Effects of Innovation Advancement on Technological Progress and Economic Growth in Uganda: A Generalized Least Squares Method

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Abstract

The paper examines the long run effects of innovation advancement on technological progress and economic growth in Uganda during the 1970 to 2020 period. The paper is unique because it measures annual innovation as a ratio of level of technology to the total productivity of labor and capital. Meanwhile, it measures annual level of technology as a ratio of output to total factor. Thus, the paper demonstrates that innovation is characterized by a creative destruction problem. In the study, data sets were collected from the United Nations Database and data analyses were conducted by using the generalized least squares (GLS) method and the philosophical principle of causality. The study finds that innovation advancement as well as innovation acceleration had positive and significant effects on technological progress and economic growth in Uganda during the given period. Hence, findings in the paper support the innovation-based growth hypothesis that there is a positive linkage between innovation and economic growth. The paper also finds that during the given period innovation gave rise to technological advancement in Uganda. This research work attempts to aid policy makers, educators and financers in Uganda to stimulate innovation advancement, technological progress and economic growth in the country.

Keywords

Economic-Growth, Innovation-Advancement, Technological-Progress

Introduction

The researchers examine the effects of innovation advancement on technological progress and economic growth in Uganda over the 1970 to 2020 period. In this theoretical models, authorstake innovation advancement to be the engine of technological progress and economic growth. Innovative activities and processes are basically competitive in practice. This competitive drive resembles Joseph Schumpeter's notion that growth processes are characterized by creative destruction in which economic growth is caused by new firms replacing incumbents and new machines and products replacing old ones (Acemoglu, 2009, p. 458; Batabyal & Beladi, 2015).

There are six well known different indicators of innovation: patents-residents, patents-nonresidents, research and development expenditure, researchers in research and development activities, high-technology exports, and scientific and technical journal articles to examine this

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long-run relationship with per capita economic growth (Maradana et al., 2017). Innovation is one of the key drivers of economic growth (Santacreu, 2015). It causes economic growth through several channels, such as global competitiveness, financial systems, infrastructure development, employment, trade openness, etc. On the other hand, increase in economic growth can also increase innovation advancement. Implying that there is a bidirectional causality between innovation advancement and economic growth (Maradana et al., 2017; Pradhan, 2016).

However, in the study the innovation measure as output (gross domestic product, i.e., GDP) raised to the addition of power one, negative returns to scale on capita and negative returns to scales on labor. Meanwhile, level of technology is measured as a ratio of output (GDP) to total factor. Researchers also discovered the measure of capital to be the product of investment spending and logarithm of investment spending. In addition, out of the GDP and capital stock series as well as returns to scale obtained and generate quantity of labor by employing the homogenous Cobb-Douglas production function. More importantly, in the study a measure of innovation was invented and introduce it in the Neoclassical technology function and use it in empirical analyses in the same way that the measure of technology was invented and introduced in the Cobb-Douglas production function. Authors employ the philosophical principle of causality that if event A occurs before B, then event A must be the cause of B. Our theoretical models indicate that increase in capital productivity and labor productivity cause increase in technological progress; but they cause decline in economic growth and innovation advancement. Our Empirical findings show that increase in either labor productivity or capital productivity cause increase in economic growth.

Innovation is a highly disruptive process. Innovating firms disrupt older ideas, lines of business, thus causing many kinds of organization obsolete. Thus, innovation causes Research and Development (R&D) to become both creative and destructive (Akcigit & Reenen, 2023). Meanwhile, economic growth depends on the endogenous introduction of product as well as process innovations (Schumpeter 1937, 1942). Stimulation of innovation, causes new technologies, and promotes adoption of these new technologies to generate rapid economic growth (Cetin, 2013). Implying that as innovation increases, both capital and labor productivity increase, and technological progress also increases; but the amounts of input be it capital or labor used to complete the same task continues to decline.

In the analyses authors find that that during the 1975 to 2020 period, a 1% increase in growth of innovation, could have caused technological progress to increase by 3.56% and 1.00% per annum on average in the short run and the long run respectively, ceteris paribus. In addition, authors find that during the given period a 1% increase in accelerated innovation could have caused economic growth to increase by 3.64% since innovation is the first application of new technology. But during the given period, a 1% increase in growth of capital and labor productivity, could have caused economic growth to decline by 0.1.56% and 0.561% per annum on average in the long run respectively, ceteris paribus; due to the disruptive behavior of both technological progress and innovation advancement. Whereas, a 1% increase in growth of capital and labor productivity, could have caused technological progress to increase by 0.1.56% and 0.561% per annum on average in the long run respectively, ceteris paribus.

Methodology

Under the methodology authors make use of the Neoclassical technology function in empirical analyses to measure innovation in the same way that the measure of technology was invented and introduced in the Cobb-Douglas production function. Technology is the systematic organization of techniques and skills, in order to produce some product, by reorganizing a raw material or some other appropriate medium. As a result, technology has four dimensions:

(a) technical knowledge and skill,
(b) organizational structure,
(c) cultural purposes and values, and
(d) resource use.

The raw materials and the environment (Drengson, 1995). Meanwhile innovation can be defined as a multi-stage process that organizations employ to transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace (Baregheh, Rowley & Sambrook, 2009). Authorsemploy the philosophical principle of causality that if event A to occurs before B, then event A must be the cause of B. Meanwhile, the Neoclassical production function is often represented in terms of output (Y_t) as a function of technology (A_t), labor (L_t), capital (K_t) stock, returns to scale on capital (α) and returns to scale on labor (β) as follows:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} \tag{1}$$

Authorsuse the same technique of representing the Cobb-Douglas production function to accurately represent the technology (A_t)function in terms of innovation (Z_t). Labor productivity (K_{pt}) and capital productivity (K_t). This is the first time the model is being introduced in economic theory.

$$A_t = Z_t K_{pt}^{\alpha} L_{pt}^{\beta} \tag{2}$$

Manipulation of Equation (2) provides the relationship between output and innovation.

$$Z_t^{1/(1-\alpha-\beta)} = A_t K_{pt}^{-\alpha} L_{pt}^{-\beta}. \tag{3}$$

Rearranging Equation (3), indicates that innovation alone can be written as a function of output.

$$Y_t = Z_t^{1/(1-\alpha-\beta)}. \tag{4}$$

Given the philosophical causality principle that if event A comes before event B, then event A must have caused event B; authorsrepresent technological progress $d(\log(A_t))$ in period t as a function of technological progress $d(\log(A_{t-1}))$ in period $t-1$ and technology acceleration $d(d(\log(A_t)))$ in period t. Then

$$d(\log(A_t)) = 1.(\log(A_{t-1})) + \beta_2 d(d(\log(A_t))). \tag{5}$$

Substitution of the innovation term $\beta_1 d(\log(Z_{t-1}))$ for the technology term $(\log(A_{t-1}))$ provides.

$$d(\log(A_t)) = \beta_1 d(\log(Z_{t-1})) + \beta_2 d(d(\log(A_t))).$$

Or

$$\frac{dA_t}{A_t} = \beta_1 \frac{dZ_{t-1}}{Z_{t-1}} + \beta_2 \frac{d(dZ_{t-1})}{dZ_{t-1}}.$$

Or $$1 = \beta_1 \frac{Z_{t-1}}{A_t} + \beta_2 \frac{dA_t}{A_t}. \quad (6)$$

Where $$1 = \frac{\partial A_t}{\partial Z_t}\frac{Z_{t-1}}{A_t}\frac{dZ_{t-1}}{Z_{t-1}}\frac{A_t}{dA_t} + \frac{\partial\partial A_t}{\partial\partial Z_t}\frac{\partial Z_{t-1}}{dA_t}\frac{ddZ_{t-1}}{dZ_{t-1}}\frac{dA_t}{ddA_t}.$$

Similarly, substitution of Equation (2) in Equation (5) provides.

$$d(\log(A_t)) = \beta_1 d(\log(Z_{t-1})) + \beta_2 d\big(\log\big(K_{pt-1}\big)\big) + \beta_3 d\big(\log\big(L_{pt-1}\big)\big) + \beta_4 d(d(\log(A_t))). \quad (7)$$

Substitution of K_{t-1} for K_{pt-1} and L_{t-1} for L_{pt-1}in Equation (7) provides.

$$d(\log(A_t)) = \beta_1 d(\log(Z_{t-1})) + \beta_2 d(\log(K_{t-1})) + \beta_3 d(\log(L_{t-1})) + \beta_4 d(d(\log(A_t))). \quad (8)$$

Effect of innovation advancement $d(\log(Z_{t-1}))$ on economic growth $d(\log(Y_{t-1}))$ can be written in a causal form and in a similar manner as given in Equation (6).

$$d(\log(Y_t)) = \beta_1(\log(Z_{t-1})) + \beta_2 d(d(\log(Y_t))). \quad (9)$$

Thus, substitution for $d(d(\log(Y_t)))$ in Equation (9) in technology and productivity terms gives

$$d\log(Y_t) = \beta_1 d\log(Z_{t-1}) + \beta_2 dd\log(A_t) + \beta_3 dd\log\big(K_{pt}\big) + \beta_4 dd\log\big(L_{pt}\big). \quad (10)$$

Whereas, substitution for $d(d(\log(Y_t)))$ in Equation (9) in technology and input terms provides

$$d\log(Y_t) = \beta_1 d\log(Z_{t-1}) + \beta_2 dd\log(A_t) + \beta_3 dd\log(K_t) + \beta_4 dd\log(L_t). \quad (11)$$

Substitution for $d(d(\log(Y_t)))$ in Equation (9) in in terms of national income variables provides

$$d\log(Y_t) = \beta_1 d\log(Z_{t-1}) + \beta_2 dd\log(C_{nt}) + \beta_3 dd\log(I_t) + \beta_4 dd\log(G_t) + \beta_5 dd\log(I_t) + \beta_6 dd\log(G_t). \quad (12)$$

Meanwhile, substitution of $d(\log(Z_{t-1}))$ for $d(\log(A_t))$in the Neoclassical model provides
$$d(\log(Y_t)) = \beta_1 d(\log(Z_{t-1})) + \beta_2 d(\log(K_t)) + \beta_3 6d(\log(L_t)). \quad (13)$$

Effect of Technological Progress $d(\log(A_{t-1}))$ in the Previous Year and Acceleration in Innovation Advancement $d(d(\log(Z_t)))$ on Economic Growth $d(\log(Y_t))$ can be represented as

$$d(\log(Y_t)) = \beta_1 d(\log(A_{t-1})) + \beta_2 d(d(\log(Z_t))). \quad (14)$$

Results and Discussion

The regression Equations (1) to (8) are free from serial correlation as indicated by the respective DW values ranging from 1.77 to 2.12. The eight regression equations are also free from heteroskedasticity because the each of the respective heteroskedasticity t value (H_t) falls within the range of 0.001 to 0.327. Also, each of the Fstatistic indicates that for each of the eight equations the respective independent variables have joint effect on each of the given dependent variable. The vector V was employed in transforming each of the respective equations in order to get rid of autocorrelation and heteroskedasticity. Hence, each of the eight equations was found to be adequate for drawing valid conclusions.

Effect of Innovation Advancement in the Previous Year $d(\log(Z_{t-1}))$ and Acceleration in Technological Progress $d(d(\log(A_t)))$ on Technological Progress $d(\log(A_t))$ in Uganda:

$$1 = 0.979\frac{Z_{t-1}}{A_t} + 1.196\frac{dA_{t-1}}{A_{t1}}. \tag{1}$$

t 194 26.4
$R^2 = 0.9994$ $DW = 2.07$ $F = 73947$ $N = 46$
Sample (Adjusted): 1974-2020 $V = 1/d(d((Y_t))^2))$ $H_t = 0.014$

Equation (1) indicates that a 1% increase in innovation advancement in the previous year and acceleration in technological progress could have caused annual technological progress to increase on average by 0.97% and 1.196% per annum respectively during the 1974 to 2020 in the long run.

Effects of Growth in Innovation $d(\log(Z_{t-1}))$, Capital Productivity $d(\log(K_{pt-1}))$ and Labor Productivity $d(\log(L_{pt-1}))$ on Technological Progress $d(\log(A_t))$ in Uganda in the long run:

$$d(\log(A_t)) = 1.000d(\log(Z_{t-1})) + 0.156d(\log(K_{pt-1})) + 0.561d(\log(L_{pt-1})) + 1.000d(d(\log(A_t))). \tag{2}$$

t 3208 1757 835 55472
$R^2 = 1.0000$ $DW = 1.98$ $F = 4.61 \times 10^{13}$ $N = 47$
Sample (Adjusted): 1974-2020 $V = 1/d(d((W_t/I_t))^2))$ $H_t = 0.095$

From Equation (2) it is clear that during the 1974 to 2020 period, a 1% increase in Growth in innovation, capital productivity and labor productivity could have caused technological progress to increase on average by 1%, 0.156% and 0.561% per annum respectively, ceteris paribus.

Effects of Growth in Innovation $d(\log(Z_{t-1}))$, Capital $d(\log(K_{t-1}))$, Labor $(\log(L_{t-1}))$ and technology acceleration $d(d(\log(A_t)))$ on Technological Progress $d(\log(A_t))$ in Uganda

$$d(\log(A_t)) = 3.556d(\log(Z_{t-1})) - 0.154d(\log(K_{t-1})) - 0.560d(\log(L_{t-1})) + 1.000d(d(\log(A_t))). \tag{3}$$

t 1559 -774 -786 1416
$R^2 = 1.0000$ $DW = 1.88$ $F = 12180292$ $N = 45$
Sample (Adjusted): 1975-2020 $V = 1/d(d((Z_{t-1}))^2))$ $H_t = 0.082$

From Equation (3) it can be deduced that during the 1975 to 2020 period, a 1% increase in growth of innovation, capital and labor could have caused technological progress to increase by 3.556% (in the short run), -0.154% and -0.560% per annum respectively, ceteris paribus.

Effect of Innovation Advancement $d(\log(Z_t))$ and acceleration in economic growth $d(d(\log(Y_t)))$ on Economic Growth $d(\log(Y_t))$ in Uganda

$$d(\log(Y_t)) = 3.562d(\log(Z_{t-1})) + 1.002d(d(\log(Y_t))). \quad (4)$$

t 1298 1365

$R^2 = 1.0000$ $DW = 2.01$ $F = 2379777$ $N = 46$

Sample (Adjusted): 1975-2020 $V = 1/d(d((Y_{dt-1}))^2))$ $H_t = 0.182$

It can be discerned from Equation (4) that during the 1975 to 2020 period, a 1% increase in innovation advancement and acceleration in economic growth could have caused economic growth to increase on average by 3.562% and 1% per annum respectively, ceteris paribus. Thus, implying that in the short run a 3.562% increase in innovation can generate the same amount of increase in technology. Thus, in the short run innovation qualifies to be the first application of new technology.

Effects of Innovation Advancement $\log(Z_{t-1})$ as well as Acceleration in Growth of Technology $dd\log(A_t)$, Capital Productivity $dd\log(K_{pt})$ and Labor Productivity $dd\log(L_{pt})$ on Economic Growth $d\log(Y_t)$ in Uganda:

$$d\log(Y_t) = 3.525d\log(Z_{t-1}) + 3.536dd\log(A_t) - 0.546dd\log(K_{pt}) - 1.984dd\log(L_{pt}). \quad (5)$$

t 1199 6432 -1553 -476

$R^2 = 1.0000$ $DW = 1.98$ $F = 55396423$ $N = 47$

Sample (Adjusted): 1974-2020 $V = 1/d(d((X_t))^2))$ $H_t = 0.002$

Equation (5) reveals that during the 1974 to 2020 period, a 1% increase in innovation advancement as well as acceleration in technological progress, capital productivity growth and labor productivity growth could have caused economic growth to increase on average by 2.625%, 3.536%, -0.546% and -1.984% per annum respectively, ceteris paribus.

Effects of Innovation Advancement $d\log(Z_t)$ as well as Acceleration in Growth of Technology $dd\log(A_t)$, Capital $dd\log(K_t)$ and Labor $dd\log(L_t)$ on Economic Growth $d\log(Y_t)$ in Uganda:

$$d\log(Y_t) = 3.535d\log(Z_{t-1}) + 1.006dd\log(A_t) + 0.1546dd\log(K_t) + 0.561dd\log(L_t). \quad (6)$$

t 1193 208 330 395

$R^2 = 1.0000$ $DW = 1.96$ $F = 55034025$ $N = 47$

Sample (Adjusted): 1974-2020 $V = 1/d(d((X_t))^2))$ $H_t = .0.003$

From Equation (5) it can be observed that during the 1974 to 2020 period, a 1% increase in innovation advancement as well as acceleration in growth of technology, capital and labor could have caused economic growth to increase on average by 3.535%, 1.006%, 0.154% and 0.561% per annum respectively, ceteris paribus.

Effects of Innovation Advancement ($\log(Z_{t-1})$), as well as Acceleration in Growth in Consumption $dd(\log(C_{nt}))$, Investment $dd(\log(I_t))$, Government Spending $dd(\log(G_{t-1}))$, Exports $dd(\log(X_t))$ and Imports $dd(\log(I_t))$ on Economic Growth $d(\log(Y_t))$ in Uganda:

$$d(\log(Y_t)) = 3.584d(\log(Z_{t-1})) + 0.744dd(\log(C_{nt})) + 0.235dd(\log(I_t)). \quad (7)$$

t 55.6 21.3 5.98

$$+0.167dd(\log(G_{t-1})) + 0.236dd(\log(X_t)) - 0.370dd(\log(M)).$$

t 7.28 7.01 −.6,47

$R^2 = 0.9999$ $DW = 1.98$ $F = 91512$ $N = 47$

Sample (Adjusted): 1974-2020 $V = 1/d(d((X_t)))^2))$ $H_t = 0.001$

Equation (7) portrays the fact that during the 1974 to 2020 period, a 1% increase in innovation advancement as well as acceleration in growth in consumption, investment, government spending, exports and imports could have caused economic growth to increase on average by 3.584%, 0.744%, 0.235%, 0.167%, 0.236% and -0.370% per annum respectively, ceteris paribus.

Effects of Innovation Advancement $d(\log(Z_{t-1}))$ in the Previous Year as well as Growth of Capital $d(\log(K_t))$ and Labor $d(\log(L_t))$ in the Current Year on Economic Growth in Uganda

$$d(\log(Y_t)) = 0.565d(\log(Z_{t-1})) + 0.172d(\log(K_t)) + 0.816d(\log(L_t)). \quad (8)$$

t 13.6 7.76 37.7

$R^2 = 0.9997$ $DW = 2.12$ $F = 78807$ $N = 47$

Sample (Adjusted): 1974-2020 $V = 1/d(d((Y_{dt})))^2))$ $H_t = 327$

Equation (8) shows that during the 1974 to 2020 period, a 1% increase in innovation advancement in the previous year as well as growth of capital and labor in the current year could have caused economic growth to increase on average by 0.565%, 0.172% and 0,562% per annum respectively.

Effect of Technological Progress $d(\log(A_{t-1}))$ in the Previous Year and Acceleration in Innovation Advancement $d(d(\log(Z_t)))$ on Economic Growth $d(\log(Y_t))$ in Uganda

$$d(\log(Y_t)) = 2.310d(\log(A_{t-1})) + 3.635d(d(\log(Z_t))). \quad (9)$$

t 73.8 21.9

$R^2 = 0.9918$ $DW = 2.12$ $F = 5468$ $N = 47$

Sample (Adjusted): 1974-2020 $V = 1/d(d((Y_{dt})))^2))$ $H_t = 0.059$

From Equation (9) it can be deduced that during the 1974 to 2020 period, a 1% increase in technological progress in the previous year and acceleration in innovation advancement could have caused economic growth to increase on average by 2.310% and 3.635% per annum respectively.

Equations (1) to (9) support the argument that technological innovation has delayed positive effects on both technological progress and economic growth, implying that quick success, and instant benefits should be avoided (Zhuo & Luo, 2018). Economic growth depends on technological innovation (technology introduction i.e., new technology), and technological progress i.e., promotion of total factor productivity (Zhang & Chang, 2015). Similarly, authorsfind a long-term equilibrium relationship between technological innovation and economic growth in Uganda and it is absolutely supported by Zhang and Chang (2015). The most successful technological innovations are often composed of a combination of technology, market and government. Meanwhile, the major driving force of technological innovation is knowledge flow to consumers and organizations. Technological innovation improves upon labor productivity and capital productivity leading directly or indirectly to economic growth. In turn economic growth leads to new market demand and improved technology (Zhang & Chang, 2015).

Authors findings are supported by some empirical results regarding the effects of innovation on economic growth in Africa. In comparison to our findings, Iyoboyi and Na-Allah (2014), use technology-embodied capital import as a proxy for innovation including human capital, structure of the economy and find that innovation had a positive effect on economic growth in Nigeria from 1970 to 2010. Forson et al. (2017) employ the number of scientific journals published as proxy for innovation and GDP per capita for economic growth, to assess a panel of 25 economies in sub-Sahara Africa with dataset (1996-2016). They find that innovation has a positive and significant effect on the growth trajectory of sub-Sahara Africa although the effect is negligible. But, Jammeh (2024) finds that technological innovation in terms of scientific and technical journal articles had a negative effect on economic growth in ECOWAS countries from 2008 to 2020. Meanwhile, Hakimi et al. (2022) by using a sample of 21 African countries from 2009 to 2028 find that economic growth does not respond to innovation in Africa, whereas they find that imported innovation is positively and significantly correlated with GDP growth.

Furthermore, Yinusa et al. (2021) use annual panel data running from 2004 to 2018 to examine the effect of financial innovation on economic growth in some selected African countries. Their result shows that financial innovation had significant impact on economic growth of the selected countries. Kasongo and Makamu (2024) examine the relationship between innovation and economic growth in 32 African countries from 2006 to 2017. Their findings show a positive association between the innovation index and economic growth; implying that during the given period innovation had a significant effect on economic growth in Africa.

Otherwise, fifty percent (50%) of the world’s natural resources in terms of minerals, large water bodies, rich forest reserves, including good climatic conditions are located mostly in Africa, the continent where Uganda is located. Yet, Africa is still the poorest in the world because of its low level of technical know-how to exploit the continent’s resources for sustainable growth and development that it requires. Therefore, by adopting appropriate innovation technologies, Africa could manage to solve Global problems such as poverty, epidemics, access to safe water that are still troubling the continent (OECD, 2012). In fact, thirty-three (33) out of thirty-nine (39) countries identified by the World Bank as Heavily Indebted Poor Countries (HICs) are in Africa. Definitely, economic growth and productivity development can surely be attained through improvement in innovation, information and technological competence of these countries (World Economic Forum, 2017; Udvari & Ampah, 2017, 2018).

In Uganda as well as in other African countries, adoption of appropriate foreign technology, improvement in innovation research and technological advancement have been at the forefront of governance in Africa (Acs & Szerb, 2012), but success has been extremely limited due to financial constraints. For these reasons, aid for innovation (Montellano & Vazquez 2015) or knowledge aid (UNCTAD, 2007) has become importance, as it aims at improving the innovation and technology capacity in developing countries (Udvari & Ampah, 2018).

Yet, in the last decade, research works have not considered the issues of economic growth and technological progress in relation to innovation advancement, particularly in the African/Ugandan context. It is against this background; that the study of effects of innovation advancement on technological progress and economic growth is important, for the understanding the contributions of innovation to economic growth and technological progress in Sub-Saharan Africa.

Conclusion

The study finds that innovation advancement and innovation acceleration had positive and significant effects on technological progress and economic growth in Uganda during the 1970 to 2020 period. Our findings in the paper support the innovation-based growth hypothesis that there is a positive linkage between innovation and economic growth. In addition, the paper finds that during the given period innovation gave rise to technological advancement in Uganda. Hence, policies for effective innovation advancement could aid policy makers, educators and financers in Uganda or any other country to stimulate innovation advancement, technological progress and economic growth in the country. In particular, the study comes up with nine conclusions. One, increase in innovation advancement and acceleration in technological progress could have caused increase in annual technological progress during the 1974 to 2020 period. Two, during the 1974 to 2020 period, increase in Growth in innovation, capital productivity and labor productivity could have caused increase in technological progress. Three, during the 1975 to 2020 period, a 1% increase in growth of innovation, capital and labor could have caused technological progress to increase by 3.556% -0.154% and -0.560% per annum respectively, ceteris paribus. Four, during the 1975 to 2020 period, increase in innovation advancement and acceleration in economic growth could have caused increase in economic growth.

Five, during the 1974 to 2020 period, a 1% increase in innovation advancement as well as acceleration in technological progress, capital productivity growth and labor productivity growth could have caused increase in economic growth in Uganda. Six, during the 1974 to 2020 period, increase in innovation advancement as well as acceleration in growth of technology, capital and labor could have caused increase in economic growth. Seven, during the 1974 to 2020 period, a 1% increase in innovation advancement as well as acceleration in growth in consumption, investment, government spending, exports and imports could have caused economic growth to increase on average by 3.584%, 0.744%, 0.235%, 0.167%, 0.236% and -0.370% per annum respectively, ceteris paribus. Eight, during the 1974 to 2020 period, increase in innovation advancement in the previous year as well as growth of capital and labor in the current year could have caused increase in economic growth. Lastly, during the 1974 to 2020 period, increase in technological progress in the previous year and acceleration in innovation advancement could have caused increase in economic growth,

References

Acemoglu, D. (2009), *Introduction to Modern Economic Growth*. Princeton University Press, Princeton, NJ.

Acs, Z. J., Szerb, L. (2012), *Global Entrepreneurship and Development Index 2012*. Edward Elgar Publishing.

Akcigit, U., & Reenen, J.V. (2023), *The Economics of Creative Destruction: New Research on Themes of Aghion Howitt*. Cambridge, Massachusetts: Harvard University Press.

Baregheh, A., Rowley, J., Sambrook, S. (2009), "Towards Multidisciplinary Definition of Innovation," *Management Decisions*, 47(8), 1323-1339. https://psycnet.apa.org/doi/10.1108/00251740910984578

Batabyal, A.A., & Beladi, H. (2015), "The Effects of Probabilistic Innovations on Schumpeterian Economic Growth in a Creative Region," *Economic Modelling*, 53, 224-230. https://doi.org/10.1016/j.econmod.2015.11.026

Cetin, M. (2013), "The Hypothesis of Innovation-Based Economic Growth: A Causal Relationship," International Journal of Economic and Administrative Studies, 6(11), 1-16. https://dergipark.org.tr/en/pub/ulikidince/issue/21616/232190

Drengson, A.R. (1995), *The Practice of Technology: Exploring Technology, Ecophilosophy, and Spiritual for Vital Links.* New York: SUNY Press.

Forson, J.A., Opoku, R.A., Peng, Z. (2017), "Innovation, Institutions and Economic Growth in Sub-Sahara Africa - an IV Estimation of a Panel Threshold Model," *MPRA* Paper No.103063, 1-35. https://ideas.repec.org/p/pra/mprapa/103063.html

Hakimi, A., Hamdi, H., Inglesi-Lotz, R. (2022), "To innovate or to import innovation? Evidence from African countries," *Regional Science Policy and Practice*, 16(3), 1-14. https://doi.org/10.1111/rsp3.12594

Iyoboyi, M., Na-Allah, A. (2014), "Innovation and Economic Growth: Evidence from Nigeria," *Euro Economica*, 33(1), 43-54. https://ideas.repec.org/a/dug/journl/y2014i1p43-54.html

Jammeh, I.Y. (2022), "The Effect of Technological Innovation on Economic Growth: Evidence from ECOWAS Countries," *International Journal of Social Sciences Perspectives*, 11(1), 1-10. https://doi.org/10.33094/ijssp.v11i1.610

Kasongo, A., & Makamu, T. (2024). Innovation and economic growth: An empirical analysis for African countries. *African Journal of Science, Technology, Innovation and Development*, *16*(6), 751–760. https://doi.org/10.1080/20421338.2024.2382612

Maradana, R.P., Pradhan, R.P., Dash, S., Gaurav, K., Jayakumar, M., & Chaterjee, D. (2017), "Does Innovation Promote Economic Growth? Evidence from European countries." Journal of Innovation and Entrepreneurship, 6(1), 1-23. https://doi.org/10.1186/s13731-016-0061-9

Montellano, A. Q., Vázquez, S.T. (2015), "Aid and Innovation: a Boost to the Effectiveness of Aid?" *Revista International de Cooperación y Desarrollo* 2(1), 5-36. https://doi.org/10.21500/23825014.2231

OECD (2012), *Innovation for Development*. Paris: The Directorate for Science, Technology, and Industry, Organization for Economic Cooperation and Development (OECD).

Pradhan, R.P., Arvin, M.B., Hall, J.H., & Nair, M. (2016), "Innovation, Financial Development and Economic Growth in Eurozone Countries," Applied Economics Letters, 23(16), 1141 1144. https://doi.org/10.1080/13504851.2016.1139668

Santacreu, A.M. (2015), "Innovation, Diffusion, and Trade: Theory and Measurement," Journal of Monetary Economics, 75, 1-20. https://doi.org/10.1016/j.jmoneco.2015.06.008

Schumpeter, J. (1942), The Process of Creative Destruction, Capitalism, Socialism and Democracy. New York: Harper and Brothers Publishers.

Udvari, B., Ampah, I.K. (2018), "Impacts of Aid for Innovation on Economic Growth in the Sub-Saharan African Countries," *Mediterranean Journal of Social Sciences*, 9(4), 99-108. https://doi.org/10.2478/mjss-2018-0119

UNCTAD (2007), *The Least Developed Countries Report 2007.* Geneva and New York: United Nations on Conference and Trade. WEF (2017), *Global Competitiveness Report 2016 2017*. Geneva: World Economic Forum.

Yinusa, O.G., Olowofela, O.E., Yunusa, A.L., Folami. R.A. (2021), "Effect of Financial Innovation on Economic Growth: Evidence from African Countries," *International Journal of Commerce and Finance*, Vol. 7, 1(1), 130-140. https://ijcf.ticaret.edu.tr/index.php/ijcf/article/view/251

Zhang, W., & Chang, C. (2015), "Research on Technological Innovation and Economic Growth Mode," The Open Cybernetics & Systemics Journal, 9, 1861-1867. http://dx.doi.org/10.2174/1874110X01509011861

Zhuo, G., & Luo, S. (2018), "Higher Education Input, Technological Innovation, and Economic Growth in China," Sustainability, 10, 4-15. https://doi.org/10.3390/su10082615