Impact of knowledge economy on economic growth in Rwanda: An empirical study during the period (2000-2019)

Dr. Nahla Ahmed Aboelezz*

* **Dr. Nahla Ahmed Aboelezz Department of Political Science and Economics, Cairo University, Faculty of African Postgraduates Studies, Giza, Egypt.**
Email: amenaaymany1red@gmail.com

Abstract

Purpose- This study aims to analyze the effect of the knowledge economy on economic growth in Rwanda, using time series data over 2000-2019.

Design/methodology/approach - We used the Auto Regressive Distributed-Lagged (ARDL) bound testing approach to estimate the relationship between knowledge economy and economic growth in Rwanda in the short and long run.

Findings- The results show that Knowledge-Economy indicators have a significant long-run relationship with the economic growth in Rwanda.

Originality/value – Actions for increasing spending on research and development with the expansion of databases and information centers within government agencies are very essential for Rwanda to increase the economic growth and competitiveness in the global markets.

Keywords

ARDL model; Economic Growth ;Knowledge Economy; Rwanda;

المستخلص

تهدف الدراسة الى قياس العلاقة بين الاقتصاد المعرفي والنمو الاقتصادي في رواندا باستخدام بيانات السلاسل الزمنية للفترة ٢٠٠٠-٢٠١٩ . ولقد تم تطبيق نموذج الانحدار الذاتي للفجوات الزمنية المتباطئة لتوضيح تلك العلاقة على المدى القصير والطويل . ولقد أظهرت النتائج وجود علاقة طردية بين مؤشرات الاقتصاد المعرفي والنمو الاقتصادي في رواندا . وأوصت الدراسة بزيادة الإنفاق على البحث والتطوير بما يتوائم مع احتياجات المجتمع الرواندي مع توسيع قواعد البيانات ومراكز المعلومات داخل الأجهزة الحكومية وذلك لدفع عجلة النمو الاقتصادي وزيادة القدرة التنافسية العالمية لرواندا في الأسواق الدولية الخارجية .

الكلمات الدالة :

نموذج الفجوات الزمنية الموزعة المتباطئة ، النمو الاقتصادى ، الاقتصاد المعرفى ، رواندا .

Introduction:

The world is living through the fourth industrial revolution, which is sometimes known as the information revolution. Along with other factors of production, information is the cornerstone of the production process. A knowledge economy can produce, transmit, and apply knowledge, which is the primary factor in growth, wealth creation, and employment in various developmental sectors. The knowledge economy is the fundamental human capital pillar for innovation, creativity, and the production of new ideas. Rwanda is one of the countries that is moving toward a knowledge society and is attempting to close the digital divide with developed countries. According to the Global Innovation Index, Rwanda was ranked 99th out of 126 countries in 2018, while it was ranked 60th and 99th in terms of institutions and infrastructure, respectively. Rwanda is one of the leading countries in Africa in the use of the knowledge economy, where the Rwandan economic development plan 2000 targeted rebuilding the business environment based on economic informatics and knowledge rather than relying on the agriculture sector's dominance in the GDP structure. According to Rwanda's successive development plans since 2000, the service sector's contribution to GDP is growing at the expense of both the industrial and agricultural sectors. The ICT sector is a key component of Rwanda's service economy and a cornerstone of long-term development.

Despite Rwanda's transformation from an agriculture-based economy to a knowledge-based economy since 2000, the influence of information technology applications is not as high as it should be. Furthermore, without underestimating the improvements in knowledge economy indicators in Rwanda due to the ICT sector's strong performance, Rwanda is still a low-income country, despite its government's efforts to enhance economic growth and adopt IT techniques since 2000 to become a middle-income country by 2020.

Nevertheless, there is little empirical research on the implications of the knowledge economy on African countries' economic progress. Furthermore, Rwandan policymakers require such research to develop economic strategies that would boost the country's information economy. As a result, the goal of this research is to determine the relationship between Rwanda's knowledge economy and economic growth. This study is trying to answer a key question, which is: Does Rwanda's shift to a knowledge economy result in quicker economic growth?

The study assumed that:

- There is a long-run relationship between the knowledge economy and economic growth in Rwanda.

- Expanding Rwanda's knowledge economy can boost economic growth.

The rest of this study is organized as follows: Section 2 is a literature review on the impact of knowledge economy on economic growth in both developed and developing countries, Sections 3 and 4 show the methodology, data sources, and the diagnostic tests used. Section 5 provides the empirical results. Finally, Section 6 concludes the paper.

2. Literature review:

New growth theories have demonstrated that knowledge is a particularly valuable factor in production, taking into consideration the unique properties of information and its capacity to be handed from one user to the next without losing its utility. Equipment acquisitions, incorporating modern technological advancements in education, invention, and other relevant fields, contribute to a gain in knowledge. To sustain economic growth, technological innovation allows higher value to be extracted from finite resources (Romer 1986; Romer 1990; Lucas 1988; Acemoglu 2008).

Brandt, 2007; Kuo & Yang, 2008; Kooshki and Ismail, 2011; Kaynak and Arslan, 2012; Gabsi and Chkir, 2012; Oluwatobi, Efobi, Olurinola, and Alege, 2015) have all looked at the knowledge economy experimentally. Many of these works have looked at the knowledge economy from a variety of perspectives. However, the examination process has remained similar. This research was consistent in its use of knowledge economy variables and framed its investigations based on endogenous growth theory. However, the indicators employed to capture the variables varied. In most situations, the discrepancy was due to data availability. For example, in studies of advanced or emerging countries, the number of patents and R&D investment have been used as indicators for innovation, but in studies of developing economies, they used articles in scientific and technical journals, high-tech exports, the number of higher education institutions, and so on as indicators for innovation. (Asongu, 2013).

Brandt (2007) considered how knowledge creation influences economies of scale and market power as a source of productivity increase. The study confirms that the gain in knowledge is proportional to R&D spending, as predicted by theory. In the gross output production function, which was the

basis for its modeling, R&D investment was utilized as a metric of innovation. In contrast to theoretical expectations, the study discovered no link between productivity and average R&D intensity. This discrepancy could be explained by the fact that the impact of R&D intensity has yet to be translated into productivity, as well as product and process innovation outputs.

In their study, Kaynak and Arslan (2012) examined the link between knowledge economy factors and the knowledge economy of the OECD's first 19 members from 2005 to 2010. The variables listed by the World Bank's Knowledge Atlas (2008) were used by the researchers. As a result, the Knowledge Assessment Methodology (KAM) validates the variables' ability to capture knowledge economy. Four estimating procedures (general statistics, panel regression analysis, panel cointegration analysis, and panel causality tests) were used in sections to complete the investigation. Given the period, their findings confirm that there is a long-term relationship between all knowledge economy components. Variables in the knowledge economy have also been discovered to have a direct relationship with the knowledge economy index. However, given the model's structure, these results may not be trustworthy. Knowledge economy factors were utilized as explanatory variables, while the dependent variable was the knowledge economy index, which was established by the World Bank (2008) using data on the knowledge economy variables. Thus, the assumptions of ordinary least squares are violated in this case. (Oluwatobi , Olurinola, Atayero, and Ogundipe, 2016)

From a comparative perspective, Bhatiasevi (2010) investigated the concept of knowledge-driven growth. He looked at the emergence and development of two knowledge-based developing economies (Malaysia and Thailand). Malaysia's government initiative to promote a knowledge-based economy began in 1991, whereas Thailand's began in 2001. His findings reveal that Thailand continues to fall behind Malaysia. This indicates that economies seeking knowledge-driven growth will have their expectations met if enough investments in the pillars that support knowledge creation have been made in advance. Malaysia's dedication to developing a knowledge-based economy has been well ahead of Thailand's for the past ten years. This demonstrates the value of an early investment in knowledge-based economic growth. (Oluwatobi , Olurinola, Atayero, and Ogundipe, 2016)

One important factor to consider is whether developing economies are ready to transition into a knowledge-based economy. However, because the World Bank (2008) had developed a technique (KAM-Knowledge Assessment Methodology) for such an assessment, it was necessary to investigate its application. Kurtic and Donlagic (2012) achieved this by using the KAM as a metric to assess Bosnia and Herzegovina's readiness to become a knowledge economy. They discovered that education was a critical part in achieving the growth of a knowledge economy after performing a survey on a sample of 150 businesses using factor analysis as the method. They also discovered that government incentives would enhance economic activity and encourage the advancement of the knowledge economy in addition to the importance of ICT infrastructure in increasing output and efficiency.

Simplice A. Asongu, Voxi H. S. Amavilah, and Antonio R. Andres (2019) investigated the link between economic growth and the knowledge economy. They ran a dynamic model on 53 African countries from 1996 to 2010 and showed that knowledge indices and economic performance have a weak relationship. Nonetheless, performance-driven by the knowledge economy plays a larger role in socio-economic progress compared with FDI, foreign aid, and even private investment as examples of traditional control variables. As a result, the literature above has offered evidence that knowledge plays a vital role in growth and economic development and that the volume and quality of innovation are outcomes of knowledge engagement. Furthermore, the quality of human capital and the amount to which they are engaged in the creation process are important factors that contribute to growth, especially when the enabling environment is present. The goal of this paper is to determine how much knowledge leads to growth in Rwanda, as well as how near the country is to become a knowledge-based economy.

3-. Empirical analysis:

3.1 *Empirical model*:

Time series data for economic variables is non-stable (non-stationary), and if we apply typical regression models to analyze them in their original form (level), we will end up in a situation known as spurious regression. As a result, conventional statistical tests are not valid, and dynamic regression models, which mix long-term and short-term correlations, are commonly

used in recent applied studies. When the variables have a cointegration property, and it is expected that economic variables tend in the long run to the direction of a steady-state (equilibrium), these models are utilized. However, in this situation, even though the variables are non-stationary on their own, we can obtain a meaningful and stable long-run relationship by combining them into a stationary linear combination. (Gujarati, & Dawn, 2009).

The researcher used the "Autoregressive Distributed Lag" (ARDL) bounds testing approach to assess the co-integration (long-run) linkages between the variables under investigation. Unlike the Johansen co-integration approach and the Engle-Granger two-stage procedure which both require that the variables under study be integrated in the same order, we choose the bound testing procedure over other methods for measuring co-integration because the bounds test approach can be used, whether the variables in the model are integrated at the level or the first difference. (Pesaran et al., 2001). In addition, if the sample size is small, the bounds test is favored then.

Because it involves time lags, ARDL analysis is a dynamic regression model that can measure relationships in both the long and short terms. The unlimited error correction model (UECM) in ARDL also allows for the analysis of short-run relationships. (Vazakidis & Adamopoulos, 2010).

The following three stages will be followed to apply ARDL: (Meddah, & Kara, 2021)

- First, estimating the order of variable integration and confirming the presence of a co-integration relation among study variables.
- Second, after establishing the existence of co-integration between variables, run the (ARDL) model to estimate the model parameters in the long run.
- Third, using the ECM to estimate short-term relationships.

The study main assumption is :

- There is a long-run relationship between the knowledge economy and economic growth in Rwanda.

The paper depended on various empirical studies which test the relation between knowledge economy and economic growth such as : Simplice A. Asongu, Voxi H. S. Amavilah, and Antonio R. Andres (2019) , and Stephen oluwatobi and others (2018) .

3.*2 Data sources and variables description*

The data range used in this paper covers the period from 2000 to 2019 for Rwanda. The data were semi-annually selected from the World Development Indicators Database provided by the World Bank. The variables used in the study were selected based on some previous experimental studies, which analyze the relationship between the knowledge economy and economic growth. These variables can be displayed as follows:

First: The per capita income of GDP (GDPPC) is the dependent variable, which is an indicator of economic growth in the neoclassical and the endogenous growth theory.

Second: Independent variables that are divided into two groups:

A- ***Main Independent Variables*** to measure the impact of the knowledge economy on economic growth, namely:

1- Information Technology Infrastructure Index, which is comprised of 3 indicators:
- Fixed telephone subscriptions per 100 people (FTS)
- Subscriptions to mobile cellular services per 100 persons (MCS)
- Subscriptions to fixed broadband services per 100 people (FBS)

2- Environmentally sustainable policies and institutions (CPIA)

3- New business density (new registrations per 1,000 people ages 15-64) (NBD)

4- Human capital expressed as School Enrollment, Primary, and Secondary (ENR)

B- ***Secondary independent variables***: They are the variables that affect the economic growth rate, but they are not knowledge economy variables, namely:

1- General Government Final Consumption Expenditure (GOVCON)
2- Gross Capital Formation (GCF)
3- Trade Openness (TRD).
4- These variables are given in Table (1):

Table (1) Variables of the Model

Description	Abbreviation of Variable
GDP per capita growth (annual %)	$DPPC$
Fixed telephone subscriptions (per 100 people)	**FTS**
Mobile cellular subscriptions (per 100 people)	**MCS**
Fixed broadband subscriptions (per 100 people)	**FBS**
School Enrollment, Primary and Secondary (gross), Gender Parity Index (GPI)	**ENR**
General government final consumption expenditure (% of GDP)	**GOVCON**
Gross capital formation (% of GDP)	**GCF**
Trade (% of GDP)	**TRD**
New business density (new registrations per 1,000 people ages 15-64)	**NBD**
CPIA policy and institutions for environmental sustainability rating (1=low to 6=high)	**CPIA**
Error Term	C

Source: By the author, based on the World Bank database.

The regression form was formulated as follows:

$$GDPPC = \alpha_0 + \alpha_1 FTS + \alpha_2 FBS + \alpha_3 ENR + \alpha_4 GOVCON + \alpha_5 GCF + \alpha_6 TRD + \alpha_7 MCS + \alpha_8 NBD + \alpha_9 CPIA + C$$

α_0 represents the constant term, while $\alpha_1, \alpha_2, \alpha_3, \ldots\ldots$ represent the parameters to be estimated in the long run.

4- The diagnostic tests:

4.1 *Unit root test*:

ARDL model can be used to analyze correlations between variables with different levels of integration, such as I (0), I (1), or both. However, it can't be used with variables that are integrated into order 2. As a result, we run a unit root test to ensure that they are not integrated into order 2. We can deduce that the variables under study are integrated of order 1, by using the Augmented Dickey-Fuller and Philips Perron Unit Root Tests. (Table No. (1) in appendix).

The ideal Lag length for the model variables must be determined before the co-integration test and ARDL model. This will be accomplished by examining both the Akaike Information Criterion (AIC) and the Schwarz Bayesian Information Criterion (SBC)., There is a loss of degrees of

freedom and multicollinearity when there are multiple lags. Choosing a lesser number of lags than is desirable, on the other hand, can result in autocorrelation. Consequently, the optimal number of lags is identified by the lowest information criteria values (Mckinnon, R.I.,1973). According to Akaike and Schwarz's information criteria, the optimal lag length for the model is determined (See Table 1 in the Appendix).

4.2 *Co-integration test*:

We will utilize ARDL bound test to examine the presence of co-integration, which will allow us to see if the variables have a long-run relationship or not. This test can be used only if the variables are integrated at the level or I (1). The following are the null hypotheses that can be tested using the autoregressive distributed lag (ARDL) bounds testing approach:

H0 = β1 = β2=β3=β4=β5= 0 (no co-integration relationship)

while the alternative hypothesis,

H1 ≠ β1 ≠ β2 ≠ β3≠ β4≠ β5≠ 0 (a co-integration relationship exists)

According to Pesaran et al. (2001), in this test, we seek to see if the estimated F-statistic values are below the lower bound, above the upper bound, or in the middle of the critical values. If the estimated F-statistic is less than the lower bound, we shall accept H0 and conclude that there is no co-integration. We will reject the null hypothesis, which proves the presence of co-integration if the F-statistic is more than the upper bound values. We can't determine whether or not there is co-integration if the F-statistics are between the top and lower boundaries. From tables (2) and (3) we noticed that the computed F and T statistic in our model is greater than the upper limit, so we can conclude that there is a co-integration relationship between the study's variables. (Shahbaz et al., 2008).

Table (2) F-Bound test

I(1)	I(0)	Signif.	Value	Test statistics
٢.٩٩	١.٨٨	%١٠	٩.٥٣٤٨٤٧	F-statistics
٣.٣	٢.١٤	%٥	٩	K
٣.٦	٢.٣٧	%٢.٥		
٣.٩٧	٢.٦٥	%١		

Source: By the author, based on E-views 10

Table (3) t-Bound test

I(1)	I(0)	Signif.	Value	**Test statistics**
٤.٥٦-	٢.٥٧-	%١٠	١٣.٨٠٩٣١-	t-statistics
٤.٨٨-	٢.٨٦-	%٥		
٥.١٨-	٣.١٣-	%٢.٥		
٥.٥٤-	٣.٤٣-	%١		

Source: By the author, based on E-views 10

4.3 *Long-run relation*:

Table (4) shows the results of estimating the long-term parameters of the model:

Table (4) long-run relation

Prob.	**t-statistic**	**Std. Error**	**Coefficient**	***Variable***
0.0000	8.588805	0.223418	1.918891	**FTS**
0.0000	7.581834	1.011892	7.671995	**FBS**
0.0002	6.163064	1.747845	10.77208	**ENR**
0.0003	5.682515	6.591072	37.45386	**GOVCON**
0.0113	3.171062	1.342068	4.255783	**GCF**
0.0000	8.421557	0.620771	5.227861	**TRD**
0.0001	6.864341	1.113359	7.642478	**MCS**
0.0000	-7.295129	0.335085	-2.444488	**NBD**
0.0001	-6.384842	0.418337	-2.671017	**CPIA**

Source: By the author, based on E-views 10

From the above table, we noticed that the parameters of fixed phone subscriptions, fixed broadband subscriptions, humane capital, General government final consumption expenditure, gross capital formation, trade openness, and Mobile cellular subscriptions came positive. Therefore, there is a direct positive relationship between the rate of economic growth in Rwanda and these variables. While the New business density parameter and the policy and institutions for environmental sustainability parameter are both negative, there is an inverse relationship between the growth rate and these variables. The reason for this is that Rwanda, on the one hand, lacks institutional experience, and on the other hand, despite all of its efforts, also lacks institutional experience.

4.4 *Short-Term relationships*:

The final stage in this study is to use the Error Correction Model (ECM) to estimate the parameters for the short term. It is calculated by first taking the error term estimated from the basic model's long-term regression equation

(ARDL) - and including it in the short-run equation after taking the first lag to it. Second, for all variables, take the first difference, and finally, use variables with a lag order lower than the long-run by one. (ECM) shows the time required for the dependent variable to establish long-term equilibrium (co-integration) with the independent variables.

From Table (2) in the Appendix, we found that ECT is significant at a level of 1% and has a negative sign. The value of the ECT parameter (-0. 88) indicates that about 88% of the previous year's variation due to shocks and disturbances in the short run between the actual and equilibrium value of the independent variables is adjusted for each year. This means that the variables return to equilibrium after about 11 months.

The explanatory ability of the model is very good, as around 95% of changes in the economic growth is explained by the independent variables included in the model, and it does not suffer from autocorrelation problem as shown by the Durban-Watson statistic.

4.5 *Robustness Test*

A set of tests can be performed to determine the model's stability. The most crucial tests are (Muhammed et al., 2011, PP. 62, 63) :

4.5.1 The normality test Jarque-Bera (JB):

To ensure that the model follows a normal distribution and adheres to the OLS approach, the Jarque-Bera test is performed. The test findings demonstrate that the parameters (JB) are insignificant, indicating that we can't refuse the null hypothesis (H0), and, as a result, the distribution takes the moderate normal distribution as shown in Figure (1) in the Appendix.

4.5.2 Breusch-Godfrey Autocorrelation Test (also known as LM Test)

After conducting this test, we can see that each of the (F-statistic and Chi-Square) values are insignificant, implying that the null hypothesis should be accepted. As a result, the model does not have an issue with autocorrelation**.**

4.5.3 Test for Heteroscedasticity

The goal of this test is to ensure that the residuals have the same variance (homoscedasticity), which is one of the key OLS assumptions. Hence, the

calculated parameters are guaranteed to be efficient. The hypothesis tests are accurate, and the estimated parameters are more trustworthy in allowing them to be relied on when making economic policy decisions. The Breusch-Pagan results indicate that the model does not suffer from the problem of heteroscedasticity.

4.5.4 *The CUSUMSQ and CUSUM tests*

The model's structural stability was examined using the CUSUMSQ and CUSUM tests. Both the sum of the residuals and the sum of their squares move inside the boundaries of significance (5%), as shown in the graphs in the appendix. This indicates that the coefficients have remained stable across the sample time and that the model is adequate for the analysis, with high match quality outcomes.

5. Results:

***First*:** The co-integration test of the knowledge economy and economic growth in Rwanda showed that there is a long-term equilibrium relationship between economic growth as a dependent variable and the explanatory variables (fixed-line telephone, mobile telephone, communications subscriptions, human capital, institutional structure, and doing business). This means that there is a causal relationship between economic growth and the information technology infrastructure index expressed by mobile phone subscriptions, fixed-line subscriptions, telecommunications subscriptions, and other knowledge economy variables such as human capital, institutional structure, and doing business.

Second: When estimating the long-term and short-term relationship between the dependent variable and the independent variables, it was found that fixed phone subscriptions, mobile phone and communications, human capital, institutional structure, and doing business have an impact on promoting economic growth in Rwanda, and this is consistent with many previous studies that have shown this.

***Third*:** Based on the above, we can accept the hypothesis that there is a long-term equilibrium relationship between economic growth and the knowledge economy in Rwanda. Also, we can accept the assumption that the increase of the knowledge economy has had a positive impact on the economic growth in Rwanda during the study period whether it be fixed phone, mobile phone, telecommunications, or human capital, while there is

a negative relationship between the institutional structure, and doing business and the economic growth rate. This means that the increase of the knowledge economy positively affects economic growth in a low-income country and this contradicts the study of (Irena Paličková, 2014) who said that it wouldn't affect economic growth in low-income countries but affects high-income countries and middle-income countries.

Consequently, the increase in the size of the knowledge economy is an important and influential factor in driving and reforming economic activity as it positively affects all economic variables that contribute to the increase of GDP. Therefore, the size of the knowledge economy was one of the direct determinants of economic growth in Rwanda.

6. Conclusions and recommendations

For a long time, knowledge has been regarded as a significant factor of production alongside labor, capital, and natural resources. However, given the scarcity of natural resources and the abundance of knowledge as a resource, as well as its potential to boost productivity and economic growth, more emphasis is now being placed on the value of knowledge.

This paper analyzes the effects of the knowledge economy on economic growth in Rwanda over the period (2000-2019), using the ARDL model. The estimation results show that except for institutional structure and doing business variables, there is a positive relationship between knowledge economy indicators and economic growth. Further, there is a positive relationship between some secondary independent variables (trade openness, government consumption expenditure, capital formation) and economic growth.

The findings of this paper open the door to some policy implications in Rwanda's knowledge-based economy and economic performance. Improvements in human capital, research, institutions, infrastructure, and business sophistication are critical for Rwanda's economic success. As a result, we can recommend the following knowledge-based policies to governments and policymakers in Rwanda: investment in education, research, institutional reform, investment in the quantity and quality of public and private infrastructures, improving knowledge absorptive capacity, building the capacity of knowledge workers, making knowledge-related investments and supporting policies that give incentives for the private sector to improve productivity.

References:

Romer, P. M. (1986). Increasing returns and long-run growth. Journal of Political Economy, 94(5), 1002– 1037.

Romer, P. M. (1990). Endogenous technological change. Journal of Political Economy, 98(5, Part 2), S71– S102

Lucas, R. E. (1988). On the mechanics of economic development. Journal of Monetary Economics, 22(1), 3– 42.

Acemoglu, D. (2008). Introduction to modern economic growth. Princeton: Princeton University Press.

Brandt, N. (2007). Mark-ups, Economies of Scale and the Role of Knowledge Spillovers in OECD Industries. European Economic Review, 51(7): 1708-1732.

Kaynak, S., & Arslan, I. (2012). In the context of the Knowledge Economy of Parameters: Econometrics Analysis of the Organization for Economic Cooperation and Development (OECD) Economies. African Journal of Business Management, 6(12): 4454-4461.

Oluwatobi, S., Ola-David, O., Olurinola, I., Alege, P., & Ogundipe, A. (2016). Human Capital, Institutions and Innovation in Sub-Saharan Africa. International Journal of Economics and Financial Issues, 6(4): 1507-1514

Kurtic, A., & Donlagic, S. (2012). Determining Key Factors for Knowledge Economy Development in Bosnia and Hercegovina. Tuzla: Management, Knowledge, and Learning International Conference.

Oluwatobi, S. O., Efobi, U. R., Olurinola, I. O., & Alege, P. O. (2015). Innovation in Africa: Why Institutions Matter. South African Journal of Economics, 83(3): 390-410.

Simplice A. Asongu, Voxi H. S. Amavilah & Antonio R. Andres (2019), "Business Dynamics, Knowledge-Economy, and the Economic Performance of African Countries", African Governance and Development Institute.

Asongu, S. A. (2013). Modeling the Future of Knowledge Economy: Evidence from SSA and MENA Countries. Munich: MPRA.

Gabsi, S., & Chkir, A. (2012). R&D Spillovers and Economic Growth: Empirical Validation in the Case of Developing Countries. Journal of Economics and International Finance, 4(5): 107- 122.

Kooshki, M. F., & Ismail, R. (2011). The Impact of Information and Communication Technology Investment on Economic Growth in newly Industrialized Countries in Asia. Australian Journal of Basic and Applied Sciences, 5(9): 508-516.

Kuo, C.-C., & Yang, C.-H. (2008). Knowledge Capital and Spillover on Regional Economic Growth: Evidence from China. China Economic Review, 19: 594-604. Elsevier.

Bhatiasevi, V. (2010). The Race towards a Knowledge-Based Economy: A Comparative Study between Malaysia and Thailand. International Journal of Business and Management, 5(1): 114-122.

Gujarati, Damodar N.; Porter, Dawn C. (2009). Basic Econometrics (5th ed.). Boston: McGraw-Hill Irwin.

Pesaran, M. H., Y. Shin, and R. Smith, 2001, Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics, 16, pp. 289-326.

Vazakidis A. & Adamopoulos A., (2010), "A Causal Relationship Between Financial Market Development and Economic Growth", American Journal of Applied Sciences, Vol. 7, PP. 575-583, http://scipub.org.

Meddah Abdelhadi, Kara Achira Nacer Eddine, (2021), The Impact of Human Capital on Economic Growth in Algeria During the Period 1970-2018: Application of ARDL Approach to Cointegration, Strategy and Development Review, Volume 11 / N°: 03 Special Issue, pp .554 - 571

Mckinnon, R.I., (1973), Money and Capital in Economic Development, Washington, DC, Brooking Institution,pp22-55.

Shahbaz M., Ahmad K. & Chaudhary A. R., (2008), "Economic Growth and Its Determinants in Pakistan", The Pakistan Development Review, Vol. 47, No. 4, Part II, PP. 471–486, http://www.pide.org.

Mmuhammed O. Z., Fatima P. I. & Omade S. I., (2011), "Co-integration Analysis of Foreign Direct Investment Inflow and Development in Nigeria", Developing Country Studies, Vol. 1, No. 1, PP 56-66, www.iiste.org.

Irena Paličková, (2014), Influence Of The Knowledge Economy On The Economic Growth And Economic Level Of The Countries, Czechia: Technical University in Ostrava, Faculty of Economic,pp1-9

Appendixes:

Table (1) unit root test

UNIT ROOT TEST RESULTS TABLE (ADF)

Null Hypothesis: the variable has a unit root

At Level

		GDPPC	FTS	FBS	ENR	GCF	GOVCON	TRD	MCS	NBD	CPIA
With Constant	t-Statistic	-5.2898	-1.3161	2.1449	-3.0275	-0.9913	-1.2327	1.1813	-1.7876	-0.9724	0.0516
	Prob.	0.0005	0.5999	0.9997	0.0502	0.7314	0.6376	0.9966	0.3725	0.7343	0.9497
		***	n0	n0	*	n0	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	-6.1971	-1.5715	0.6631	-1.4008	-0.9961	-0.7266	-1.6402	-0.2058	-3.0114	-3.8143
	Prob.	0.0005	0.7657	0.9986	0.8268	0.9174	0.9554	0.7373	0.9859	0.1611	0.0436
		***	n0	n0	n0	n0	n0	n0	n0	n0	**
Without Constant & Trend	t-Statistic	-0.4272	-0.8090	2.7556	1.3287	-2.9550	-0.2020	2.4776	-2.1395	-0.1439	2.4551
	Prob.	0.5126	0.3522	0.9965	0.9476	0.9980	0.6002	0.9947	0.0350	0.6175	0.9944
		n0	n0	n0	n0	n0	n0	n0	**	n0	n0
	At First Difference										
		d(GDPPC)	d(FTS)	d(FBS)	d(ENR)	d(GCF)	d(GOVCO)	d(TRD)	d(MCS)	d(NBD)	d(CPIA)
With Constant	t-Statistic	-5.7446	-4.0910	-6.4062	-3.2852	-5.7070	-3.6534	-4.6654	-1.5102	-3.1657	-4.5057
	Prob.	0.0003	0.0062	0.0001	0.0313	0.0003	0.0151	0.0019	0.5029	0.0416	0.0037
		***	***	***	**	***	**	***	n0	**	***
With Constant & Trend	t-Statistic	-5.5873	-4.1592	-3.6136	-4.1353	-5.6372	-3.8769	-5.7742	-2.3953	-3.0140	-4.2213
	Prob.	0.0021	0.0215	0.0634	0.0224	0.0016	0.0359	0.0011	0.3675	0.1585	0.0233
		***	**	*	**	***	**	***	n0	n0	**
Without Constant & Trend	t-Statistic	-6.0408	-4.1677	-5.6125	-3.2444	-1.3126	-3.7676	-1.3929	-1.6323	-0.9935	-3.1960
	Prob.	0.0000	0.0003	0.0000	0.0028	0.1672	0.0008	0.1463	0.0953	0.2724	0.0031
		***	***	***	***	n0	** *	n0	*	n0	***

a: (*)Significant at the 10%; (**)Significant at the 5%; (***) Significant at the 1% and (no) Not Significant

b: Lag Length based on SIC

c: Probability based on MacKinnon (1996) one-sided p-values

. Table(2) ARDL Error Correction Model

ARDL Error Correction Regression
Dependent Variable: D(GDPPC)
Selected Model: ARDL(1, 2, 2, 2, 2, 2, 2, 2, 2, 2)
Case 3: Unrestricted Constant and No Trend
Date: 06/03/21 Time: 14:23
Sample: 2000S1 2019S2
Included observations: 38

ECM Regression
Case 3: Unrestricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-11.10425	0.803306	-13.82318	0.0000
D(FTS)	4.800649	0.370180	12.96842	0.0000
D(FTS(-1))	3.084008	0.258462	11.93215	0.0000
D(FBS)	8.203147	0.612465	13.39365	0.0000
D(FBS(-1))	1.464437	0.151798	9.647254	0.0000
D(ENR)	20.68390	1.424459	14.52053	0.0000
D(ENR(-1))	11.14910	0.891612	12.50443	0.0000
D(GOVCON)	0.402423	0.731530	0.550112	0.5956
D(GOVCON(-1))	-31.92905	2.629160	-12.14420	0.0000
D(GCF)	16.17861	1.163356	13.90684	0.0000
D(GCF(-1))	12.28130	1.008521	12.17754	0.0000
D(TRD)	-0.541900	0.260852	-2.077425	0.0675
D(TRD(-1))	-4.402984	0.492558	-8.939021	0.0000
D(MCS)	12.93906	0.942880	13.72292	0.0000
D(MCS(-1))	6.479253	0.495479	13.07675	0.0000
D(NBD)	-1.532358	0.134344	-11.40619	0.0000
D(NBD(-1))	0.542497	0.074856	7.247242	0.0000
D(CPIA)	-0.741630	0.058107	-12.76316	0.0000
D(CPIA(-1))	1.625257	0.119397	13.61224	0.0000
CointEq(-1)*	-0.885773	0.064143	-13.80931	0.0000

R-squared	0.953955	Mean dependent var	0.001020
Adjusted R-squared	0.905353	S.D. dependent var	0.024432
S.E. of regression	0.007516	Akaike info criterion	-6.638043
Sum squared resid	0.001017	Schwarz criterion	-5.776155
Log-likelihood	146.1228	Hannan-Quinn criter.	-6.331390
F-statistic	19.62768	Durbin-Watson stat	2.203789
Prob(F-statistic)	0.000000		

* p-value incompatible with the t-Bounds distribution.

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
F-statistic	**9.534847**	**10%**	**1.88**	**2.99**
K	**9**	**5%**	**2.14**	**3.3**
		2.5%	**2.37**	**3.6**
		1%	**2.65**	**3.97**

t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
t-statistic	**-13.80931**	**10%**	**-2.57**	**-4.56**
		5%	**-2.86**	**-4.88**
		2.5%	**-3.13**	**-5.18**
		1%	**-3.43**	**-5.54**

Table (3) ARDL results

Dependent Variable: GDPPC
Method: ARDL
Date: 06/03/21 Time: 14:20
Sample (adjusted): 2001S1 2019S2
Included observations: 38 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): FTS FBS ENR GOVCON GCF TRD MCS NBD CPIA
Fixed regressors: C
Number of models evaluated: 19683
Selected Model: ARDL(1, 2, 2, 2, 2, 2, 2, 2, 2, 2)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDPPC(-1)	0.114227	0.080220	1.423914	0.1882
FTS	4.800649	0.499628	9.608451	0.0000
FTS(-1)	-0.016939	0.170461	-0.099370	0.9230

FTS(-2)	-3.084008	0.462273	-6.671402	0.0001
FBS	8.203147	0.870690	9.421433	0.0000
FBS(-1)	0.056939	0.163202	0.348887	0.7352
FBS(-2)	-1.464437	0.308532	-4.746463	0.0010
ENR	20.68390	2.328393	8.883336	0.0000
ENR(-1)	0.006826	0.664157	0.010278	0.9920
ENR(-2)	-11.14910	1.186770	-9.394493	0.0000
GOVCON	0.402423	0.833119	0.483032	0.6406
GOVCON(-1)	0.844170	1.441692	0.585541	0.5726
GOVCON(-2)	31.92905	4.558420	7.004410	0.0001
GCF	16.17861	1.875672	8.625504	0.0000
GCF(-1)	-0.127653	0.566620	-0.225288	0.8268
GCF(-2)	-12.28130	1.149772	-10.68152	0.0000
TRD	-0.541900	0.349278	-1.551483	0.1552
TRD(-1)	0.769616	0.431326	1.784304	0.1080
TRD(-2)	4.402984	0.419243	10.50223	0.0000
MCS	12.93906	1.496950	8.643616	0.0000
MCS(-1)	0.309694	0.260295	1.189781	0.2646
MCS(-2)	-6.479253	0.827118	-7.833526	0.0000
NBD	-1.532358	0.144981	-10.56935	0.0000
NBD(-1)	-0.090407	0.104709	-0.863418	0.4103
NBD(-2)	-0.542497	0.114182	-4.751175	0.0010
CPIA	-0.741630	0.082430	-8.997102	0.0000
CPIA(-1)	0.000971	0.023995	0.040479	0.9686
CPIA(-2)	-1.625257	0.187027	-8.689936	0.0000
C	-11.10425	1.380199	-8.045394	0.0000

R-squared	0.953509	Mean dependent var	0.051125
Adjusted R-squared	0.808870	S.D. dependent var	0.024314
S.E. of regression	0.010630	Akaike info criterion	-6.164358
Sum squared resid	0.001017	Schwarz criterion	-4.914622
Log-likelihood	146.1228	Hannan-Quinn criter.	-5.719712
F-statistic	6.592336	Durbin-Watson stat	2.203789
Prob(F-statistic)	0.002810		

*Note: p-values and any subsequent tests do not account for model selection.

Figure (1) Histogram-Normality Test.

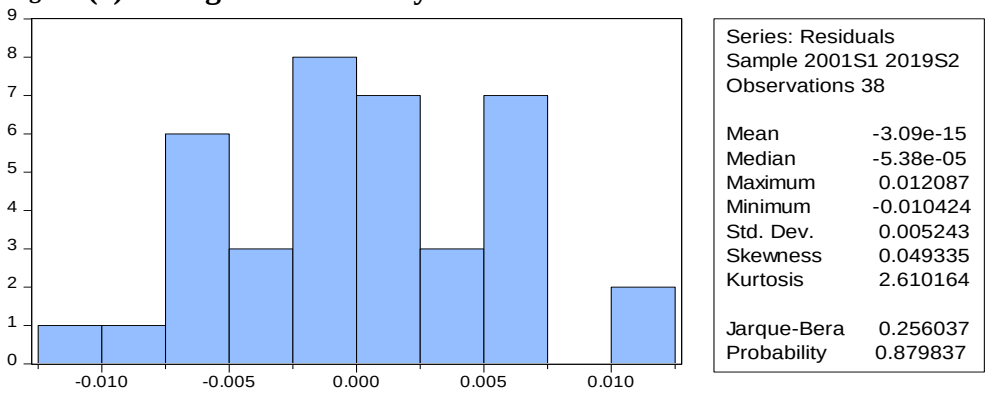

Figure (2) CUSUM test

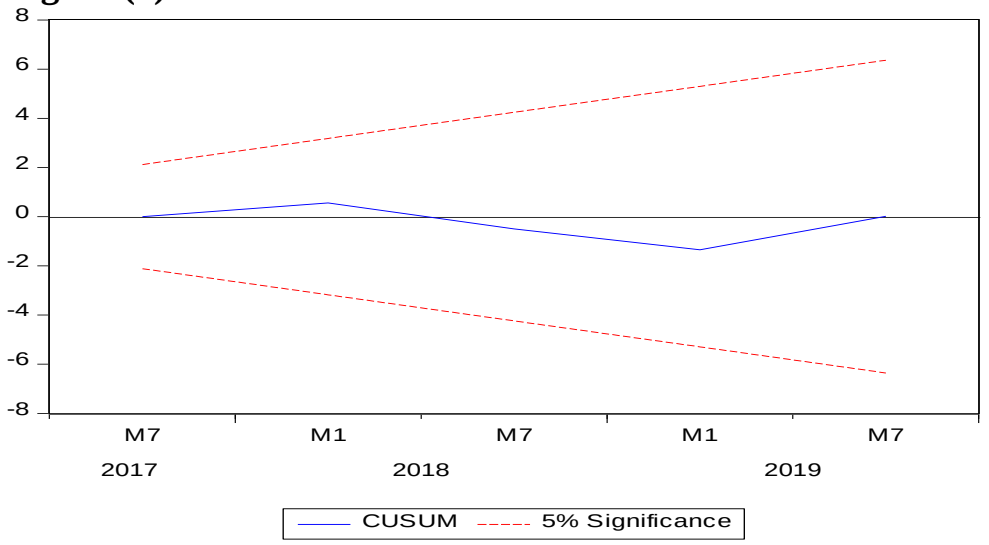

Figure (3/) CUSUMSQ test