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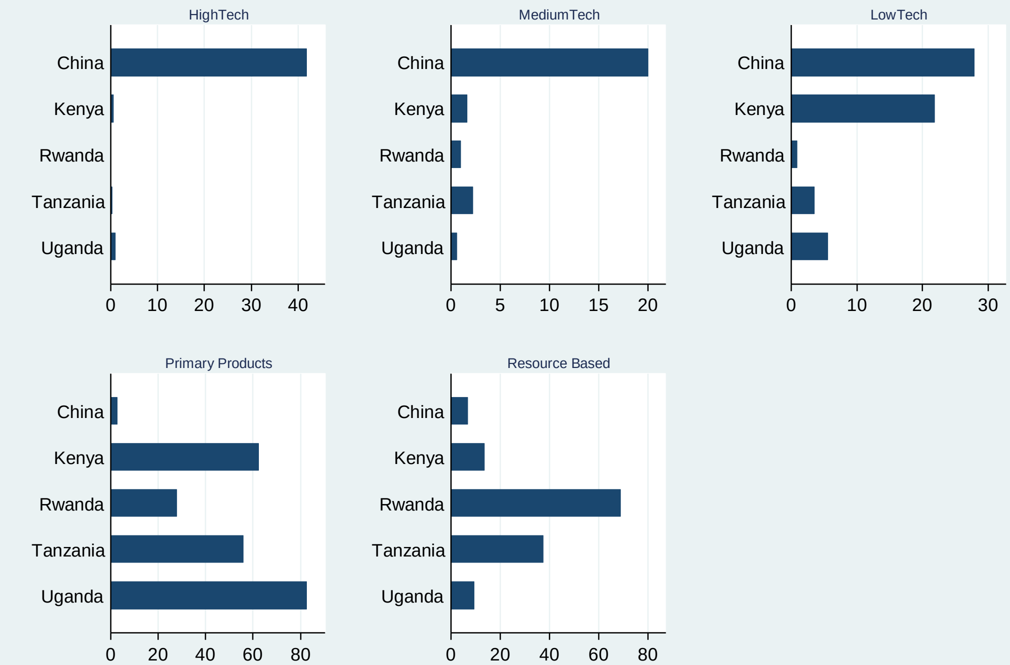
1.0 Introduction

The plunge in oil & commodity prices and the slowdown in China has fuelled a debate about Africa's growth prospects. Some analysts have argued that the dependence on commodity exports, coupled with the failure to diversify, will have dire consequences for African growth in the next decade[1]. This debate about the direction of Africa's growth highlights the importance of innovation, diversification and industrialization in Africa.

East African governments have long recognized the importance of industrialization and structural transformation for sustainable growth in the region. However, the region has not successfully diversified its production and export patterns (Figure 1). In light of the changing global environment and the need for sustainable job creation, it is necessary to explore domestic and regional economic policies that will drive industrialization and the structural transformation in the region. Given the importance of regional trade in the East African Community (EAC) and the role of innovation in diversification, we investigate the role of regional trade in driving innovation in the EAC region.

[1] http://foreignpolicy.com/2015/12/31/africas-boom-is-over/ and http://www.economist.com/news/middle-east-and-africa/21677633-there-long-road-ahead-africa-emulate-east-asia-more-marathon

Figure 1: Exports by technology levels (% of total exports, 2014)



Source: Data from WITS World Bank, 2016

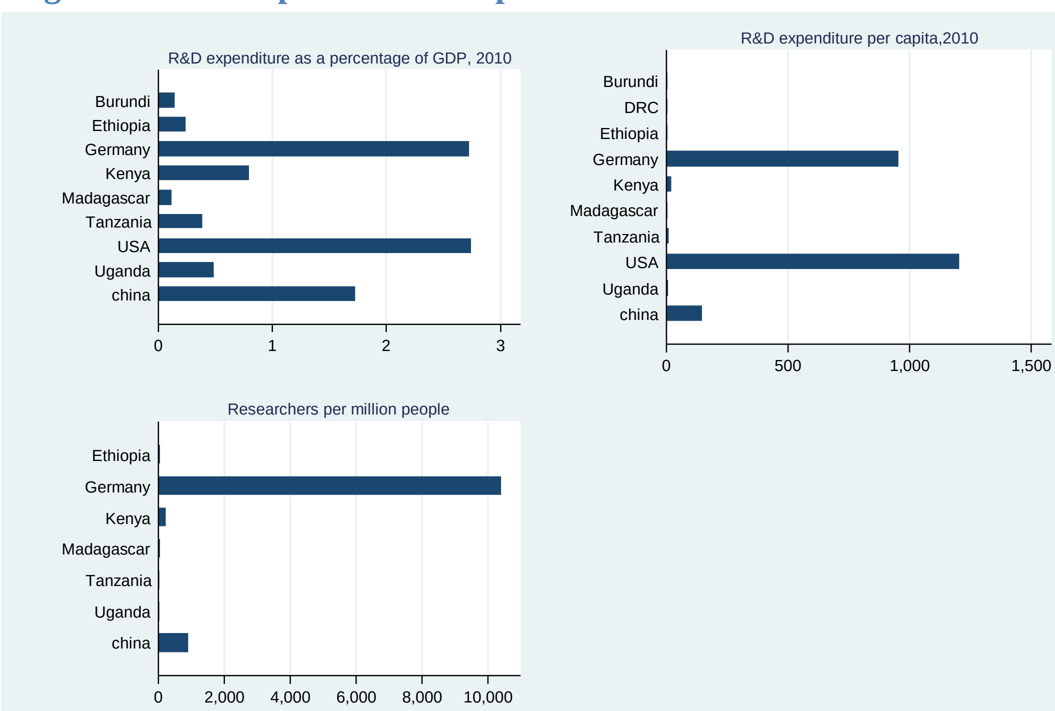
1.1 The role of R&D in economic development

Technology is the driving force of long-term growth and according to the endogenous growth model technological innovation is created in the research and development (R&D) sectors using human capital and the existing knowledge stock (Romer, 1986 & 1990). The empirical studies of endogenous growth have found a positive effect of R&D variables on total factor productivity (TFP) growth (Frantzen, 2000; Griffith, Redding and Reenen 2002). There is also strong evidence that R&D spillovers from industrialized countries to developing countries have positive effects on the TFP growth of the latter (Coe, Helpman and Hoffmaister 1995).

Given that there is a possibility of positive spillovers from industrialized countries and other developing nations to African countries, why then should African countries undertake domestic R&D? According to UNIDO (2005), there are three reasons why a poor country should invest in research and development. Firstly, there is no trade-off between international procurement and domestic generation. The requirements of adaptation of foreign technology regarding investment and personnel specialized in technology may be quite heavy. A prerequisite to acquiring relatively advanced knowledge might be that the host country must develop its innovative capacity. Second, domestic R&D may not simply be a matter of choice but also a matter of necessity. It is very likely that every country is endowed with some specific factors. Techniques making use of these specific factors would not be available outside that country. Third, the choice between domestic R&D and the import of technology should take into account the social value of R&D as compared to its market value. This is the case, for instance, with general-use technologies in the fields of food, health or environment. For example in the case of drugs that are not developed by the market because patients are poor and concentrated in developing countries.

While there is a strong case for innovation in the East African region, the data on R&D expenditures and personnel shows the region performing poorly relative to countries like the China, Germany or the USA (figure 2).

Figure 2: R&D expenditure and personnel



Source: UNESCO, 2016

1.2 The role of industrial trade in technological diffusion

Trade is considered a major channel of technology transfer among countries. According to Grossman and Helpman (1990), countries can benefit from innovation spillovers generated by investments in knowledge in trade partner countries. Less developed countries potentially stand the most to gain from their international trade relationships, since these countries can draw upon the stock of knowledge capital already accumulated by the more advanced trading partners. Eaton and Kortum (2002) analysed the role of trade in spreading the benefits of new technology and found that trade does allows a country to benefit from foreign technological advances through spillover effects. But the magnitude of the gains from foreign innovations was conditional on the proximity to the innovating country. This implied that geography was important for foreign R&D to be effective through the trade channel. Coe, Helpman, and Hoffmaister (1997) showed that trade played a significant role in the transfer of technology across countries. Hakura and Jaumotte(1999) found that intra-industry trade was more effective than inter-industry trade for technology transfer because countries were more likely to absorb foreign technologies when their imports were from the same sectors as the products they produced.

What do geography, distance and intra-industry trade imply for innovation in the EAC region? This paper analysed the role of trade and R&D spillovers in transferring technology within the East African Community. We examined the impact of R&D that reduced the costs of production in the innovating country(Kenya)and also led to technology spillovers through intra-industry trade within the East African Community and thereby reducing the costs of production in other countries in the region.

The paper is arranged as follows: Section 2 presents the literature review of empirical studies. Section 3 describes data, sources and empirical model. Section 5 presents the main results and the robustness checks. A final section summarises the main findings.

2.0 Literature Review

In this section, we examined the empirical literature on innovation in the African context. We looked at trade and innovation, and the effects of innovation on agriculture and firm performance.

2.1 Trade and innovation in the Africa

Empirical studies that have focused on the impact of geography and foreign R&D on productivity in Africa have generally found evidence of R&D spillovers. Seck (2012) analysed the extent of foreign R&D spillovers to countries in the West African Monetary Union(WAEMU) through the import and FDI channels. He found that foreign R&D spillover effects were stronger in the import channel in comparison to the FDI channel. A ten-percent increase in foreign R&D capital led to a two percent increase in total factor productivity that accrued through the import channel and half- a-percentage-point increase through the FDI channel. Nyantakyi (2013) examined how imports from OECD countries lead to productivity gains for domestic firms in Nigeria, Kenya, and Tanzania. He found that domestic companies with technology standards farther away from the international frontier benefited more from trade than those with technology standards closer to international standards. He also found that firms with highly skilled workers realized higher productivity gains from trade. Nyantakyi and Munemo (2014) used firm and industry level data from Ghana, Tanzania, and Kenya to examine the effect of capital goods imports on domestic firms' productivity. Their results showed that increasing imports of capital goods and closing the technology gap had significant positive impact on productivity. Also, local firms with technology standards further from the international frontier benefited more from capital goods imports.

We examine the trends in imports of foreign technology to the EAC region to study the distribution of the sources of imported technology to the region. The data in Table 1 shows that technology imports increased between 2000 and 2014 in all three categories of high technology, medium technology, and low technology. The OECD remains the most important source of high and medium technology capital goods for the EAC region, although the OECD's share of technology imports has decreased significantly (Figure 3). For the case of low technology goods, Africa has overtaken the OECD as the primary source of low technology imports for the EAC region. The distribution of technology imports has implications for R&D in the region because geography and distance matter for the intensity of foreign spillovers. It's unlikely that countries in the EAC will close the technology gap with OECD through the trade channel. They are more likely to close the technology gap with other less advanced countries in the vicinity of the region. Therefore, it is important to use regional trade and industrial policies as tools for the development of regional R&D projects to create "domestic" innovations that can easily be spread across the region.

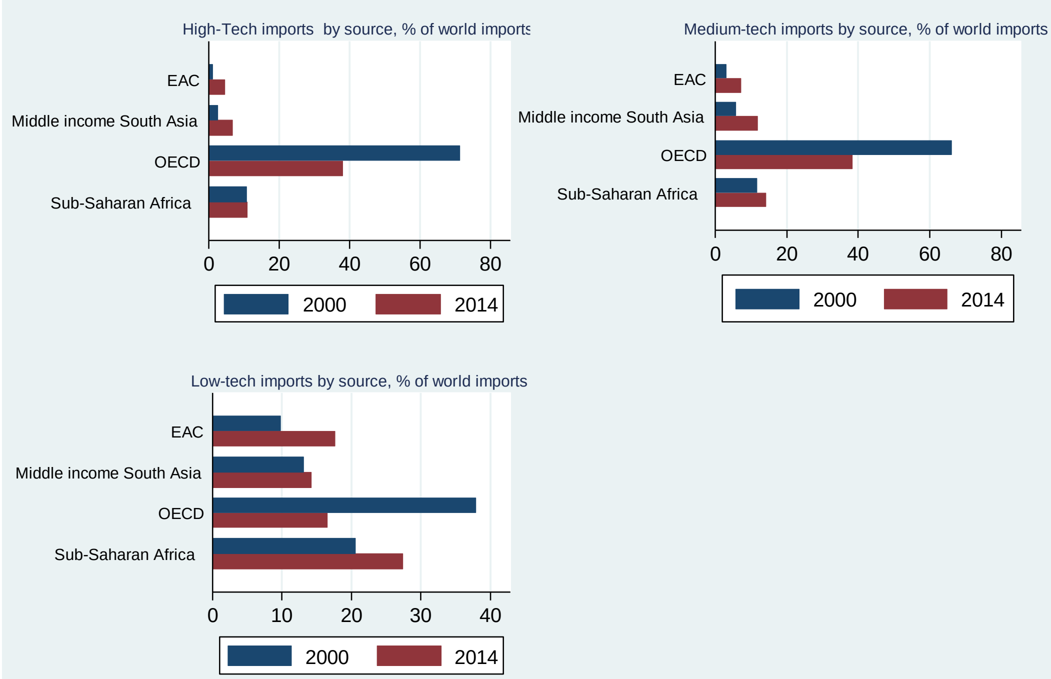
Table 1: EAC imports of capital goods by technology intensity, 2000 and 2014

Technology imports	Trade partner	**2000**	**2014**
hightech imports(USD, millions)	EAC	8.1	85.6
	OECD	479.2	686.6
	Middle-income South Asia	18.9	126.6
	Sub-Saharan Africa	71.5	197.4
	World	669.7	1,800.0
mediumtech imports(USD, Millions)	EAC	44.7	371.1
	OECD	928.9	2,000.0
	Middle-income South Asia	81.2	629.0
	Sub-Saharan Africa	166.0	737.8
	World	1,400.0	5,200.0
lowtech imports(USD, Millions)	EAC	69.8	475.5
	OECD	269.3	449.2
	Middle-income South Asia	92.8	383.9

	Sub-Saharan Africa	146.8	740.2
	World	710.2	2,700.0

Source: Comtrade data, 2016

Figure 3: EAC imports of capital goods, % of world imports, 2000 and 2014



Source: Comtrade 2016

2.2 Agriculture and innovation in Africa

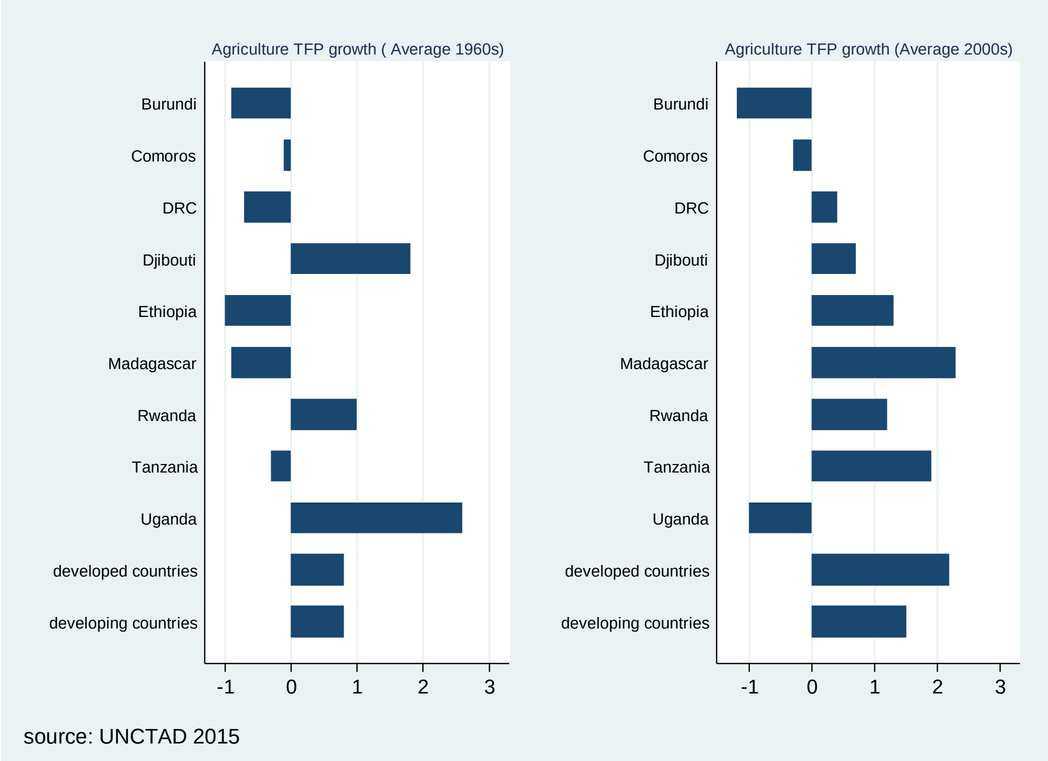
The literature has observed over time that, as countries develop, production shifts away from primary goods into more sophisticated manufactured goods and services, while the bulk of economic activity moves from agriculture to industry and other urban-based activities. In his seminal paper, Lewis (1954) described the theoretical framework for structural transformation. Lewis argued that the traditional sector is characterized by surplus labor (a situation in which labor can be removed without loss in output). In principle, this permits, industrial development with unlimited supplies of labor, at least until the surplus-labor phase comes to an end. Development is characterized by an ongoing move of labor and resources from a “traditional sector” to a “modern sector.” Ongoing capital accumulation in the modern sector provides the fuel for sustained transfers. The Lewis model viewed agriculture as playing a passive role in the process of structural transformation, simply supplying labour and resources to more dynamic sectors. However, the literature has shown that successful structural transformation entails not only moving labour out of agriculture to higher productivity sectors, but also increasing agricultural productivity. Schultz (1964, 1968) argued that productivity-led agricultural transformation was critical to economy-wide transformation than merely providing surplus labor and savings to support industrialization. According to Schultz, efficient farmers responded to economic incentives and therefore with the right incentives farmers could improve agricultural productivity by investing in invest in modern technologies. Kuznets (1966) argued that since agricultural growth was higher during periods of structural transformation, the industrial revolution is always accompanied by an agricultural revolution. Jorgenson (1961) emphasized the importance of agricultural productivity growth, stating that “unless productivity growth in agriculture was sufficiently rapid to outpace the growth of population and the force of diminishing returns in the land, the industrial sector might not become economically viable.”

Irz and Roe (2005) found that small variations in agricultural productivity had strong implications for the rate and pattern of economy-wide growth Tiffin, and Irz (2006) found that agriculture has been the engine of growth in most developing countries. Causality runs from agricultural growth to economy-wide growth. Therefore, it is recognized that successful structural transformation involves both the movement of labour from agriculture to higher productivity sectors and also increased agricultural productivity. The transformation of agriculture into a modern, productive sector is a key element in the process of structural transformation.

According to UNCTAD(2015), agricultural productivity is critical for structural transformation and the major determinant of the income gap that separates low developed countries and developed countries. Gollin et al. (2002) showed that low agricultural productivity can substantially delay industrialization. Improvements in agricultural productivity can speed up the process of industrialization and, hence, have large effects on a country’s relative income. They argue that in the short run, such changes will have a larger impact than comparable increases in non-agricultural productivity, even though in the long run it is productivity in the non-agricultural sector that is most important for growth. Increasing agricultural productivity is a precondition for industrialization (Timmer, 1988). By increasing productivity and reducing the labour required in agriculture, labour is released for employment in other sectors of the economy. Murphy et al. (1989) suggest that there are two necessary conditions for industrialization, firstly leading sectors such as agriculture (in the case of African countries) must grow and provide demand for the manufacturing sector. Secondly, income generated from this leading sector must be broadly distributed to provide sufficient demand for the manufacturing sector. Increasing agricultural productivity is also important for international trade, firstly through its impact on real wages, lower food prices can boost the export competitiveness of the tradable sector and secondly through the increased agricultural output that generates a large exportable surplus (UNCTAD, 2015).

While it's acknowledged that growth in agricultural productivity is critical for structural transformation, agricultural productivity growth in the East African region has lagged behind growth in other regions of the world. The data shows that growthofagricultural total factor productivity (TFP) in the region was less than growth rates of other developing and developed countries in the 2000s (Figure 1). However, most countries in the region experienced positive growth in agriculture TFP between the 1960s and the 2000s. The exceptions to positive growth were Uganda and Burundi, and the decline in Uganda's TFP growth was concerning because in the 1960s the country had one of the fastest growth rates in the world.

Figure 4: Agricultural total factor productivity growth



Empirical evidence shows that investments in agricultural research and development (R&D) have tremendously enhanced agricultural productivity in Africa. Block (1994) reported a recovery of aggregate agricultural TFP in sub-Saharan Africa during the 1980s, and he found that agricultural research explains an important share of TFP growth in African agriculture. The estimated coefficient on lagged research expenditures per hectare was significant and explained up to one- third of the measured TFP growth rate from 1983-88. Lusigi and Thirtle (1997) found a significant and positive effect of agricultural R&D on TFP growth in Africa. They calculated indices of total factor productivity (TFP) for agriculture in 47 African countries, for the period 1961–91. The average rate of TFP growth was found to be 1.27 percent. Block (1995) measured agricultural productivity in Africa based on measures of wheat output. His analysis revealed growth in agricultural productivity during the mid-1980s in Africa. Technical change measured by expenditures for agricultural research and macroeconomic reform accounted for up to two-thirds of the growth and productivity.

Wiebe et al. (2001) examined trends in agricultural productivity in Africa and found that for Africa to continue to meet its food security needs would require one to two percent greater agricultural production per year. Education of the rural labourforce, as well as agricultural research, would improve the prospects for productivity growth in Africa. Also, policy reforms to improve physical infrastructure, political stability, and the institutional environment were needed to facilitate increased to high yielding inputs. Alene and Coulibaly, (2009) investigated the aggregate impacts of R&D on productivity growth and poverty reduction in sub-Saharan Africa (SSA). Using a polynomial distributed lag structure for agricultural research within a simultaneous system of equations framework, they demonstrated that agricultural research contributed significantly to productivity growth in SSA. They also found an aggregate rate of return of 55%, to agricultural research and that agricultural research reduced the number of poor by 2.3 million or 0.8% annually. The results showed that doubling research investments in SSA would reduce poverty by 9% annually. However, this would not be realized without more efficient extension, credit, and input supply systems.

Dias and Evenson, (2010) computed measures of total factor productivity (TFP) growth in developing countries for crop production, livestock production, and aggregate agricultural production for two periods, 1961–1980 and 1981–2001. They found that highest TFP growth rates were achieved in East Asia, followed by South Asia and the countries of Latin America. Lowest TFP growth rates were in East and Central Africa. They also found a positive correlation between TFP and investment in industrial R&D, extension systems and in the schooling of farmers. Alene (2010) focused on the contributions of R&D expenditures to productivity growth in African agriculture for the periods 1970-2004. He found an average TFP growth rate of 1.8% per year for the period 1970- 2004 and a 33% annual rate of return on investments in agricultural R&D in Africa. He argued that rapid growth in R&D expenditures during the 1970s helped to explain strong productivity growth after the mid-1980s while the slower growth of R&D expenditures in the 1980s and early 1990s led to slower productivity growth since 2000.

Despite the positive effect of R&D in Africa, the long-term rates of return of agricultural R&D in Africa have been lower than in developed regions (Alston et al., 2000). Also Africa has benefited less from spillovers of agricultural technologies developed elsewhere. Johnson and Evenson, (2000) argue that foreign research is less applicable in sub-Saharan Africa, and thus has lower impacts than in other regions. If sub-Saharan Africa had enjoyed even the average level of foreign spillovers, growth in agriculture would have been much faster. They also argue that if Sub-Saharan Africa had performed domestic research at a level comparable to Southeast

Asia, growth would have been at least another 0.25% higher in each year (an important effect in an area where the actual growth rate averaged only 0.6% per year).

Even though the evidence shows that the payoffs to agricultural research are considerable, many countries in the region continue to under-invest in agricultural research. Stands and Beintema (2015) argue that overall investment levels in most African countries is volatile and well below the levels required to sustain agricultural R&D needs. In 2011, SSA invested just 0.51 percent of agricultural output in agricultural R&D, well below the UN's and NEPAD's 1 per cent minimum national R&D investment target. Agricultural R&D spending for the region as a whole shows much higher volatility compared with spending in other developing regions of the world. Low levels of government funding, coupled with a much higher dependence on donor and development bank funding compared with other regions, is the main driver of SSA's high volatility in agricultural R&D expenditures.

According to Fuglie and Rada, (2013) the significance of agricultural R&D is underscored by the fact that the recovery in productivity gains in Africa in the 1990s has been due to increased spending on agricultural R&D and extension services. They examined the long-term performance of agriculture in African countries and the roles of agricultural research, economic policy reform, labor force education and the presence of armed conflict. They found that agricultural productivity in Africa remained low and was falling farther behind other regions of the world. They showed that increased productivity was correlated with investments in agricultural research, wider adoption of new technologies, and policy reforms that have strengthened economic incentives to farmers. Returns to national agricultural research were robust although investment in agricultural research remained low.

Regarding knowledge spillovers generated from agricultural research and development (R&D) in Africa, studies have found evidence of positive spillovers. Maredia & Byerlee, (2000), examined the issue of research efficiency in 35 developing countries using a global model that incorporated direct research spill-ins and found positive spillover effects. Abdulai et al. (2006), use a partial equilibrium model to investigate the potential for spillovers from greater cooperation in agricultural research, and from trade liberalization. Their results show that permitting greater cross-border transfers and adopting improved technologies could have large spillover multiplier effects on overall economic welfare in the region.

2.3 Innovation and Productivity in African Firms

Innovation is a crucial driver of long-term economic growth and prosperity. According to Romer's seminal paper on endogenous technological change, productivity growth is driven by innovation and innovation is created by investment in the research and development (R&D) (Romer 1990).

Many of the empirical studies on innovation at the firm level have focused on the developed world; fewer studies have focused on low-income countries, especially countries in Africa. Some studies on African firms have focused on determinants of innovation using firm-level data. Rajlakshmi (2014) analyzed firm-level data from Kenya and Uganda to determine drivers of innovation in both countries. He investigated the effects of financial investment, human capital, economies of scale, technology, competition, external infrastructure, organizational structure, and corruption on innovation. Using a generalized linear model framework, he found strong evidence for financial and human capital theories in both countries. Purchasing fixed assets and a training program for full-time employees were significant determinants of innovation in both countries. Moez (2014)investigated the key determinants of innovation and their impact on the performance of firms in three North African countries (Algeria, Egypt, and Morocco) using World Bank survey data on the investment climate. He found that R&D intensity did not have a significant effect on innovation in these countries while firm size had a significant effect on innovation. Koubaa et al. (2010) analysed the determinants of innovation in Tunisian firms and found that R&D was the most important factor determining the innovative activity. They also found that small firms were more innovative than larger firms.

Other studies have looked at the effect of innovation on productivity. Goedhuys et al. (2006) examined the determinants of productivity among manufacturing firms in Tanzania. They evaluated the importance of technological variables - such as R&D, education and training, innovation, foreign ownership, licensing and ISO certification - and institutional variables – such as access to credit, health of the workforce, regulation and business support services. They found that R&D and innovations failed to produce any significant impact on productivity, and only foreign ownership, ISO certification and high education of the management appear to affect productivity.

Rakotoarisoa et al. (2014) employed Romer's endogenous growth model to determine the impact of human capital accumulation and allocation on value-added per worker in manufacturing in Ethiopia, Kenya, and Mauritius. They used a model that differentiated between human capital allocated to the production and non-production (such as research and management) workers. Their results showed that human capital accumulated and allocated to the non-production workers had the most significant effect on growth in manufacturing value added in these countries. Biesebroeck (2004) examined the effect of exporting on firm productivity in nine African countries. He found that exporters in these countries were more productivethan non-exporters and, more importantly, exporters increased their productivity advantage after entry into the export market. Dedehouanou (2014) analysed the effect of high-value exports in agriculture on household productivity in Senegal. He found that rural farmers involved in high-value green bean export production were more productive and efficient than their counterparts that were not involved in this type of crop diversification.

3.0 Model Data and Specification

We use the GTAP 9 database that describes global bilateral trade patterns, production, consumption and intermediate use of commodities and services. The underlying data in the GTAP 9 database refers to a 2011 baseline that represents a marked improvement on the previous GTAP 8 database, which included less regional detail and was based on 2007 input-output data. The model is run using an aggregation that includes the 16 regions included in the GTAP model, countries that make up the East African Community and 10 aggregated sectors.

The standard GTAP model assumes perfect competition and constant returns to scale in production (Hertel et al., 2007). The functional forms are nested constant elasticities of substitution (CES) production functions. Land, labour (skilled and unskilled) and capital substitute for one, and composite intermediates substitute for value added at the next CES level (with fixed proportions applying in the standard model). The land is specific to agriculture in the GTAP database and has imperfect mobility amongst alternative agricultural uses. A Constant Elasticity of Transformation (CET) function is employed to allow land to be transformed from one use to another. The closer the transformation elasticity is to zero; the more unresponsive land supply is to changing relative returns to land across agricultural uses.

In the default GTAP closure, labour and capital are assumed to be mobile across all uses within a country and immobile internationally. Bilateral international trade flows are modelled to follow the Armington specification by which products are differentiated by country of origin. These Armington elasticities are the same across regions but are sector-specific, and the import elasticities have been estimated at the disaggregated GTAP commodity level.

The standard GTAP closure assumes that the levels of each region's employment of productive factors are fixed in the aggregate and that the regional balance of trade is determined by the relationship of regional investment and savings, where international capital mobility seeks to equalize rates of return across regions. Our study uses the standard employment closure that allows for flexible wages in the region. This way the model can determine changes in employment (and evidence of structural transformation) as a result of increased agriculture productivity in labour within the East African region. We also use the standard GTAP savings-driven model where changes in savings rates drive investment.

This experiment examines the impact of R&D that reduces the costs of production in the innovating country within the East African Community and also leads to technology spillovers that reduce costs of production in other countries in the East African Community. It is assumed that the increase in productivity is driven by a labor-augmenting technology. An increase in the labor-augmenting technology parameter of 10% is equivalent to a downward shift of the unit cost function by 10%. The shock applied to the GTAP model is a 10% increase in the labor-augmenting parameter [AFE (i, j, r)] for the processed food, light manufacturing and textile sectors. Alternatively, one might think of the 10% productivity increase as the sum effect of all research activities in the countries of the East African Community.

We carry out two different experiments, in the first case innovation from one country Kenya is allowed to spill over to the other countries in the EAC while in the second case innovation from Kenya does not spill over to other countries in the EAC.

In the first experiment, we examine the effect of a ten percent unit cost reduction, with spillover effects, in three different sectors - processed food, light manufacturing and textile sectors – that are considered important in the early stages of industrialization. For example, a productivity increase in the processed food sector in Kenya spills over to other countries in the EAC region, and as a result, all the processed food firms in the EAC experience the same productivity increase. We also compare the effect of the 10 percent productivity increase between the three different sectors.

In the second experiment, we examine the effects of a ten percent unit cost reduction in the processed food in Kenya with no spillover effects to other processed food firms across the region. In this experiment, Kenyan food processing firms are more innovative and productive than the other firms in the EAC. Innovation in Kenyan firms does not spread to the other firms in the region.

4.0 Results and Discussion

4.1 Experiment 1: Effects of technological spillovers

The simulation results suggest that the benefits from R&D induced productivity could be highly significant, resulting in a boost to trade in the East African Community. The direct effect of innovation in the processed food sector was an increase of processed food exports from the East African Community by US$ 92.5 million while light manufacturing and textiles sector innovations increased light manufacturing and textiles exports by US$ 70.2 million and US$ 69.6 million respectively (Table 2).

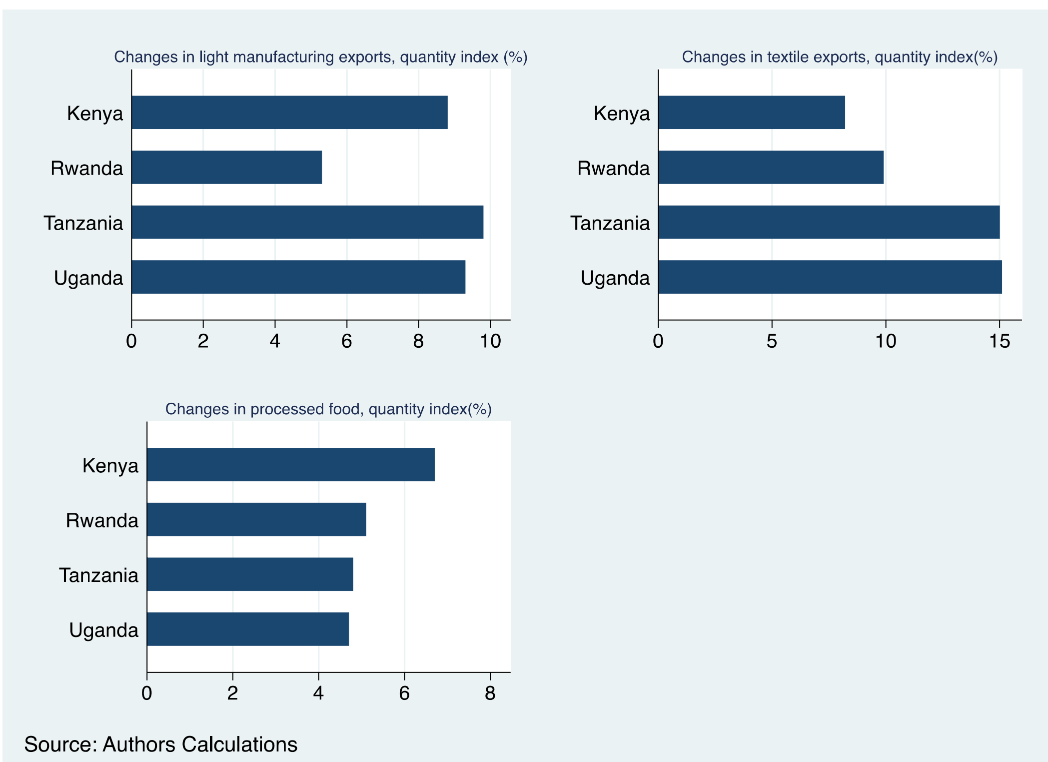
Innovation and productivity changes in the three sectors resulted in a realignment of demand and supply for factors of production used by other sectors of the economy. As a consequence, the other sectors of the economy experienced changes in output and prices, with the net effect being positive or negative for the export sector. Innovation in the processed food sector resulted in a net increase of exports for the EAC region(US$ 167 million) while innovations in the light manufacturing and textiles sectors led to decreased net exports for the EAC (US$ 130 million and US$ 20 million respectively).

Table 2: Changes in exports per sector due to increased productivity within the sector(USD, Millions)

	Region	Proc food innovation	lightMNFC innovation	Textiles innovation
Changes in only innovating sector	Kenya	52.4	38.6	33.9
	Rwanda	1.8	1.6	0.3
	Tanzania	22.5	19.8	29.3
	Uganda	15.9	10.2	6.1
	EAC	92.5	70.2	69.6
Change in all sectors	Kenya total	56.93	-48.59	-1.01
	Rwanda total	1.04	-0.49	-0.43
	Tanzania total	14.17	-8.61	-7.18
	Uganda total	11.29	-7.17	-1.23
	Total EAC	166.86	-129.72	-19.7

Source: GTAP simulation results

Figure 5: Percentage changes in innovating sector exports(quantity index)



What happens to regional output as a result of the productivity changes? Total production would increase as a consequence of the productivity changes with the biggest net gains due to innovations in the processed food sector at US$ 663 million followed by the light manufacturing and textiles sectors at US$ 265 million and US$ 154 million respectively (Table 3). In all the three cases total net output gains exceed the output gains accrued to only the innovating sector.

Figure 6 shows the percentage changes in innovating sector output for each country in the region; the biggest average increase would be in the textile sector with an average increase of 5.3%, followed by the light manufacturing and processed food sectors with average gains of 3.9% and 1.2% respectively.

Table 3: Change in real output due to increased productivity within the sector (USD, Millions)

	Region	**Proc food innovation**	**Light MNFC innovation**	**Textiles innovation**
Changes in only innovating sector	Kenya	228.02	134.1	78.76
	Rwanda	6.48	3.73	1.38
	Tanzania	50.15	37.74	39.9
	Uganda	33.11	32.38	14.15
	EAC	317.76	207.95	134.19
Change in all sectors	Kenya total	497.64	183.49	109.78
	Rwanda total	16.34	5.68	2.18
	Tanzania total	66.7	36.65	27.75
	Uganda total	82.48	38.87	14.41
	Total EAC	663.16	264.69	154.12

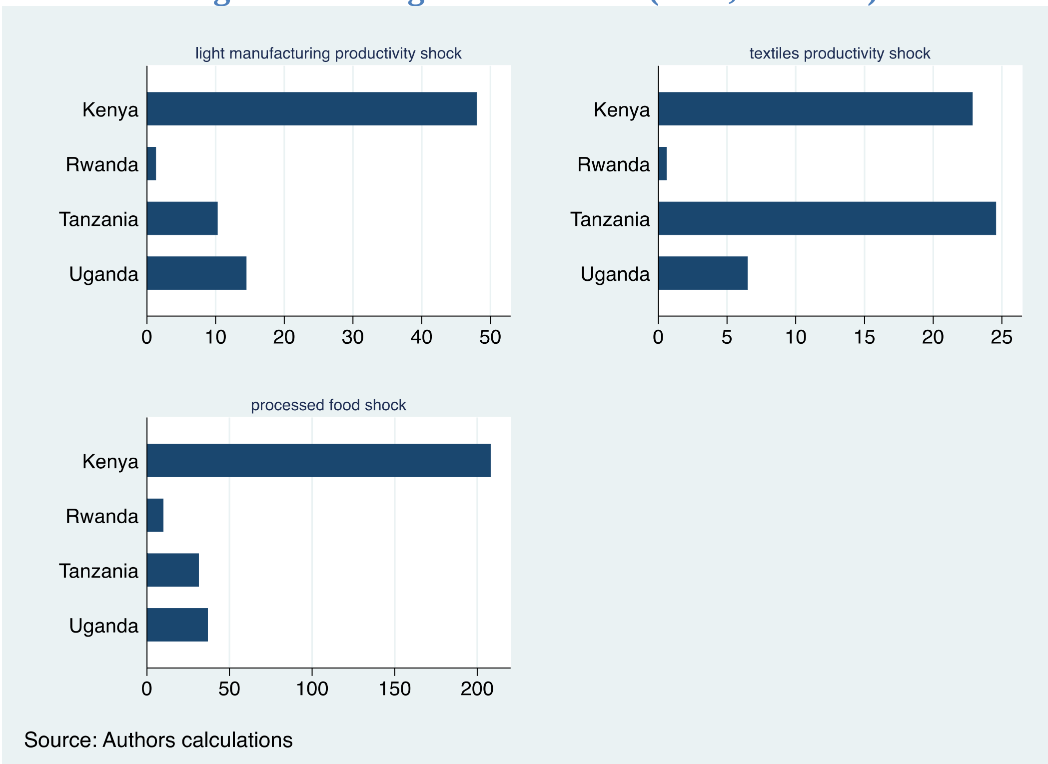
Source: GTAP simulation results

Figure 6: Changes in innovating sector output,(%)

Source: Authors calculations

Regarding the GDP changes, the productivity increase in all three sectors would result in increased GDP for all countries in the East African Community (Figure 7). The biggest increase in the value of total EAC GDP would be due to the processed food innovation effect (US$ 286 million) followed by light manufacturing (US$ 74 million) and textile innovation effects (US$ 54 million) respectively.

Figure 7: Changes in real GDP (USD, Millions)



Concerning the welfare impact, the results reveal a net welfare gain for all the countries in the East African Community due to innovation effect in all the three sectors (Table 4). The biggest increase in the total EAC net welfare would be due to the processed food innovation effect (US$ 253 million) followed by light manufacturing (US$ 109 million) and textile innovation effects (US$ 72 million) respectively.

Table 4:Changes in equivalent variation(USD, Millions)

	Proc food innovation	lightMNFC innovation	Textiles innovations
Kenya	177.1	75.7	33.9
Rwanda	11.1	1.7	0.7
Tanzania	29.2	14.8	30.5
Uganda	35.0	17.0	6.9
EAC total	252.4	109.1	71.9
Rest of Africa	7.0	2.3	1.8
RestofWorld	26.0	-42.5	-26.8

Source: GTAP simulation results

4.2 Experiment 2: Technical change in Kenyan food processing firms with no spillovers to the rest of the EAC

We compared the welfare impact of innovation in the processed food sector with spillover effects to innovation with zero spillovers, where the benefits accrue to only the innovating country, Kenya. The results reveal a difference in net welfare gain for all the countries in the region due to innovation spillover effect in the processed food sector (Table 5). The total EAC net welfare due to the innovation spillover effect would be US$ 253 million compared to US$ 181 million for the experiment with zero innovation spillovers. In addition the distribution of the gains would be extremely skewed in the experiment with zero spillovers, 99% of the gains would accrue to Kenya the innovating country.

Table 5: Comparing equivalent variation for region, spillovers vs. zero spillovers(USD, Millions)

Country	Innovation in Kenya with spillovers to EAC	Innovation in Kenya only, no spillovers
Kenya	177.1	179.5
Rwanda	11.1	0.38
Tanzania	29.2	0.29
Uganda	35.0	0.94
Total	252.4	181.1

Source: GTAP simulation results

4.3 Sensitivity Analysis

For sensitivity analysis we compared the welfare impact of innovation in the processed food sector with two different kinds of closures; the fixed wage closure, which assumes an exogenous wage and the flexible market clearing labor model with endogenous wages (which we used in our experiments). The results reveal positive net welfare gains for all the countries in the region with both types of closure (Table 6). The fixed wage model closure led to higher welfare gains (US$ 384 million) relative to the flexible wage closure model (US$ 317 million).

Table 6: Equivalent variation due to increased processed food sector productivity with different closures (USD, Millions)

Country	fixed wage closure	flexible wage closure
Kenya	299.55	177.1
Rwanda	22.43	11.09
Tanzania	62.86	29.17
Uganda	52.22	35.04
EAC	437.06	252.4

5.0 Conclusion

In this paper, we analysed the role of trade and R&D spillovers in transferring technology within the East African Community. We examined the impact of R&D that reduced the costs of production in the innovating country (Kenya) and also lead to technology spillovers through intra-industry trade within the East African Community and thereby reducing the costs of production in other countries in the region. The results showed that total production in the EAC would increase as a consequence of the productivity changes with the spillover effects. The biggest net gains would be due to innovations in the processed food sector at US$ 663 million followed by the light manufacturing and textiles sectors at US$ 265 million and US$ 154 million respectively.

How can regional integration in the EAC be leveraged to drive R&D in critical sectors that respond to the particular needs of East African Countries, particularly where market incentives for the promotion of R&D by the private sector are absent? To address market imperfections that hamper innovation and industrial development, countries in the EAC can do the following;

- Collaboration between public research and technical education institutes within the EAC The EAC countries should engage in joint R&D projects in key sectors such as agriculture and manufacturing. This is especially important because, at the individual level, the countries may not have the resources to finance large R&D projects.

- Build regional partnerships for technology and innovation. Under the regional integration framework, they should promote the exchange of experiences in policy-making for technology and innovation.
- Given the importance skills in the development of R&D, governments in the region should subsidize tuition for students in the science and technology fields.
- Provision of financial and fiscal incentives to support local firms' R&D activities. EAC firms should be entitled to tax benefits if R&D is undertaken within the region.
- The use of public procurement policies to drive innovation. Products manufactured in the EAC should get preference in procurement by governments to encourage EAC firms to develop and manufacture products embodying new technologies.
- Acquisition of scientific and technological knowledge through collaboration with foreign research institutions, foreign firms or joint ventures.
- Foreign firms investing in the EAC should be subject to a local content requirement to create backward linkages with local firms.

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