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The Effect of Technological Innovation on Economic Growth: Empirical evidence from Kenya

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List of Abbreviations

2TSLS - Two-stage Least squares

AIC- Akaike Information Criteria

ARDL-Autoregressive Distributed Lag

BRICS-Brazil, Russia, India, China & South Africa

CEE-Central and Eastern Europe

CUSUM-Cumulative sum

CUSUMQ- Cumulative sum of squares

EAC-East African Community

ECM-Error correction Model

EU-European Union

FDI-Foreign Direct investments

GDP-Gross domestic Product

GERD -Gross domestic expenditure on R&D

GMM-Generalized method of moments

GNI-Gross National Income

GNP-Gross National Product

ICT-Information and Communications Technology

IP-Intellectual Property

IPR-Intellectual Property Regime

JB-Jarque–Bera test

LIC-Lower Income Country

LMIC- Lower Middle-Income Country

ABSTRACT

Kenya's recent classification as a Lower- middle-income country (LMIC) is proof that the economy of Kenya is growing as per the Vison 2030 Plan set in 2008. As technological innovation development is a known factor for increasing the growth of a nation's economy, Kenya's objective to transition into a knowledge-based economy requires a proper understanding of the relationship between technological innovation, that produces technological knowledge, and economic growth. This study puts technological innovation into perspective and aims to empirically examine its relationship to economic growth. It employs the use of Patent registered, Number of trademarks registered in Kenya, and Scientific and Technical Journal articles in Kenya as measures of technological innovation as well as Labour productivity Growth rate as a proxy for economic growth. It establishes whether there exists a long-run relationship between technological innovation and economic growth from 1981 to 2018 with data sourced from The World Bank database. This study also seeks to examine whether there exists bidirectional causality between technological innovation and economic growth. The Autoregressive distributed Lag model and pairwise Granger causality test technique are used for estimation. There is a short run relationship between total number of patent applications and Labour productivity growth rate although the impact is quite small. There is no presence of a significant long run relationship between technological innovation and economic growth. The study also concludes that, there exists no bidirectional granger causality between technological innovation and economic growth.

Key Words: ARDL model, Economic growth, Technological innovation, Kenya.

(Ciobanu, Bumbac, & Petrariu, 2013). It has been empirically found that the quality of government institutions coupled with government effectiveness, has significant positive effects on the growth of both technology (representing innovation) and GDP (a proxy for economic growth) in the European countries (d'Agostino & Scarlato, 2016). Examining the impact of the quantity and quality of innovation on economic growth on a global scale, Hasan & Tucci (2010) show that there is a positive correlation between quality and quantity of innovation and economic growth. Contrary to the popular result, Kacprzyk & Doryń (2017) find that there is no consequential impact of R&D, the most commonly used proxy for innovation, on economic growth and no positive relation between growth and patent activities in the new European Union member states (EU-13).

Though economies like Europe and the United States have had a head start when it comes to innovation and economic growth, advanced developing nations like Singapore, India, and Brazil have also made progress when it comes to innovation. Since the first national science and technology plan in 1991, the Singaporean government has invested heavily in research and development (R&D) consequently strengthening certain sectoral clusters, such as the life sciences cluster in Singapore (Wong, Ho, & Singh, 2010). However, the socio-economic return on the R&D investment at the macro level has not been evaluated recently sparking the interest of researchers especially with the question of whether R&D has contributed to the overall growth in the Singaporean economy (Ho, Wong, & Toh, 2009). Ho, Wong, & Toh, (2009) examined the impact of R&D on productivity in Singapore over the period 1978 to 2001, finding evidence of a stable long-run correlation and relatively low R&D elasticity value compared to the OECD average.

In Brazil, the government advanced a brand new legal structure to promote inventiveness, implementing the *Lei do Bem* (Law of property) and establishing mechanisms for ease of their financing (Cassiolato, Matos, & Lastres, 2013). Meanwhile, R&D investments mostly from a minute percentage of private brokers and the Brazilian government accounts for more than 1% of GDP (Jimenez, Fernández, & Menéndez, 2013). This demonstrates the regime's commitment to the promotion of innovative activities within the Brazilian Nation. This in turn has led to research works that have developed addressing innovation– economic growth issues in two ways: The Regional disparities of economic

Africa. For some of the countries in the East African Community (EAC), Kenya, an authoritative economy in the community, is the principal provenance of foreign direct investment (FDI) (Kimenyi, Mwega, & Ndung'u, 2016). In the 2000s the country started from low economic growth rates. The economy started recovering consistent with the Africa Rising narrative, which states that owing to the series of good leadership and economic reforms in the continent, economies in African countries are transformed into engines of growth (McKenzie, 2016). This leads to a revival of economic growth in the region in the new millennium. The rapid economic growth in Africa, Kenya especially has been attributed to the quick expansion in telecommunication and financial services (Robertson, 2013). The rate of investment has also been attributed as a significant influence on the economic growth in Kenya. The Second Medium Term Plan of Vision 2030 sets ambitious targets for raising the public and private investments in Kenya (Kenya R. o., 2013).

It started becoming common knowledge in the developing world that technological development is important with regards to increasing the growth rate of the economy at the macro and micro levels. The United States is a globally leading when it comes to technological innovation. World Economic Forum's 2018 Global Competitive Index indicates that the country's competitive advantage is because of its vibrant innovation system, business dynamism, pillars of institutions that are strong, and the financing mechanisms (Schwab, 2018). Yet with the world's focus on sustainable economic growth which is provided through innovation Raghupathi & Raghupathi (2017), Kenya which is sometimes referred to as "The Silicon Savannah" is yet to embrace the maximum innovation benefits for its economy. Innovation adoption by a developing country is important for several reasons. On a micro level, companies in low-income countries can adopt innovation to be able to have a competitive advantage as they compete with similar companies in the same industry on a global scale. On a macro level, innovation is necessary as it will assist in the production of more output with the same number of input boosting the countries' GDP.[6]

Despite the evident relevance of the effect of innovation on growth in an economy, major empirical research work that has been conducted in this field has always focused on developed economies with few studies having their focus on developing economies (Ho, The current case in Kenya is quite different. While there is a common goal, the roadmap to achieve these ambitious goals seems to be disconnected evidenced by the fact that policies specific to engaging the ICT innovation ecosystem are not yet in proper implementation (The Kenya ICT innovation ecosystem report , 2019). Stakeholders in the digital innovation ecosystem are working in silos and are not engaging with each other adequately in either communication or implementation. Innovating on a national level is proving to be difficult because of the absence of a Co-ordinated National Research Objective policy, the poor state of infrastructure and equipment for higher education and research, Inadequate financial investments in research, and Lack of ST&I advocacy at high political and policy levels (Kenya, 2013).

Research that has developed in this field has focused on financial innovation and its correlation with the growth in the economy in Kenya (Mwinzi, 2014). The reason for this is the fact that as the second leading innovative economy in Sub-Saharan Africa, Kenya's innovative strength is access to credit especially microfinance loans.[7] This level of innovation is mainly through the private sector and on a micro-level. To be able to compete with leading innovative economies like South Africa that have put in place science and technology infrastructure and research apparatus, Kenya ought to develop its R&D to build an innovative knowledge-based economy. It then becomes important for key policymakers and higher political powers to be able to understand how innovation affects the growth in the Kenyan economy and if they are to invest in R&D, how desirable would their return on investment be when it comes to economic prosperity and this is what this study seeks to do. Analyzing the correlation between technological innovation and economic growth in Kenyan and establish whether there exists a long-run correlation between innovation and economic growth will be critical in building local capabilities to identify the appropriate technology and transfer mechanism according to the prevailing local conditions in Kenya.

This is due to the fact that data is available within the selected research period for the variables used in the study.

The theory of Radical and Incremental innovation categorizes innovation into two types: Radical and incremental. Incremental innovation at a rate consistent with the current technological path meets the needs of the current markets or customers (Benner & Tushman, 2003; Gatignon, Tushman, Smith, & Anderson, 2002) and calls for the ability to combine, reinforce, whilst taking advantage of current knowledge resources (Danneels, 2002; Subramaniam & Youndt, 2005). Radical innovation however requires new knowledge exploitation and always results in products that are far superior to existing ones (Singh, 2015). It is easier for new and emerging economies as well as new market adopters to adopt radical innovation as they embrace the technological benefits of an innovative economy.

Henderson and Clark's model theory argues that building products require two kinds of knowledge (Henderson & Clark, 1990). Firstly, knowledge of a product's components (Component Knowledge) and secondly knowledge of the linkages between components (Architecture knowledge). The combination of the two leads to four kinds of innovation (Popadiuk & Choo, 2006): (a) Incremental innovation, where both architectural and component knowledge are concurrently enhanced; (b) Radical innovation, where architectural and component knowledge are ''tore down''; (c) Modular innovation, where component knowledge is dismantled but architectural knowledge is enhanced; (d) Architectural innovation, where component knowledge is enhanced but architectural knowledge is dismantled. The theory argues the rationale behind the four types of innovation is that categorizing innovation as either radical or incremental is misleading and does not explain much about the Firm's ability to innovate nor does it explain the circumstances surrounding the innovation (Singh, 2015).

applications tend to have a proportional relationship although patents differ across industries. Nations institute regulatory structures in the form of Intellectual property rights i.e. patents and copyrights, to protect intellectual property and innovation (Blind & Thumm, 2004). These two indicators are popular because of comparability over time and across countries since they are available for longer periods and in most countries (Mohammed, 2018).

Trademarks, although a feasible innovation measure Greenhalgh & Rogers (2010), have enjoyed less spotlight in academic literature as compared to Patents. A trademark protects brand names, logos, and gives a company or an individual absolute power to mark their goods and services and prevents people from using their symbol, slogan, or brand name in a particular region. It lasts ten years and can be renewed after ten years. Trademarks are used in a more extensive range of sectors of the economy and due to the relatively low cost of application and maintenance, the small firms and those new market entrants with access to limited resources are much more likely to use trademarks (Sirilli, 1998).

International trade in High technology products is the other indicator used to measure technological innovation. This includes high-technology exports as a share of manufactured exports as well as Capital goods Imports. These are the fastest-growing segment of international trade especially with the importation of capital goods as many countries are importing foreign equipment's which embody foreign knowledge (Chuang, 1998). The countries then use the knowledge to produce high technology goods which are then exported (Mohammed, 2018). The high - technology exports are an output of innovative activities in these countries.

Bibliometrics, an application of statistical methods to data on articles in scientific journals, books, and other means of communication, is used to observe the condition of science and technology through the overall publication of scientific studies (Sirilli, 1998). Bibliometric indicators include Scientific journals published, citations, and co-citations. While this indicator is used, it is assumed that advances in Science, Technology, and Innovation are captured in the published journals.

a steady-state (an economic state where there are constant wages and knowledge embedded in human capital), a hypothesis that is at odds with the observations in the real world. In reality, countries diverge instead of converging (Hasan & Tucci, 2010).

In the year 1986, Romer pioneered the Endogenous Growth model theory. This is when the growth economics theory took a turn. In the theory, Romer stated that ideas are non-rival and partially excludable, implying growth in returns and suggesting the existence of monopolistic competitive rents that were utilized in paying for the innovation generating resources (Boianovsky & Hoover, 2009). Also referred to as the new economic growth theory, it states that technological innovation is mainly affected by factors such as; the level of human resource and accumulation as well as the establishment of a different analytical framework based on the breadth and depth of analysis (Zhou & Luo, 2018). Technology is then an endogenous variable(one which can be explained within the model's framework). The new growth model can generate positive growth rates within economic variables because growth has a positive relationship with the deliberate production of knowledge and technology. This implies that growth in per – capita output in the long- term depends on investment decisions, which is an endogenous variable, and not on an unexplained exogenous variable as stated in The Neo-classical Framework (Alexiadis, 2012).

Economic growth is measured using the variables gross domestic income (GDI) or gross national income (GNI) or the gross domestic product (GDP) or gross national product (GNP) per head of population or head of the (potential) workforce population Frenkel & Hemmer (1999) and Labour productivity Indicators.

2.3 Empirical Studies

After Romer's New Growth Theory, several empirical studies after the 1990s such as (Iyoboyi & Na-Allah, 2014; Maradana, Rana P., et al., 2017) have sought to investigate the importance of innovation in economic growth. The papers sought to understand how the study of Petrariu, Bumbac, & Ciobanu (2013) between innovation and growth in the economy. Andabaka, Sertić, & Harc (2019) explores the importance of the growth in the economy, institutions, and recycling behavior on the eco-innovation index in the 28 European Union member states. A robust standard error GMM estimator was used in the analysis. The findings indicated that the quality of institutions, the rate of growth in GDP, and the rate at which the municipal waste is recycled had a statistically significant positive impact on eco-innovation. High rates of economic growth are usually associated with higher investments that provide an incentive for eco-innovation activities while Institutional support through EU policies stimulate innovation. Since the EU and other developed countries have had a head start with innovation, the recent focus on green technology for sustainable economic growth indicates that this is where the innovation-economic growth nexus is heading next. This sets a blueprint for the developing nations as they build their National Innovation system and boost innovation in their economies.

Little literature has focused on the Newly Industrialized economies(NIE) and developing countries and this is because of the availability of data on the innovation indicators such as patent applications and R&D expenditure as a percentage of GDP. In recent decades, however, there has been a lot of discussion about emerging economies and this is because data on variable proxying Innovation is now available in the majority of these countries.

Ho, Wong, & Toh (2009) using a Cobb–Douglas based analysis examined the impact of R&D on productivity in Singapore between 1978 and 2001. The study found that investments in research and development had a substantial effect on total factor productivity performance hence a stable long-run relationship and relatively low R&D elasticity value compared to the OECD average. Bayarcelik & Taşel (2012) examine the effects of innovation on economic growth as stated by research and development-based growth models that are endogenous using an instrumental variable technique called Two-Stage Least Squares (2TSLS). Results show the existence of a statistically significant positive relationship between R&D investment and the number of the workers in the R&D department with GDP but there is a statistically significant but negative relationship between technology-embodied capital imports and growth in the economy. This finding is consistent with the findings of some previous research studies (Akinwale, Dada, Oluwadare, Jesuleye, & Siyanbola, 2012; Ho, Wong, & Toh, 2009). The findings in the study pose a major policy implication that is, efforts to enhance the growth in the economy should look for ways to promote the application of knowledge in economic activities. One way of bringing this into being is through the promotion of the intensive use of capital (Iyoboyi & Na-Allah, 2014).

Phate, Paramaiah, & Machema (2015) used the Johansen Cointegration technique to evaluate the existence of a long-run correlation and found that there exists a significant positive long-run relationship between R&D, innovation, and the growth in the economy. A 1% increase in R&D investment leads to a 2.1% increase in economic growth (GDP). Hence any policy that is being developed, formulated, or exists will have an impact on Science and Technology. Policy in South Africa should be designed to support an increase in human resources in science and technology, increase patent registration, and increase investment in the areas of R&D. Such investment will have tremendous positive effects on the South African economy as indicated in the research findings.

Mohammed (2018) examines the relationship between innovation and economic growth using Patent, imported capital goods, and research and development during the period of 1996 to 2017. The study used an ARDL multiple regression model and a Granger causality test technique for estimation. The Ethiopian economy has registered an outstanding economic growth in the last few years and the GDP rate is rapid, in broad-based, and well above the average growth rate of other Sub-Saharan African countries. It becomes imperative to examine if globalization, which has forced many developing economies to employ technology as well as innovation, has a role to play in Ethiopia's growth. Mohammed (2018) finds that R&D has a positive significant impact on economic growth both in the short and long term. The unidirectional causality that goes from growth to R&D indicates economic growth is causing the R&D investment. On the other hand, patent has a negative significant impact on both the short and long term indicating rampant imitation in the economy. Furthermore, the unidirectional causality that goes from growth

The Intellectual Property (IP) variables that will be used in measuring technological innovation include trademark applications and patent applications by both residents and non- residents in Kenya. Similar to Mohammed (2018) and Shukla (2017) whose research is in developing economies, the use of patent applications as an indicator is because of the availability of data in Kenya. The use of the IP indicators in this study is largely dependent on the idea that intellectual property, an important factor in global innovation, is now widely accepted in the academic literature and the majority of the published research portrays IP generally as supporting rather than inhibiting global innovation (Willoughby & Mullina, 2019).

The study will employ the use number of scientific journals published in Kenya as another innovation variable. Although there is strong evidence Srholec (2007) showing that emerging and developing economies are increasingly becoming exporters of high-tech products, this study will not use high technology exports as a share of manufactured exports indicator owing to the unavailability of data for the specified study period. The case is the same when it comes to using the number of scientific journals published in Kenya as an indicator and Research and development indicator, there is a lack of data for the chosen study period. The proxy for economic growth that will be employed in this study is Labour productivity growth rate. This is because is a revealing indicator of several economic indicators as it offers a dynamic measure of economic growth, competitiveness, and living standards within an economy. It helps explain the principal economic foundations that are necessary for both economic growth and social development (OECD, 2001)af

Despite the methodological difference in the research papers used to study the correlation between innovation and the growth in the economy,(Andabaka, Sertić, & Harc, 2019; Maradana, Rana P., et al., 2017; Iyoboyi & Na-Allah, 2014), the results seem to be consistent. Innovation and economic growth have a positive long-run correlation. There is an exception in the case of a research study in India where Shukla (2017) finds that there is a negative relationship between innovation and economic growth in India indicating that the growth in the economy is being driven by other variables and not innovation. Methodological differences are because economic modeling depends on the

2.6 Conceptual Framework

From the literature review discussed above, the following figure below is an inclusive framework that summarizes the scope and focus of this study.

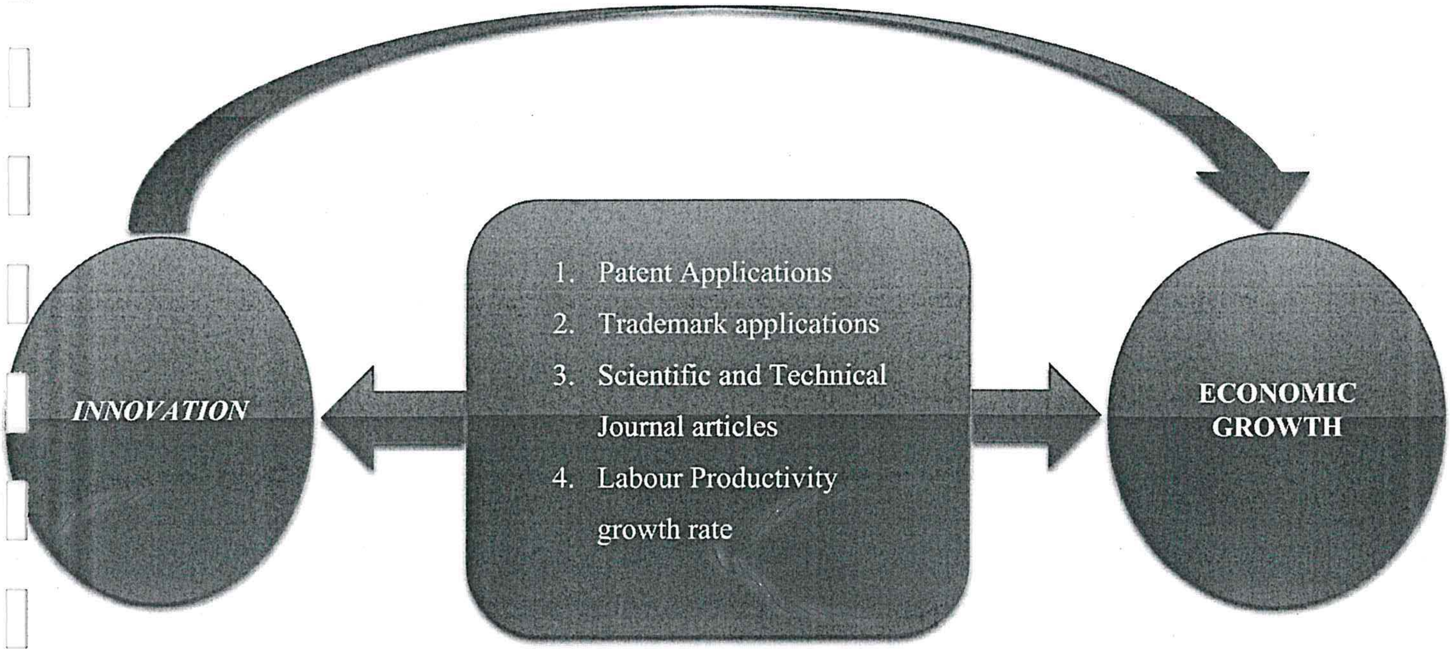

Figure 1: Diagrammatic representation of the conceptual framework

Variable	Description	Measure
Patent Applications	These are the worldwide patent applications filed through the Patent Cooperation Treaty or sometimes with a Country's National Patent office for the exclusive rights for an Innovation. A) Patent application by residents- are the applications made by applicants in Kenya B) Patent application by non-residents- these are applications made by applicants outside of Kenya This variable is a summation of both patents applied by non-residents and residents.	The annual number of patent applications (Resident &Non-resident).
Trademark applications	This refers to applications to register a trademark (brand, logo, or product protection) within a region's IP office in this Case Kenya.	Annual Number of trademark applications (total applications)
Scientific and Technical Journal articles	These refer to engineering and science journals published in chemistry, clinical medicine, biology, biomedical research, engineering and technology, and space sciences.	Annual Number of scientific journals published.
Labour Productivity growth rate	This is the % change in the ratio between GDP and the total number of hours worked or total employment in Kenya.	Annual Percentage (%)

Source; World Bank database

3.2.2 Unit root test

Although the ARDL model does not require a Stationarity test, using the Augmented Dickey-Fuller test for unit root, this study checks for stationarity in the variables to ensure that none of these variables are integrated of the second-order (I(2)), which is a pre-condition for ARDL model as it only works with all variables as I(0), all as I(1)or a combination of both I(0) and I(1) (Mohammed, 2018). The null hypothesis is that there is the presence of a unit root while the alternative is that there is no unit root. Rejecting the null will prove that the differenced/ detrended variable is Stationary and hence will not lead to spurious regressions. The preference of the Augmented Dickey-Fuller test over The dickey Fuller test for stationarity is because the former takes into account any possibility of autocorrelation in the error process (Nkoro & Uko, 2016).

3.2.3 Optimal Lag Selection

This study employs the Akaike Information Criteria (AIC) Over other lag selection models(i.e. Schwartz information criteria (SIC)) as the AIC is better for smaller sample size data(60 observations and below) and is found to produce the lowest possibility of underestimation among all criteria available (Liew, 2004).

3.2.4 Autoregressive Distributed Lag Co-integration model

The bounds test is carried out to establish whether there exists a long-run correlation. The test result proves that the F statistics for the joint significance of all lagged levels of variables and lower and upper critical bounds. The conclusion is that if the F statistics are higher than the lower and upper bounds, this indicates evidence for a long-run relationship among the variables (Jalil & Ma, 2008).

The model specification for the ARDL model is as below;

3.2.5 Causality analysis

The long-run causality effect and the existence of a bidirectional causality can be established using a Pairwise Granger causality test Mohammed (2018) where;

Ho: There is no Granger causality

H1: Granger causality exists

The decision criterion is to reject the null if the value of the f-statistic is ≤ 0.05.

3.2.6 Model diagnostic checks

The diagnostic test is done to ensure that there is no violation in the data and that the model estimated shall have an accurate and reliable test result.

3.2.6.1 Model Stability

The cumulative sum of recursive residuals test (CUSUM test) and the cumulative sum of squares of recursive residuals test(CUSUMQ test) are applied to check for the stability of the short-run dynamics and long-run coefficients forming the error correction term (Adams, 2011). The hypothesis is ;

Ho: Coefficients are constant

H1: Coefficients are not constant

3.2.6.2 Normality test

The Shapiro- Wilk test is applied to establish the normality of the error term in the model (Mohammed, 2018). The hypothesis for the normality test is described as below:

Null: Error term is normally distributed

Alternative: Error term is not normally distributed

The decision criteria are to reject the null hypothesis if the p-value of the Shapiro- Wilk test is less than the significance level.

CHAPTER 4: RESULTS

4.1 Optimal Lag selection

Employing the Akaike Information Criteria(AIC), the optimal lag selection of the variables is as follows:

Variable	*Lag Selection*
Labor productivity Growth rate	1
Scientific & Technical Journal articles	4
Trademark Applications	2
Patent Applications	1

4.2 Augmented dickey Fuller test

The hypothesis of the test is :

H_0= No stationarity (Presence of unit root)

H_A= Stationarity exists

Variable	*Test Statistic*	*5% Critical Value*	*Stationarity*
Labour productivity Growth rate	-5.86	-2.972	I(1)
Scientific & Technical Journal articles	2.804	-2.978	I(0)
Trademark Applications	-5.051	-2.978	I(1)
Patent Applications	-3.698	-2.972	I(1)

The decision criteria are that if the test statistic > 5% critical value; reject the null. Scientific and Technical Journal articles variable is stationary at level while the remaining variables are stationary at first difference. This is okay for the ARDL model as it can be used with variables that are a combination of I(1) and I(0). An ARDL model cannot have an I(2) variable, because it will produce spurious results.

rate and the independent Innovation variables(Trademark applications, patent applications, and Scientific Journals Published). This means that an error correction model needs to be specified.

	I(1) L_1	I(1) L_05	I(1) L_025	I(1) L_01
k_3	3.77	4.35	4.89	5.61

Table 2: Pesaran/Shin/Smith (2001) ARDL Bounds Test result

4.4 Error Correction Model

Given that there exists a long-run relationship between the variables of the study, an error correction model is estimated.

VARIABLE	COEFFICIENT	P-VALUE
Adjustment Co-efficient	-1.295447	0.000
Labour Productivity L_1		
Long-Run Dynamics		
Patent Applications	0.022698	0.286
Trademarks	0.0001174	0.486
Scientific Journals	-0.0004551	0.684
Short Run dynamics		
Patent Applications D1	-0.0341892	0.143
Patent application LD	-0.0427996	0.032
Patent applications L2D	-0.0190287	0.187
constant	0.2818573	0.737

The adjustment coefficient is negative (1.295%) and significant at the 1% significant level, this means there will be long-run convergence among the variables to the equilibrium which is at 129.5% annually. It also shows that previous errors will be corrected in the current period. This adjustment process does explain the consistent growth of the Kenyan

Equation	Excluded	P-VALUE
Labour Productivity rate	Trademarks	0.7993
	Patent Applications	0.4697
	Scientific Journals	0.6225
	ALL	0.6073
Trademarks	Labour Productivity rate	0.3815
	Patent Applications	0.0861
	Scientific Journals	0.2062
	ALL	0.2254
Patent Applications	Labour Productivity rate	0.4691
	Trademarks	0.7488
	Scientific Journals	0.4530
	ALL	0.5727
Scientific Journals	Labour Productivity rate	0.8152
	Trademarks	0.5535
	Scientific Journals	0.2695
	ALL	0.6120

Table 3: Granger test results

Given the above results, in the short run, patent applications, trademark applications, and scientific and technical journals published do not Granger cause economic growth. This is because Intellectual property rights i.e., patents and trademarks and technology are more significant in higher-income countries as compared to lower and emerging economies such as Kenya (Mahmood, 2011).

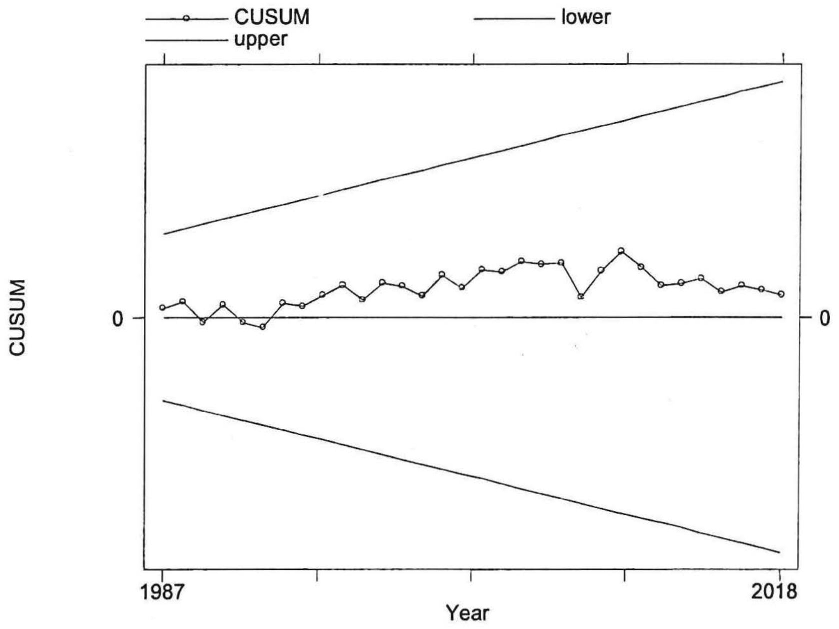

Figure : CUSUM graph for model stability check.

application fees for the Kenyan citizens to encourage innovation hence more patents and trademarks.

The government should devise a policy to invest in reverse innovation. This will create awareness of innovation. They should collaborate with entrepreneurial hubs and university research centers by funding and holding competitions. The reason for this is because spillover effects take longer to reflect on economic growth and hence the need for reverse innovation.

An investment in Research and development, both the public and private sector, to promote sustainable economic growth. Kenya's research and development expenditure take up less than 1% of the GDP, which is very low. However, in countries such as Singapore, significant investments by the government and policymakers in research and development have significantly impacted economic growth positively (Wong, Ho, & Singh, 2010) The same can be adopted for Kenya since both countries are emerging economies.

Policymakers should develop a set of coherent and complementary policies to ensure the potential maximum impact of intellectual property and intellectual property rights increasing competition and innovativeness in the country. This will in turn have a significant impact on the economic growth in Kenya.

Although there exists a Science and Technology and Innovation (STI) policy, the results of this study has made it abundantly clear that there needs to be stronger political advocacy of STI on higher political levels. Giving innovation attention will definitely signal to the public and private sector the importance of research and development in propelling our economic growth.

5.3 Limitations of the study

Like any research study, this study had several limitations. The first is the usage of only three innovation variables (Patent applications, trademark applications, and scientific journals published). This was because of the unavailability of data for the other available innovation variables(Research and development, Capital goods imports among others). Secondly, this study equates patent applications to innovation, a common practice in the study of innovation. This can be problematic because, in reality, a good portion of the innovations often do not qualify for patent protection. This means that patent applications as a variable does not capture all innovations but rather only those that do get the legal protection.

5.4 Future research direction

This research study investigates the relationship between technological innovation and economic growth in Kenya from the period 1981-2018. The technological variables employed included scientific and technical journals published, total trademark applications, and total patent applications. Future studies should consider using variables

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APPENDIX

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