Innovation, Economic Growth and Macroeconomic Variables: Empirical Evidence from Uganda

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Abstract

Over the last decades, effect of innovation on economic growth has received significant attention in the developed world. But little is known about the effect of innovation on economic growth in the context of developing countries (e.g., Uganda) due to lack of data. Examining the relationship between innovation and macroeconomic variables is important because innovation has systematic effects on economic growth and other macroecnomic variables. The paper uses the generalized least squares method to examine the effects of innovation on economic growth and other macroeconomic variables in Uganda in 1970 - 2020 . Data sets were collected from the United Nations database. The paper is based on the neoclassical growth model with decreasing returns to scale since production takes place within the feasible region of production. In addition, examine the effects of innovation on capital, labor, capital productivity, labor productivity, household consumption, investment spending, government spending, exports, imports in Uganda in the given period. Furthermore, the paper examines the influence of other variables on innovation and the individual influence of innovation on those variables. Empirical results show that innovation advancement caused economic growth and growth of other macroeconomic variables in Uganda during the given period. Most of the variables considered had significant feedback effects on innovation. Hence, the paper recommends the application of innovation advancement to a great extent to enhance Uganda's economic growth, considering its significant long term effects on economic growth in Uganda during the given period.

Keywords: *Economic growth, Innovation, Macroeconomic variables, Capital productivity, Labor productivity, Technological progress.*

JEL Codes: 011, 031, 043

Introduction

Over the last few decades, effect of innovation on economic growth has received significant attention in the developed world. But due to lack of data little is known about the effect of innovation on economic growth in the context of developing countries (e.g., Uganda). The main question that this present paper attempts to answer is: To what extent has innovation affected particularly economic growth and generally some important macrocosmic variables in Uganda? The major objective is to examine effects of innovation on economic growth in Uganda during the 1970 to 2020 period by using the generalized least squares (GLS) method. In the paper, innovation is derived from the neoclassical model and defined as the ratio of the total product (output) to output raised to the sum of capital and labour output elasticities. In both macroeconomics and microeconomics, the paper marks the beginning of expressing or estimating innovation in terms of levels of technology, capital productivity, labour productivity, and output elasticities of capital and labour. Meanwhile, the level of technology is defined as the ratio of output to total factor. On the other hand, the paper defines the technology index as the ratio of the logarithm of technology to the logarithm of output. In contrast, the innovation index is defined as the ratio of the logarithm of innovation to the logarithm of output. However, in most existing quantitative research, innovation has been measured in terms of the total number of patents, trademarks, and Research and Development (R&D) expenditures.

Recent economic growth theories postulate innovative products, processes, and business models to be outcomes of continuous research and that innovation to be the key driver of productivity and economic growth. These hypotheses have not been empirically tested in the case of Uganda, especially at a macroeconomic level. Empirical findings show that a 1 per cent increase in innovation could have output to rise by 3.537% yearly in Uganda during the given period. Similarly, a 1% increase in innovation could have caused the microeconomic variables to indibidually rise by approximately 3.537% yearly in the country during the 1970 to 2020 period. Meanwhile, in the short run during the 1974-2020 period, a 1% increase in innovation could have caused (a) consumption, (b) investment, (c) government spending, (d) exports, (e) imports, (f) profit, (g) total cost, (h) capital, (i) labor, (j) capital productivity and (k) labor productivity could have caused annual innovation advancement to rise by (a) 4.262%, (b) 22.35%, (c) 39.29, (d) 28.08%, (e) -15.11%, (f) 16.84%, (g) 4.47%, (h) 12.86%, (i) 3.44%, (j) 3.54% and (k) 3.54% respectively, during the given period. These results indicate very high contribution of innovation to output and other macroeconomic variables in Uganda during the given period.

The atructure of paper is as follows: (a) Introduction, (b) Review of Literature that consists of threoretical literature, empirical literature, (c) Theoretical Framework (d) Methodology, (e) Presentation and Discussion of Results, (f) Conclusion and (g) Policy Prescriptions fllowed by (h) References.

Review of Literature

In the twentieth century, some writers used the term innovation to explain technological change. As a subject innovation was used as a body to explain literature assessing the processes behind the term. Early theories focused on the psychological dimensions linked to innovation, and the development of linear process models while recognizing the creative dimension of innovation. In the mid twentieth century innovation was viewed as a tool of economic growth and economic survival for organizations. In the late twentieth century the term innovation had already been viewed as advancement, technological change, social change and development across many dimensions of knowledge, and across society and possessed by the individual. Meanwhile, in the twenty first century the term innovation conveyed various meanings and concepts influenced by different factors over the centuries (Taylor, 2017). According to Taylor (2017), there are numerous definitions of innovation that exist in different fields in academia, industry, government and service provision. The available academic literature relates to a wide body of disciplines that sometimes cut across discipline areas. This present study, adopts the plausible definition of innovation by Taylor (2017) that is suitable for the subject and research being undertaken as follows: Innovation can be defined or identified with the creation of a new product or service or an improvement of an existing product or service. Implying that the aggregation of goods and services often referred to as gross domestic product (GDP) is tightly related to innovation.

Hence, indicating that the measure of innovation in terms of GDP raised to a unique index is a valid measure of innovation. However, according to Tiruneh (2014, pp.44-47), the minimum requirement for innovation may be the product, process, marketing method, or organizational method that must be new or significantly new to a firm or market. The four common types of innovation are: product, process, marketing, and organizational innovations. Product and process innovations are the most popular. They are closely related to the concept of technological product and process innovation. However, marketing and organizational innovations are not popular or recognized due to measurement problems.

Theoretical Literature

Technological innovation can affect economic growth directly or it can influence economic growth through macroeconomic mechanisms, such as economic indicators or variables. Technological advancement is considered as a major driver of economic growth (Bae & Yoo, 2015; Santacreu, 2015). Maradana *et al.* (2017). Meanwhile, innovations in turn affect factors such as employment, global competitiveness, trade openness, quality of life, financial systems and infrastructure development (Anakpo & Mishi, 2021).

Technological innovation is the key for driving productivity and economic development, especially in emerging countries (Schniederjans, 2017; You *et al.*, 2019; Amankwah-Amoah *et al.*, 2018; Pradhan, Arvin and Bahmani, 2018; Lawa, Sarmidib and Gohc, 2020). Promoting an innovation-driven strategy is based on a higher material and technological foundation. The higher material foundations: innovation, higher education, and technology preparation have a positive and significant impact on entrepreneurial activities in innovation-driven countries but not in factor-driven countries (Rostami *et al.*, 2019).

In addition, innovation creates a social innovation culture in the economy by promoting the understanding of creativity and innovation resources (Kim & Yoon, 2015; Xiao *et al.*, 2022). Rapid global competition in science and technology, science, technology, and innovation (STI) has become the key drivers of national economic growth, necessary for industrial transformation, productivity enhancement, and product quality improvement (Karafyllia & Zucchella, 2017; Akisik *et al.*, 2020; Xu, *et al.*, 2023).

Empirical Literature

It was only after 1945 that interest in development theories started to flourish (Currie-Alder *et al*, 2013). Innovation was neglected or omitted in some of these economic growth theories. Although some development theories were composed of innovation, they treated it as an exogenous factor. Neoclassical economics focuses on the optimal allocation of resources and the adaptations following exogenous shocks such as demographic change and changing preferences. Innovation is internal to the economy and it is reponsible for driving internally the economy personified by the active entrepreneur (Omar, 2019). In economic research, there are seven different types or measures of technological innovation used such as: (1) patent owned by residents, (2) patents owned by non-residents, (3) expenditure on research and development (R&D), (4) researchers in R&D, (5) information and communication technologies graduates, (6) science, technology, engineering and mathematics graduates, and (7) scientific and technical journal outputs ((Pradhan *et al.*, 2016; Maradana *et al.*, 2017; Adenle *et al.*, 2017; Owoeye *et al.*, 2020; Anakpo & Oyenubi, 2022). In the last century, technological development has progressed more rapidly as compared to the previous years. Such a comparison has evolved into a structure with a large amount of information in the 2000s (Caliskan, 2015). In African, Lu *et al.* (2019) used Solo Model to study foreign investment effects on South Africa's economics and technology development in the long term and short term, and the risks and opportunities of international trade with South Africa. They find that more investment through research potentially drives GDP growth. But Broughel and Thierer (2019) indicate that most of the existing studies on technological change measured factor productivity. However, technological change is essentially different from technological innovation whareas the Solow model focuses only on the traditional factor productivity to explain technological innovation, unlike the new growth theory (Anakpo & Oyenubi, 2022).

Xiao *et al.*, 2022). Whereas, empirical finding shows that the inadequacy of innovative technology flow into Malaysia over a long time caused detrimental effects on the country's national innovative capacity (Lawa, Sarmidib and Gohc, 2020). Empirical findings show that technological innovation indicators such as (a) researchers in research and development, (b) graduates from information and communication technology, (c) patents-nonresidents, (d) graduates from science, technology, engineering and mathematics and (e) scientific and technical outputs; have significant positive relationships with per capita economic growth in the long run. But they find no relationships exist between (i) patents-residents and (ii) government expenditure; and per capita economic growth (Anakpo and Oyenubi, 2022; Broughel & Thierer, 2019). Meanwhile, studies in the context of developing countries focus mainly in isolated areas such as technological innovation, economic growth and drivers such as human capital (Rangongo & Ngwakwe, 2019; Anakpo & Oyenubi, 2022), financial development (Abeka *et al.*, 2021), direct foreign investment (Uwubanmwen and Ogiemudia, 2016), automation and artificial intelligence (Anakpo & Kollamparambil, 2021a, 2021b) among others, leading to a gap in empirical work that examines a link between technological innovation and economic growth in Africa, in particular Uganda.

How new knowledge translates into superior economic performance by countries has neither been described by the growth theories nor found to have an unequivocal empirical explanation. Empirical studies that lack theoretical underpinnings focus on networks (Tsvetkova, 2015; Maradana *et al.*, 2017). In this study, the gross expenditure on research and development (GERD) as a per cent of gross domestic product GDP is extended to the current literature by measuring innovation using an alternative approach. Thus, in the paper innovation (Z) measured as the ratio of GDP to GDP raised to power $\alpha + \beta,$ where α, β are the coefficients of capital and labour, respectively. Therefore, innovation can be defined mathematically as follows:

$$Z = Y/(Y^{\alpha+\beta}) = Y^{1-\alpha-\beta} = A/(K_p^{\alpha}.L_p^{\beta}),$$

where K_p is capital productivity and L_p is labour productivity. In the last two decades, both researchers and policymakers have increasingly investigated the relationship between innovation, entrepreneurship, and regional outcomes (Galindo and Mendez-Picazo, 2014). However, the paper specifically examines the relationship between innovation and economic growth in Uganda with reference to Bae and Yoo (2015); Santacreu (2015) and Mardana *et al.*, 2017).

However, economic growth indeed increases the level of innovation in the development process. Therefore, it is possible to have a bidirectional causality between innovation and economic growth (Pradhan *et al.*, 2016; Mardana *et al.*, 2017). Hence, the study's main motivations are examining (i) effects of innovation on economic growth and other macroeconomic variables, (ii) effects of economic growth and other macroeconomic variables on innovation in Uganda during the given period; as well as settle the conundrum regarding the effect of labor productivity on economic growth.

Theoretical Framework

A typical Neoclassical production function is often written in terms of output as a function of level of technology (A_t), capital (K_t) and labor (L_t) as follows:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta}. \quad (3.1)$$

Equation (3.1) shows that output equals level of technology times total factor (TF_t).

$$Y_t = A_t TF_t. \quad (3.2)$$

From Equations (3.1) and (3.2) it can be discerned that total factor is given by

$$TF_t = K_t^{\alpha} L_t^{\beta} \quad (3.3)$$

Equation (3.2) indicates that level of technology (A_t) can be defined as total factor productivity $i.e.$ $(A_t = TFP_t)$ and can be written as the ratio of output (Y_t) to level of total fector (TF_t).

$$A_t = \frac{Y_t}{TF_t}. \quad (3.4)$$

In order to derive the relationship between output and level of technology, capital productivity and labor productivity, Equation (3.1) is divided through by $\mathrm{Y_t^{\alpha} Y_t^{\beta}}$.

$$\frac{\mathrm{Y_t}}{\mathrm{Y_t^{\alpha} Y_t^{\beta}}} = \frac{\mathrm{A_t K_t^{\alpha} L_t^{\beta}}}{\mathrm{Y_t^{\alpha} Y_t^{\beta}}}. \quad (3.5).$$

Where α, β are coeffcicients of returns to scale on capital and labor respectively.

Equation (3.5) can then be rewritten as follows:

$$Y_t^{(1-\alpha-\beta)} = A_t \left(\frac{K_t}{Y_t}\right)^{\alpha} \left(\frac{L_t}{Y_t}\right)^{\beta}. \quad (3.6)$$

Meanwhile, Equation (3.6) can be rewritten as follows:

$$Y_t^{(1-\alpha-\beta)} = A_t \left(\frac{Y_t}{K_t}\right)^{-\alpha} \left(\frac{Y_t}{L_t}\right)^{-\beta}. \quad (3.7)$$

Rewriting Equation (3.7) in terms of level of technology, capital productivity and labor productivity provides an expression that can be used to introduce innovation into the modified form of the Cobb-Douglas production function as follows:

$$Y_t^{(1-\alpha-\beta)} = A_t K_{pt}^{-\alpha} L_{pt}^{-\beta}. \quad (3.8)$$

For Equations (3.1) and (3.8) to be compatible, i.e. for output to mean what it means in both Equations, and for level of technology to mean what it means in both equations, and be established as a dependent variable in both equations, Equation (3.8) must be defined (specified) as innovation (Z_t) or product innovation and be represented as follows:

$$Y_t^{(1-\alpha-\beta)} = Z_t. \quad (3.9)$$

Thus, Equation (3.9) can be rewritten in terms of output as a function of innovation (or product innovation) and represented as follows:

$$Y_t = Z_t^{\overline{\frac{1}{1-\alpha-\beta}}} \quad (3.10).$$

Therefore, substitution of Equation (3.2) in Equation (3.10) provides the relationships among level of technology, total factor and innovation.

$$A_t.TF_t = Z_t^{\overline{\frac{1}{1-\alpha-\beta}}} \quad (3.11).$$

Meanwhile, substitution of Equation (3.9) in Equation (3.8) provides relationships among level of technology, capital productivity labor productivity and innovation for empirical investigations.

$$Z_t = A_t K_{pt}^{-\alpha} L_{pt}^{-\beta}. \quad (3.12)$$

Rewriting Equation (3.12) provides a technology function that has been translated (derived) from the Cobb-Douglas production function. Meaning that the level of innovation is a function of innovation, capital productivity and labor productivity.

$$A_t = Z_t K_{pt}^{\alpha} L_{pt}^{\beta}. \quad (3.13)$$

Substitution of Equation (3.10) in Equation (3.1) provides a function that can be manipulated for examination of the relationships among innovation, level of technology, labor and capital.

$$Z_t^{\overline{\frac{1}{1-\alpha-\beta}}} = A_t K_t^{\alpha} L_t^{\beta} \quad (3.14).$$

In the short run, (i) the influence of capital and labor productivity on output, and (ii) the influence of labor and labor productivity on output can be represented as follows:

$$Y_t = K_t K_{pt} = L_t L_{pt}. \quad (3.15)$$

Substitution of Equation (3.10) in Equation (3.15) yields Equations (3.16) and (3.17). Equation (3.16) can be used in empirical analysis to investigate the effects of on innovation on capital and capital productivity.

$$K_t K_{pt} = Z_t^{\frac{1}{1-\alpha-\beta}} \quad (3.16).$$

Similarly, Equation (3.17) can be used in empirical analysis to investigate the short run effects of on innovation on capital and capital productivity.

$$L_t L_{pt} = Z_t^{\frac{1}{1-\alpha-\beta}} \quad (3.17).$$

Output can be defined as the product of population (P_{0t}) and income per capita (Y_{pt}): $Y_t = Y_{pt} P_{0t}$. Substitution for output in Equation (3.10) produces an expression that can be used to investigate the short run influence of innovation on either income per capita or population size.

$$Y_{pt} P_{0t} = Z_t^{\frac{1}{1-\alpha-\beta}} \quad (3.18).$$

The classical theory can be expressed in terms of output as a function of capital and labor as follows:

$$Y_t = K_t^{\alpha} L_t^{\beta}. \quad (3.19)$$

Substitution of Equation (3.10) in Equation (3.19) provides an expression that can be employed to empirically examine the relationships among innovation, labor and capital.

$$K_t^{\alpha} L_t^{\beta} = Z_t^{\frac{1}{1-\alpha-\beta}}. \quad (3.20)$$

In an economy the firms' decision problem is one of choosing output level arising from their motive of profit-maximization. It is clear that the firm's profit maximizing level of output is determined by the inputs it chooses to use in production. Thus, the firms' economic profits (W_t) can be expressed as a function of only the inputs it uses (Nicholson and Snyder, 2012, p.389).

$$W_t = Y_t - TC_t = f(K_t, L_t) - (\alpha K_t + \beta L_t).$$

Where α and β are fixed parameters of capital and labor respectively and total cost (TC_t); and the total cost function is given by the costs of inputs.

$$TC_t = \alpha K_t + \beta L_t$$

Implying that output can be expressed as a sunction of profit, capita and labor:

$$Y_t = W_t + \alpha K_t + \beta L_t;$$

or as a function of profit and total cost: $Y_t = W_t + TC_t$. The equations here indicate that the production function in logarithm form, the linear economic profit function can be rewritten as follows:

$$Y_t = W_t K_t^{\alpha} L_t^{\beta}. \quad (3.21)$$

However, empirical findings show that the returns to scale on profit is never one (1) as indicated in Equation (3.21). Therefore, it means that the production function with profit as one of the factors, is always unstable. Hence, to make it stable, a balancing term must be introduced in the equation.

$$Y_t = W_t K_t^{\alpha} L_t^{\beta} B_t. \quad (3.22)$$

Dividing Equation (3.22) by Equation (3.1) reveals that level of technology is the product of the balancing term and the level of economic profit.

$$A_t = W_t B_t. \quad (3.23)$$

Substitution of Equation (3.10) in Equation (3.23) provides an equation system that can be used for empirical investigation, of the relationships among profit, capital labor and innovation.

$$W_t K_t^{\alpha} L_t^{\beta} B_t = Z_t^{\overline{\frac{1}{1-\alpha-\beta}}}. \quad (3.24)$$

The six common national income variables can be used to formulate a production function as follows:

$$C_{nt}^{\beta_1} I_t^{\beta_2} I_t^{\alpha} G_t^{\beta_3} X_t^{\beta_4} M_t^{\beta_5} = Z_t^{\overline{\frac{1}{1-\alpha-\beta}}} = Y_t. \quad (3.25)$$

Given $Q_{it} = C_{nt}, I_t, G_t, X_t, M_t, W_t, TC_t,$ for $i = 1,2,\dots,7.$

Where, $Q_{1t} = C_{nt}, Q_{2t} = I_t, Q_{3t} = G_t,\ Q_{4t} = X_t,\ Q_{5t} = M_t,\ Q_{6t} = W_t,\ Q_{7t} = TC_t.$

Therefore, the bidirectional relationship between innovation and each of the seven variables can be more compactly represented as follows:

$$Q_{it}^{\beta_i}(Y_t - Q_{it})^{(1-\beta_i)} = Z_t^{\overline{\frac{1}{1-\alpha-\beta}}}. \quad (3.26)$$

In logarithm form the effect of innovation on each of the seven variables can be given as follows:

$$d\mathrm{logQ_{it}} = \frac{d\mathrm{logZ_t}}{\beta_i(1-\alpha-\beta)} - \frac{(1-\beta_i).\,d\log(Y_t - Q_{it})}{\mathrm{\beta_i}}. \quad (3.27)$$

To derive an equation representing the effect of innovation on household disposable income, the first step must be the formulation of a tight relationship between income and disposable income.

$$Y_{dt} = \left(\frac{Y_{dt}}{Y_t}\right) Y_t. \quad (3.28)$$

Substitution of Equation (3.10) in Equation (3.28) yields

$$Y_{dt} = \left(\frac{Y_t}{Y_t}\right) Z_t^{\overline{\frac{1}{1-\alpha-\beta}}}. \quad (3.29)$$

The capital accumulation equation is often represented as flows:

$$K_t = K_t - \delta K_{t-1} + I_t. \quad (3.30)$$

Where, δ is the rate of capital depreciation and $\delta K_{t-1} = I_{t-1}$ level of capital depreciation. Thus,

$$K_t = K_{t-1} - I_{t-1} + I_t. \quad (3.31)$$

Thererfore, taking logarithms of variables in Equation (3.31) and differencing each of the logarithm of the respective variables, followed by taking antilogarithms gives

$$\frac{K_t}{K_{t-1}} = \frac{I_t}{I_{t-1}}. \quad (3.32)$$

Hence, substitution for capital in Equation (3.16) i.e., substitution of Equation (3.32) in Equation (3.16) provides an equation that depicts the influence of innovation on capital productivity.

$$K_{t-1}\left(\frac{I_t}{I_{t-1}}\right)K_{pt} = Z_t^{\frac{1}{1-\alpha-\beta}}. \quad (3.33)$$

Methodology

The dataset employed in the study was composed of secondary data collected from the United Nations (2020) database. The time series dataset collected contained household consumption, investment spending, government spending, exports, imports, and population of Uganda covering 1970 to 2020. Data got from the dataset were: capital, labour, capital productivity, labour productivity, disposable income, economic profit, level of technology, innovation, total factor, technology index, innovation index, innovation productivity, and capital productivity.

Having obtained the time series data on the annual long run capital stock (K_{t-1}) and aggregate disposable income (Y_{dt}), the annual quantities of labour (L_{t-1}) can be generated by using the classical Cobb-Douglas production function [$Y_{dt} = K_{t-1}^{\alpha} L_{t-1}^{\beta}$] and by causality theory where α is average propensity to invest (MPI_t) and β is average propensity to consume (APC_t).

From the Cobb-Douglas, L_{t-1} can be made the subject to obtain

$$L_{t-1} = \left[Y_{dt}/\left((K_{t-1})^{(API_t)}\right)\right]^{[1/APC_t]}. \quad (4.1)$$

since the long run MPC_t equals long-run APC_t. Implying a marginal propensity to invest (MPI_t) and average propensity to invest (API_t) are equal in the long run. Data analysis was done by using the (a) philosophical theory of causality which states that if event A comes before event B, then it should be event A that causes B, (b) Say’s law of markets, (c) capital accumulation equation, (d) the balancing term for profit and technology.

Using the generalized least squares (GLS) method, the paper performs linear regression analyses on secondary data collected from the United Nations Data Base on Uganda covering 1970 to 2020. Data used in empirical analyses are on aggregate household consumption and investment spending, government spending, exports and imports because they are the variables commonly present in the household consumption function, national income model and neoclassical function.

Data generated were as follows: gross domestic product (GDP), household disposable income, capital productivity, labour productivity and total factor. Innovation, technology, innovation index, and income taxes. The t, F, DW and HT statistical tests were conducted by comparing the computed t, F, DW and HT values with their respective critical values from the standard Statistical Tables. The HT is the computed t value used in testing for heteroscedasticity (variances that are not constant) by conducting the usual t tests.

Results and Discussions

Equation (3.18) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.4).

The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused income per capita to increase on average by 3.54% per annum, ceteris paribus.

$$d\log Y_{pt} = 3.54d\log Z_{t-1} - 1.00d\log P_{0t} + 3.54dd\log A_t - 0.5484dd\log K_{pt}$$

$$t \qquad 113548 \qquad -117051 \qquad 304437 \qquad -292147$$

$$-1.9888dd\log L_{pt} - 0.9986dd\log P_{0t} \qquad (5.1)$$

$$t \qquad -264538 \qquad -3261$$

$$R^2 = 1.0000, \quad DW = 1.9801, \quad F = 3.70 \times 10^{11}, \quad N = 46$$

$$Period = 1975 - 2020,\ HT = 0.1469,\ V = 1/d(d((\Big(d\Big(d(Y_{pt-1} * TF_{t-1})\Big)\Big))^2\Big))$$

Equation (3.18) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.5).

The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused population size to increase on average by 3.54% per annum, ceteris paribus.

$$d\log P_{0t} = 3.54d\log Z_{t-1} - 1.00d\log Y_{pt} + 3.54dd\log A_t - 0.55dd\log K_{pt}$$

$$t \qquad 256449 \qquad -113711 \qquad 4302 \qquad -4193$$

$$-1.9904dd\log L_{pt} - 1.0008dd\log P_{0t} \qquad (3.2)$$

$$t \qquad -4354 \qquad -4300$$

$$R^2 = 1.0000, \quad DW = 1.8571, \quad F = 5.38 \times 10^{11}, \quad N = 47$$

$$Period = 1974 - 2020, \quad HT = 0.0542,\ V = 1/d(d((\Big(d\Big(d(Y_{pt} * TF_t)\Big)\Big))^2\Big))$$

Equation (3.25) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under

Equation (5.6). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in consumption could have caused innovation level to increase on average by 0.269% per annum, ceteris paribus.

$$\begin{array}{lllll} d\log Z_t = 0.2690\log C_{nt-1} & + 0.0178 d\log I_t & + 0.0183 d\log G_t & + 0.0190 d\log X_t & \\ t \quad 6268 & 5.634 & 8.418 & 14.55 & \\ \quad -0.0443 d\log M_t & + 1.0019 dd\log Z_t & & & (5.3) \\ t \quad -31.21 & 397.8 & & & \end{array}$$

$$R^2 = 1.0000, \quad DW = 1.8268, \quad F = 267837, \quad N = 47$$

$$Period = 1974 - 2020, \quad HT = 0.0538, \quad V = 1/d(d((d(d(Y_{dt}/Z_t)))^2))$$

Equation (3.10) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.7). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in output could have caused innovation level to increase on average by 0.28% per annum, ceteris paribus.

$$\begin{array}{lllll} d\log Z_t = 0.28 d\log Y_{t-1} & + 1.0 dd\log A_t & - 0.16 dd\log K_{pt} & - 0.56 dd\log L_{pt} & (5.4) \\ t \quad 87384 & 110250 & -14369 & -4844 & \end{array}$$

$$R^2 = 1.0000, \quad DW = 1.8944, \quad F = 1.45 \times 10^{11}, \quad N = 47$$

$$Period = 1974 - 2020, \quad HT = 0.0373, \quad V = 1/d(d((d(d(X_t/TF_t)))^2))$$

Equation (3.13) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.8). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused level of technology to increase on average by 1.00% per annum, ceteris paribus.

$$\begin{array}{lllll} d\log A_t = 1.00 d\log Z_{t-1} & + 0.16 d\log K_{pt} & + 0.56 d\log L_{pt} & + 100 dd\log A_t & (5.5) \\ t \quad 115360 & 542119 & 28232 & 342808 & \end{array}$$

$$R^2 = 1.0000, \quad DW = 2.0947, \quad F = 6.52 \times 10^{11}, \quad N = 46$$

$$Period = 1975 - 2020, \quad HT = 0.1416, \quad V = 1/d(d((d(d(X_t/TF_t)))^2))$$

Equation (3.13) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.9).

The specific required result shows that in Uganda during the 1975 to 2020 period a 3.54% increase in innovation could have caused level of technology to rise on average by 1.000% per annum, ceteris paribus.

$$\begin{array}{lllll} d\log A_t = 3.54\log Z_{t-1} & - 0.16 d\log K_{t-1} & - 0.56 d\log L_{t-1} & + 1.00 dd\log Z_t & \\ t \quad 71452 & -51773 & -45697 & 1078519 & \\ \quad +0.1550 dd\log K_{pt} & + 0.5623 dd\log L_{pt} & & & (5.6) \end{array}$$

$$t \quad 97268 \quad 321575$$
$$R^2 = 1.0000, \quad DW = 2.0343, \quad F = 8.17 \times 10^{11}, \quad N = 46$$
$$Period = 1975 - 2020, \; HT = 0.1014, \; V = 1/d(d((d\left(d(TF_{t-1}/L_{pt-1})\right))^2))$$

Equation (3.12) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.10). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in level of technology could have caused level of output to increase on average by 3.54% per annum, ceteris paribus.

$$d\log Y_t = 3.54d\log A_{t-1} - 0.55d\log K_{pt-1} - 1.0d\log L_{pt} + 1.00dd\log Y_t \quad (5.7)$$
$$t \quad 366338 \quad -119296 \quad -57368 \quad 724608$$
$$R^2 = 1.0000, \quad DW = 2.0093, \quad F = 9.72 \times 10^{12}, \quad N = 46$$
$$Period = 1975 - 2020, \; HT = 0.0555, \; V = 1/d(d((d(d(TC_{t-1})))^2))$$

Equation (3.16) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.11). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused capital stock to increase on average by 3.54% per annum, ceteris paribus. Coefficient of determination (R^2) is one because variations in the independent variables can fully explain all variations in the dependent variable. In addition, $d\log Y_{t-1} = 0.53d$logZ. Meanwhile, K_{t-1} is the ration Y_{t-1}/K_{pt-1}, meaning $d\log K_{t-1} = d\log Y_{t-1} - d\log K_{pt-1}$.

$$d\log K_t = 3.54d\log Z_{t-1} - 1.00d\log K_{pt-1} + 1.d\log K_{t-1} + 1.0dd\log I_t \quad (5.8)$$
$$t \quad 7129 \quad -3393 \quad -5712 \quad 26187$$
$$R^2 = 1.0000, \quad DW = 1.9981, \quad F = 9.04 \times 10^{09}, \quad N = 46$$
$$Period = 1975 - 2020, \; HT = 0.0405, \; V = 1/d(d((d(d(TC_{t-1})))^2))$$

Equation (3.16) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.12).

The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused capital productivity to increase on average by 3.54% per annum, ceteris paribus. Coefficient of determination (R^2) is one because variations in the independent variables can fully explain all variations in the dependent variable.

$$d\log K_{pt} = 3.5371d\log Z_{t-1} - 0.9999d\log K_{t-1} + 1.0000dd\log K_{pt} \quad (5.9)$$
$$t \quad 85447 \quad -60971 \quad 137795$$
$$R^2 = 1.0000, \quad DW = 2.1699, \quad F = 1.60 \times 10^{11}, \quad N = 46$$

$Period = 1975 - 2020, \;\; HT = 0.0227, \;\; V = 1/d(d((d(d(Y_{dt-1})))^2))$

Equation (3.17) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.13). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused labor productivity to increase on average by 3.54% per annum, ceteris paribus. Coefficient of determination (R^2) is one because variations in the independent variables can fully explain all variations in the dependent variable.

$$d\log L_{pt} = 3.5365 d\log Z_{t-1} - 0.9998 d\log L_{t-1} + 1.0000 dd\log K_{pt} \quad (5.10)$$

$t \qquad 40773 \qquad -38348 \qquad 80651$

$R^2 = 1.0000, \quad DW = 1.9558, \quad F = 5.27 \times 10^{09}, \quad N = 46$

$Period = 1975 - 2020, \;\; HT = 0.2606, \;\; V = 1/d(d((d(d(Y_{dt-1})))^2))$

Equation (3.11) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.16). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused total factor to increase on average by 3.54% per annum, ceteris paribus.

$$d\log TF_t = 3.54 d\log Z_{t-1} - 1.00 d\log A_{t-1} + 0.72 dd\log Y_t - 0.16 dd\log K_{pt}$$

$t \qquad 203043 \qquad -81363 \qquad 1316905 \qquad -97190$

$$-0.5623 dd\log L_{pt}) \quad (5.11)$$

$t \qquad -85448$

$R^2 = 1.0000, \quad DW = 1.9975, \quad F = 9.38 \times 10^{11}, \quad N = 46$

$Period = 1975 - 2020, \;\; HT = 0.3456, \;\; V = 1/d(d((d(d(Y_{dt} * L_{pt})))^2))$

Equation (3.27) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.17). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused investment to increase on average by 22.35% per annum, ceteris paribus.

$$d\log I_t = 22.349 d\log Z_{t-1} - 5.3153 d\log Y_{uit-1} + 1.0087 dd\log I_t \quad (5.12)$$

$t \qquad 69.21 \qquad -6204 \qquad 430.3$

$R^2 = 1.0000, \quad DW = 1.9058, \quad F = 2.27 \times 10^{08}, \quad N = 46$

$Period = 1975 - 2020, \;\; HT = 0.0000, \;\; V = 1/d(d((d(d(C_{nt-1})))^2))$

Equation (3.27) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.18).

The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused household consumption to increase on average by 4.262% per annum, ceteris paribus.

$$d\log C_{nt} = 4.2618 d\log Z_{t-1} - 0.2091 d\log Y_{uct-1} + 1.0002 dd\log C_{nt} \quad (5.13)$$

$$t \qquad 133.7 \qquad -36.13 \qquad 9763.7$$

$$R^2 = 1.0000, \quad DW = 1.9283, \quad F = 5.56 \times 10^{09}, \quad N = 46$$

$$Period = 1975 - 2020, \; HT = 0.0002, \; V = 1/d(d((d(d(C_{nt-1})))^2))$$

Equation (3.27) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.19). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused government spending to increase on average by 39.29% per annum, ceteris paribus.

$$d\log G_t = 39.291 d\log Z_{t-1} - 10.106 d\log Y_{ugt-1} + 0.9978 dd\log G_t \quad (5.14)$$

$$t \qquad 122.9 \qquad -112.9 \qquad 127.0$$

$$R^2 = 1.0000, \quad DW = 1.9343, \quad F = 3283560, \quad N = 46$$

$$Period = 1974 - 2020, \; HT = 0.0002, \; V = 1/d(d((d(d(Y_t)))^2))$$

Equation (3.27) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.20). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused exports to increase on average by 28.08% per annum, ceteris paribus.

$$d\log X_t = 28.077 d\log Z_{t-1} - 6.9584 d\log Y_{uxt-1} + 0.9901 dd\log X_t \quad (5.15)$$

$$t \qquad 279.6 \qquad -318.5 \qquad 124.5$$

$$R^2 = 0.9998, \quad DW = 2.0205, \quad F = 141700, \quad N = 46$$

$$Period = 1974 - 2020, \; HT = 0.2306, \; V = 1/d(d((d(d(Y_t)))^2))$$

Equation (3.27) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.21). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused imports to decline on average by 15.11% per annum, ceteris paribus.

$$d\log M_t = -15.109 d\log Z_{t-1} + 5.2713 d\log Y_{amt-1} + 1.0014 dd\log M_t \quad (5.16)$$

$$t \qquad 89.17 \qquad 111.2 \qquad 746.4$$

$$R^2 = 1.0000, \quad DW = 1.9743, \quad F = 940813, \quad N = 47$$

$$Period = 1974 - 2020, \; HT = 0.0130, \; V = 1/d(d((d(d(I_t)))^2))$$

Equation (3.27) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.22). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused economic profits to increase on average by 16.84% per annum, ceteris paribus.

$$d\log W_t = 16.841 d\log Z_{t-1} - 3.763 d\log Y_{uwt-1} + 1.0075 dd\log W_t \qquad (5.17)$$

$$t \qquad 48.72 \qquad -38.14 \qquad 308.9$$

$$R^2 = 1.0000, \quad DW = 2.0773, \quad F = 576913, \quad N = 47$$

$$Period = 1974 - 2020, \quad HT = 0.0555, \quad V = 1/d(d((d(d(M_t)))^2))$$

Equation (3.27) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.23). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused total cost to increase on average by 4.465% per annum, ceteris paribus.

$$d\log TC_t = 4.4648 d\log Z_{t-1} - 0.2625 d\log Y_{utt-1} + 1.0023 dd\log TC_t \qquad (5.18)$$

$$t \qquad 191.6 \qquad -14.18 \qquad 1138$$

$$R^2 = 1.0000, \quad DW = 2.0536, \quad F = 736924, \quad N = 47$$

$$Period = 1974 - 2020, \quad HT = 0.0740, \quad V = 1/d(d((d(d(M_t)))^2))$$

Equation (3.20) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.24). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused capital stock to increase on average by 12.86% per annum, ceteris paribus.

$$d\log K_t = 12.857 d\log Z_{t-1} - 2.5046 d\log L_{t-1} + 0.9721 dd\log K_t \qquad (5.19)$$

$$t \qquad 8.826 \qquad -5.991 \qquad 5122$$

$$R^2 = 0.9952, \quad DW = 1.9263, \quad F = 4521, \quad N = 47$$

$$Period = 1974 - 2020, \quad HT = 0.1373, \quad V = 1/d(d((d(d(I_t)))^2))$$

Equation (3.20) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.25). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in innovation could have caused labor to increase on average by 3.441% per annum, ceteris paribus.

$$d\log L_t = 3.4409 d\log Z_{t-1} - 0.0926 d\log K_{t-1} + 0.9657 dd\log L_t \qquad (5.20)$$

$$t \qquad 56.33 \qquad -4.904 \qquad 391.5$$

$$R^2 = 1.0000, \quad DW = 2.0940, \quad F = 1.49 \times 10^{08}, \quad N = 46$$

$$Period = 1975 - 2020, \quad HT = 0.0002, \quad V = 1/d(d((d(d(C_{nt-1})))^2))$$

Equation (3.16) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.26). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused capital productivity to increase on average by 3.535% per annum, ceteris paribus.

$$d\log K_{pt} = 3.5356d\log Z_{t-1} - 0.9997d\log K_{t-1} - 1.0005dd\log K_t$$
$$t \qquad 3217 \qquad -3335 \qquad 8818$$
$$+1.0001dd\log A_t + 1.0006dd\log TF_t \qquad (5.21)$$
$$t \qquad 3073 \qquad 4710$$
$$R^2 = 1.0000, \quad DW = 1.9577, \quad F = 3.77 \times 10^{09}, \quad N = 47$$
$$Period = 1974 - 2020, \quad HT = 0.0451, \quad V = 1/d(d((d(d(X_t/TF_t)))^2))$$

Equation (3.17) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.27). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused labor productivity to increase on average by 3.535% per annum, ceteris paribus.

$$d\log L_{pt} = 3.5353d\log Z_{t-1} - 0.9995d\log L_{t-1} - 0.9996dd\log L_t$$
$$t \qquad 12807 \qquad -12627 \qquad -19828$$
$$+0.9995dd\log A_t + 0.9996dd\log TF_t \qquad (5.22)$$
$$t \qquad 12800 \qquad 20872$$
$$R^2 = 1.0000, \quad DW = 2.1590, \quad F = 3.72 \times 10^{09}, \quad N = 47$$
$$Period = 1974 - 2020, \quad HT = 0.0962, \quad V = 1/d(d((d(d(M_t/TF_t)))^2))$$

Equation (3.12) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.28). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in level of technology could have caused capital productivity to increase on average by 6.450% per annum, ceteris paribus.

$$d\log K_{pt} = 6.4496d\log A_{t-1} - 6.4492d\log Z_{t-1} - 3.6273d\log L_{pt-1}$$
$$t \qquad 38465 \qquad -30756 \qquad 14004$$
$$+1.0000dd\log K_{pt} \qquad (5.23)$$
$$t \qquad 46733$$
$$R^2 = 1.0000, \quad DW = 2.0766, \quad F = 4.24 \times 10^{10}, \quad N = 46$$
$$Period = 1975 - 2020, \quad HT = 0.0038, \quad V = 1/d(d((d(d(Y_{dt-1})))^2))$$

Equation (3.12) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.29). The specific required result shows that in Uganda during the 1975 to 2020 period a 1% increase in level of technology could have caused labor productivity to increase on average by 1.779% per annum, ceteris paribus.

$$d\log L_{pt} = 1.7785 d\log A_{t-1} - 1.7785 d\log Z_{t-1} - 0.2757 d\log K_{pt-1}$$
$$t \qquad 44515 \qquad -41386 \qquad -31838$$
$$+1.0000 dd\log L_{pt} \tag{5.24}$$
$$t \qquad 87224$$

$R^2 = 1.0000,\quad DW = 2.0067,\quad F = 6.13 \times 10^{09},\quad N = 46$

$Period = 1975 - 2020,\quad HT = 0.1298,\quad V = 1/d(d((d\left(d(Y_{pt-1})\right))^2))$

Equation (3.29) was transformed into an econometric model and regressed under the generalized least squares framework and the empirical results are presented under Equation (5.30). The specific required result shows that in Uganda during the 1974 to 2020 period a 1% increase in innovation could have caused household disposable income to increase on average by 3.558% per annum, ceteris paribus.

$$d\log Y_{dt} = 1.037 d\log(Yd_{t-1}/Y_{t-1}) + 3.5575 d\log Z_{t-1} + 0.8600 dd\log C_{nt-1}$$
$$t \qquad 148.5 \qquad 515.6 \qquad 435.6$$
$$+0.1411 dd\log I_t \tag{5.25}$$
$$t \qquad 66.68$$

$R^2 = 1.0000,\quad DW = 1.8943,\quad F = 5061488,\quad N = 47$

$Period = 1974 - 2020,\quad HT = 0.1212,\quad V = 1/d(d((d(d(Y_{dt})))^2))$

In fouteen regressions conducted, the study finds that a 1% increase in innovation caused on average each of the variables to increase by 3.537% per annum during the 1974 to 2020 period. In summary the variables affected were: GDP, household disposable income, income per capita, population, household consumption, labor, capital, capital productivity, labor productivity, total factor and level of technology. All these effects could have been the long term effects. But the short run effects of innovation on the respective variable were such that a 1% increase in innovation could have caused the respective variable to increase as follows: investment (22.35%), consumption, (4,262%), government spending (39.2%), exports (28.08%), imports (-15.11%), economic profits (16.84%), ttotal cost (4.468%), capital (12.86%), and labor (3.441%). The regression results imply there were both short run and long run bidirectional causality between innovation and economic growth in Uganda during the given period. The results confirm that innovation is the key driver of economic growth and other macroeconomic variables. Innovation leads to an increase in economic growth and other macroeconomic variables in both the short run and the long run with long run bidirectional causal relationship between technological innovation and GDP, as well between innovation and other macroeconomic variables, hence leading to further stimulation of innovation and consequently GDP. In addition, innovation enables creation of more competitive products, and it enables firms to introduce new products into more markets.

Conclusion

For over thirty years the effect of innovation on economic growth has received significant attention in the developed world. However, in developing countries (e.g., Uganda) little is known about the effect of innovation on economic growth due to lack of data. The major objective is to examine the effects of innovation on economic growth in Uganda during the 1970 to 2020 period by using the GLS method. In the paper, innovation is derived from the neoclassical model and defined as the ratio of the total product (output) to output raised to the sum of capital and labour output elasticities. Data employed in conducting empirical analyses were collected from the United Nations database. One, empirical findings show that a 1% increase in innovation could have caused output to rise by 3.537% yearly in Uganda during the given period. Two, a 1% increase in innovation could have caused other microeconomic variable to rise by approximately 3.537% yearly in the country during the given period. Three, the short run effects of innovation on the respective variable were such that a 1% increase in innovation could have caused the respective variable to increase as follows: investment (22.35%), consumption, (4,262%), government spending (39.2%), exports (28.08%), imports (-15.11%), economic profits (16.84%), total cost (4.468%), capital (12.86%), labor (3.441%). Four, a 1% increase in output could have caused innovation to rise on average by 0.283%, and consumption to increase by 0.269% per annum. Finally, the paper finds that during the given period, innovation had negative consequences on both productivity of labor and capital in the long run. Meanwhile. increase in innovation had relative consequences on productivity of both labor and capital in the long run.

Policy Prescriptions

The innovation policy must aim to: (i) boost and coordinate applied research, innovation and research and development to improve the quality of life; (ii) promote research, innovation and entrepreneurship culture; (ii) enforce the development and application of advanced and innovative technology to meet the needs of industries; (iv) enable private sector participation in research and development and innovation; and (v) promote commercialization and utilization of the results of research and development and innovation, in the national interest; (vii) actualize connection between, and collaboration among, innovators and funding partners; (vii) develop and manage research and development and innovation programs and schemes, in areas of national priorities, emerging sectors and social innovation; (viii) establish, and provide for the development and management of drivers of innovation; (ix) adopt a strong business focus to drive innovations and growth to facilitate start-ups and assist innovators to launch, build and grow successful businesses with the participation of the private sector; (x) establish strategic links between research and development, innovation, intellectual property and other components of the knowledge economy; (xi) participate in a process of internationalization to: (a) acquire and utilize globally dispersed knowledge and technology; (b) collaborate with research and innovation centers to attract aspiring entrepreneurs globally; (c) devise innovation strategic plans and major policies; and (d) adopt and implement appropriate accountability standards in the various operations of the country.

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References

Abeka, M. J., Andoh, E., Gatsi, J. G., & Kawor, S. (2021). Financial development and economic growth nexus in SSA economies: The moderating role of telecommunication development. *Cogent Economics & Finance, 9*(1), 1-24, 1862395. https://doi.org/10.1080/23322039.2020.1862395

Adenle, A. A., Manning, L., & Azadi, H. (2017). Agribusiness innovation: A pathway to sustainable economic growth in Africa. *Trends in Food Science and Technology*, *59*, 88–104. https://doi.org/10.1016/j.tifs.2016.11.007

Akisik, O., Gal, G., & Mangaliso, M. P. (2020). IFRS, FDI, economic growth and human development: The experience of Anglophone and Francophone African countries. *Emerging Markets Review*, *45*, 100725. https://doi.org/10.1016/j.ememar.2020.100725

Currie-Alder, B., Kanbur, R., Malone, D. M., & Medhora, R. (2013). The state of development thought, Charles H. Dyson School of Applied Economics and Management Cornell University, Working paper: WP 2013-13.

Anakpo, G., & Kollamparambil, U. (2021a). Artificial intelligence and average wages in Southern Africa: A panel VAR approach. *Development Southern Africa*, 1–14. https://doi.org/10.1080/0376835X.2021.1938097

Anakpo, G., & Kollamparambil, U. (2021b). Effect of automation on unemployment: The case of Southern Africa. *Development Southern Africa,* 1–12. https://doi.org/10.1080/0376835X.2021.1940865

Anakpo, G., & Mishi, S. (2021). Business response to COVID-19 impact: Effectiveness analysis in South Africa. *Southern African Journal of Entrepreneurship and Small Business Management*, *13*(1), 7.

Anakpo, G., & Oyenubi, A. (2022). Technological innovation and economic growth in Southern Africa: Application of panel dynamic OLS regression. D*evelopment Southern Africa, 39*(4), 543–557. https://doi.org/10.1080/0376835X.2022.2052017

Bae, S. H., & Yoo, K. (2015). Economic modeling of innovation in the creative industries and its implications. *Technological Forecasting and Social Change*, *96*, 101–110. https://doi.org/10.1016/j.techfore.2015.02.010

Bank, W. (2022). *World Development Indicators*. https://databank.worldbank.org/source/world-development-indicators

Broughel, J., & Thierer, A. D. (2019). Technological Innovation and Economic Growth: A Brief Report on the Evidence. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3346495

Caliskan, H. K. (2015). Technological change and economic growth. *Procedia, Social and Behavioral Sciences*, *195*, 649–654.

Galindo, M.A., Méndez, M. T. (2014), 'Entrepreneurship, economic growth, and

innovation: Are feedback effects at work?', Journal of Business Research, 67(5), 825–829. https://doi.org/10.1016/j.jbusres.2013.11.052

Karafyllia, M., & Zucchella, A. (2017). Synergies and tensions between and within domestic and international market activities of firms. *International Business Review*, *26*(5), 942–958. https://doi.org/10.1016/j.ibusrev.2017.03.003

Kim, S., & Yoon, G. (2015). An innovation-driven culture in local government: Do senior manager's transformational leadership and the climate for creativity matter? *Public Personnel Management, 44*, 147–168. https://doi.org/10.1177/0091026014568896

Lawa, S. H., Sarmidib, T., & Gohc, L. T. (2020). Impact of innovation on economic growth: Evidence from Malaysia. *Malaysian Journal of Economic Studies, 57*(1), 113–132.

Lu, Y., Lei, T., & Guo, Y. (2019). Technology and economics opportunities in South Africa by hosting SKA. *Journal of Economics, Business and Management*, *7*(3), 1–5.

Maradana, N. R., Pradhan, R., Dash, S., Gaurav, K., Jayakumar, M., & Chatterjee, D. (2017). Does Innovation Promote Economic Growth? Evidence from European Countries. *Journal of Innovation and Entrepreneurship*, *6*(1), 1–23.

Nicholson, W., Snyder, C. (2012). *Microeconomic Theory: Basic Principles and Extensions (Eleventh Edition).* South Western: Cengage Learning.

Okumu, I. M., & Buyinza, F. (2020). Performance of Small and Medium-sized Enterprises in Uganda: The Role of Innovation. In *African Economic Research Consortium (AERC) Research Paper* (Issue 363).

Omar, N.S. (2019). Innovation and economic performance in MENA region. *Review of Economics and Political Science*, 4 (2), 156-175. 10.1108/REPS-12-2018-0042

Owoeye, T., Olanipekun, D. B., Ogunsola, A. J., & Kutu, A. A. (2020). Energy prices, income and electricity consumption in Africa: The role of technological innovation. *International Journal of Energy Economics and Policy*, *10*(5), 392.

Pradhan, R. P., Arvin, M. B., & Bahmani, S. (2018). Are innovation and financial development causative factors in economic growth? Evidence from a panel granger causality test. *Technological Forecasting & Social Change*, *132*, 130–142. https://doi.org/10.1016/j.techfore.2018.01.024

Pradhan, R. P., Arvin, M. B., J.H., H., & Nair, M. (2016). Innovation, Financial Development, and Economic Growth in Eurozone Countries. *Applied Economics Letters*, *23*(16), 1141–1144.

Rangongo, M. F., & Ngwakwe, C. C. (2019). Human capital investment and economic growth: A test of endogenous growth theory in two developing countries. *Acta Universitatis Danubius, Economica*, *15*(1), 92–107.

Rostami, N., Khyareh, M. M., & Mazhari, R. (2019). Competitiveness, entrepreneurship, and economic performance: Evidence from factor, efficiency, and innovation; driven countries. *Economic Annal*, *64*(221), 33–64.

Santacreu, A. M. (2015). Innovation, Diffusion, and Trade: Theory and Measurement. *Journal of Monetary Economics*, *75*, 1–20.

Taylor, S. P. (2017). What Is Innovation? A Study of the Definitions, Academic Models and Applicability of Innovation to an Example of Social Housing in England. *Open Journal of Social Sciences*, *5*, 128–146. https://doi.org/10.4236/jss.2017.511010

Tiruneh, E. A. (2014). *Essays on Effects of Human Capital, Innovation and Tech. on Economic Performance*. School of Social Sciences, University of Trento.

Tsvetkova, A. (2015). Innovation, Entrepreneurship, and Metropolitan Economic Performance: Empirical Test of Recent Theoretical Propositions. *Economic Development Quartely*, 29(4), 299-316. 10.1177/0891242415581398

Uganda, G. of. (2015). *Uganda micro, small and medium enterprise policy. Sustainable MSMEs for wealth creation and socio-economic transformation*. Ministry of Trade, Industry and Cooperatives.

Uwubanmwen, A. E., & Ogiemudia, O. A. (2016). Foreign direct investment and economic growth: Evidence from Nigeria. *International Journal of Business and Social Science*, *7*(3), 89–103.

Yu, W., Lin, X. (2025). Digital inclusive finance for green transformation: Insight from green innovation, industrial upgrading, and employment quality. Journal of Innovation & Knowledge, 10, 1-17. https://doi.org/10.1016/j.jik.2025.100726

Xiao, W., Kong, H., Shi, L., Boamah, V., & Tang, D. (2022). The impact of innovation driven strategy on high-Quality economic development: Evidence from China. *Sustainability*, *14*(7), 4212. https://doi.org/10.3390/su14074212

Xu, G., Hong-hao, L., & Hui-ting, Q. (2023). Research Hotspots and Frontiers of Scientific and Technological Innovation Cooperation in Guangdong Hong Kong Macao Greater Bay Area: Based on the Visual Analysis of Cite Space. *Strategy for Innovation and Development of Science and Technology*, *7*(05),6–67.