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IMPACT OF ICT INVESTMENT AND DIFFUSION ON ECONOMIC GROWTH: A CASE STUDY OF PAKISTAN

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Abstract: *Technological advancements are crucial to the growth of any economy's potential. This, however, is not a straightforward undertaking. Economic growth has historically been accelerated or slowed depending on whether new technology is transferred, developed, or fails to achieve its full potential. It is particularly true that information and communications technology (ICT) impacts the production processes of businesses, which in turn has an effect on the overall production processes of businesses themselves. Because of this, empirical inquiry is necessary to confirm the existence of such a link. Instead of measuring ICT investments directly, the imports and exports of information and communications technology (ICT) are used to measure ICT spread. Internet and mobile cellular subscriptions are used as proxy for ICT diffusion. The results demonstrate that the diffusion of information and communications technologies has a major and positive impact on economic development. However, when it comes to the impact of ICT investments on economic development in Pakistan, there has been a slew of contradictory findings. In other words, exports have a positive impact on the economy, but imports have a negative impact on it. All factors have a substantial influence on the growth of the economy.*

INTRODUCTION

Despite the fact that technological breakthroughs play an important part in the economic growth of any country (Kuznets 1978), this function does not occur in a seamless manner (Field 2006). In the past, it has been observed that the transfer, invention, or failure of the most recent technology causes economic development to accelerate or decrease unexpectedly. The economy's production processes, in particular, are transformed by information and communication technologies (ICT), which in turn alters the country's total production process (Jalava and Pohjola 2008). As a result, more empirical examination of this relationship is required. The present literature, which is interesting, gives sufficient data from the industrialized countries. Nonetheless, this kind of realistic inquiry is seldom carried out in developing markets such as Pakistan (Erumban and Das 2016). The influence of information and communications technology (ICT) investment and spread on Pakistan's economic development has not yet been investigated empirically, to the best of our knowledge. Increasing ICT imports to our recommended level would

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greatly increase the intermediate input to capital goods, which will eventually result in increased economic growth (Colecchia and Schreyer 2002).

Currently available empirical research uses the growth accounting approach to investigate the relationship between information and communications technology (ICT) and economic growth. This topic has a lengthy history that extends back to the 1980s when it was first introduced. The issue was brought to light, however, by Solow (1987), who linked productivity estimates to the use of information and communications technology (ICT) (Triplett 1999). There are three hypothesized pathways via which this impact may express itself: (1) improved labor efficiency, (2) efficient production process, and (3) increased multi-factor productivity. Manufacturing new products and services, such as computers, laptops, tablets, the internet, and accompanying peripherals, takes place in the first channel of distribution (Blau et al. 1976). The second mechanism is based on labor efficiency, in which information and communications technologies (ICTs) have an impact on industrial components (such as labor). In-depth discussion of facts technology as a production factor is provided by Brynjolfsson and Hitt (1995), who give further information. According to O'Mahony and Vecchi (2005), investments in these technologies boost labor efficiency by incorporating new and complex processes into the production process. When it comes to automated manufacturing and production processes, this channel performs well. According to Blanchard (2017), this leads to an increase in labour efficiency, which results in a drop in labor cost, which is a substantial component of per-unit cost. A third reason is that technological advances in the fields of information, communication, and technology encourage the usage of multi-factor production processes in the manufacturing business (Van Ark et al. 2003).

Obtainable research supports these transmission mechanisms, which improve economic growth via technological innovation. The research in this body of studies suggests that information and communication technologies have a positive impact on economic growth. A well-developed telecommunications infrastructure also has an indirect influence on economic development. This involves promoting trade (Dutta 2001), education (Cieslik and Kaniewska 2004), public health (Micevska 2005), and social services (Martin and Rogers 1995). It is anticipated that imports of information and communications technology (ICT) would boost output by enhancing intermediate inputs, for example, as a result of the increased use of these technologies. As an example, between 2007 and 2012, the telecom providers in Pakistan considerably extended their service regions, a time during which the nation saw great growth and development.

Alternative study suggests that the level to which information and communication technologies (ICTs) are used in a nation has an influence on the amount of economic success that country has seen over the course of time. Numerous challenges, such as a scarcity of information technology and an insufficient degree of expertise, have a detrimental impact on economic growth.

Baloch (2014) presents some fascinating details regarding the degree of information and communication technology in Pakistan along these lines. For example, according to this survey, Pakistan is the nation with the least amount of connectivity, ranking 142nd out of 180 countries. These findings are based on a study of a total of 162 countries and economies. Generally in Pakistan consider the degree of information and communication, the national average of amount of connection is more than Baluchistan.

As a result, four out of every five individuals are disconnected from the internet, and modern technologies are inaccessible, particularly in Pakistan's rural areas. However, as the regulatory authorities provided large incentives to ICT investors over the previous two decades, the degree of connection has expanded significantly. In this vein, we examine the most recent developments in information and communications technology (ICT) and economic growth. Depicts the rising patterns in ICT spread, development, and economic growth from 2003 to 2020, using the year 2003 as the starting point. This is the most complete set of data on these variables that is currently accessible. A deeper look at these developing patterns suggests that imports of ICT items (as a percentage of overall imports) are projected to have an impact on economic growth in the next years. Similar tendencies have been found in the past, notably during the Global Financial Crisis. As a result, we believe that ICT goods imports (as a percentage of overall imports) will have a major influence on economic development.

A similar study conducted in 2015 by Moomal and Masrom (2015) examined the most recent information and communications technology (ICT) developments in Pakistan, evaluated their influence on human resource management and e-Business strategies, and made comparisons between these innovations of information technology and those in advanced countries. After much deliberation, they come to the conclusion that Pakistan is still lagging behind the industrialized countries when it comes to information and communication technologies. It has been suggested that the empirical data from Pakistan's e-Government programs is equivalent to what we have seen so far.

Arfeen and Khan (2009) provide empirical data from Pakistan's e-Government programs that is comparable to what we have seen so far (Bhutto et al. 2012). While some researchers provide variables for Pakistan's technology and science policy. The behavior of research students in Pakistan when it comes to embracing new technology, such as digital libraries. These shards of indication suggest that the Pakistan's regulatory authorities should alter their strategies regarding the growth and diffusion of information and communications technology (ICT). Although this information comes from the previous decades, the ICT industry has done very well throughout the current decade. As far as we know, empirical data has been unable to produce any proof on the influence of technical innovation on the development of Pakistan's economic sector. To the best of our knowledge, this is the first empirical examination of the influence of information and communications technology (ICT) innovation on economic development in Pakistan. This research was undertaken with the purpose of examining the possible relationship between ICT investment and diffusion and economic development in Pakistan. As in our opinion, ICT good imports as a percentage of overall imports will have a substantial influence on economic development. In view of this, the second purpose of this research is to offer a particular amount of ICT products imports in areas where they have an impact on the intermediate input in the manufacturing process.

LITERATURE REVIEW

The rapid expansion of information technology during this period has resulted in an increase in empirical study on the impact of information and communications technology innovation on economic growth, which has gained popularity since the late 1990s. This is because of the widespread use of information technology during this time period. Despite the fact that economists anticipate a favorable benefit, past empirical research on this topic indicates that there is inconsistent data. If you want more details on the conflicting results in the United States. A total of three sets of empirical studies have been conducted on the impact of information and communications technology breakthroughs on economic growth. According to the first strand of literature, the underlying assumption of the link between technological innovation and economic growth is erroneous, as is the relationship between technological innovation and economic development. It has been shown via empirical evidence that technological discoveries have minimal impact on economic development (Wang 1999). In accordance with the second strand of literature, technologically driven economic development has a positive impact on a country's economic growth. It is noteworthy that the third strand of study on the effect of ICT breakthroughs on economic development reveals that there is a negative and ambiguous link between technological innovation and economic growth, as well as an equivocal relationship between the two variables. A limited number of studies have shown the ambiguous and equivocal link between information and communications technology development and economic growth. For example, if we look at the empirical data supplied by the first strand of study, information and communication investment had no statistically significant impact on economic development. The researcher, who was looking into the elements that impact economic growth in developing nations, was unable to include information and communication technology in his list of drivers of economic development. For Wang (1999), who was unable to provide any evidence demonstrating the direct effect of technological innovation and advancement on Taiwan's economic growth, the situation was similar to that of Wang (1999). Alternatively, Wang (1999) indicates that technological advancements may have an influence on economic growth via a number of channels, including the development of information infrastructure (IE). The majority of past research have shown that technical breakthroughs had a favorable influence on economic development in developing (Baliamoune-Lutz 2003). According to Dewan and Kraemer (2000), who conducted research along similar lines, there is a positive relationship between technical innovation and economic development in industrialized nations. Some academics do this empirical examination throughout a broad variety of nations, according to their findings. The data from 102 economies, for example, was analyzed by Vu (2011), and the results of this empirical inquiry revealed that information and communication diffusion had a statistically significant influence on economic growth. Afterwards, in 2013, an study conducted an empirical investigation into this relationship in Singapore and discovered that technical investment increases an economy's economic development. Some scholars investigate the relationship between the two from the standpoint of investment. Investing in information and communication technology, for example, has been identified as one of the most important economic development drivers (Seo et al. 2009). Several academics have focused their research on the development of telecommunications infrastructure (DTI) and its relevance to economic growth in the developing world. In order to offer an example, the association between DTI and economic growth in their study. They discover evidence of bi-directional causation between the DTI and economic development in G20 countries when panel VAR and Granger Causation are used to data from 1991 to 2012, according to the authors. Taking a look at the third body of research, only a few studies have shed light on the perplexing findings about the relationship between technical innovation and economic development. However, the majority of researches have shown that the development and distribution of ICT has had a detrimental influence on

economic growth. For example, Freeman and Soete (1997) report on the detrimental effect of information technology on economic growth—which is communicated via labour and employment in developed nations—in the developed economies. This deleterious effect is supported by a substantial body of theoretical evidence. Thus, according to the findings of Freeman and Soete (1997), technological improvements lead to the exclusion of unskilled and low-wage employees from the labour market (Ceccobelli et al. 2012), which is a major cause of higher-income inequality in any economy. In the end, these economic conditions result in poverty in emerging countries. This has an impact on labour productivity as well. See also Ceccobelli, Gitto, and Mancuso for further information (Ceccobelli et al. 2012). Technology capital, according to Shahiduzzaman and Alam (2014), contributes to economic development and productivity in the early 1990s, which is consistent with the results of their study. The impact of the environment, on the other hand, becomes less significant with time. Ishida (2015) takes this notion a step further by include the utilization of energy in the nexus of factors. According to Ishida (2015), using autoregressive distributed lag limitations and data covering the years 1980 to 2010, he has arrived to the conclusion that higher ICT investment does not result in improved economic development in the country of Japan. However, according to the conclusions of this study, ICT investment is assisting Japan in reducing its energy use. According to the results of this literature review, most empirical research is conducted in developed economies, such as the United Kingdom, Spain, Greece, Italy, Finland, and the United States. Further study of the current literature reveals that there is no empirical data available that examines the influence of ICT diffusion and development on Pakistan's economic growth. The subject of our long-awaited problem is this research, which attempts to fill a vacuum in the empirical literature by addressing our long-awaited issue, which is the subject of our long-awaited difficulty.

METHODOLOGY

This section describes the data extraction process, the model, and the empirical technique(s) that were used in this empirical study. This component is further subdivided into two sections: (1) data and descriptive analysis; and (2) model and experimental approach. Data and descriptive analysis go into further detail on data difficulties, data sources, variable contractions, and descriptive analysis of those variables, for example. The econometrical model and estimate technique presented in this section describe the model and estimation approach that were employed in this empirical inquiry.

Data and Descriptive Statistics

We evaluate the influence of ICT investment and diffusion on Pakistan's economic development using yearly data spanning the years 2003 to 2020. We use the most up-to-date data available from the World Bank and the Pakistan Telecommunication Authority to create this report. At the time of data collection, this was the most complete set of information available on these variables. Our data includes information on ICT goods exports (as a percentage of total goods exports), ICT goods imports (as a percentage of total goods imports), mobile cellular subscriptions (per 100 people), Individuals using the Internet (as a percentage of total population), and gross domestic product (GDP) at constant 2015 levels. After all of the data has been collected, two variables (ICT goods exports and imports) are utilized as proxies for ICT investment.

The following two variables (mobile cellular subscriptions and individual internet use) are used as proxies for people' adoption of information and communications technology (ICT). Furthermore, we use GDP as a dependent variable, which may be thought of as a proxy for economic expansion.

	LGDP	LICTM	LICTX	LINTERNET	LMOBILE
Mean	26.19768	1.574962	-1.495725	2.211712	3.587311
Std. Dev.	0.207402	0.290182	0.582704	0.381528	1.160940
Skewness	-0.022252	0.638739	0.000192	0.471714	-1.768694
Kurtosis	1.979913	2.847857	2.592158	2.101678	4.744367
Jarque-Bera	0.781918	1.241323	0.124751	1.272778	11.66694
Probability	0.676408	0.537589	0.939530	0.529200	0.002928

Table 1: Descriptive Statistics

The descriptive statistics shows that all variables are normally distributed expect mobile subscribers. While the values of kurtosis imply that expect mobile subscribers data all other variables are playkurtic. The GDP and mobile subscribers are negatively skewed while others are positively skewed.

The Model

Under the umbrella of the literature review, focus of this study and availability of data the following model is selected to fill the research gap.

$$GDP_t = \beta_1 ICTM_t + \beta_2 ICTX_t + \beta_3 INTERNET_t + \beta_4 MOBILE_t + \delta_t$$

Where β's are the parameters of independent variables at time "t". GDP is the gross domestic product of Pakistan, ICTM represents goods imports of information communication and technology, ICTX is exports of goods related to information communication and technology. Internet is basically the percentage of populations of individuals using internet, Mobile is used as mobile cellular subscriptions per 100 persons and δ is the error term.

RESULTS

With respect to the empirical methodology of this research, we firstly find the stationarity of the variables by using unit root test of augment dickey fuller (ADF) selecting lag lengths on the basis of akakie info criterion (AIC). GDP is stationary at level, while imports and exports of ICT and internet is stationary at first difference. While the mobile variable is stationary at second difference.

	I (0)		I (1)		I (2)	
	t-Value	P-Value	t-Value	P-Value	t-Value	P-Value
GDP	-3.73895	0.0495				
ICTM			-2.74836	0.0879		
ICTX			-4.24109	0.0073		
Internet			-4.33176	0.0179		
Mobile					-3.52354	0.0269

Table 2: Results of Augment Dickey Fuller (ADF) Test

	LGDP	LICTM	LICTX	LINTERNET	LMOBILE
LGDP	1	-0.1658	-0.4446	0.9786	0.7997
LICTM	-0.1658	1	0.4686	-0.0996	-0.2720
LICTX	-0.4446	0.4686	1	-0.5469	-0.0562
LINTERNET	0.9786	-0.0996	-0.5469	1	0.6882
LMOBILE	0.7997	-0.2720	-0.0562	0.6882	1

Table 3: Correlation Matrix

The GDP is negatively correlated with ICT imports and exports. But gross domestic product is highly positively correlated with internet and mobile. While ICT imports are positively correlated with ICT exports but have negative correlation with internet and mobile. Similarly other hand the exports of ICT also have negative correlation with internet and mobile. On the other hand, internet is strongly correlated with mobile. The above cited model was transformed into log log model, as upon testing several combinations of regression, the best results are obtained through log-log model. Results are as follow.

Variable	Coefficient	Standard Deviation	t-Statistic	Probability
LICTM	-0.072179	0.030626	-2.356778	0.0348
LICTX	0.048026	0.020471	2.346075	0.0355
LINTERNET	0.522296	0.038238	13.65923	0.0000
LMOBILE	0.021185	0.010722	1.975925	0.0698
C	25.15202	0.050895	494.1945	0.0000

R-squared	0.991896	**F-statistic**	397.7835
Adjusted R-squared	0.989402	**Prob. (f-Statistic)**	0.000000
		Durbin-Watson stat	1.490183

Table 4: Results of Regression Analysis

The results shows that there is a negative relation among ICT imports and gross domestic product. The coefficient value of -0.07 having significant p-value of 0.0348 implies that one percent increase in imports of ICT products will decline gross domestic product of Pakistan by 0.072. This negative impact of imports of goods of ICT on Gross domestic product is in line with the economic theories. However, a significant positive impact of exports of goods of ICT is observed on gross domestic product in the result. Internet usage has high significant impact on Pakistan's gross domestic product. While the mobile cellular subscription also has positive impact on the economic growth of Pakistan. Overall model is significant having F-statistics of 397.78. The selected model has goodness-of-fit of 99 percent and adjusted R-square of 98 percent. The following graph of actual fitted and residuals shows that the selection of variables represents almost 99 percent of the model.

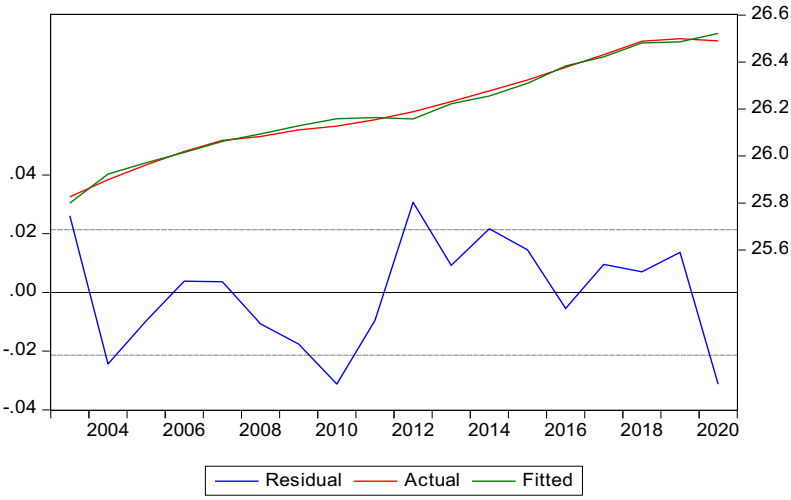

Figure 1: Actual Fitted and Residuals

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
LICTM	0.000938	94.81309	2.945368
LICTX	0.000419	42.32367	5.306118
LINTERNET	0.001462	290.3453	7.936898
LMOBILE	0.000115	64.19026	5.777808
C	0.002590	102.2796	NA

Table 5: Results of Coefficient Diagnostic Test

There is **no severe multicollinearity** among the independent variables as all the centered VIF values are less 10. Thus, this model follows the one of the assumptions of best linear unbiased estimator.

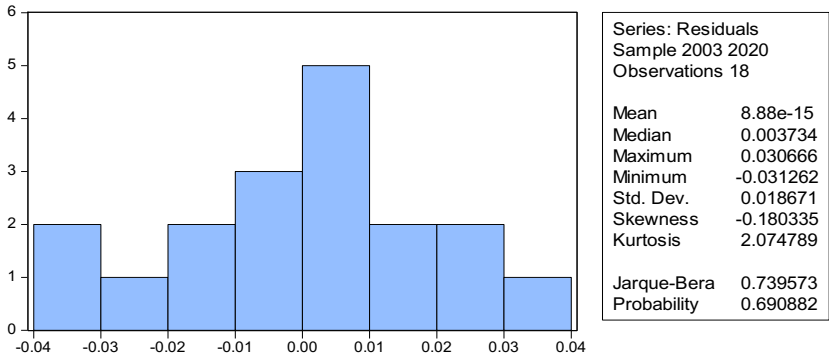

Figure 2: Results of Residual Diagnostic Test for Normality

The residual are normally distributed as the values of Jarque-Bera and its probability are in the acceptance region of null hypothesis.

f-Statistic	0.146410	**Prob. F (2,11)**	0.8655
Obs*R-squared	0.466737	**Prob. Chi-Square (2)**	0.7919

Table 6: Breusch-Godfrey Serial Correlation LM Test

The breusch-Godfrey serial correlation LM test value implies that there is no-auto-correlation in the model. Another assumption of best linear unbiased estimator is fulfilled.

f-Statistic	2.785202	**Prob. F (4,13)**	0.0716
Obs*R-squared	8.306870	**Prob. Chi-Square (4)**	0.0810
Scaled explained SS	2.328480	**Prob. Chi-Square (4)**	0.6756

Table 7: Heteroskedasticity Test: Breusch-Pagan-Godfrey

In the light of the above table of result of heteroskedasticity test, we can say that there is no heteroskedasticity in the model.

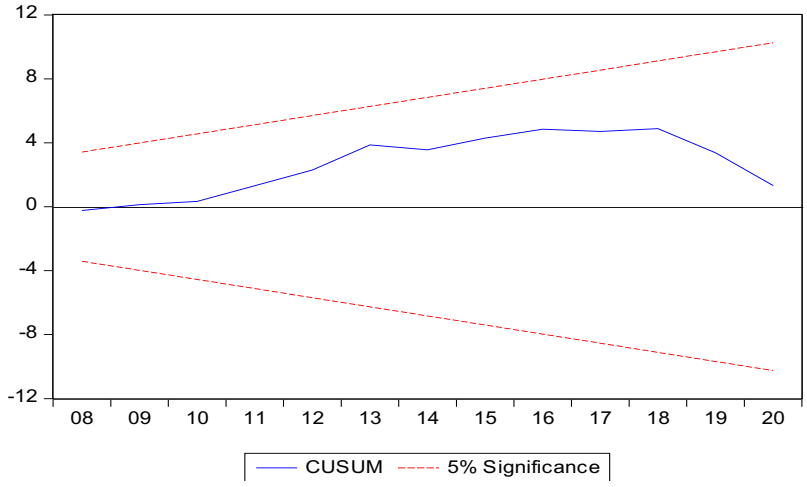

Figure 3: Representation of CUSUM

As shown in the above graph the blue line represents the CUSUM and its under the 5% significance. Hence the model parameters are strongly stable. Overall, the ICT diffusion and investment both have significant impact on economic growth of Pakistan.

Johansen Cointegration test is applied to check the long run relation between the dependent variable and independent variables. Table 8 shows that a long run relation does exist in the model.

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None*	0.964878	53.58265	33.87687	0.0001
At most 1*	0.936771	44.17590	27.58434	0.0002
At most 2*	0.821001	27.52603	21.13162	0.0055
At most 3*	0.676469	18.05537	14.26460	0.0120
At most 4*	0.314004	6.030139	3.841466	0.0141

Table 8: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Null Hypothesis	Obs	f-Statistic	Prob.
LGDP does not Granger Cause LICTX		9.49109	0.0040
LGDP does not Granger Cause LINTERNET		5.56454	0.0214
LICTX does not Granger Cause LICTM	16	13.1904	0.0012
LINTERNET does not Granger Cause LICTM	16	5.37354	0.0235
LMOBILE does not Granger Cause LICTM	16	3.97474	0.0502
LINTERNET does not Granger Cause LICTX	16	8.39248	0.0061
LMOBILE does not Granger Cause LICTX	16	5.83017	0.0188
LICTX does not Granger Cause LMOBILE		5.31112	0.0243
LINTERNET does not Granger Cause LMOBILE		5.82373	0.0188

Table 9: Results of Granger Causality Test

The causality test shows that there is majority unidirectional causality. Only bi-causality is found between mobile and ICT goods exports. The GDP causes ICT exports and Internet. While Internet causes mobile and ICT import and export. Mobile causes ICT imports. This is mainly because in Pakistan there are imported mobiles more than the locally produced handsets. In the end ICT export does cause ICT imports as in case of Pakistan, technology is borrowed from abroad.

CONCLUSION

It is the goal of this study to first assess the influence of ICT investment and diffusion on the economic growth of Pakistan. Second, this study provides a precise amount of ICT product imports and exports in the nations where they have an influence on the manufacturing process, as determined by the research. In a regression study conducted on data spanning the years 2003 to 2020, it was discovered that ICT diffusion had an impact on Pakistani economic growth. When we looked at ICT investment as proxies by ICT products exports and imports, we found mixed evidence, which means that imports have a negative influence while exports have a favorable impact on ICT investment. It is estimated that exports of information and communications technology (ICT) goods have a substantial influence on the growth of Pakistan's economy. When ICT imports are taken into account, we determined that a one percent increase in ICT product imports leads in a 0.07 percent decrease in economic growth when ICT imports are taken into consideration (percentage of total imports). As a result of the results of this empirical investigation, we believe that policymakers should prioritize the development of ICT infrastructure by providing financial incentives for ICT investment in order to promote the country's economic growth. It is recommended that the level of ICT products imports (measured as a proportion of overall imports) be higher than the level specified in this report. However, because of the data constraints discussed above, caution should be used in the interpretation of these findings. According to these findings, policymakers and the ICT industry are functioning admirably, since ICT products exports have a favorable influence on economic growth and development. Both the variables of internet access and mobile cellular subscriptions, when it comes to ICT diffusion, have a considerable favorable influence on the economic growth. Consequently, policymakers are encouraged to create much improved infrastructure in order to accelerate technical progress in this industry. Because we are living in a period of technological advancement, it is recommended that legislators create simple access to the internet in the economy. As a result, internet and mobile technology may assist the country's economy in maintaining its momentum even during difficult times caused by unforeseen tragedies. The spread of information and communications technology (ICT) aids in keeping people linked. As a result of this constraint, it is proposed that additional research may be carried out in order to identify ICT proxies for which longer time series are available.

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