant to the EAC states, a similar study for EAC states was necessary which this study has met.

Fuglie and Marder (2015) in their study on the effect of the adoption of improved crop varieties of 20 crops from 1970 to 2010 which covered 37 Sub Saharan countries found that the improved varieties had a major positive impact on agricultural productivity. Their finding proves satisfactory as it is in line with the endogenous growth theory. However, their study was biased towards the relationship between agricultural research and agricultural productivity. To address this problem, this study has factored in the relationship between R&D in other sectors and agricultural sector growth besides the relationship between agricultural R&D and agricultural sector growth.

Bagherzadeh and Komeijan (2010) considered the impact of agricultural R&D spending on agricultural total factor productivity of Iran during 1979-2009 using Almon Distributing lag and concluded that the long run elasticity of this factor is 0.17 percent and the rate of return of investing in agricultural R&D spending is 0.36 percent that is much lower comparing the world mean rate (0.51). The findings of Bagherzadeh and Komeijan (2010) are as per the endogenous growth theory of economic growth and thus satisfactory but their study failed to cover the influence of R&D in other sectors on agricultural total factor productivity. This knowledge gap has therefore been bridged in this study by factoring in the effect of R&D in other sectors on agricultural sector growth besides the effect of agricultural R&D.

Mehrabi and Javdan (2011) investigated the relationship between agricultural R&D expenditure and agricultural total factor productivity for Iran during 1974-2007 using Auto Regression Distributing Lag model. They computed agricultural total factor productivity using Kendrick's Index for selected data and concluded that R&D spending has positive significant effect on total factor productivity in both long-run and short run in agriculture sector. That is one percent increase in agricultural R&D spending will increase agricultural total factor productivity by 0.1 percent. They suggested that R&D spending is one of the main factors to improve agricultural growth. Their findings are convincing and satisfactory since they have supported the endogenous growth theory. However, they did not take into consideration the effect of R&D in other sectors on agricultural total factor productivity which this study has addressed

Lastly, Pardy *et al*. (2016) in their analysis on the estimates of returns to agricultural R&D in 25 countries in Africa from 1975 to 2014 found high rates to agricultural R&D with a median of 35% and a mean of42%. Their results truly reflect endogenous growth theory. However, their study concentrated only on returns to agricultural R&D and ignored returns to R&D in other sectors. This knowledge gap has therefore been closed in this study by determining the effect of R&D in other sectors on agricultural sector growth in the EAC.

In summary, empirical studies on the effect of R&D on growth have led to different results in different economies hence they have been inconclusive. In addition, studies on embodiment of technology in capital and labour are also lacking hence studies needs to be done to close these gaps.

2.4 Theoretical Framework

This study was based on Romer (1990) model of technological change. The model identifies a research sector specialising in the production of ideas. This sector involves human capital along with the existing stock of knowledge to produce ideas or new knowledge. To Romer, ideas are more important than natural resources. He cites the example of Japan which has very few natural resources but it was open to new western ideas and technology. Therefore, ideas are essential for the growth of an economy. These ideas relate to improved designs for the production of producer durable goods for final production. In the Romer model, new knowledge enters into the production process in three ways. First, a new design is used in the intermediate goods sector for the production of a new intermediate input. Second, in the final sector, labour, human capital and available producer durables produce the final product. Third and a new design increase the total stock of knowledge which increases the productivity of human capital employed in the research sector. Romer's approach that postulates innovation of new capital goods that make production of final goods less costly is true and satisfactory and this has been supported by the arguments of Grossman and Helpman (1991) together with Aghion and Howitt (1992) who developed models where innovation improves the quality of existing varieties of capital goods.

Romer (1990) model is based on the following assumptions: First, economic growth comes from technological change; Secondly, technological change is endogenous. And thirdly, market incentives play an important role in making technological changes available to the economy, fourthly, invention of a new design requires a specified amount of human capital, fifthly, the aggregate supply of human capital is fixed, sixthly, knowledge or a new design is assumed to be partially excludable and retainable by the firm which invented the new design. Seventhly, technology is a non-rival input i.e. its use by one firm does not prevent its use by another. Eighthly, the new design can be used by firms and in different periods without additional costs and without reducing the value of the input. Ninth, it is also assumed that the low cost of using an existing design reduces the cost of creating new designs and lastly, it is assumed that when firms make investments on research and development and invent a new design, there are externalities that are internalised by private agreements. However, the shortcoming in Romer's (1990) model is that there is an infinite life for a R&D patent, this contradicts facts in real life, which are usually less than twenty years. Interestingly, R&D patents still work in favour of the Romer (1990) endogenous growth model because it will encourage other firms or countries to do their own research which will lead to increase in the stock of knowledge which will in turn have spillover effects in the economy.

Romer (1990) model of endogenous growth is derived as follows:

Assume that technological progress occurs when innovators seek out innovations.

In the neo-classical model, the stock of ideas, A is assumed to change over time, separately from the production decision. For example, in the Cobb- Douglas production function we write:

$$Y = AK^{a}L^{1-a} \quad (1)$$

The Romer (1990) model describes how capital stock, K and labour, L_Y combine using a stock of knowledge, A, if A is assumed to represent a stock of knowledge.

$$Y=K^{a}(AL_{Y})^{1-a} \qquad (2)$$

Where a is a parameter between 0 and 1. For given level of technology, A, the production function shows constant returns to scale in K and L_Y, but if A increases, then there will be increasing returns. If capital, labour, and the stock of technology all double, then output more than doubles.

We could develop the Romer (1990) model assuming that the savings rate is given exogenously.

Capital accumulation is:

$$\dot{K}= s_{k}Y-dK \qquad (3)$$

Labour grows exponentially at a constant rate, n:

$$\dot{L}/L=n \qquad (4)$$

In the neoclassical model, the productivity term A grows exogenously at a constant rate. In the Romer (1990) model, growth in A is endogenous. A_t is the stock of knowledge at time, t. It changes as a function of the number of innovators.

$$\dot{A}=\bar{\delta}L_{A} \qquad (5)$$

So labour can be used either for innovation or production. The rate of innovation might be constant or it might be positive function of the past stock of knowledge, or, if there are diminishing returns to the application of science, it might be a decreasing function of the stock,Romer (1990) asserts that,

$$\bar{\delta}=\delta A^{\Phi} \qquad (6)$$

Where $\Phi>0$ means that the productivity of research increases with the stock of A and $\Phi<0$ means that productivity is declining. Noticing that R&D tended to concentrate in a few central locations, Romer (1990) added a term, L^{λ}, to his model of the stock of knowledge. If $\lambda<1$, then researchers were wasting their time re-discovering knowledge that was already known. If $\lambda>1$, then there were complementarities (positive knowledge spillovers) in research. If $\Phi>0$, then current scientists benefit from the knowledge of earlier science.

In the Romer (1990) model, if a constant fraction of the population is employed in R&D, the model follows the neoclassical model in predicting that all per capita growth is due to technological progress.

$$G_{Y}=g_{k}=g_{A} \qquad (7)$$

Percapita output, the capital-labour ratio, and the stock of knowledge all grow at the same rate. If there is no technological progress, then there is no growth.

$$g_A=\dot{A}/A=\delta\, L_A^{\lambda}/A^{1-\Phi} \qquad (8)$$

The growth rate of A is constant only if the numerator and denominator of this expression are growing at the same rate. Taking logs and derivatives of both sides, this requires that:

$$0=\lambda\, \dot{L}_A/L_A-(1-\Phi)\, \dot{A}/A \qquad (9)$$

Along a balanced growth path, the growth rate in the number of researchers equals the growth of population (otherwise it eventually exceeds the population.) That is, $\dot{L}_A/L_A=n$. Substituting this into 1.8 yields

$$g_A=\lambda_n/1-\Phi \qquad (10)$$

This says that long run growth depends by the growth rate of innovators and the innovation production function. This means that if $\lambda=1$ and $\Phi=0$ so that the productivity of researchers is constant at δ, then the productivity of a researcher today is independent of the stock of ideas that have been discovered in the past. The production function for knowledge is:

$$\dot{A}=\delta L_A \qquad (11)$$

Notice, if the output of new knowledge is constant, at 100 new ideas per period, and unrelated to the stock of knowledge is getting larger, then the growth rate of the stock of ideas falls over time, approaching zero.

In order to generate growth, the number of new ideas must be expanding over time for example the number of researchers is increasing.

In the neoclassical model, a higher population growth rate reduces the level of per capita income a long a balanced growth path. More people means that more capital is needed to keep K/L constant, but capital runs into diminishing returns.

In the Romer (1990) model, people create new innovations which are non-rivalrous, so everyone benefits.

In the original model, assumed that $\lambda=1$ and$\Phi=1$ so that:

$$\dot{A}=\delta L_A A \qquad (12)$$

And

$$\dot{A}/A=\delta L_A \qquad (13)$$

In this case, the productivity of research is proportional to the existing stock of ideas:

$\bar{\delta}=\delta A$

In this form, the productivity of researchers grows over time even if the number of researchers is constant.

In case of a permanent increase in the R&D share (assuming that $\lambda =1$ and $\Phi=0$?), temporarily technological progress, $\frac{\dot{A}}{A}=\delta L_A$ exceeds population growth, n, so the ratio, L_A/A declines over time.

As this ratio declines, the rate of technological progress gradually falls until the economy returns to a balanced growth path where, $g_A =n$. The level of technology is permanently higher as a result of the permanent increase in R&D. There is a scale effect in levels; a larger world economy is a richer economy. Romer (1990) model was concluded on as the theoretical model for this study because it is a R&D based model which recognises the creation of new ideas just as this study is, besides being an endogenous growth model.

2.5 Conceptual Framework

This is a presentation that explains graphically the key variables and the presumed relationship among them. It shows the dependent variable, independent variables and the intervening variables.

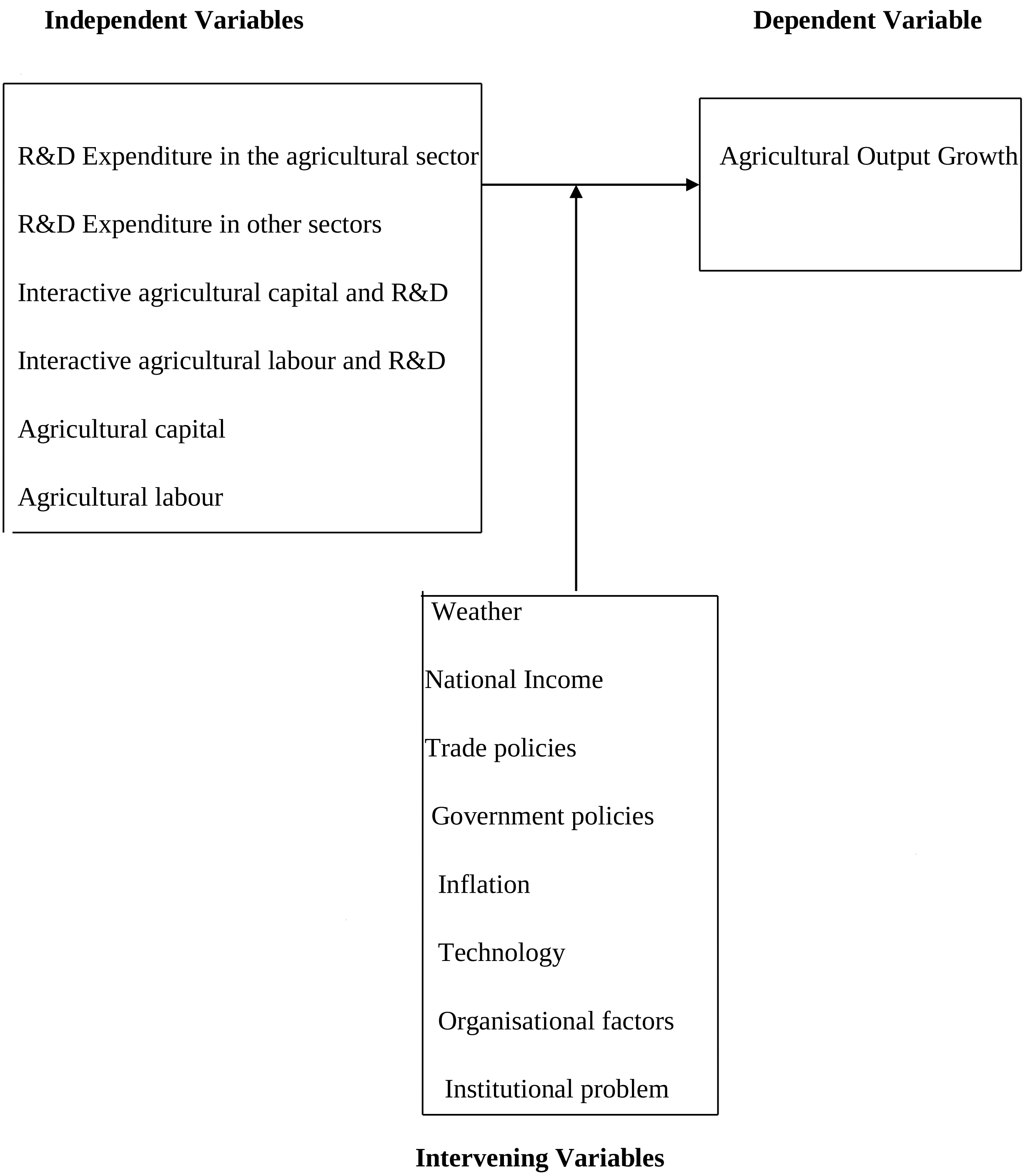

Figure 1: Conceptual Framework

Research and Development in the agricultural sector makes research institutions and researchers to conduct more and serious research activities which lead to new and improved products, processes, markets and increase in the stock of knowledge which has got spillover effects hence increase in agricultural sector growth. Research and development in other sectors may also leads to new and improved products and has got spillovers which leads to agricultural sector growth. Interactive agricultural capital and agricultural R&D is likely to lead to agricultural sector growth because of increased efficiency. Interactive agricultural labour and agricultural R&D may also lead to increased productivity due to increased efficiency hence increased agricultural sector growth. Factors like trade, government policies, inflation, technology, organisational factors and institutional problems have got influence on agricultural sector growth though indirectly.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodological basis of this research. The chapter describes the research design, the model upon which the study was grounded, variables, sources of data, methods of analysis and the methods that were employed in the analysis and presentation of findings.

3.2 Research Design

This study used historical research design as it sought to establish the effect of research and development on agricultural sector growth in East African Community over the period 2000-2014. This research design was the most appropriate as the study involved using secondary data and analysing the relationship between variables over time. This is because this design captures the trend of variables over time (Howell *et al,* 2001).

3.3 Study Area

The East African Community is an intergovernmental organisation comprising five countries in the African Great Lakes region in Eastern Africa: Burundi, Kenya, Rwanda, Tanzania and Uganda. The organisation was originally founded in 1967, collapsed in 1977, and was officially revived on 7th July 2000 (Tumushabe and Mugabe, 2012). Southern Sudan is also a new member of the EAC but it just joined recently when 90% of this study had been done and so made it difficult for it to be included.

The EAC partner states have a long history of cooperation on STI. The first three partner states-Kenya, Uganda and Tanzania-of the EAC had established a relatively strong institutional framework for cooperation in scientific research and technological activities prior to the collapse of the first EAC. They had common research programmes in the fields of agriculture, health, forestry, fisheries and technical institutes for industrial research. These countries also had common policies for STI, particularly in the areas of agriculture and Health (Tumushabe and Mugabe, 2012).

The revival of the EAC has come with renewed emphasis on cooperation in STI. The partner states have integrated STI considerations into a range of policy frameworks and adopted a protocol on STI. They have also launched a number of regional STI initiatives (Tumushabe and Mugabe, 2012).

The EAC is found in Africa and is located between (5^0N, 29.2^0E); (5^0N, 41^0E) and (11^0S, 29.2^0E); (11^0S, 41^0E) respectively as is shown in the map below which is the map of the study area.

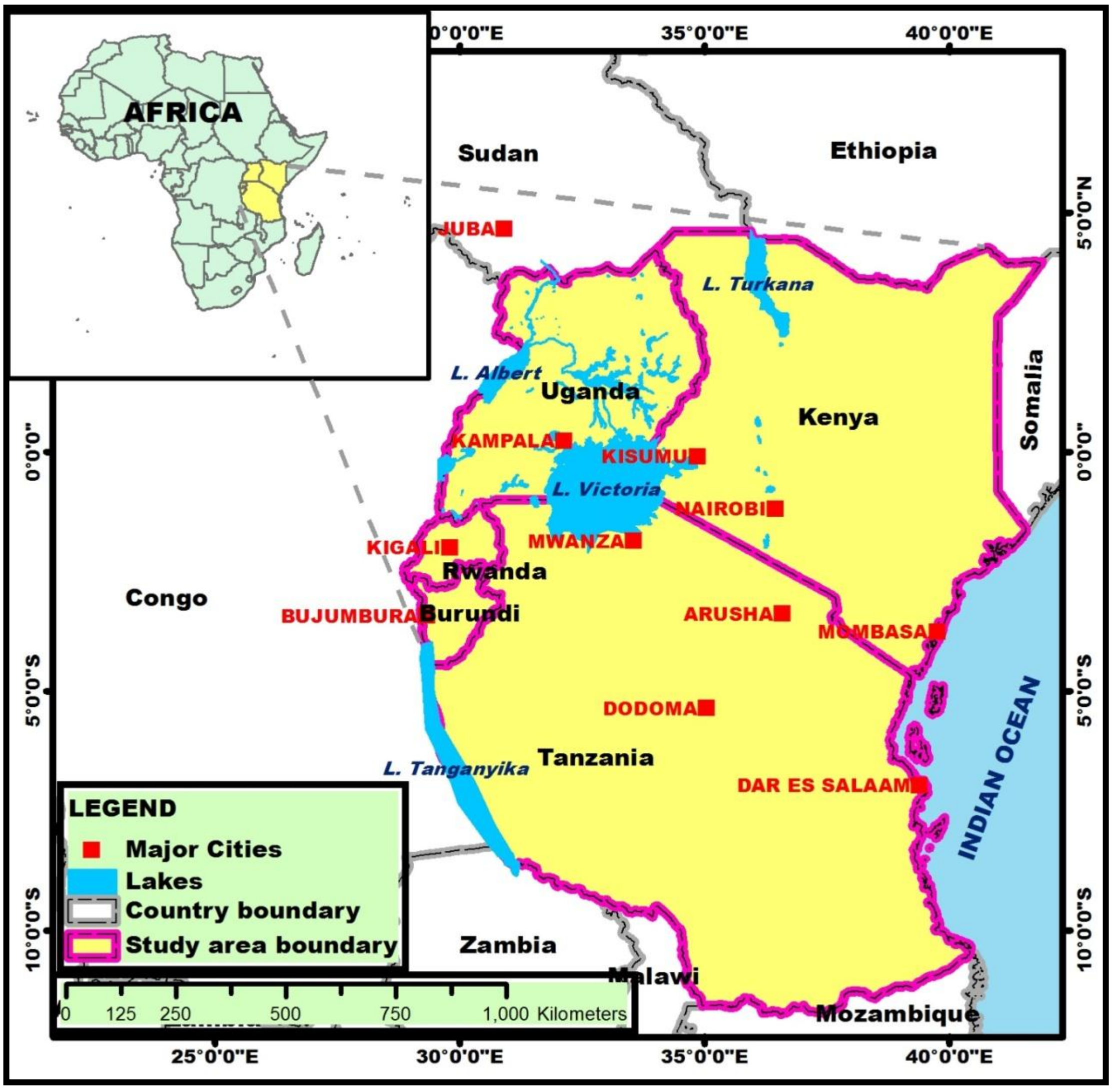

Figure 2. Study Area

3.4 Analytical and Empirical Framework

3.4.1 Descriptive Statistics

Descriptive methods were used to show relevance of the information as this gave information on the mean, variance and standard deviation of the variables. Random effect model was used to estimate the data.

3.4.2 Empirical Model: Panel Data Estimation

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

$$\ln Y_{i,t} = \beta_1 \ln REA_{i,t} + \beta_2 \ln REO_{i,t} + \beta_3 \ln REA.AC + \beta_4 \ln REA.AL + \beta_5 \ln AC_{i,t} + \beta_6 \ln AL_{i,t} + \mu_i + v_t + \varepsilon_{i,t} \quad \text{...} (1)$$

Where;

$Y_{i,t}$ –is the dependent variable i.e. Agricultural sector growth (Agricultural output).

$REA_{i,t}$ is the agricultural R&D.

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

$REA.AC_{i,t}$ is the embodiment/ interaction of agricultural R&D and agricultural capital.

$REA.AL_{i,t}$ is the embodiment/interaction of agricultural R&D and agricultural labour.

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

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

μ_i represents unobserved country specific effects.

v_t represents unobserved time specific effects.

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

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 proxy for research and development while agricultural capital and agricultural labour were used as control variables since they also influence agricultural sector growth.

3.4.3 Pre-Diagnostic Test

3.4.3.1 Panel Unit Root Test

Unit root test was aimed at establishing stationarity of a data series. Panel unit root test was conducted to avoid analysing non stationary data at level which in turn could lead to spurious results or results that do not make sense. Data found to be non-stationary at level were differenced for stationarity to be achieved. Stationary data were then analysed because the results were now sensible. Levin, Lin and Chu (2002) developed a unit root test for panel data. Individual unit root tests have limited power. The power of a test is the probability of rejecting the null when it is false and the null hypothesis is unit root. Levin-Lin-Chu Test (LLC) suggests the following hypotheses.

H_o: Each time series contains a unit root

H_A: Each time series is stationary

▼

3.4.3.2 Panel Co integration Test: Pedroni Residual Based (1999) Test

Co integration refers to the long-run linear movement of two variables that are stationary after differencing. When the linear combination of the two variables is I(0), then the variables are said to be co integrated. Differencing leads to lose of long run relationship between variables and so co integration test is being conducted to check whether the variables have got long run relationship or not. Pedroni (1999) developed a residual-based panel co integration test statistics based on within dimension and between- dimensions. The null hypothesis of no co integration for the panel co integration test is the same for each statistics,

$H_o : \gamma=1$ for all $i=1,...,N$

Whereas the alternative hypothesis for the between-dimension-based statistic is;

$H_1: \gamma_i<1$ for all $i=1,...,N$

Where a common value for $\gamma_i=\gamma$ is not required. For within dimension based statistics the alternative hypothesis,

$H_1: \gamma_i<\gamma$ for all $i=1,...,N$, assumes a common value for $\gamma=\gamma$.

3.4.3.3 Hausman Test

To establish whether to employ fixed effects model or random effects model, the study conducted Hausman Test which was developed by Hausman (1978). The test basically tries to establish whether the error terms are correlated with the regressors, with the null hypothesis stating absence of such correlation. Therefore, the test's null hypothesis posits that the preferred model is the random effects model against the alternative hypothesis denoting preference of fixed effects model.

3.4.4 Post-Estimation Diagnostic Tests

There are some econometric problems which when present in the regression results makes the parameter estimates biased and may lead to biased estimations. These are heteroscedasticity, autocorrelation and multicollinearity. Therefore tests for the mentioned problems were conducted so as to effect the appropriate corrections.

3.4.4.1 Test for Cross-Sectional Dependence

Cross-sectional dependence is the inter-dependence between cross-sectional units. It has been found that cross-sectional dependence is a problem in macro panels with long time series (over 20-30 years). This is not much of a problem in micro panels (few years and large number of cases). This problem results into efficiency loss for least square estimators and renders invalid conventional t-test and F-tests that use variance-covariance estimators. This study therefore used Pesaran's (2011) test of independence. The test's null hypothesis posits that there exists no correlation of residuals across the entities.

3.4.4.2 Test for Autocorrelation

Autocorrelation occur when there exist a correlation between error terms of different time periods. Thus complicates the application of statistical tests because autocorrelation reduces the number of independent observations. Autocorrelation in linear panel data models causes biased standard errors and makes the estimators less efficient. To test for this problem in panel data, Wooldridge Test (2002) was employed as it requires relatively few assumptions and it is easy to implement. This test's null hypothesis is a statement of absence of first order autocorrelation.

3.4.4.3 Test for Heteroscedasticity

Heteroscedasticity refers to a case where the error terms do not exhibit a constant variance across observations. This problem can be caused by errors of measurement or if there are sub-population differences. Even though heteroscedasticity does not lead to biased parameter estimates, it can cause standard errors to be biased and this could lead to biasness in tests statistics and confidence intervals.

Breusch and Pagan Langrangian multiplier test for heteroscedasticity in random effects regression (1980) was used to test for heteroscedaticity. This test is viable when the assumption of normality is violated, especially in asymptotic terms. The test's null hypothesis states that: $\sigma_i^2=\sigma^2$, for all i=1... N_g,

Where N_g is the number of cross-sectional units

3.5 Justification of Panel Approach

Recently, panel data econometric techniques have rapidly gained popularity in analyzing the relationship between variables. Use of panel data in estimations of common relationships across countries is appropriate because it allows the identification of country-specific characteristics (effects) that control for missing or unobserved variables and so panel data controls country specific characteristics and policies can apply across all entities involved in a study. Panel data estimation may also avoid the problem of multicollinearity caused by high correlation of explanatory variables as they vary in two dimensions. It also reduces or even eliminates estimation bias.

3.6 Variables, Descriptions and Derivations

All the data that were used in this study were from secondary sources that included: publications and websites of the member states Statistical Bodies; the publications and website of Agricultural Science and Technology Indicators; and the World Development Indicators website. The variables that were used in this study were agricultural sector growth as the dependent variable, agricultural R&D, R&D in other sectors, interactive agricultural capital stock and agricultural R&D, interactive agricultural labour and agricultural R&D, agricultural capital stock and agricultural labour size as explanatory variables.

3.6.1 Agricultural Research and Development (REA)

Agricultural research and development leads to; new and improved products, processes and markets, and increase in knowledge which has got spill over effects hence leading to agricultural sector growth. Agricultural R&D was measured by expenditure on agricultural R&D. Increased expenditure on agricultural R&D makes researchers and research institutions to do more and serious research. Data was collected from Agricultural Science and Technology Indicators through their website (www.asti.cgiar.org). This expenditure was measured in US dollars. Agricultural R&D was expected to have a positive sign after regression analysis.

3.6.2 Research and Development in other Sectors apart from the Agricultural Sector (REO)

Research and development in other sectors apart from agricultural sector leads to new and improved products and services and this in turn leads to spill over effects on the agricultural sector hence leads to improvement in the performance of the agricultural sector. Expenditure on research and development in other sectors apart from the agricultural sector in US dollars was used as a measure of Research and development in other sectors. Data was collected from the World Data Atlas through their website (www.world-data-atlas.com).

3.6.3 Interactive Agricultural Capital Stock and Agricultural R&D (REA.AC)

Interaction of agricultural capital and agricultural R&D leads to increased efficiency and hence increased agricultural output. The product of agricultural capital and agricultural R&D expenditure was used as a measure of interactive agricultural capital and agricultural R&D. Interactive agricultural capital and agricultural R&D was expected to have a positive result after regression analysis.

3.6.4 Interactive Agricultural labour Size and Agricultural R&D (REA.AL)

Interaction of agricultural labour and agricultural R&D leads to increased efficiency and hence increased agricultural output. The product of agricultural labour and agricultural R&D was used as a measure of interactive agricultural labour and agricultural R&D. Interactive agricultural labour and agricultural R&D was expected to have a positive sign after regression analysis.

3.6.5 Agricultural Capital (AC)

Agricultural capital was used as a control variable because it also influences the performance of the agricultural sector. Availability of agricultural capital leads to increased agricultural productivity because it augments labour in the production process. Agricultural capital was measured through the use of expenditure on inputs. Data sources were the member countries Statistical Bodies through their Statistical Abstracts and websites (www.knbs.or.ke, www.ubos.org, www.nbs.go.tz, www.bnr.rw, www.isteebu.bi). Agricultural capital was expected to have a positive sign after regression analysis.

3.6.6 Agricultural Labour (AL)

Agricultural labour was used as a control variable because it influences the level of agricultural sector growth. Agricultural labour leads to agricultural sector growth because it is a factor of production in the production process in agriculture hence increases the productivity of the agricultural sector. Agricultural labour was measured through the use of the actual number of people employed in the agricultural sector in these countries. Data was gotten from World Bank data bank through their website (www.worldbank.org). Agricultural labour was expected to have a positive sign after regression analysis.

3.6.7 Agricultural Sector Growth

Agricultural output of the member countries was used as a measure of agricultural sector growth and the data was collected from the member countries statistical bureaus websites (www.knbs.or.ke, www.ubos.org, www.nbs.go.tz, www.bnr.rw, www.isteebu.bi)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

In this chapter, the descriptive statistics and correlation of the variables employed in this study are presented to provide the general characteristics of the variables in terms of mean, range, standard deviation and correlation. Also presented are results for panel unit root test, Hausman test, random effects regression, heteroscedasticity test, cross sectional dependence test and test for autocorrelation results. Finally, the results of the inferential statistical analysis with respect to the variables in the objectives and hypotheses of the research are discussed.

4.2 Descriptive Analysis

4.2.1 Descriptive Statistics

Table 4.1: Results of Descriptive Analysis

Variable	N	Mean	Std.	Min	Max
LnY	75	18.7870	2.9991	9.2103	24.9867
LnREA	75	17.5018	1.1847	14.2210	18.8844
LnREO	75	14.5473	2.5737	9.0478	18.9860
LnREA.AC	75	25.2661	3.0492	20.0109	28.6754
LnREA.AL	75	25.6560	1.6623	21.7914	27.7325
LnAC	75	7.7643	2.0343	4.0943	9.9332
LnAL	75	8.1542	0.6287	7.3492	9.2485

Where,

LnY is the natural log of agricultural output (agricultural sector growth)

LnREA is the natural log of agricultural R&D.

LnREO is the natural log of R&D in other sectors

LnREA.AC is the natural log of the interactive effect of agricultural capital and agricultural R&D expenditure.

LnREA.AL is the natural log of the interactive effect of agricultural labour and agricultural R&D expenditure.

LnAC is the natural log of agricultural capital.

LnAL is the natural log of agricultural labour.

From Table 4.1 above, the mean of agricultural output growth is 18.7870. This means that on average, agricultural output growth for the period 2000-2014 in EAC was 18.7870.The standard deviation is 2.9991 which means that for the period 2000-2014, agricultural output growth in EAC was deviating from the mean by 2.9991. The minimum of agricultural output growth in EAC for the period 2000-2014 was 9.2103 while the maximum of agricultural output growth for the same period was 24.9867. This means that the range of agricultural output growth in EAC for the period 2000-2014 was 15.7764.

For the case of agricultural R&D expenditure, the mean is 17.5018. This means that for the period 2000-2014, the average expenditure on agricultural R&D was 17.5018 in EAC. The standard deviation is 1.1847. This means that for the period 2000-2014, expenditure on agricultural R&D deviated from the mean by 1.1847 in EAC. The minimum agricultural R&D expenditure for the period 2000-2014 was 14.2210 while the maximum was 18.8844. This means that the range for agricultural R&D expenditure for the period 2000-2014 in EAC was 4.6634.

The mean for R&D expenditure in other sectors is 14. 5473. This means that for the period 2000-2014, the average expenditure on R&D in other sectors was 14.5473 in EAC. The standard deviation for R&D expenditure in other sectors is 2.5737. This means that for the period 2000-2014, expenditure on R&D in other sectors deviated from the mean by 2.5737 in EAC. The minimum R&D expenditure in other sectors is 9.0478 and the maximum is 18.9860. This means that for the period 2000-2014, the range of R&D expenditure in other sectors was 9.9382 in the EAC.

For the case of the interaction of agricultural capital and agricultural R&D expenditure, the mean is 25.2661. This means that for the period 2000-2014, the interaction of agricultural capital and agricultural R&D expenditure was on average 25.2661 in the EAC. The standard deviation is 3.0492. This means that for the period 2000-2014, the interaction of agricultural capital and agricultural R&D expenditure was deviating from the mean by 3.0492 in the EAC. The interaction of agricultural capital and agricultural R&D expenditure has a minimum level of 20.0109 and a maximum level of 28.6754. This means that for the period 2000-2014, the range of the interaction of agricultural capital and agricultural R&D expenditure was 8.6645 in the EAC.

Looking at the case of the interaction of agricultural labour and agricultural R&D expenditure, the mean is 25.6560. This means that for the period 2000-2014, the interaction of agricultural labour and agricultural R&D expenditure was on average at the level of 25.6560 in the EAC. The standard deviation of the interaction of agricultural labour and agricultural R&D expenditure is 1.6623. This means that in the period 2000-2014, the interaction of agricultural labour and agricultural R&D expenditure was deviating from the mean by 1.6623 in the EAC. The minimum of the interaction of agricultural labour and agricultural R&D expenditure is 21.7914 and the maximum is 27.7325. This means that for the period 2000-2014, the range of the interaction of agricultural labour and agricultural R&D expenditure was 5.9411 in the EAC.

Concerning agricultural capital, the mean is 7.7643. This means that for the period 2000-2014, on average, agricultural capital was 7.7643 in the EAC. The standard deviation for agricultural capital is 2.0343. This means that in the period 2000-2014, the level of agricultural capital was deviating from the mean by 2.0343 in the EAC. The minimum level of agricultural capital is 4.0943 and the maximum level is 9.9332. This means that in the period 2000-2014, the range of agricultural capital level was 5.8389 in the EAC.

For agricultural labour, the mean is 8.1542. This means that in the period 2000-2014, the average number of agricultural labour was 8.1542 in the EAC. The standard deviation for agricultural labour is 0.6287. This means that in the period 2000-2014, agricultural labour was deviating from the mean by 0.6287 in the EAC. The minimum number of agricultural labour is 7.3492 while the maximum number is 9.2485. This means that for the period 2000-2014, the range of agricultural labour was 1.8993 in the EAC.

4.2.2 Correlation Results

Correlation is the measure of the degree of association between variables. It also shows the direction of relationship between variables and the correlation coefficient ranges from -1 to +1 with closeness to absolute 1 showing a strong correlation between variables.

Table 4.2: Results of Correlation Coefficients

	LnY	LnREA	LnREO	LnREA.AC	LnREA.AL	LnAC	LnAL
LnY	1.0000						
LnREA	0.3637***	1.0000					
LnREO	0.4164**	0.6732**	1.0000				
LnREA.AC	0.4731**	0.9084**	0.5679**	1.0000			
LnREA.AL	0.4132***	0.9575***	0.5671***	0.9477***	1.0000		
LnAC	0.4973**	0.7792***	0.4592**	0.9699**	0.8628**	1.0000	
LnAL	0.4072***	0.6473***	0.2309**	0.7939***	0.8396***	0.8131***	1.0000

*** is significance at 1%; ** is significance at 5% and * is significance at 10%

From Table 4.2 above, the correlation coefficient between agricultural R&D and agricultural output growth is 0.3637. This means that there is a weak positive correlation between agricultural R&D expenditure and agricultural output growth. As agricultural R&D expenditure increases, agricultural output growth also increases and when agricultural R&D expenditure decreases, agricultural output growth also decreases. The positive correlation of 0.3637 between agricultural R&D expenditure and agricultural output growth is statistically significant at 1% level. The positive relationship is because agricultural R&D expenditure leads to more and serious research on the agricultural sector which in turn leads to better techniques of production in the agricultural sector hence increased agricultural output.

For the case of R&D in other sectors and agricultural output growth, the correlation coefficient is 0.4164. This means that there is a weak positive correlation between R&D expenditure in other sectors and agricultural output growth. As R&D in other sectors increases, agricultural output growth also increases and as R&D expenditure in other sectors decreases, agricultural output growth also decreases. The positive correlation of 0.4164 between R&D in other sectors and agricultural output is statistically significant at 5% significance level. The positive relationship is because R&D expenditure in other sectors leads to more and serious research in other sectors which leads to increased stock of knowledge which in turn spillsover to the agricultural sector hence increased agricultural output.

The correlation coefficient between interactive effect of agricultural capital and agricultural R&D expenditure and agricultural output growth is 0.4731. This means that there is a weak positive correlation between the interactive effect of agricultural capital and agricultural R&D expenditure and agricultural output growth. When there is increased interaction of agricultural capital and agricultural R&D expenditure, agricultural output growth also increases and when the interaction of agricultural capital and agricultural R&D expenditure decreases, agricultural output growth also decreases. The positive correlation between interactive agricultural capital and agricultural R&D expenditure of 0.4731 is statistically significant at 5% level. The positive relationship is because agricultural capital and agricultural R&D expenditure complement each other and this makes agricultural capital to be more efficient in production hence increased agricultural output.

For the interaction of agricultural labour and agricultural R&D expenditure and agricultural output growth, the correlation coefficient is 0.4132. This means that there is a weak positive correlation between the interaction of agricultural labour and agricultural R&D expenditure and agricultural output growth. When there is an increase in the interaction of agricultural labour and agricultural R&D expenditure, agricultural output growth also increases and when it decreases, agricultural output growth also decreases. The positive correlation of 0.4132 between the interactive agricultural labour and agricultural R&D expenditure and agricultural output growth is statistically significant at 1% level.

Agricultural capital and agricultural output growth has a correlation coefficient of 0.4973. This means that there is a weak positive correlation between agricultural capital and agricultural output growth, as agricultural capital increases, agricultural output growth also increases and when agricultural capital decreases, agricultural output growth also decreases. The positive correlation of 0.4973 between agricultural capital and agricultural output growth is statistically significant at 5% level. The positive relationship is because agricultural capital helps in facilitating the production process in the agricultural sector hence increased agricultural output.

In the case of agricultural labour and agricultural output growth, the correlation coefficient is 0.4072. This means that there is a weak positive correlation between agricultural labour and agricultural output growth. As agricultural labour increases, agricultural output growth also increases and when it decreases, agricultural output growth also decreases. The positive correlation of 0.4072 between agricultural labour and agricultural output growth is statistically significant at 1% level. The positive relationship is because agricultural labour plays the role of operating agricultural capital and offering other agricultural related services like planting and weeding hence increased agricultural output.

4.2.3 Econometric Tests

4.2.3.1 Panel Unit Root Test

Unit root test was conducted to find out whether the variables were stationary at level or whether they were non stationary. When a regression is done with variables being non stationary, it leads to spurious results. The Levin Lin Chu panel unit root test was used to conduct stationarity test and it is based on the following hypotheses:

Ho: Each time series contains a unit root

H_A: Each time series is stationary

Table 4.3: Results of Levin-Lin-Chu Panel Unit Root Test

Variable	LLC (level)	LLC(first difference)	LLC(p-value)	Order of integration
LnY	-4.1090***		0.0000	I(0)
LnREA	-1.6347**		0.0511	
		-5.6177***	0.0000	I(1)
LnREO	-3.5410***		0.0002	I(0)
LnREA.AC	0.7237*		0.7654	
		-5.6177***	0.0000	I(1)
LnRE.AL	1.2275*		0.1098	
		-5.5079***	0.0000	I(1)
LnAC	0.6643*		0.7467	
		-1.9144***	0.0278	I(1)
LnAL	-3.0665***		0.0011	I(0)

*** 1% significance level, ** 5% significance level, * 10% significance level

From Table 4.3 above, agricultural output growth, R&D expenditure in other sectors and agricultural labour were found to be stationary at level and statistically significant at 1% level while the remaining variables, that is, agricultural R&D expenditure, interactive agricultural capital and agricultural R&D expenditure, interactive agricultural labour and agricultural R&D

expenditure and agricultural labour were found to be non stationary but became stationary after first differencing and this was statistically significant at 1% level.

4.2.3.2 Cointegration Test

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. Usually after differencing, variables tend to lose long-run relationship and so cointegration test is being conducted to establish whether variables have got long-run relationship after differencing. Since the dependent variable (agricultural output 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.

4.2.3.3 Hausman Test

In order to determine whether to use fixed effects or random effects regression model, Hausman (1978) test was conducted based on the hypotheses below:

H_O: Preferred model is random effects model

$H_{A:}$ Preferred model is fixed effects model

Fixed effects model explores the relationship between the predictor and outcome variables and so fixed effects model helps in removing the effect of time invariant characteristics from the predictor variables so that the predictor net effect can be assessed. For example the political system in a country can have effect on trade and so fixed effects model will control the effect of political system on trade. Random effects model assumes that entity error term is not correlated with predictors which allows for time invariant variables to play a role as explanatory variables. The rationale behind random effect is that the variation across entities is assumed to be random and uncorrelated to the predictor or independent variables included in the model and therefore if there is a reason to believe that differences across entities have some influence on dependent variable, then random effects model is to be used. The results of Hausman test were as follows:

Table 4.4: Results of Hausman Test

	(b) Fixed	(B) random	(b-B) Difference	Sqrt(diag(v_b-v_B))
Diff LnREA	1.0966	0.8533	0.2432	-
LnREO	-0.2622	0.3159	-0.5781	0.1697
Diff LnREA.AL	-1.0918	-0.9728	-0.1190	-
LnAL	5.3647	1.6134	3.7513	3.0019

Chi2 (4) = 5.12

Prob>chi2=0.2754

From the Hausman test in Table 4.4 above, the p-value is greater than 0.05 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.

4.2.3.4 Test for Cross Sectional Dependence

Cross sectional dependence is the inter-dependence between cross sectional units. Cross sectional dependence results into efficiency loss for least square estimators and renders invalid conventional t-test and F-tests that use variance-covariance estimators. Pesaran’s (2011) test was used to test for cross sectional dependence. The hypotheses of Pesaran’s test states as follows:

H_o: There exists no correlation of residuals across entities

H_A: There exists correlation of residuals across entities

The results for Pesaran’s test for cross sectional dependence were as follows:

Pesaran’s test of cross sectional independence =1.022, pr = 0.3067

From the results of Pesaran’s test for cross sectional dependence, the P-value is greater than 0.05 hence the null hypothesis of cross sectional independence was not rejected. This means that there was cross sectional independence in the regression analysis. This means that there was no efficiency loss for least square estimators and so conventional t-test and F tests that used variance-covariance estimators were valid.

4.2.3.5 Heteroscedasticity Test

Heteroscedasticity refers to a situation whereby the error terms do not have constant variance across observations. This is a problem caused by errors of measurement and even sub- population differences. Heteroscedasticity causes standard errors to be biased and this leads to biasness in test statistics and confidence intervals. Breusch Pagan Langrange Multiplier (1980) test for heteroscedasticity was used to conduct heteroskedasticity test. The hypotheses for Breusch Pagan Langrange Multiplier test states as follows:

H_o: Variance across observations is constant (Homoscedasticity)

$H_{A:}$ Variance across observations is not constant (Heteroscedasticity)

The results of Breusch Pagan Langrange Multiplier test were as follows:

Table 4.5: Results of Heteroscedasticity Test

	Var	Sd=sqrt(var)
LnY	7.6204	2.7605
E	2.6455	1.6265
U	0	0

Test: var(u) =0

Chibar2(01)=0.00

Prob>chibar2=1.0000

From the results in Table 4.5 above, the p-value is greater than 0.05 and so the null hypothesis of constant variance was not rejected. This means that heteroscedasticity was not a problem in the regression analysis. This means that the standard errors were unbiased and so there was unbiasness in test statistics and confidence intervals.

4.2.3.6 Test for Autocorrelation

Autocorrelation is caused by correlation between error terms of different time periods. Autocorrelation in linear panel models causes biased standard errors and makes the estimators less efficient. Wooldridge test (2002) was used to test for autocorrelation. The test's hypotheses are stated as follows:

H_o: There is absence of first order autocorrelation

H_A: There is presence of first order autocorrelation

The results for Wooldridge test (2002) for autocorrelation were as follows:

F(1, 4) =21.627

Prob> =0.097

From the results above, the p-value is greater than 0.05 and so the null hypothesis of no serial correlation was not rejected at 10% level. This means that autocorrelation was not a problem in the regression results. This means that the standard errors were unbiased and so the estimators were efficient.

4.3 Inferential Analysis

4.3.1 R&D and Agricultural Sector Growth in the EAC

This section covers the testing of the hypotheses regarding the agricultural sector growth and R&D nexus. The agricultural sector growth and R&D analysis was based on panel data. This was because panel data controls for endogeneity, multicollinearity, omitted variables and also explores data across time. The estimation technique that was applied was the random effects model and the results were as follows:

Table 4. 6: Results of Random Effects Regression

	Coef.	Std. Err.	Z	P>Z	95% Confidence Interval	
Diff LnREA	0.8533**	0.3969	2.15	0.032	0.8406	0.8660
LnREO	0.3160***	0.1232	2.56	0.010	0.3147	0.3172
Diff LnREA.AL	-0.9728**	0.4537	-2.14	0.032	-0.9873	-0.9583
Diff LnAC	0.1216**	0.0576	2.11	0.035	0.1196	0.1236
LnAL	0.1613***	0.0595	2.71	0.007	0.1609	0.1618
-cons	0.2975	0.6071	0.49	0.627	-0.0832	0.6782
R-Squared: within = 0.5628						
Between = 0.5012						
Overall = 0.5820						

*** 1% significance level, ** 5% significance level, * 10% significance level

From the results in Table 4.6 above, the within R squared is 0.5628. This means that 56.28% of the variations on the agricultural sector growth (dependent variable) within the individual countries are explained by the explanatory variables in the model. The between R squared is 0.5012. This means that 50.12% of the variations on the agricultural sector growth between the entities (countries of the EAC) are explained by the explanatory variables in the model. The overall R squared is 0.5820. This means that 58.20% of the changes on the dependent variable (agricultural output) in EAC are explained by the explanatory variables that are included in the model.

The constant is 0.29750.This means that without the variables like agricultural R&D, R&D in other sectors, the interaction of agricultural labour and agricultural research, agricultural capital and agricultural labour in the EAC, agricultural output growth remains at the level of 0.29750. The p-value is 0.627 and being that the p-value is greater than 0.05, this implies that the constant is not statistically significant at 10% level.

4.3.2 Effect of Agricultural R&D on Agricultural Sector Growth.

This sub-section presents results that meet objective (i) which was to determine the effect of agricultural R&D on agricultural sector growth in the EAC.

From the regression results, the coefficient of agricultural R&D (REA) is 0.8533.This means that a one percent increase in agricultural R&D leads to 0.8533% increase in agricultural output (growth). Since the p-value (0.032) is less than 0.05, it means that the 0.8533% increase in agricultural output is statistically significant at 5% level. This means that there is a positive relationship between agricultural R&D and agricultural sector growth. The coefficient is positive and this conforms to economic theory. The endogenous growth theory says that R&D leads to increase in the stock of knowledge which in turn has got spill over effects hence leads to economic growth.

This positive relationship could be because of increased allocation of funds for agricultural research which leads to increased agricultural research which causes increased knowledge about high yielding crops, the invention of drought resistant crops which helped in preventing crop failures in the event of a drought, better ways of improving soil fertility which leads to increased yields, introduction of advanced machines in production which made the production process to go faster hence high quality and quantity of products within a short period of time. These advanced machines may include machines for tilling land like tractors, milking machines, harvesting machines and planting machines. Agricultural research and development could have also led to the discovery of crop and livestock diseases; what causes the diseases; how the diseases can be prevented and even the curative measures of the diseases should they occur. This boosts crop and livestock productivity and hence increased agricultural sector growth.

Through agricultural research and development, better preservation and storage measures and facilities of agricultural products could have been invented and this helps to reduce post harvest losses by the farmers hence leading to increased agricultural productivity. Agricultural research also leads to better planting and farming methods which increased agricultural productivity. In addition, agricultural research and development leads to high quality breeds of animals like dairy cows, goats, sheep, and in poultry that are highly productive in terms of milk production, meat and eggs hence leading to increased agricultural output. Improved marketing services also arise as a result of agricultural research and development which further leads to improved agricultural productivity. Once agricultural research and development has been done by a particular research institution or university 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. The positive and significant effect of agricultural R&D expenditure could have been as a result of proper dissemination of knowledge generated through agricultural R&D.

The finding on the effect of agricultural R&D on agricultural sector growth has coincided with the findings of other researchers like Pardy et al. (2012) who studied the effect of R&D in the agricultural sector in Asia and Pacific region for the period 1960-2009 and found that countries with larger agricultural economies are likely to invest more in agricultural R&D and those with smaller agricultural economies are likely to invest less in agricultural R&D simply because of congruent effect. Fuglie and Marder (2015) studied the effect of the adoption of improved crop varieties of 20 crops from 1970 to 2010 which covered 37 Sub Saharan countries and found that the improved varieties had a major positive impact on agricultural productivity. Their finding was therefore similar to the findings of this study.

The study has also given a similar finding to the one of Bagherzadeh Komeijan (2010) who studied the impact of agricultural R&D spending on agricultural total factor productivity of Iran during the period 1979-2009 using Almon Distributing Lag and found that the long-run elasticity of this factor is 0.17 percent and the rate of return of investing in agricultural R&D spending is 0.36 percent. In addition, Pardy et al (2016) in their analysis on the estimates of returns to agricultural R&D in 25 countries in Africa from 1975 to 2014 found that high rates to agricultural R&D with a median of 35% and a mean of 42%. These were also positive results like the one for this study.

Lastly, the finding for this study is also similar to the finding of Mehrabi and Javdan (2011) who investigated the relationship between agricultural R&D expenditure and agricultural total factor productivity for Iran during the period 1974-2007 using Auto Regression Distributing Lag model and concluded that R&D spending has a positive significant on total factor productivity in both long-run and short-run in agricultural sector that is, a one percent increase in agricultural R&D spending will increase agricultural total factor productivity by o.1 percent. They even recommended that R&D spending is one of the main factors to improve agricultural growth. All these findings showed that agricultural R&D or agricultural R&D spending had positive effects on the agricultural sector hence they are similar to the finding of this study.

4.3.3 Effect of R&D in other Sectors on Agricultural Sector Growth.

This subsection presents interpretation and explanation of results related to objective (ii) which was to determine the effect of R&D in other sectors a part from the agricultural sector on the agricultural sector growth in the EAC.

From the random effects regression results, the coefficient of research and development in other sectors (REO) is 0.3160. This means that a one percent increase in research and development in other sectors apart from the agricultural sector leads to an increase in the agricultural sector growth (output) by 0.3160%. The p-value is 0.010 and being that it is less than 0.05, it means that the 0.3160% increase in agricultural output is statistically significant at 1% level. This implies that there is a positive relationship between R&D in other sectors and agricultural sector growth. The coefficient is positive and conforms to economic theory specifically the endogenous growth theory which says that R&D leads to increase in the stock of knowledge which in turn has got spill over effects hence leading to economic growth.

The positive effect is because research and development in other sectors have got spill over effects on the agricultural sector and hence lead to increased agricultural productivity. For example, research and development in the health sector leads to improved health services through better nutrition, improved sanitation, discovery of drugs that can treat some diseases and even how the diseases can be prevented and this leads to a healthy population that can be a good and reliable source of labour in the agricultural sector.

In addition, a healthy population has appetite to eat and so their demand for food increases which leads to increased agricultural output to meet their demand for food. Research in the industrial sector, for example, leads to improved and better ways of communication and this spillover to the agricultural sector by enabling farmers to communicate faster and have access to the relevant information and this leads to agricultural sector growth. Industrial sector research also leads to the invention of products that can be made of agricultural products for example industrial research led to the invention that wool and cotton can be used to make clothes and this leads to agricultural sector growth because of increased production of agricultural products due to their increased demand as raw materials.

This finding has coincided with the findings of Wu (2010) who studied provincial data in China and found that R&D has got a positive effect on the regional innovation and that innovation has a positive effect on productivity and consequently economic growth in China. The other finding that is similar to the one for study is for Kim (2009) who analysed the effect of R&D activities on economic growth for Korea by using the R&D based Cobb-Douglas production function and data for the period 1976-2009. According to his empirical findings, the contribution of R&D stocks on economic growth was approximately 35% and detailed analysis showed that the contribution of private and public R&D stocks on economic growth was 16% and 19% respectively. The similarity is therefore the positive effect of R&D.

The other researcher who has a finding similar to the one for this study is Peng (2010) who analysed the relationship between R&D expenditure on economic growth for China and concluded that increased R&D expenditure by 1% leads to an increase in the GDP of China by approximately 0.92%.

A similar finding was also made by Sadraoui *et al*. (2014) who analysed the causality between R&D collaboration and economic growth by using data of 32 industrialised and developed countries for the period 1970-2012 and his finding was that there is a strong causality between economic growth and R&D collaboration. Altin and Kaya (2009) who analysed the relationship between R&D expenditures and economic growth by using the data for Turkey for the period 1990-2005 found was that there is no causal relationship between R&D expenditure and economic growth in the short term, but there is a causal relationship from R&D expenditures to economic growth in the long term. His finding therefore coincided with the finding of this study.

Another interesting finding that is similar to the finding for this study on the effect of R&D is the one for Taban and Sengur (2013) who analysed the relationship between R&D and economic growth by using the data for the period 1990-2012 in Turkey and co-integration models and their conclusion was that R&D expenditures affect economic growth positively in the long term. This finding also showed a positive effect of R&D on growth just as this study has also found it. Lastly, the finding for this study on the effect of R&D in other sectors on agricultural sector growth has also coincided with the finding of Genc and Atasoy (2010) who analysed the relationship between R&D expenditures and economic growth by using the data for the period 1997-2008 and causality method and their finding was that there is a unilateral causality relationship from R&D expenditure to economic growth. All these mentioned researchers had findings that are similar to the one of this study as far as R&D relates with growth. R&D has been found to have a positive effect on growth and therefore, economies should invest more on R&D in terms of human capital and other related services.

4.3.4 Interactive Effect of agricultural labour and Agricultural R&D on Agricultural Sector Growth.

This sub-section presents discussion of results related to objective (iv) of this study which was to determine the interactive effect of agricultural labour and agricultural R&D on the agricultural sector growth in EAC.

Interaction of agricultural capital and agricultural research (REA.AC) was omitted in the analysis because it was found to be contributing to multicollinearity. The coefficient of the interaction between agricultural labour and agricultural research is -0.9728. This means that a one percent increase in the interaction of agricultural labour and agricultural research leads to a decrease in the agricultural sector growth (output) by 0.9728%. The p-value is 0.032 and being that it is less than 0.05, it means that the decline in agricultural sector growth (output) by 0.9728% is statistically significant at 5% level. This translates that there is an elastic relationship between the interaction of agricultural and agricultural labour and agricultural sector growth.

This negative result could be attributed to substitutability between agricultural labour and agricultural R&D expenditure. This implies that increased agricultural labour reduces resources for investment in agricultural R&D hence limited the discovery of new methods of agricultural production hence low agricultural output. Technological unemployment could have also contributed to this whereby the technological advancements made through agricultural R&D makes the skills of the agricultural labour obsolete hence leading to low agricultural output. The negative result could also be attributed to the presence of unskilled labour or lack of properly educated agricultural labour force that did not have the ability to assimilate and properly use the new and advanced technologies developed as a result of agricultural research and development.

In addition, the negative effect could have been as a result of a short-period use of the advanced technologies developed through agricultural research and development by the agricultural labour and hence the capability of workers to improve their productivity by regularly repeating the same type of action which is achieved through practice and self perfection was not the case in this situation and hence the negative coefficient.

Another factor that could have made this variable to affect agricultural output growth negatively could be resistance by agricultural labourers and labour unions to embrace the use of advanced technologies developed through agricultural R&D as this could be seen as a way of rendering workers jobless in addition to the general negative mentality towards some new technologies and machines.

The issue of underemployment can also be attributed to this result because highly educated, trained and skilled workers when assigned low-skilled and low-wage jobs may feel demoralised and frustrated and as a result their productivity becomes very low even if the use of advanced technologies and better machines developed through agricultural R&D is embraced.

4.3.5 Effect of Agricultural Capital on Agricultural Sector Growth.

This sub-section presents interpretation and explanation of results related to objective (v) of this study which was to determine the effect of agricultural capital on agricultural sector growth in EAC.

For the case of agricultural capital, the coefficient is 0.1216. This implies that a one percent increase in agricultural capital leads to a 0.1216% increase in agricultural sector growth (output). The p-value is 0.035 and it is less than 0.05, meaning that the increase in agricultural sector growth by 0.1216% as a result of a 1% increase in agricultural capital is statistically significant at 5% level. This means that there is an elastic relationship between agricultural capital and agricultural sector growth.

The result is positive and conforms to economic theory. This could be because agricultural capital helps in faster facilitation of agricultural activities for example in faster tilling of land, faster planting, faster weeding, faster harvesting of crops, faster milking of cows, faster spraying of domestic animals and faster milling of grains hence helps to increase and improve the quality and quantity of agricultural products. In addition, it could be because transportation of the agricultural products or agricultural raw materials is made easier and faster to the markets, stores and factories. There could also be reduced wastage of agricultural products which may lead to increased productivity as raw materials could be easily transported to the factories for processing.

The other reason for the positive relationship between agricultural capital and agricultural sector growth is perhaps agro-based industries had good stocks of raw materials, for example the sugar milling factories had a good stock of sugar cane for processing hence good quantity of sugar was being produced, the tea factories had good a stock of tea leaves for processing hence increased quantity of tea, the milk processing plants had a good stock of milk for processing hence increased quantity of milk products such as yoghurt and cheese hence the problem of capacity under utilisation may be was eliminated.

Another reason for the positive result of agricultural capital may be because there were adequate factories to process agricultural products for example the sugar milling factories that are using sugar cane as their main raw material, milk processing plants that use milk as their main raw material, tea factories that use tea leaves as their main raw material and so these were contributing to increased agricultural output. The positive result can also be attributed to the availability of fuel that was being used to run machineries used in the agricultural sector like tractors that were being used to till land, to plant seeds, to weed and to harvest and this could have helped to lower the cost of production hence increased agricultural output which is a boost to the agricultural sector.

The finding of this study on the effect of agricultural capital on agricultural sector growth is similar to the finding of Kim (2009) who analysed the effect of R&D activities on economic growth in Korea by using R&D based Cobb-Douglas based production function and the data for the period 1976-2009 and according to his empirical findings, traditional production factors that is labour and capital contributed to economic growth by approximately 65%. This showed that capital had a positive effect on growth and this is similar to the finding of this study. This means that firms and economies should therefore invest more on agricultural capital.

4.3.6 Effect of Agricultural Labour on Agricultural Sector Growth.

This sub-section presents interpretation and explanation of results related to objective (vi) of this study which was to determine the effect of agricultural labour on agricultural sector growth in the EAC.

For the case of agricultural labour, the coefficient is 0.1613. The implication is that an increase in agricultural labour by 1% leads to an increase in the agricultural sector growth by 0.1613%. The p-value is 0.007 and since it is less than 0.05, it means that the 0.1613% increase in agricultural sector growth as a result of a 1% increase in agricultural labour is statistically significant at 1% level. This implies that there is an elastic relationship between agricultural labour and agricultural sector growth. The coefficient is positive and conforms to economic theory. The positive relationship may be attributed to the presence of a healthy and energetic agricultural labour force who could actively participate in the various roles assigned to them like driving of tractors for tilling land, planting, weeding and harvesting and this could lead to increased agricultural productivity.

The other factor that could have contributed to this positive relationship between agricultural labour force and agricultural output growth could be a good work environment for the agricultural labour force through better wages, provision of security and working tools, appropriate working hours, proper laws and regulations that were protecting their rights and which were being implemented and these could have prevented things like strikes and go-slows and instead boosted their morale in their work and hence increased agricultural output. In addition, the positive coefficient could have been because of the presence of trained, skilled and experienced agricultural labour force which implies that they had the capability to use the farm tools and equipment and were also well versed with the way the farm tools and equipments were being used in the production process and hence led to increased agricultural output.

Again, the finding on the effect of agricultural labour on agricultural sector growth has coincided with the finding of Kim (2009) who analysed the effect of R&D activities on economic growth for Korea by using R&D based Cobb- Douglas production function and the data for the period 1976-2009 and his empirical findings showed that traditional production factors which is labour and capital contributed to economic growth by approximately 65%. This means that labour had a positive effect on economic growth as has been shown by the finding of this study whereby labour has been found to have a positive effect on agricultural sector growth in the EAC. This therefore means that firms labour is an important factor of production and firms should always motivate them.

CHAPTER FIVE

SUMMARY, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Introduction

This chapter presents the summary of the findings contained in the preceding chapters. Based on the findings, a number of conclusions are drawn and policy implications discussed. Areas of further research are also suggested.

5.2 Summary

The general objective of this study was to determine the effect of R&D on agricultural sector growth in the EAC. Historical research design was used with panel data analysis while the sources of data were purely secondary. The study analysed the relationship between agricultural sector growth and agricultural R&D, R&D in other sectors, interaction of agricultural capital and agricultural R&D, interaction of agricultural labour and agricultural R&D, agricultural capital and agricultural labour.

From the analysis, descriptive statistics showed that the volatility of the variables was very low while the correlation analysis showed that there were positive correlations between the dependent variable and the explanatory variables. Levin-Lin-Chu panel unit root test was carried out and agricultural output growth, R&D in other sectors and agricultural labour were found to be stationary at level and their stationarity was statistically significant at 5% level while the rest were stationary after first differencing and this was also statistically significant at 5% level. Being that the dependent variable was stationary at level with some independent variables also stationary at level and others stationary after first differencing, cointegration test could not be conducted because the dependent variable and the explanatory variables were therefore not integrated of the same order as per the condition for cointegration test.

Hausman (1978) test was conducted and the random effects model was found to be the preferred model while Pesaran's (2011) test for cross sectional dependence showed that there was no cross sectional dependence. Breusch Pagan (1980) Langrange Multiplier test for heteroscedasticity showed that heteroscedasticity was not a problem in the regression analysis and Wooldridge (2002) test for autocorrelation also showed that serial correlation was not a problem in the regression analysis.

The random effects regression analysis showed that all the explanatory variables except the interactive effect of agricultural capital and agricultural R&D and the interactive effect of agricultural labour and agricultural R&D were influencing the agricultural sector growth positively and their influences were also statistically significant. For the interactive effect of agricultural labour and agricultural R&D, the influence was negative and was statistically significant while the interactive effect of agricultural capital and agricultural R&D was omitted as it was contributing to multicollinearity.

5.3 Conclusion

The positive and statistically significant relationship between agricultural R&D and agricultural sector growth could be because of the spillover effects of agricultural knowledge generated through agricultural R&D. This finding coincided with the findings of Pardy *et al*. (2012); Fuglie and Marder (2015); Bagherzadeh and Komeijan (2010) and Mehrabi and Javdan (2011) who found that agricultural R&D expenditure or agricultural R&D leads to agricultural sector growth in the various regions and periods that they conducted their studies.

The positive and statistically significant effect of R&D in other sectors on the agricultural sector growth could be because of the spillover effects of R&D in general. This finding coincided with the findings of Wu (2010); Nunes *et al*. (2012); Kim (2009); Peng (2010); Altin and Kaya (2009); Taban and Sengur (2013); Gulmez and Yardimcioglu (2012) and Genc and Atasoy (2010). They all found that R&D leads to growth in the various regions and time periods that they conducted their studies. The negative and statistically significant interactive effect of agricultural labour and agricultural R&D on agricultural sector growth implies that agricultural labour and agricultural R&D were substitutes and so when there was increased agricultural labour, there was a decrease in agricultural R&D.

The positive and statistically significant relationship between agricultural capital and agricultural sector growth implies that farm tools and equipment, means of transportation of agricultural products and raw materials for agro based industries were available and were being used well hence led to increased agricultural output and this finding coincided with the finding of Kim (2009). Agricultural labour also influenced the agricultural sector growth positively and the influence was statistically significant and this could be attributed to favourable work environment for the agricultural labour and also the presence of a healthy and energetic agricultural labour. This finding also coincided with the finding of Kim (2009).

5.4 Policy Recommendations

5.4.1 Effect of Agricultural R&D on Agricultural Sector Growth.

Based on the results of this study, agricultural R&D influenced agricultural sector growth positively and the influence was statistically significant and to enhance the influence, the following may be done so as to maintain the positive and significant effect of agricultural R&D expenditure. The governments of EAC states may consider increasing the budgetary allocations to agricultural R&D possibly every fiscal year so that more and serious agricultural research can be undertaken so as to increase the stock of knowledge which will in turn have spill over effects hence will lead to agricultural sector growth. More agricultural research scientists may be employed, trained and educated by the government to facilitate serious agricultural research and lead to more discoveries on agriculture which will have spill over effects on the agricultural sector. That employment terms and conditions may be made favourable to agricultural research scientists in terms of remunerations and job security so as to motivate them put more efforts in their work.

The governments of EAC states may also consider ensuring that the knowledge generated through agricultural research is disseminated to the public by employing more agricultural extension officers so as to increase the spill over effects of the knowledge generated through farmers' education. Intellectual property rights may be enhanced to some extent through patents, copyrights and trademarks so as to encourage firms producing agricultural products and inputs to carry out agricultural research and also to invest more on agricultural research. Lastly, the EAC governments may consider to ensure that more agricultural research institutions and stations are established so to increase the intensity of agricultural R&D.

5.4.2 Effect of R&D in other Sectors on Agricultural Sector Growth.

Research and development in other sectors also contributes positively to agricultural sector growth and the growth was statistically significant and because of that, budgetary allocations to R&D in other sectors may be increased by the governments of EAC states every financial year so as to lead to more and serious research that leads to increased stock of knowledge in other sectors that in turn spills over to the agricultural sector, more research scientists in other sectors may also be employed, trained and educated and also to have good remuneration and job security as this helps to improve the returns to their work. In addition, the governments may also ensure that the knowledge generated through R&D in other sectors is disseminated to the public through publications in journal articles as this helps to strength the spill over effects of the knowledge generated.

Intellectual property rights may also be enhanced to some extent by the governments to encourage individual private firms to carry out their own research instead of depending on the research results of other firms. Lastly, more research institutions and stations may be established by the governments so as to increase the intensity of R&D in other sectors. However, agricultural research should be given more priority as far as agricultural sector growth is concerned since it yields more benefits.

5.4.3 Interactive Effect of agricultural labour and Agricultural R&D on Agricultural Sector Growth.

The interaction of agricultural labour and agricultural R&D was found to be influencing agricultural sector growth negatively and the influence was statistically significant. This implies that agricultural labour and agricultural R&D are substitutes. The governments of the EAC states and the firms also may consider ensuring that agricultural labour is trained on new skills to match the technological advancements that have been made. Firms may also consider ensuring that only trained and skilled agricultural labourers are employed since they can catch up with new technological changes faster compared to untrained and unskilled agricultural labour.

In addition to these, firms may also ensure that agricultural labourers are educated on the importance of the use of new technologies or new machines developed through agricultural R&D so as to avoid resistance from labourers as far as their use is concerned, labour unions may also be consulted whenever new technologies and new machines developed through agricultural R&D are to be used so as to avoid their resistance also. Allocation of duties and responsibilities by firms to labourers may also be done in such a way that their skills, education levels and experience are matched for them to feel motivated since this helps in boosting productivity. Lastly, the governments and also the firms may consider carrying out agricultural R&D that responds to the needs of the society since this will not lead to technological unemployment.

5.4.4 Effect of Agricultural Capital on Agricultural Sector Growth.

Agricultural capital influenced agricultural sector growth positively and the influence was statistically significant. To accelerate this effect, the governments of EAC states may consider subsidizing the cost of farm tools and equipment and also make loans easily accessible to farmers by lowering the interest rates to enable them acquire agricultural capital. Taxation on agricultural products that serve as raw materials to the agro-based industries may also be lowered to make raw materials easily available to these industries. Agricultural firms may also invest properly on farm tools and equipment and ensure that they are well serviced and maintained as these efforts will make the agricultural sector not to be capital deficient.

5.4.5 Effect of Agricultural Labour on Agricultural Sector Growth.

Lastly, agricultural labour was found to influence agricultural sector growth positively and the influence was statistically significant. To enhance this influence, the governments may consider subsidising health services for easy access and this will make people to be healthy and energetic and hence more productive in the agricultural sector especially the agricultural labour. In addition, the governments may consider ensuring that there are laws in place that protect the rights of workers in terms of their minimum wage rates and the working hours and also ensure that the laws are adhered to and this will make workers productive as strikes and go slows will not be experienced when the laws are adhered to.

Employers may also consider making the work environment conducive to the labourers by recognising hard working labourers and rewarding them, ensuring their safety while at work and providing them with the necessary tools they require to perform their duties and these will make workers more productive. Firms may also develop work ethics for workers and ensure that the ethics are adhered to by the workers as this will prevent laziness and irresponsible behaviours by workers. In addition, firms may always avoid adopting inappropriate technologies in the production process as this will render labourers jobless hence unproductive.

5.5 Areas of Future Research

Based on this study, the scope was limited and more studies should be done on more countries and increase the time period. The second objective (R&D in other sectors) was aggregated and so disaggregated studies on R&D are recommended on this so as to determine the effect of R&D in the health sector on agricultural sector growth, determine the effect of R&D in the manufacturing sector on the agricultural sector growth, to determine the effect of R&D in the financial sector on agricultural sector growth and other sectors. More studies could also be done on the interactive effect of agricultural research and agricultural capital and also on the interactive effect of agricultural research and agricultural labour on agricultural sector. Studies could also be done on the effect of R&D on agricultural labour on agricultural sector growth.

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