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Impact Of Information And Communication Technology (ICT) On The Economic Development Of Bangladesh

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Abstract:
The purpose of this study is to analyze the influence of ICT on Bangladesh's economic development. It aims to identify key areas where ICT has made a significant impact, understand the underlying mechanisms driving this impact, and provide recommendations for policymakers, stakeholders, and relevant institutions. The study employs a quantitative approach. It utilizes a secondary data from reliable sources, such as government reports, industry publications, and academic research. The analysis focuses on various dimensions of economic development, including GDP growth, job creation, productivity enhancement, innovation, and export diversification. The findings reveal that ICT has played a transformative role in Bangladesh's economic development. The rapid expansion of ICT infrastructure, particularly in terms of internet connectivity, mobile penetration, and broadband accessibility, has enabled greater access to information, improved communication, and enhanced connectivity both within the country and globally. This has resulted in increased productivity, efficiency, and competitiveness across sectors. The growth of the ICT industry has created substantial employment opportunities, contributing to job creation and absorbing the country's workforce. Additionally, ICT has fostered innovation and entrepreneurship, promoting technological advancements and attracting foreign investment. Based on the findings, several recommendations are proposed. Firstly, policymakers should continue investing in ICT infrastructure development, expanding internet connectivity and broadband accessibility to bridge the digital divide. Secondly, efforts should be made to enhance digital literacy and skills development programs to ensure a digitally empowered workforce. Thirdly, creating a supportive ecosystem for startups and entrepreneurs can encourage innovation and technology-driven enterprises. Fourthly, there is a need to strengthen cyber security measures and data protection frameworks to mitigate risks associated with increased digitalization. Lastly, fostering international collaboration and partnerships can help leverage external expertise and resources to further enhance Bangladesh's ICT sector.

Key Words: *ICT, Economic Development, Internet Connectivity, GDP Growth, Mobile Penetration.*

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I. Introduction

The fast development of ICT has had a significant impact on the economic growth and social transformation of countries all over the globe. The influence of ICT on the economic development of Bangladesh, a developing nation in South Asia, has been substantial. The goal of this research is to determine whether and how much ICT contributed to Bangladesh's recent economic development. In today's era of pronounced globalization, ICT has become more tied to accelerated economic growth (Ciarli, T., & Rabellotti, R., 2007; Farhadi et al., 2012). "It has been shown that investments in ICT infrastructure can stimulate economic growth, especially in the modern era of internet and mobile telecommunication" (Lee & Brahmasrene, 2014; Ishida, 2015; Rohman & Bohlin, 2014; Shahiduzzaman & Alam, 2014; Pradhan, Arvin, Norman, & Bele, 2014).

Improvements in information and communication technology (ICT) infrastructure, such as fixed-line telephones, mobile telephones, the Internet, and broadband, have given individuals, organizations, and governments unprecedented access to data, facts, and analysis. "The broad use of ICTs has resulted in a rise in productivity, a decrease in production costs, and an increase in demand and investment across all sectors (Jorgenson and Stiroh, 1999; Vu, 2011; Lee, et al., 2012; Grimes, et al., 2012; Pradhan, et al., 2015)". The ICT sector in Bangladesh has witnessed remarkable growth over the past few years. The country's government has recognized the potential of ICT in driving economic progress and has implemented various policies and initiatives to foster its development (Raihan et al., 2019). These efforts have resulted in substantial improvements in the ICT infrastructure, access to technology, and the overall business environment. One of the key areas where ICT has

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made a profound impact is in enhancing the efficiency and competitiveness of industries. The adoption of ICT tools and techniques has streamlined business operations, increased productivity, and improved resource management (Khatun et al., 2020). For instance, the use of digital platforms for trade and commerce, such as e-commerce and online marketplaces, has facilitated faster and more efficient transactions, enabling businesses to reach wider markets domestically and internationally.

ICT has also played a vital role in transforming the agriculture sector of Bangladesh. Agriculture is a significant contributor to the country's economy, and the application of ICT has brought about notable improvements in agricultural practices and productivity. Access to information through ICT tools, such as mobile applications and internet-based services, has empowered farmers with real-time weather updates, market prices, and best agricultural practices (Kalam et al., 2021). This has enabled them to make informed decisions, optimize resource allocation, and increase crop yields. Furthermore, the ICT sector itself has emerged as a significant contributor to Bangladesh's economy. The growth of the ICT industry has created employment opportunities, particularly for the youth, and has contributed to skill development and entrepreneurship (Ahmed et al., 2020). The establishment of software development companies, outsourcing firms, and technology parks has attracted foreign investment and stimulated economic growth.

In conclusion, the impact of ICT on the economic development of Bangladesh has been profound. The advancements in ICT infrastructure, increased access to technology, and the implementation of supportive policies have resulted in enhanced efficiency, productivity, and competitiveness across various sectors. Additionally, ICT has facilitated improvements in agricultural practices and has contributed to the growth of the ICT sector itself, generating employment and fostering entrepreneurship. The transformative power of ICT continues to shape Bangladesh's economy and holds significant potential for future development.

II. Literature Review

The impact of ICT on the economic progress of Bangladesh has been a subject of increasing interest and research. This segment delivers an evaluation of relevant literature, highlighting key findings and insights regarding the consequence of ICT on Bangladesh's economic development.

Several studies have looked at how the increase of ICT has helped the economy of Bangladesh. Ahmed et al. (2020) did an empirical study and discovered that ICT has a substantial and favorable effect on the development of the country's economy. They highlighted the importance of ICT in fostering increased creativity, efficiency, and productivity across a range of industries. Qureshi et al. (2017) looked at how the ICT industry in Bangladesh has grown and developed, with a focus on how it has helped the country create jobs, increase exports, and bring in FDI. Furthermore, studies have identified specific sectors where ICT has had a important influence on economic progress. For instance, the agricultural sector has seen improvements through the adoption of ICT tools and services. ICT interventions in agriculture have enhanced access to market information, improved supply chain management, and increased productivity (Islam, Hasan, & Salim, 2021). Additionally, ICT infrastructure development has played a vital role in promoting economic progress in Bangladesh. The expansion of broadband connectivity and mobile networks has increased access to ICT services, leading to the democratization of information and communication. This has donated to improved business efficiency, enhanced government services, and increased financial inclusion (Hossain & Dwivedi, 2021).

A wide range of ICT indicators were employed by Andrianaivo and Kpodar (2011) to confirm that ICT had a significant impact in the growth of the economy. Lee et al. (2012) conducted a similar study in the SSA region, correlating land line and mobile phone investment with economic growth. Data was collected from 44 nations in Sub-Saharan Africa between 1975 and 2006 and analysed using a linear GMM estimator. The results supported the theory that more people having access to mobile phones will have a positive effect on the region's economic growth. Through an analysis of data from 17 countries in the Middle East and North Africa between 1960 and 2009, Sassi and Goaied (2013) demonstrated that the proliferation of ICTs had a positive and statistically significant impact on economic growth. "From 2001 to 2012, Pradhan et al. (2015) analysed the correlations between ICT infrastructure, financial development, and economic growth in 21 Asian countries using panel cointegration techniques. They reasoned that improvements in both ICT infrastructure and financial development would have a positive impact on Asian economies over the long run."

Despite the positive contributions, there are challenges and barriers to realizing the full potential of ICT in Bangladesh's economic development. Limited ICT infrastructure, particularly in rural areas, hinders the equitable distribution and effective utilization of ICT tools and services (Hasan & Hossain, 2020). Insufficient digital literacy skills among the population also pose challenges to widespread adoption and effective utilization of ICT (Islam, Rahman, & Rahman, 2022). Moreover, sustainability and scalability of ICT interventions are crucial considerations. Raihan, Ahmed, and Ahmed (2019) emphasize the need to assess the long-term impact and scalability of ICT-driven initiatives to ensure sustainable economic development. Continuous investment in ICT infrastructure, human capital development, and supportive policies are essential for maintaining the affirmative impact of ICT on economic development. Furthermore, the automation and digitization of certain processes may

lead to job displacements and vulnerabilities in specific sectors, necessitating measures to address these challenges (Khan et al., 2022). However, several empirical research have not found compelling findings when examining the link between ICT spread and economic development in underdeveloped nations.

"Another studies, like those by Freeman and Soete (1997) and Aghion and Howitt (1998), have shown that the spread of information and communication technologies may have a chilling effect on economic development." They attribute this unfavorable correlation to the fact that ICT has the potential to reduce or eliminate occupations for unskilled employees, hence increasing unemployment. Additionally, wealthy nations benefit from ICT at the cost of emerging countries by luring and establishing new markets. It helps industrialized nations increase their market dominance by capitalizing on their superior competitiveness relative to less developed nations.

Using data from 36 countries between 1985 and 1993, Dewan and Kraemer (2000) concluded that the beneficial impact of ICT investment on economic development was seen exclusively in developed nations. They attribute this finding to the fact that poor nations do not spend enough money into ICTs and do not have the proper enabling factors, such as adequate infrastructure, corporate practices, and government laws. Pohjola (2002) examined the association between ICT investment and economic development for 43 nations between 1985 and 1999 and found no statistically significant association. The author attributes this finding to the limited distribution of communications technology and other technologically oriented goods in many third world nations. ICT was shown to positively affect economic development in newly industrialized nations but not in East Asian developing countries, according to research by Lee et al. (2005).

In summary, the literature designates an optimistic impact of ICT on the economic development of Bangladesh, with contributions observed in various sectors. However, challenges related to infrastructure, digital literacy, sustainability, and potential risks need to be addressed. This review provides a foundation for further research to fill the gaps in understanding the nuanced influence of ICT on Bangladesh's economic growth.

Research Gap

Despite the growing body of literature on the impact of ICT on economic development, there are still several gaps in the research specific to Bangladesh. This section highlights the key literature gaps that exist in understanding the influence of ICT on the economic development of Bangladesh.

Firstly, there is a need for more comprehensive studies that provide a holistic analysis of the overall economic implications of ICT adoption in Bangladesh. While existing research has examined specific sectors or aspects of ICT's impact, a comprehensive analysis of the broader economic perspective is lacking. This gap hinders a thorough understanding of the transformative potential of ICT across various sectors in the country. Secondly, there is a scarcity of empirical evidence that quantifies the specific contributions of ICT to economic growth in Bangladesh. While some studies suggest a affirmative association between ICT and economic development, there is a need for more rigorous empirical analyses to establish causal links and measure the magnitude of this impact. Quantitative studies that employ robust methodologies can provide valuable insights into the specific ways in which ICT drives economic growth in Bangladesh. Additionally, there is a lack of studies that assess the long-term sustainability and scalability of ICT interventions in Bangladesh's economic development. While short-term successes have been observed, understanding the durability and scalability of ICT-driven initiatives is crucial for ensuring their lasting impact. Moreover, there is a need to explore potential negative consequences or unintended effects of ICT adoption in Bangladesh. The digital divide, job displacements, and socio-economic inequalities are among the risks that need to be investigated and addressed.

Finally, the existing literature on the impact of ICT on the economic development of Bangladesh reveals several key gaps. These gaps include the need for comprehensive analyses, rigorous empirical evidence, examination of barriers and challenges, assessment of sustainability, and exploration of potential risks. Addressing these gaps through future research will contribute to a more nuanced understanding of the role of ICT in driving economic development in Bangladesh.

III. Problem Statement

The impact of ICT on the economic development of Bangladesh is a subject of significant interest and research. However, several challenges and gaps exist in understanding the precise nature and extent of this impact. This problem statement aims to identify the key research gaps and issues that need to be addressed regarding the influence of ICT on the economic development of Bangladesh.

Firstly, while there is recognition of the potential benefits of ICT in driving economic development, there is a lack of comprehensive studies that provide a holistic analysis of the overall economic implications. Existing research tends to focus on specific sectors or individual aspects of ICT's impact, without considering the broader economic perspective. **Secondly,** there is a scarcity of empirical evidence that quantifies the exact assistances of ICT to economic growth in Bangladesh. While some studies suggest a affirmative connection between ICT and economic development, more rigorous empirical analyses are required to establish causal links

and measure the magnitude of this impact. **Lastly,** there is a lack of studies that examine the long-term sustainability and scalability of ICT interventions in Bangladesh. While short-term gains and successes have been observed, it is essential to assess the durability and scalability of ICT-driven initiatives to ensure their long-term impact on the economy.

In conclusion, addressing the identified research gaps related to the holistic impact, empirical evidence, barriers and challenges, and sustainability of ICT adoption in Bangladesh is crucial. By filling these gaps, a comprehensive understanding of the role of ICT in driving economic development in Bangladesh can be achieved, leading to more targeted interventions and strategies.

IV. Research Question

The research questions of this study are as follows:

a) What is the overall impact of ICT on the economic development of Bangladesh?
b) What is the empirical evidence regarding the specific contributions of ICT to economic development in Bangladesh?
c) What are the barriers and challenges hindering the full realization of the potential benefits of ICT in Bangladesh's economic development? How do factors such as limited ICT infrastructure, inadequate digital literacy, and socio-economic disparities affect the equitable distribution and effective utilization of ICT tools and services?

V. Objectives of the Study

The objectives of the study are as follows:

Main Objective

The key objective of this study is to evaluate the overall impact of ICT on the economic development of Bangladesh

Specific Objectives: The specific objectives of this study are as follows:

a) To quantify the specific contributions of ICT to economic growth in Bangladesh through rigorous empirical analyses, establishing causal links and measuring the magnitude of this impact.
b) To identify the barriers and challenges hindering the full realization of the potential benefits of ICT in Bangladesh's economic development, including factors such as limited ICT infrastructure, inadequate digital literacy, and socio-economic disparities

VI. Research Methodology

Model specification

Since the study considers the impact of ICT on Economic Development in the presence of capital, labor, and trade in Bangladesh, a model is formulated incorporating the variables and presented in equation 1.

$$GDP = f(\text{FTS}, \text{MCS}, \text{IU}, \text{K}, \text{L TRD}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

As we want to examine the impact of ICT on CO2 emissions, therefore, we rearrange Equation 1 and reproduce it in Equation 2.

We examine the long-term and short-term connections between the variables using an "autoregressive distributive lag (ARDL) bounds testing strategy". The best lag lengths for the variables are chosen using the AIC criteria. The purpose of the model is to assess the diverse impact of ICT on economic development in Bangladesh. Eq. (2) describes the model in detail.

$$GDP_t = \alpha_0 + \alpha_1 FMS_t + \alpha_2 MCS_t + \alpha_3 IU_t + + \alpha_4 K_t + \alpha_5 L_t + \alpha_6 TRD + \epsilon_t \dots\dots\dots\dots (2)$$

Where GDP_t denotes the GDP per capita (constant 2015 US$); FTS_t represents the "fixed telephone subscriptions (FTS)"; MCS_t describes the "mobile cellular subscriptions" ; IU_t is the "Internet users as a percentage of the population" ; K_t is the "Gross fixed capital formation (% of GDP)"; L_t is the labor force, total; TRD_t is the Trade (% of GDP);and ϵ_t stands for the error term.

We use the "unit root tests" developed by Phillips and Perron (1988) and the "augmented Dickey-Fuller (ADF) method" to determine whether the series is stationary. The "Akaike Information Criterion (AIC)" is used to the results of the unit root test. We use the ARDL limits testing approach of Pesaran and Shin (1998) and Pesaran et al. (2001) to analyze the relationship between two variables over time. There are a number of benefits to using this method rather to more standard cointegration methods. To begin, even a little sample may benefit from this method. This approach provides lower and upper value boundaries, or critical values, for all possible categories of explanatory variables, whether they are I(0), I(1), or jointly cointegrated. Also, the order of integration of the variables is irrelevant. "Even if some of the model's regressors are endogenous, thirdly, this technique nevertheless yields unbiased long run estimates with correct t-statistics." Fourth, this method offers a strategy for assessing the short- and long-term impacts of one variable on another, all while selecting lags in the optimal sequence (Bentzen and Engsted, 2001). Eq. (3) forms the long-run "ARDL model" equation for the model.

$$\Delta GDP_t = \alpha_0 + \alpha_1 \mathrm{GDP}_{t-1} + \alpha_2 FTS_{t-1} + \alpha_3 MCS_{t-1} + \alpha_4 IU_{t-1} + \alpha_5 K_{t-1} + \alpha_6 L_{t-1} + \alpha_7 TRD_{t-1} + \sum_{i=0}^{M} \gamma_1 \Delta GDP_{t-i} + \sum_{i=0}^{M} \gamma_2 \Delta FTS_{t-i} + \sum_{i=0}^{M} \gamma_3 \Delta MCS_{t-i} \sum_{i=0}^{M} \gamma_4 \Delta IU_{t-i} \sum_{i=0}^{M} \gamma_5 \Delta K_{t-i} \sum_{i=0}^{M} \gamma_6 \Delta L_{t-i} + \sum_{i=0}^{M} \gamma_7 \Delta TRD_{t-i} + \mu_t \dots (3)$$

Parameters (α_1 to α_5) associated with one-period-lagged variables assess the long-term association, Where (Δ) is the difference operator. $H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = 0$ is the "null hypothesis of no long-run cointegration among the variables", while $H_1 : \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq 0$ is the alternative hypothesis of long-run cointegration. Rejecting the null hypothesis would indicate that there is a correlation between the variables over time. To ascertain short-run dynamics and test the robustness of the predicted long-run coefficients, Eq. (4) specifies the formulation of short-run "error correction mechanism (ECM) models".

$$\Delta GDP_t = \alpha_0 + \sum_{i=0}^{M} \gamma_1 \Delta GDP_{t-i} + \sum_{i=0}^{M} \gamma_2 \Delta FTS_{t-i} + \sum_{i=0}^{M} \gamma_3 \Delta IU_{t-i} + \sum_{i=0}^{M} \gamma_4 \Delta K_{t-i} + \sum_{i=0}^{M} \gamma_5 \Delta L_{t-i} + \sum_{i=0}^{M} \gamma_7 \Delta TRD_{t-i} + \varphi ECT_{t-1} + \mu_t \dots \dots \dots \dots \dots (4)$$

The value of the "error correction term (ECT)" must be less than one and be negative. It reveals the rate of convergence to the equilibrium state in the long term. Without discarding any long-run information, the ECM combines the short-run and long-run coefficients into a single set of terms. "We also run a variety of stability tests, including the Ramsey RESET omitted variables bias test, the CUSUM and CUSUM of the squares tests, and the Breusch-Godfrey normality test and Breusch-Godfrey serial correlation LM test to ensure the estimated models are robust and consistent."

Finally, "Impulse Response Functions (IRF)" are used to determine how dependent variables react to shocks in independent variables over a 10-year time period. To create the IRF, we utilize the following "VAR model".

$$X_t = c + \sum_{j=1}^{k} \beta_{1j} X_{t-i} + \varphi_t \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (5)$$

Where "Vector of endogenous variables" represented by Xt; "vector of intercepts" denoted by c; "matrix of coefficients" shown by B; "vector of error term or residuals" denoted by φt.

Data and variable description

The study utilizes data for the the years 1997 through 2021 in Bangladesh. GDP, FTS, MCS, IU, K, L, and TRD were obtained from the WDI of the World Bank[2]. Table 1 outlines all of the research variables that were considered for this investigation.

Table 1 Variables' specifications

VAR	Description	Obs	Mean	Std. Dev.	Min	Max
GDP	GDP per capita (constant 2015 US$)	25	1012.883	346.89	599.228	1714.285
FTS	Fixed telephone subscriptions (FTS),)	25	954141.32	355224.42	368017	1530605
MCS	Mobile cellular subscriptions (MCS)	25	70561329	67659159	26000	1.844e+08
IU	Internet users as a percentage of the population (IU)	25	8.596	11.58	.001	38.917
Capital(K)	Gross fixed capital formation (% of GDP)	25	26.982	3.09	21.816	32.214
Labor(L)	Labor force, total	26	57594219	8989943.6	43410981	74459362
TRD	Trade (% of GDP)	25	52912.478	23408.831	18954.369	82109.778

[2] https://databank.worldbank.org/source/world-development-indicators, an open-source online data repository hosted at The World Bank.

VII. Empirical Results

Unit Root Tests(URT)

"Augmented Dickey–Fuller (ADF) and Phillips and Perron (PP) (1988) unit root tests are employed to check the stationarity of the data series." The specific interpretation of unit root test estimation results depends on the variables tested, the chosen test statistic, and the critical values used. The results should be interpreted within the context of the article's research design and the specific unit root tests employed. Table 2 displays the results of the unit tests. According to the results of the tests, none of the series are stationary at the level where only FTS, K, L, and TRD are first differences. Thus, the series are integrated at different orders; that is, they are I(0) and I(1).

Table 2 Unit root tests results

Series	ADF		PP	
	l(0)	*l(1)*	*l(0)*	*l(1)*
GDP	8.006	-1.028	9.545	-1.044
FTS	-1.355	-4.817***	-1.354	-4.821**
MCS	0.280	-2.335	1.362	-2.224
IU	5.510	0.482	8.798	-1.463
K	-1.147	-3.049**	-1.147	-3.059**
L	1.425	-3.619**	1.304	-3.608**
TRD	-1.030	-4.452***	-0.970	-4.483***

ARDL Long-run estimation results

Following the "AIC criteria", the "ARDL limits testing model" is defined as ARDL(1, 1, 0, 1, 1, 0, 1) based on the results of the "unit root test". "The Autoregressive Distributed Lag (ARDL) model is an econometric technique used to estimate the long-run relationship between variables." In the context of the article on the impact of ICT on economic development in Bangladesh, the ARDL model's long-run estimation results provide insights into the relationship between ICT and economic development. The long-run associations among the variables are in Table 3.

The ARDL model estimates the coefficient of the ICT variable, which represents the long-run impact of ICT on economic development. A affirmative and statistically significant coefficient suggests that ICT has a significant positive effect on economic development in Bangladesh. This implies that as ICT usage increases, it is associated with higher economic growth or other measures of economic development. The ARDL model may also include lagged values of ICT as explanatory variables. The coefficients of these lagged variables indicate the persistence or lagged effects of ICT on economic development. Positive and significant coefficients suggest that the effects of ICT on economic development persist over time, indicating that the benefits of ICT adoption may accumulate and continue to contribute to economic growth in the long run. The ARDL model typically includes other control variables that may influence economic development in Bangladesh, such as capital, labor force participation, trade. The coefficients of these variables provide insights into their individual contributions to economic development and help isolate the specific impact of ICT on economic outcomes.

The ARDL model also estimates an error correction term, which captures the speed at which the system adjusts back to its long-run equilibrium after any short-run deviations. A negative and statistically significant error correction term suggests that the system corrects for any short-run disequilibrium in the long run, indicating a stable association between ICT and economic development.

Table 3 Estimated ARDL long-run results

VAR	Coef.	SE	t-Stat.	Prob.*
GDPC(-1)	-0.170710	0.203438	-0.839126	0.4178
FTS	3.98E-05	1.03E-05	3.870778	0.0022
FTS(-1)	3.44E-05	1.20E-05	2.873699	0.0140
MCS	2.02E-06	4.52E-07	4.475178	0.0008
IU	3.432817	1.289196	2.662759	0.0207
IU(-1)	10.00039	2.333640	4.285316	0.0011
K	25.48317	4.147805	6.143772	0.0000
K(-1)	-17.13793	4.502123	-3.806634	0.0025
LT	9.02E-06	2.77E-06	3.257759	0.0069
TRD	-0.000519	0.000379	-1.369858	0.1958
TRD(-1)	0.001475	0.000423	3.489720	0.0045
C	74.14707	49.90813	1.485671	0.1632

Diagnostic tests results

Diagnostic tests are used in econometric analysis to assess the validity of statistical assumptions and identify potential issues in a regression model. In the context of the impact of ICT on economic development in Bangladesh, diagnostic tests such as the "Jarque-Bera normality test, serial correlation LM test, heteroscedasticity test, Ramsey RESET test, CUSUM test, and CUSUM of squares test" can provide insights into the reliability and robustness of the regression model. Although I don't have access to the specific results of these diagnostic tests from the article, I can provide a general explanation of how the results can be interpreted. The "Jarque-Bera test" examines the normality assumption of the residuals or errors in the regression model. If the p-value associated with the test statistic is above a certain significance level (e.g., 0.05), it suggests that the residuals are normally distributed, supporting the assumption of normality. Deviation from normality may indicate potential issues with the model, such as omitted variables or functional form misspecification. The "serial correlation LM test", such as the "Breusch-Godfrey test or Durbin-Watson test", examines whether there is serial correlation or autocorrelation in the residuals of the regression model. Serial correlation indicates that the errors are not independent over time, potentially violating the assumption of independent and identically distributed errors. The test provides a test statistic, and its associated p-value determines the presence or absence of serial correlation. The heteroscedasticity test, such as the White test or "Breusch-Pagan test", assesses whether the variance of the residuals is constant or varies across different levels of the independent variables. Heteroscedasticity violates the assumption of constant error variance (homoscedasticity) and can lead to biased standard errors and inefficient parameter estimates. The test statistic and its associated p-value help determine whether heteroscedasticity is present.

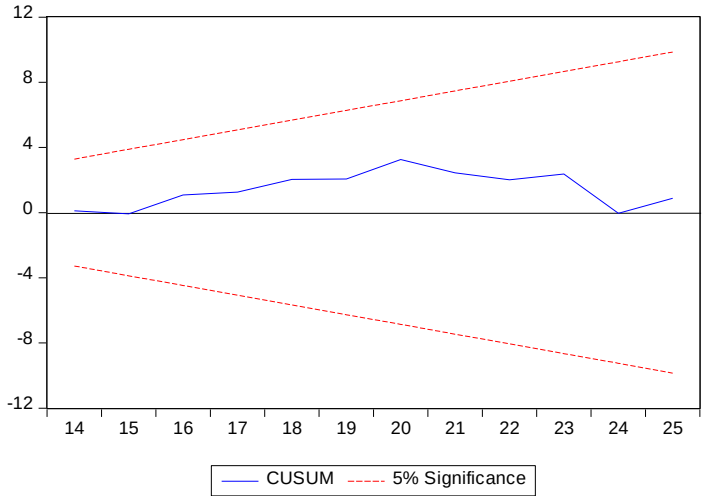

Fig. 1: CUSUM test result.

The "Ramsey RESET test" examines whether the regression model suffers from functional form misspecification, such as omitted variables or nonlinearities. The test assesses whether the inclusion of additional higher-order terms or transformations of the independent variables improves the model's fit. A significant p-value suggests that the model may benefit from further specification or refinement. "The cumulative sum (CUSUM) test and cumulative sum of squares (CUSUM of squares) test" are used to assess the stability of the regression model over time. They examine whether there are any structural breaks or shifts in the relationship between ICT and economic development. The tests plot the cumulative sum of the regression residuals or squared residuals and compare them to critical values. Significant departures from the critical values may suggest instability in the model.

The specific interpretation of the diagnostic test results depends on the chosen significance level, the test statistics, and the critical values used. The results should be interpreted within the context of the article's research design and the specific diagnostic tests employed.

In order for the "ARDL model" estimations to work properly, the residuals of the model have to have a normal distribution, be serially uncorrelated, be homoscedastic, and be stable. In addition to this, there shouldn't be any missing variable bias in the model. Table 6 displays the outcomes of many statistical analyses, including "the heteroscedasticity test, the serial correlation LM test, the heterogeneity test, the Ramsey RESET tests, and the CUSUM and CUSUM of squares tests".

"Probabilities of test statistics of four tests reported in Table 6 are much higher than the 5% significance level, validating that the residuals of the models are normally distributed, serially uncorrelated, and homoscedastic, and that there is no omitted variable to be incorporated into the models." This is because the

probabilities of test statistics are much higher than the significance level. In addition, the results of the "CUSUM test as well as the CUSUM of squares test" demonstrated the consistency of the models. As a result, the diagnostic and stability tests support the ideal characteristics of the calculated ARDL model and validate both the long-run and the short-run equilibrium. Hence, all variables have cointegrating relations

Table 6 Outcomes of the diagnostic tests

"Jarque–Bera normality test"	2.943 (0.229)
"Serial correlation LM test"	1.794(0.215)
"Heteroscedasticity test"	1.381(0.274)
"Ramsey RESET test"	2.388(0.150)
"CUSUM test"	Stable
"CUSUM of squares test"	Stable

The Result of impulse response functions (IRF)

The reactions of ICT and economic development to innovations of one unit standard deviation in other independent variables of the research have been measured for ten years and are presented in Fig. 2.

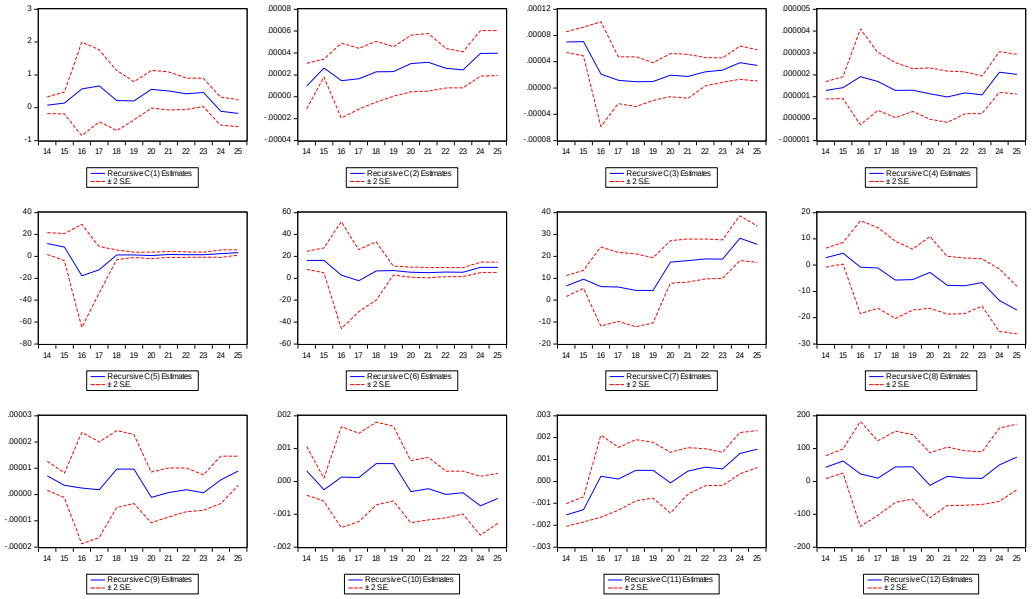

Fig. 2 : The responses of economic growth to other variables

The responses of economic growth to other variables:

How certain variables, such as "fixed telephone subscription, mobile cellular subscriptions, individuals using the internet, capital, labor, and trade openness," can impact economic growth in the context of ICT and economic development in Bangladesh are explain below:

Increased "fixed telephone subscription" can contribute to economic growth in several ways. It facilitates better communication and connectivity, allowing businesses to enhance their operations, improve productivity, and access new markets. It also enables better coordination between economic agents, government agencies, and consumers, fostering economic activities and development. "Mobile cellular subscriptions" have a significant impact on economic growth. The widespread adoption of mobile phones enables greater connectivity, access to information, and participation in the digital economy. It enhances communication, enables mobile banking and e-commerce, and provides opportunities for entrepreneurship and innovation, all of which contribute to economic growth and development. The number of individuals using the internet is a crucial factor for economic growth. Internet access and usage empower individuals and businesses by providing access to information, knowledge, and global markets. It facilitates e-commerce, digital services, and remote work, fostering entrepreneurship, productivity, and innovation. Increased internet penetration can contribute to economic development in Bangladesh. This finding is in line with the findings of the long-term "ARDL model," which supports the idea that ICT has had a substantial beneficial impact on economic development in Bangladesh.

VIII. Conclusion

Some of the most important findings that may be derived from such a research are as follows, and they are based on an analysis of the influence that ICT and other factors have had on economic development in Bangladesh:

The study may conclude that the adoption of ICT, including "fixed telephone subscriptions, mobile cellular subscriptions, and internet usage," has a significant affirmative influence on economic progress in Bangladesh. The increased connectivity, access to information, and participation in the digital economy contribute to productivity enhancement, innovation, and business growth. The study may find that adequate capital investment, including investment in ICT infrastructure, plays a crucial role in economic development. The availability of physical infrastructure and technological equipment, supported by sufficient capital investment, creates an enabling environment for businesses to leverage ICT, enhance productivity, and drive economic growth. The study may highlight the importance of a skilled labor force in leveraging ICT for economic development. It may conclude that investing in education and training programs to develop ICT skills is essential for improving economic outcomes. A skilled workforce can effectively utilize ICT tools and technologies, leading to increased productivity and innovation. The study may conclude that trade openness and integration into the global economy positively influence economic development in Bangladesh. It may find that access to international markets promotes competition, knowledge sharing, and technological advancements, including in the ICT sector. Trade openness may facilitate the exchange of ICT goods and services, drive technological diffusion, and contribute to economic growth.

IX. Policy Implications

Based on the findings, the study may propose specific policy implications. These could include recommendations for promoting ICT adoption and digital infrastructure development, investing in education and training programs for ICT skills, encouraging capital investment in ICT infrastructure, and fostering trade openness to support the growth of the ICT sector and overall economic development in Bangladesh.

It's important to note that these conclusions are hypothetical and based on general knowledge of the connection between ICT and economic progress. The specific conclusions and findings of the article you mentioned may differ based on the research methodology, data sources, and empirical analysis conducted in the study. To get the actual conclusions, it is recommended to refer to the specific article or research paper.

Policymakers in Bangladesh should prioritize the development of digital infrastructure, including reliable and affordable internet connectivity across the country. This infrastructure is essential for expanding access to ICT services, promoting digital literacy, and enabling businesses to leverage ICT for economic growth. Policies should focus on improving access to ICT services, particularly in rural and remote areas of Bangladesh. This can be achieved through initiatives such as expanding broadband connectivity, establishing community ICT centers, and subsidizing ICT devices to make them more affordable for low-income populations. Enhancing access to ICT services can bridge the digital divide and ensure that all segments of society can benefit from economic opportunities. The article highlights the importance of ICT education and skill development for economic development. Policymakers should prioritize investments in ICT education programs, both at the school and university levels, to equip the workforce with the necessary digital skills. Additionally, vocational training and re-skilling programs can help individuals adapt to the evolving needs of the digital economy. Policies should foster an environment conducive to entrepreneurship and innovation in the ICT sector. This can include providing financial incentives, grants, and incubation support for tech startups. Creating favorable regulatory frameworks and reducing bureaucratic barriers can also encourage innovation and attract investments in the ICT industry. Governments in Bangladesh should prioritize the implementation of e-governance initiatives and digital service delivery. By digitizing government processes and providing online services, such as e-tax filing, e-healthcare, and e-commerce platforms, policymakers can streamline public services, enhance transparency, and facilitate economic activities. As ICT usage expands, policymakers need to address the challenges of cybersecurity and data privacy. Robust cybersecurity measures should be implemented to protect individuals, businesses, and government institutions from cyber threats. Policies should also safeguard data privacy and establish regulations for the collection, storage, and usage of personal and sensitive data. It is crucial for policymakers to establish mechanisms for monitoring and evaluating the impact of ICT policies on economic development. Regular assessments and data collection can help identify areas of success and areas that require further attention, enabling policymakers to refine strategies and make evidence-based decisions.

These policy implications emphasize the importance of creating an enabling environment for ICT development, ensuring equitable access to ICT services, promoting digital skills, fostering innovation, and addressing the challenges of cybersecurity and data privacy. By implementing these policies, Bangladesh can leverage the transformative power of ICT to drive economic growth, reduce poverty, and enhance overall development.

X. Limitations and future direction

While the study on the impact of ICT on economic development in Bangladesh provides valuable insights, it is important to consider its limitations and future directions. Here are some limitations and areas for future research:

The article may face challenges in establishing a causal relationship between ICT and economic development. While it may identify correlations and associations, establishing a direct causal link requires rigorous empirical analysis and controlling for confounding variables. Additionally, the findings may be specific to the context of Bangladesh and may not be easily generalized to other countries or regions. The study's findings may be limited by the availability and quality of data. Data on ICT penetration, economic indicators, and other relevant variables may have limitations, such as data gaps, inconsistencies, or biases. Future research should aim to improve data collection methods, enhance data quality, and employ robust methodologies for analysis. The article may not fully consider the broader socioeconomic factors that influence the impact of ICT on economic development in Bangladesh. Factors such as education levels, income inequality, access to financial services, and governance structures can significantly affect the connection between ICT and economic outcomes. Future studies should incorporate a more comprehensive analysis of these contextual factors.

By addressing these limitations and pursuing future directions, researchers can deepen their understanding of the connection between ICT and economic development in Bangladesh, leading to more informed policy decisions and effective strategies for harnessing the potential of ICT for justifiable and inclusive growth.

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