ESTIMATING THE RELATIONSHIP BETWEEN TECHNOLOGY AND ECONOMIC GROWTH - EVIDENCE FROM SIERRA LEONE EXPERIENCE

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Abstract:

The study analyzes the relationship between technology and economic growth in Sierra Leone from 2011 to 2022 and the data are treated via the E-Views program. ARDL methodology was used. The results showed a co-integration relationship between the study variables (computer use in general; computer use at work; and computer use in education, training, and economic growth) and the results presented that the deviation from long-term equilibrium is corrected using an error correction model which long term corrected as a percentage correction (−0.06) each year from the short term to the long term and showed the results of the structural stability test of the (ARDL) model. It is a structural stability test for long and short-term coefficients, which showed that the data used in this study are free from any structural changes but has stable parameters over time. The study also used CUSUM's Squares test, where the test results showed that the study model used is economically good and can be relied upon to anticipate economic solutions in Sierra Leone according to the situation in the coming years, and among the most important recommendations of the study are the following: the need to encourage the use of technology in work, education, and training, and the need for expansion in using these technological means as a gateway to the digital economy and the digital state.

JEL: O33, O47, C51, C22, O14, O55

Keywords: technology, computers at work, computers in education and training, economic growth, digital economy

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1. Introduction

ICT has gained increasing importance in most countries of the world because of its significant impact on economic variables in general. On the demand side, it affects the economic behavior of the consumer. On the supply side, producer behavior is affected because technological development has led to the deepening of capital and the reorganization of economic and productive processes, especially in developing countries, as a major driver and actor in achieving economic and social development. Technology has also witnessed growth over the past years until it has a major role in economic development due to its direct connection to many economic sectors and as a very important productive component.

In this regard, Magdi S. (2011) indicates that information technology can affect economic growth through four main channels: producing goods and services, increasing the productivity of production in this sector, and contributing to financing trade, which leads to an increase in productivity in these sectors use information technology capital as an input in the production of real and non-real goods such as services. In addition, the main technological indicators, such as computer use in general, computer use at work, and computer use in education and training, play an important role in data monetization, big data analytics, data visualization, advanced analytics, and in memory databases, which are used in ways that contribute to distinguishing data from other technical concepts, such as quantitative measurement, measurement, recording, or digitization. These indicators contribute greatly to supporting economic decisions, directly promoting digital economic growth. These tools are also considered an important gateway to the digital economy. The digital state must provide people with basic technical skills that enable them to use these tools as sources of information as a gateway to the digital economy. There will be alternatives to traditional services or a new form of technological development. Moreover, these technological indicators are part of the infrastructure for digital economic technologies, which is necessary to enable users to benefit from the achievements of technology and communications in economic activities.

Technology plays an important role in all countries of the world, especially in non-industrial countries such as Sierra Leone, because these electronic tools can greatly affect development in general through their ability to develop the level of services, save time and effort, reduce costs, increase trade and digital investment, thus raising economic growth rates.

In this regard, according to the statistics of ICT sector indicators, Sierra Leone witnessed the highest growth rates in the indicators of the technology sector, as the percentage of computer use in training and education increased from 49.3% in 2011 to 60% in 2018. The percentage of computer use at work also increased between 2011 to 2018, which in turn led to an increase in the contribution to economic growth in Sierra Leone. Accordingly, the study aims to track the developments in the rates of information technology indicators in Sierra Leone during the study period, in addition to

investigating the impact of technology indicators such as computer use, computer use at work, and computer use in education and training on economic growth in Sierra Leone.

Based on the foregoing, the problem of the study revolves around answering the following main questions: Do technological indicators in Sierra Leone reflect positively on economic growth? Is there a common integration between ICT indicators (the percentage of computer use in general, the percentage of computer use at work, and the percentage of computer use in training and education) and economic growth in Sierra Leone? Is there a relationship between ICT indicators (the percentage of computer use in general, the percentage of computer use at work, and the percentage of computer use in training and education) and economic growth? Is there a long-term equilibrium relationship between (economic growth, the percentage of computer use in general, and the percentage of computer use in work and the percentage of computer use in training and education)?

By reviewing the study literature and relying on previous studies, the study hypotheses can be formulated as follows:

1) There is a statistically significant co-integration ($\alpha \leq 0.05$) between ICT indicators (the percentage of computer use in general, the percentage of computer use at work, and the percentage of computer use in training and education) and economic growth in Sierra Leone.
2) There is a significant relationship ($\alpha \leq 0.05$) between indicators of ICT (computer use in general, computer use at work, and computer use in training and education) and economic growth.
3) There is a statistically significant long-term equilibrium relationship ($\alpha \leq 0.05$) between economic growth and the percentage of computer use in general, the percentage of computer use at work, and the percentage of computer use in training and education.

2. Previous Studies

Many international and International studies have discussed the impact of ICT on economic indicators in general and on economic growth in particular. These studies were diverse in terms of dealing with the elements of technological development.

The study showed that there is a single relationship of cointegration in the long term between the impact of the digital economy and economic growth through the impact of each of the number of fixed-line subscribers and mobile subscribers on the gross domestic. The research discussed the role of technological changes and economic growth. The study showed that the use of technology and new technologies leads to reduced costs and increased productivity gains. In addition, the use of new technologies is the way to produce new, cheaper commodities and accumulate capital, in addition to enhancing the international competitiveness of countries and scientific research institutions. The research discussed the relationship between ICT development and economic growth in

OECD European Union countries and clarified the impact of ICT development on economic growth.

In this context, Mohamed, M., *et al.* (2022) sought to measure the impact of technological innovation on economic growth in developing countries during 1990, using an error correction model method. The results showed that the variables are stable after taking the first difference. Co-integration was tested, showing an increase in the indicators of technological innovation (such as spending on education, the number of patents for residents and non-residents, research and development expenditures, the number of researchers in research and development, high-tech exports, and scientific and technical research papers). Co-integration leads to increased economic growth. The relationship between technological innovation and GDP is two ways, and the analysis showed a short-term causal relationship that extends from technological innovation to GDP. The study also concluded that technological innovation directly impacts the sustainability of the country's economic growth Also, Raéf, B., & Alaa, A. Q. (2019) aimed to clarify the effects on the economic growth of a selected group of developing countries in the Middle East, North Africa, and Southern Africa from 2007 to 2016. The analysis showed a positive impact of (ICT) on economic growth.

Alawneh A. M. (2021) discussed and analyzed the effects of the growth of the (ICT) and education sectors on the growth of the industrial sector from 2005 to 2019 the study revealed a positive relationship between the growth of the (ICT) sector and the growth of the industrial and education sectors. (Abdullah A., 2020) studied the role of digital transformation in supporting tax revenues in Egypt the study concluded that there is a risk of erosion of the tax base in light of the growing digital economy and the inadequacy of tax legislation in Egypt to digital transformations in financial transactions. Bin Musa H. (2012) showed that the digital economy plays a large and positive role in expanding the outlets of services and increasing the volume of bank transactions and profits.

Muhammad K. & bin Omar L. (2022) showed the reality of the digital economy and its impact on economic growth in Algeria from 1990 to 2020, using joint integration, population, and inflation rate.

Kabeel (2021) tested the relationship between the digital economy and economic growth in Egypt using the least squares method. The results showed a positive relationship between private investment spending and economic growth and between the digital economy and economic growth in Egypt.

However, Hussein E. (2020) measured the impact of ICT in its three dimensions, namely, access, use, and skills, on inclusive growth. The study concluded that access has a positive and significant effect in a sample of countries, particularly developing and Arab countries on inclusive growth. The impact of skills on inclusive growth is negative and non-significant in the sample of non-industrialized countries. But Tanira & Barbakh Tanira M., Barbakh (2020) found a direct positive relationship between internet use and the rate of economic growth. In addition, Zhao J. (2022) indicates that the digital economy has a significant impact on economic growth.

2.2 Distinguishing the Study

The study points necessity and importance of ICT for economic growth. A review of the meaning of ICT and measurable indicators and their links to economic growth is done also. The study contributes to the empirical analysis of the impact of technology (expressed in terms of computer usage) on economic growth by examining Sierra Leone's case. What distinguishes this study from previous international studies, and that it aimed to track ICT developments in Sierra Leone. Moreover, it aims to know the impact of some indicators of ICT, such as computer use, computer use at work, and computer use in education and training, on economic growth in Sierra Leone during the study period.

2.3 Materials and Methods

2.3.1 ICT and Economic Growth

Pointed out that in the 1960s, banks began to use computers for record-keeping and data storage. In the 1970s, companies began trading stocks electronically. In 1981 the first IBM personal computer was invented, ending the dominance of time-sharing peripheral computing. In the 1990s, e-commerce and Internet business models flourished.

For this reason, retail investors have been online stock trading through 50 years of developments in Finch, and innovators have created complex treasury management, risk management, data analytics tools, and trade stops for financial services firms and institutional banks. Financial services have been digitized for individuals through crowd-funding platforms and robot advisors for retirement and wealth planning, payment apps, and mobile wallets (Rubini A., 2018)

ICT is defined as the use of technologies such as computers, printers, the Internet, wireless networks, scanners, cellular, numbering devices, and other modern means to process, preserve, distribute, and transmit data with great speed and accuracy, supporting decision making, problem-solving, and data analysis to achieve some goals. As for economic growth, Franco Perot believes that the continuous increase during one period or long period in the gross domestic product, which is the continuous increase in gross income to the net real value, increases economic production over time (gross domestic product).

2.3.2 Importance of Using Computers in Economic Activities

A computer is an electronic device that processes data quickly and accurately. It stores and processes input data to produce the correct and required information. Computers implement many programs to achieve the correct result.

Computers have made many contributions in various fields, including education, technology, science, and many others; they are now everywhere as these devices help perform mathematical operations, save a lot of effort and money, and store information (Sami, 2021)

The computer also provides many advantages in various businesses. It provides accuracy and speed in preparing documents, performing calculations, and implementing accounting procedures such as recording, tabulating, analyzing, and saving operations.

In turn, it saves time and effort, reduces the size of computational errors, and lessens costs because it operates the accounts carried out by the facility. Using the computer improves bookkeeping and accounting documents and facilitates information collection, storage, and retrieval through facility management.

Similar operations can be completed at one time, recording many accounting operations and using fewer people quickly.

Accuracy in extracting information and final results can be achieved because the computer can control and verify results. Using a computer also increases confidence in the resulting information from operating on the computer and displaying reports, which decision-makers can use as a sound and reliable basis for making decisions. In the field of education and training, many computers analytical programs are used in management and business, such as Excel and Access.

Quality control can be achieved through the Minitab program and the SPSS program. The use of computers in digital transformation has developed greatly, especially in automation systems that are concerned with the manufacturing of automated robots. It also facilitates the completion of many other works.

It is also widely used today in many economic activities owing to the multiple and important services it provides to business owners or workers. It is also possible through the computer to do many different jobs, such as making online sales, transferring funds between accounts, carrying out bulk account operations, and other corporate work that requires speed and accuracy. The computer also allows business firms to create economic forecasting plans according to some of the data provided.

In addition, computers protect companies' data and information from theft. The computer also facilitated the process of managing employee records in the company through specialized programs and the possibility of using the computer to prepare the company's budget and tax forms (Al Asi E., 2021).

The computer also allows for recording and processing many important documents. New solutions and tools with considerably higher performance are needed in the era of big data and rapidly growing volumes of processed information. It also appears to be used in digital public finance. It is considered the basic structure for developing the digital economy, which includes using all digital transformation tools (cloud computing and robots). The use of technology is considered a duty for the state to carry out four functions to encourage the use of technology (Gąsiorkiewicz & Monkiewic (Gąsiorkiewicz L., Monkiewic J., 2023). Thus, identifying four basic functions of the state concerning the use of digital tools is necessary. Above all, it must act as a protector. This function includes all aspects related to the regulatory activities of the state as well as its efforts to protect the rule of law. Playing the role of a protector also includes certain activities in the social field, such as taking steps to eliminate social exclusion. Another function of the state is the function of the promoter in supporting research and development as well as innovation. The researchers also see that the support and development process include computers, artificial intelligence, and modern technologies, including financial technologies. The third function relates to the producer role, which

often includes activities aimed at providing access to broadly defined public services and infrastructure, including that required to maintain the provision of services developed by the digital economy. Finally, the fourth function is that of the forecaster, whose task is to create scenarios for the future regarding social and economic changes. In addition to being sources of information for private entities that make microeconomic decisions, these scenarios must, above all, be the basis for the actions implemented by the state as part of its development strategies and long-term policies. This infrastructure is necessary for transforming the digital economy and financial technology to achieve the desired growth of countries worldwide (Rubini A., 2018).

Rubini (2018) indicates that using modern technologies, including financial technologies, requires devices and equipment connected in a cloud to communicate with each other and even facilitate intelligent payments. Moreover, conducting financial operations called peer-to-peer (p2p) requires interconnected computers to complete deals and other means of modern technology that rely on computers directly performing technical tasks via the internet.

3. Methodology

3.1 Data Collection
The data issued by the Statistics Sierra Leone (Stats Sierra Leone) will be used for the period of analysis from 2011 to 2022, which is also the period available in the statistics Sierra Leone (Stats Sierra Leone). Given the small period of annual data, the researchers converted the data into quarterly data from 2011 to 2022 using the E-views program in order to increase the number of views, because the model used requires a number of views of not less than 30, and to avoid the problem of bias primary sources of books and journals will be utilized to achieve the best results and enhance the theoretical aspect of the study.

3.2 Model specification
Based on the study literature and the theoretical aspect, the following model was adopted.

GDP = f (X, Y, Z)   Eq (1)

where,
GDP: Economic growth rate in Sierra Leone,
X: Percentage of computer use in Sierra Leone,
Y: Percentage of computer use at work in Sierra Leone.
Z: Percentage of computer use in training and education in Sierra Leone.
The model can be used in the linear equation by generalizing the variable with the study objective.

Below is the generalized equation of the model;

$$GDP_t = \alpha_0 + \beta_1 X_t + \beta_2 Y_t + \beta_3 Z_t + \mu_t \hspace{4cm} \text{Eq (2)}$$

where:

T is the time period of the research,

α is the constant,

β_1, β_2, and β_3 are the slope or the coefficient of the parameter within the model, and

μ is the error term.

The E-views program using the ARDL methodology will be utilized to achieve the study's objective, and other tests will be conducted to ensure no standard problems in the study model.

4. Presentation and Discussion of Empirical Findings

4.1 Descriptive Statistics

This section briefly discusses the basic statistical properties of the relevant variables of the study. Table 4.1 presents the descriptive statistics of the variables.

Table 4.1: Descriptive Statistics Result

Variables	GDP	X	Y	Z
Mean	3.754089	12.30274	39.57412	46.28350
Median	4.193905	9.585833	35.79741	42.74348
Maximum	26.52413	54.66667	79.28293	81.02872
Minimum	-20.49107	4.485833	10.52107	4.514775
Std. Dev.	7.509553	0.331004	8.073042	23.66185
Skewness	0.430140	0.727904	-0.048049	1.502950
Kurtosis	1.994796	2.416006	11.50181	4.079397
Observation	30	30	30	30

**Source:** E-views 12 output.

Table 4.1 shows that the average growth rate was 3.75%, the highest rate was 26.52% and the lowest rate was -20.49% with a standard deviation of 7.50%. The table also shows that the average computer use in Sierra Leone generally amounted to 12.30%, which is considered a fairly acceptable percentage given that the highest percentage of computer use was recorded at 54.66% while the lowest rate was recorded at 4.48%, with a standard deviation of 0.33% during the study period. The average was 39.57% for using the computer at work, which is a modest percentage. The highest rate was recorded at 79.28 during the study period, and the lowest rate was 10.52% with a standard deviation of 8.07% during the study period. One of the highest averages was using the computer in training and education, reaching 46.28%, a good indicator. In Sierra Leone, the highest rate was 80.01% and the lowest rate was 4.51%, with a standard deviation of 23.66%. Accordingly, noting from the indicators the percentages are higher, the highest rates during the study period were the use of computers in training and education by 51.8%,

and the use of computers in general by 44.42%. The lowest percentage of computer use at work was 36.76% during the study period.

4.2 Development of Study Variables over Time

Figure 4.1 shows the study variables fluctuate over time in general. Economic growth was high at the beginning of the study period, but it decreased with fluctuation over time until it reached its lowest level in 2016. Then, it returned to a slight increase until the end of the study. The percentage of computer use in general fluctuated across the study periods, as it was high until it reached its lowest at the end of the study period in 2018, due to the use of individuals to more flexible and more advanced technologies such as smartphones. The percentage of computer use at work was low at the beginning of the study. Then, it rose during the study period until it reached its highest at the end of the study period which led to a continuous decline in usage in 2020. Education is different as it fluctuated greatly during the study periods, indicating the different nature of computer use in training and education from year to year in Sierra Leone, according to the capabilities and support in using computers for this education and training sector although its importance in supporting development and growth in Sierra Leone was generally high.
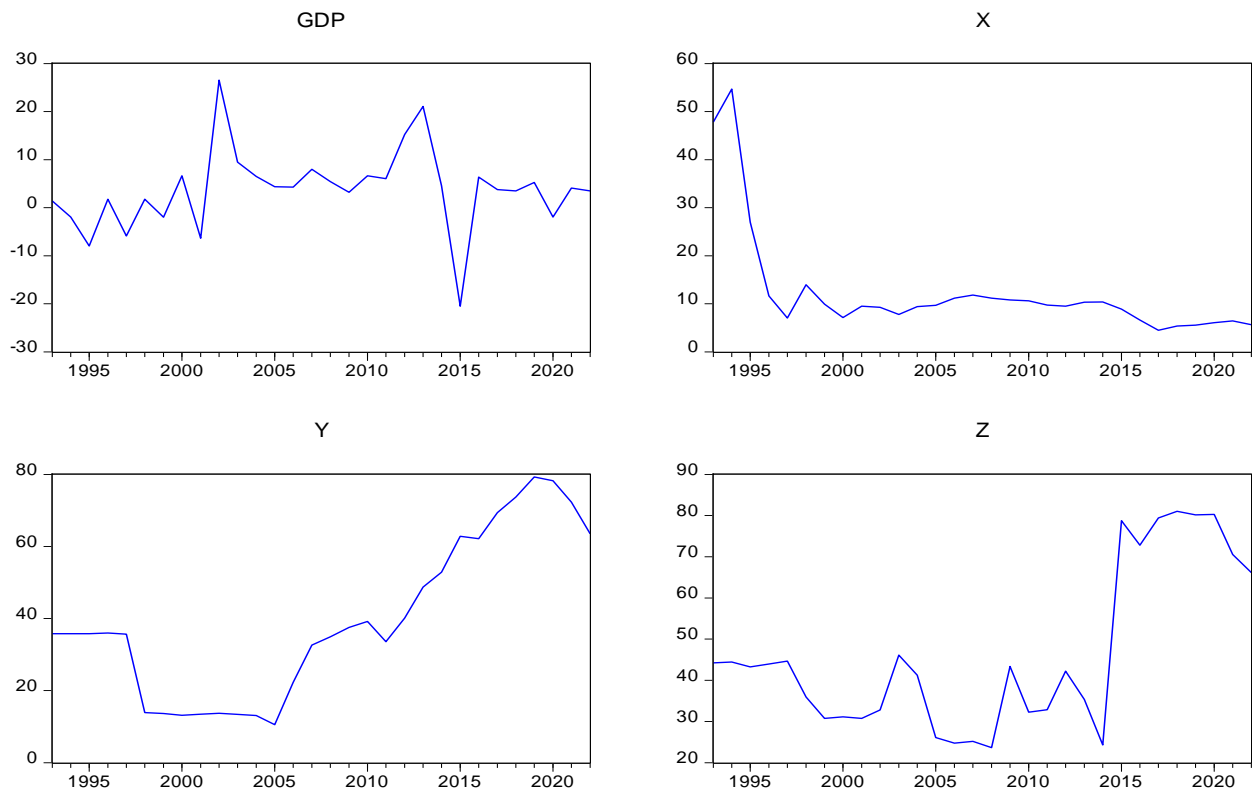
4.3 Correlation Matrix

In order to address the problem of multicollinearity in the model, the research estimates a correlation matrix to determine the extent of correlation among the variables. Correlation explains the magnitude to which a change in one variable alters the other. If

there is a correlation among two variables that is above 70%, then there is a multicollinearity in the model.

Table 4.2 Correlation Matrix

Variables	GDP	X	Y	Z
GDP	1.0000			
X	0.2890	1.0000		
Y	0.2229	0.4659	1.0000	
Z	-0.2199	-0.2435	-0.4324	1.0000

From the result in Table 4.2, it shows that there is a positive correlation between the economic growth and the percentage of computer use in Sierra Leone. The result further reveals that all the indicators have a positive correlation with the dependent variables and show a high degree of significance at the 5% significant level.

4.4 Stationarity Test

Although the bound test Autoregressive Distributed Lag (ARDL) approach to cointegration does not require the pretesting of the variables for unit roots. It is important to conduct this test to confirm the order of integration of the variables. Hence, in order to ensure that some variables are not integrated at higher order, there is a need to complement the estimated process with unit root tests. In view of this, prior to applying the (ARDL) approach to cointegration, unit root tests were conducted in order to investigate the stationarity properties of the data. Therefore, the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) tests were applied to all variables in levels and in the first difference in order to determine their order of integration and confirm stationarity. The maximum lag length used was determined based on the lag selection by Schwartz-Bayesian Criterion (SBC) and the Akaike Information Criterion (AIC). The results of both Augmented Dickey-Fuller and Philips Perron for unit root with intercept only in the model for all variables are presented in Table 4.3.

Table 4.3: Stationarity Test Results

Variables	Augmented Dickey-Fuller		Phillips Perron		Order of integration
	Level	1st difference	Level	1st difference	
GDP	-4.76255**	-8.743600**	-4.743600**	-20.27947	I (0)
X	-3.748009**	-4.46318**	-8.5989**	-4.58266**	I (0)
Y		-3.730326**		-3.715793**	I (1)
Z		-6.521761**		-6.550302**	I (1)

Note: 5 percent level of significance, with critical value = -2.9411.
Source: E-views 12 output.

From the unit root test results in Table 4.3, it found that all of the variables are integrated of order one I (1), which is non-stationary, except GDP and X which are I (0), which is stationary at levels. The decision rule states that we accept the null hypothesis if the

absolute critical value at a 5% level of significance is greater than the absolute t-statistic value.

From Table 4.3, it is clear that the corresponding critical values at level for each of the I (0) variables are greater than the t-statistic values, hence we accept the null hypothesis at level and conclude that the variables are non-stationary. But at the first difference, the corresponding critical value at 5% is less than the t-statistic values of these variables, and we, therefore, reject the null hypothesis and accept the alternative hypothesis, and conclude that Y and Z are stationary at first differencing for both ADF and PP tests, which shows that these variables are integrated order one I (1)

Similarly, the corresponding critical values for GDP and X are less than the t-statistic value. Hence, we reject the null hypothesis and conclude that these variables are stationary in levels, i.e. they are integrated of order zero I (0). Since the unit root test results above confirmed the absence of I (2) variables, the ARDL framework is used for estimation.
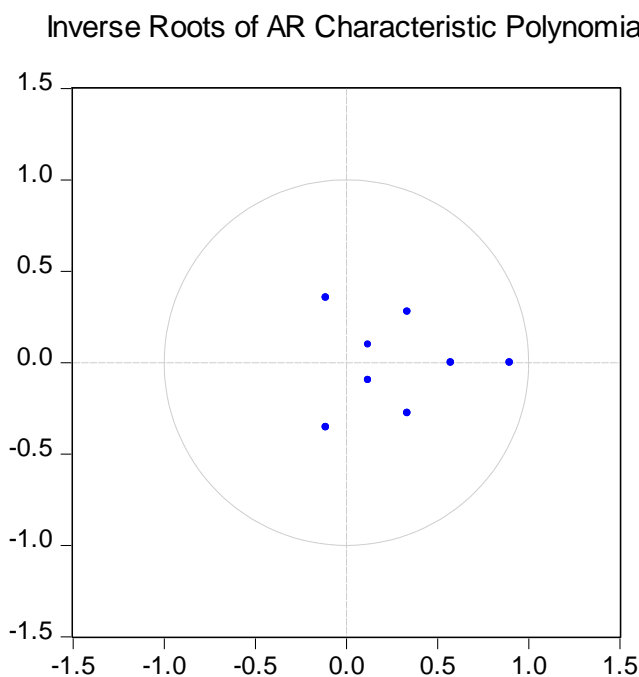
4.5 Lag selection

Figure 4.2: Lag selection of the variable

4.6 Bound Test for Cointegration Analysis

Fundamentally, the primary objective of this study is to assess the main determinants of export performance in Sierra Leone. Because of this, it is essential to test the existence of long-run relationships among variables within the framework of the bounds-testing approach to cointegration. The decision rule states that the null hypothesis, of no co-integration, must be accepted if the f-statistic is less than the lower bound. However, if the computed F-statistic is less than the lower critical bound, then the test fails to reject the null hypothesis, suggesting that a long-run relationship does not exist.

Thus, the results of the ARDL F-bounds test are computed below in Table 4.4.

Table 4.4: Bounds Test Cointegration Result

Test statistic	value	Signif.	I (0)	I (1)
		Asymptotic: n = 1000		
f-statistic	8.144981	10%	2.12	3.23
k	6	5%	2.45	3.65
		2.5%	2.75	3.99
		1%	3.15	4.43

Source: E-views 12 output.

Based on the results in Table 4.4, we conclude that the calculated F-statistic 8.144981 is higher than the upper bound critical value at the 5 percent level of significance (3.65). This simply shows that the null hypothesis of no cointegration is rejected at the 5 percent level and that there is indeed a cointegration relationship among the determinants of technology on economic growth. Therefore, the study proceeds to estimate both the long-run and short-run models within the ARDL framework. The long-run result is presented in Table 4.5

4.7 Long-run Estimation

Table 4.5: ARDL Long-Run Result

Variables	Coefficient	Std. Error	t-Statistic	Probability
LNX	-15.80248	4.562574	-3.463581	0.0071
LNY	0.361563	0.194558	1.858380	0.0030
LNZ	2.088038	0.601489	3.471448	0.0070

From the table above, the result shows that there is a negative relationship between the percentage of computer use generally in Sierra Leone and economic growth and it is statistically significant at the 0.05 significant level since the p-value is less than the 0.05. A 1% increase in the percentage of computer use generally in Sierra Leone would approximately decrease the economic growth by (15.80248) in the long run. The study implies that an increase in access to cell phones and smartphones will affect the general thinking of the student which will lead to poor output in their examination and this will increase government expenditure on education and this will affect the economic growth. The findings are in line with Olu K.'s (2014) study on the determinant of ICT on the economic growth in Ghana, the findings reveal that the increase in access to computers in the country would lead to a decrease in economic growth. The result further shows that the percentage of computer use in the workplace and the percentage of use in training and education in Sierra Leone have a positive impact on the economic growth in Sierra Leone. It also shows that it is significant at the 5% level of significant at a p–value of (0.003) and (0.007) respectively.

4.8 Short-run Estimation

The estimation of the short-run model with the Autoregressive Distributed Lag Model (ARDL) is based on the Akaike Information Criterion (AIC) employed. Table 4.6 shows that the percentage of computer use generally has a positive impact on the economic growth in the short run and it is statistically significant at the 5% level of significance. A 1% increase in the percentage of computer use generally in Sierra Leone would approximately increase economic growth by (0.776) at 77% in the short run.

Table 4.6: Error Correction Model Representation for Selected ARDL Model- ARDL (1, 4, 4, 4)

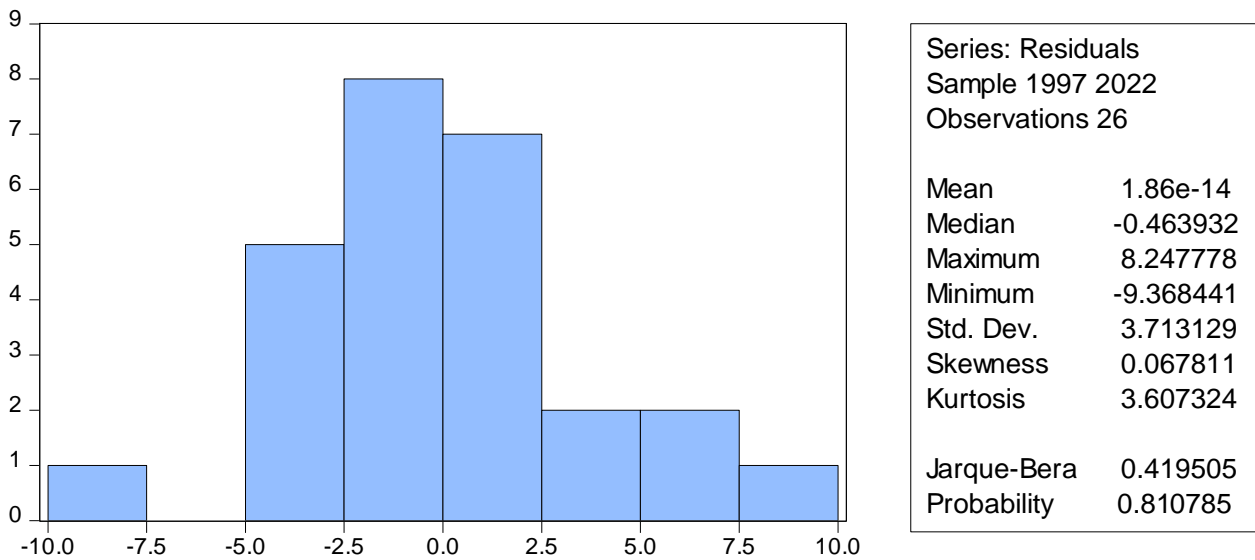| Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	220.7141	51.45195	4.289714	0.0000
GDP	0.006584	0.187493	0.035114	0.0024
D(LNX)	0.776758	0.318388	1.993485	0.0205
D(LNY(-1))	1.306793	0.473878	1.293940	0.0002
D(LNZ)	0.324410	0.146458	2.215039	0.1673
ECT(-1)*	-0.993416	0.129524	-7.669737	0.0000
R-squared 0.816361; Mean dependent var 0.149938; Adjusted R-squared 0.647007; S.D. dependent var 6.663247; S.E. of regression 3.958851; Akaike info criterion 5.737178; Sum squared resid 485.8476; Schwarz criterion 5.998408; Log-likelihood -100.1378; Hannan-Quinn criterion 5.829274; F-statistic 14.19699; Durbin-Watson stat 2.300080 Prob(F-Statistic) 0.000000.				

Source: E-views 12 output.

From the short-run result, the coefficient of the error correction term ECT (-1) has a negative sign with a statistically significant coefficient at the one percent level. With a coefficient of 0.99, the result indicates that approximately 99 percent of the disequilibrium caused by the previous year's shocks converges back to the long-run equilibrium in the current year. The result indicates a high speed of adjustment to long-run equilibrium.

They further reveal that the value of the R-squared is 0.816361, indicating that approximately 81 percent of the variation in the dependent variable (economic growth) is well explained by the exogenous variables, which is an indication of a very good fit. The overall model is highly statistically significant as shown by the probability value of the F-statistic (0.000000). Moreover, the Durbin-Watson statistic of 2.300080 confirms the existence of no autocorrelation in the residuals and therefore ensures that the estimated results are not spurious.

4.9 Normality Test

The model also passed the normality test based on the Jarquer-Bera value of 0.419505 and the probability of 0.810785 which is above the required normal 5 percent level. Hence, the residuals are normally distributed across observations as shown in Figure 5.

Series: Residuals	
Sample 1997 2022	
Observations 26	
Mean	1.86e-14
Median	-0.463932
Maximum	8.247778
Minimum	-9.368441
Std. Dev.	3.713129
Skewness	0.067811
Kurtosis	3.607324
Jarque-Bera	0.419505
Probability	0.810785

Figure 4.3: Stability Test

4.10 Stability Test

Pesaran and Pesaran (1997) suggest that the test for the stability for parameters using cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) plots be conducted after the model is estimated. This is done to get rid of any bias in the results of the estimated model due to unstable parameters. The results for CUSUM and the results depict that the plots of CUSUM and CUSUMSQ for the estimated ARDL model show CUSUMSQ are depicted in Figure 4.3.

In the absence of instability of the coefficients, the plots of all coefficients fall within the critical bounds at a 5 percent significance level. Therefore, the estimated coefficients in the model are stable over the study period.
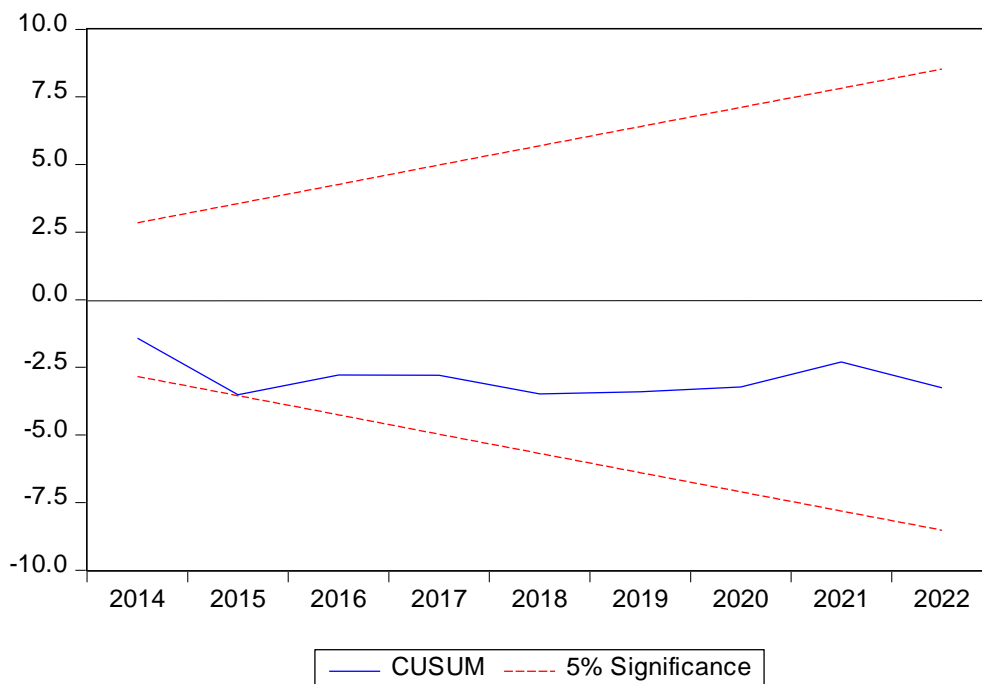
5. Conclusion and Discussion

Many countries, including Sierra Leone, are interested in technology as a major element of production, especially at present when technology has developed greatly. Thus, this study focused on analyzing the relationship between the main indicators of technology (computer use in general, computer use at work, and computer use in education) on economic growth.

The study analyzes the relationship between technology and economic growth in Sierra Leone during 2011 Q1 – 2022 Q4, where all the data was collected through the data issued by Statistics Sierra Leone (Stat Sierra Leone), and given the lack of quarterly data, it was converted into quarterly data using the E Views program.

The results of the analysis showed the existence of a cointegration relationship between the variables of the study.

Moreover, they showed the existence of a positive effect with a long-term statistical significance between the independent variables (computer use in general, the use of the computer at work, and the use of the computer in education) and economic growth. Furthermore, the results presented that the deviation from long-term equilibrium is corrected using an error correction model. The coefficient of slowing down the error correction limit reveals the speed of the return of the economic growth variable toward its equilibrium value in the long run at a rate of 0.06

The reason is the inverse relationship in the short term to spending on infrastructure and equipment in the long term to obtain positive results on economic growth.

The results confirm that economic growth is greatly affected by technology. Based on these results, technological indicators are considered an important component of the production elements that lead to an increase in the economic growth rate in Sierra Leone. Thus, decision makers must pay attention to the technology sector as an important component of the production elements.

By analyzing a long-term complementary relationship according to the ARDL model, where the analysis indicated that the use of computers at work has the strongest impact on economic growth, and this is a good indicator for the national economy in the possibility of strengthening computers at work in government institutions, departments, and private civil society institutions, as well as Training employees and encouraging them to use computers and robots at work to increase production and productivity and reduce costs in general at work, which in turn is reflected in increasing economic growth in Sierra Leone

Based on the results, the study recommends the following:

The results show that the government should pay great attention to the information technology sector and create the appropriate environment for using information technology by increasing use, provision, and training. It must work to exploit the existing human resources to receive appropriate training on the use of modern technologies to promote development and economic growth, as well as cooperation with

leading countries in the field of information technology, benefiting from their experience in this field as a gateway to the digital state. Moreover, decision-makers and economic and financial policies in the country must encourage technology and the use of modern technologies by supporting research and development in this field and supporting small and medium-sized companies in the field of digital innovation as a gateway to the gradual transition toward electronic services replacing traditional services in the country and society as a whole.

The Ministry of Digital Economy in the country must also take into account global technological development, such as the use of smartphones, smart assets, and robots in work and training, in addition to the aspiration by government departments to use cloud computing and big data analysis that directly helps to forecast economic growth.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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