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The dynamic impact of ICT on the economic growth in the developing countries

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Abstract:

This paper explores the impact of the information communication and technology (ICT) on the economic growth in the developing countries, the study collect a data for 33 years (1990-2022) and a panel of eighteen developing countries , the purpose is to evaluate how the using of the ICT's impact the economic growth in the short and long term. Employing a panel series and an autoregressive distributed lag (ARDL) co-integration approach. Our research incorporates some key economic indicators such as GDP growth, individual using of the internet (INT), mobile cellular subscriptions (MCS), and gross fixed capital formation (GFCF). Our empirical results indicate a co-integration link between the variables based on Westerlund test. The results of (PMG-ARDL) reveal that (INT) negatively affect the GDP growth in both the short and long run, those results elucidate that a 1% increase in (INT) results in a -1.02% and -0.03% growth in growth economic. However, the same output showed that the MCS positively effect the economic growth, in the long term, a 1% increase in the MCS results in a 0.001% growth in the GDP growth, and a 0.04% in the short run. The robustness check using (CS-ARDL) showed that the ICT is negatively affect the economic growth in both short and long run. The causality test indicate that both of MCS and INT cause the economic growth.

Key words: Economic growth, PMG-ARDL, CS-ARDL, Causality relationship.

JEL Classification Codes : O3 ،O1 ،C8.

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Introduction :

In the last few years, information communication and technology (ICT) has dramatically changed the world, whereas, ICT contributes significantly to societal progress, his role does not only connect people but it also can improve transparency, participation, accountability, and also the human development (kashif, syad tauseef, hui, & khurshaid, 2019). In the modern days, the world has seen change from the agricultural to a digital economy, where ICT's like the internet and mobile phone are important element for economic growth and development (ernesto & inmaculada, 2019).

The scientific literature has identified significant correlations between GDP and ICTs (khuong, 2011) (shu-chun, robert, & ting-peng, 2011). Therefore, the impact of ICTs becomes supportive of the economic growth of countries (dale & khuong, 2016). Examples can found at the macroeconomic level (ronald, peter, & aristeidis, 2016) (francesco, 2015), as well as at the institutional level (sunday, vera, & adenike, 2018) (shqipe, veland, hyrije, leo-paul, & vanessa, 2017). That is, research indicates a relationship between ICTs and technological change involving economic growth, either due to changes in the production process (dale & khuong, 2016) (francesco, 2015), or to external factors related to the dissemination of knowledge and innovations (khuong, 2011) (ronald, peter, & aristeidis, 2016) (masoud & zunaidah, 2017).

Various literature shows the studies on this relationship have shown mixed results (khuong , 2011) (seifallah & mohamed, 2013) . A number of empirical studies have also confirmed that the spread of ICTs have a positive and important role in driving economic growth, especially in developed countries (lars-hendrik & leonard, 2001) (pantelis, 2009). Although the prevailing view indicates a positive correlation from ICT and economic growth (khuong, payam, & erik, Telecommunications Policy), According to Mayer, Madden and Wu (walter, gary, & chen, 2019). In fact, there are many opinions that question the existence of a correlation between ICT and economic performance (antonio , manual, & ricardo, 2020), for example or Haller and Lyons (stefanie & sean, 2015) or Thompson and Garbacz (harberts & christopher, 2011), search the impact found some variables of ICT and business productivity, they found No relationship or significant

impact. Some Other studies have found that the spread of ICTs have a negative effects on economic growth in many countries and regions of the world (sanjeev & kenneth, 2000) (matti, 2002) (sotiris & sophia, 2007) (rudra, mak, & neville, 2015)….etc.

Many previous studies have search about this relationship for developing countries to understand the relationship between ICT penetration and economic growth (ebrahim & majid, 2009) (seifallah & mohamed, 2013) (rudra, girijasankar, & tapan, 2018). These studies yielded conflicting results. Therefore, this problem is open to investigation (raef & alaa, 2019).

At the empirical level, we apply the PMG-ARDL model than we check the robustness with CS-ARDL model in a sample from 1990 to 2022 for 18 developing countries (Algeria, Egypt, Morocco, Tunisia, Argentina, Bahrain, Brazil, China, Thailand, Colombia, Indonesia, India, Korea, Mexico, Turkey, South Africa, Malaysia, Saudi Arabic) in the Figure 1. ICT and Economic Growth data collected from World Bank database (World , 2024).

Figure 1. Eighteen development nations map.

1.1 problem statement

What is the impact of ICT on the economic growth in the developing countries?

1.2. Hypotheses: the main purpose of this paper is to test the following hypothesis:

- There is a log-run relationship between the ICT and economic growth.

- There is a statistically significal positive effect of the ICT indicators on the economic growth in the developing countries in the short term.

- There is a statistically significal positive effect of the ICT indicators on the economic growth in the developing countries in the long term.

- There is a bidirectional causality between ICT indicators and growth economic.

1.3. Research gap

The Importance and difference of this study are better appreciated by those shortcomings and gaps in the literature. There are a large number of research on the relationship between ICT and economic growth, but those related to developing countries are few. The outputs of this research are more powerful and more modern in terms of tests and models used.

2. Data and methodology

2.1. Data and model

This study search about The impact of some ICT indicators like Individuals using the Internet and Mobile cellular subscriptions on the economic growth in developing countries, for this we choose the 18 following countries (Algeria, Egypt, Morocco, Tunisia, Argentina, Bahrain, Brazil, China, Thailand, Colombia, Indonesia, India, Korea, Mexico, Turkey, South Africa, Malaysia, Saudi Arabic) over the period 1990–2022. The STIRPAT

Model can written as follows:

$$Ui = \alpha + \beta Bi + \gamma Ci + \delta Di + \varepsilon i \quad (1)$$

The U variable is the GDP index, B, C and the D is the Individuals using the Internet index. , Mobile cellular subscriptions and the Gross fixed capital formation respectively (Table summarizes all the data). Hence, the model after the form is as follows:

$$GDPi = a + b\,INTi + c\,MCSi + d\,GFCFi + \varepsilon i \quad (2)$$

2.2. Methodology

With the development witnessed by panel studies through improvements to various tests and estimating methods by addressing the limits of traditional procedures, Estimation steps flowchart introduced in the Figure 2.

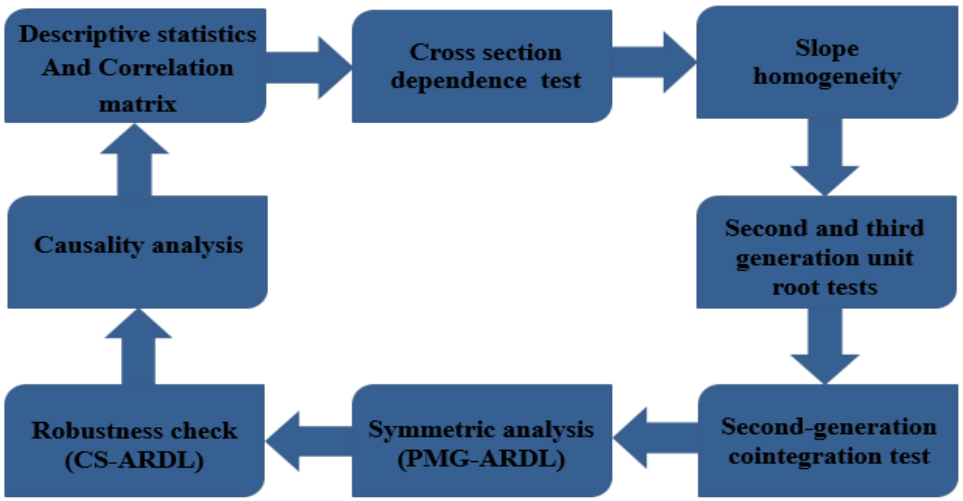

Figure 2 . Estimation steps flowchart.

Table 01 : Variable description and data source:

	Acronyms	Source
GDP growth	GDP	World Bank database (2024)
Individuals using of the Internet	INT	World Bank database (2024)
Mobile cellular subscriptions	MCS	World Bank database (2024)
Gross fixed capital formation	GFCF	World Bank database (2024)

3. Literature Review

Economic theories refer to two economic approaches such as exogenous Theory (t.w, 1956), and the Endogenous Theory (robert & lucas, 1988). You see some well-known contemporary theories, such as Schumpeter's new theories. (Schumpeter & joseph, 1934) (andreas & esben sloth, 2012) And neoclassical growth theory (robert M. , 1956)

Some studies have also looked at the role of ICT services in driving the economy forward. The mobile phone industry has established a substitute effect for telephone lines in developing countries while creating a complementary effect in developed countries (michael & shiling, 2016). Most studies have shown that Internet penetration has a greater impact on high-income countries than low-income countries (lars-hendrik & leonard, 2001) (Štefan & emre, 2012) (mohammad & jef, 2016). Some others found a strong effect of ICTs in the economic growth (Inklaar, O'Mahony, & Timmer, 2005) (Koutroumpis, 2009) (Gruber & Koutroumpis, 2010) (khuong M. , 2011).

The study of (aghaei & Rezagholizadeh, 2017) using the static panel in the OIC Countries in period of 1990-2014 the finding confirm that there is a positive effect of ICT on the economic growth. These results are same with (Sepehrdoust & Ghorbanseresht, 2018) on petroleum exporting countries (OPEC) during the period 2002–2015. Others Used panel co-integration models (Pradhan, Arvin , & norman , 2015) (rudra, girijasankar, & tapan,

2018), those studies found a positive association between ICT infrastructure and economic growth.

Moving to some, other empirical studies who has found a negative relationship like (Freeman & Soete, 1997) (Aghion & Howitt, 1998) in a sample of developing countries. They explain these results might be comes from the dismissal and layoff of some workers.. Also (Wamboye, Tochkov , & S Sergi , 2015) study find a negative linear effect of ICT indicators by using the GMM method in the SSA region.

Another group of literature has searched about the non-linear impact of the ICT on economic growth (Gruber & Koutroumpis, 2011)in their study on 192 cross-sections find that the mobile telecommunication has a positive effect on economic. Another study of (Sassi & goaied, 2013) in MENA region find a positive non-linear effect of ICT on economic growth. Some other studies have found a negative no-linear or no-existent effect of ICT on economic growth, for example (hawash & lang, 2010). The study of (R Kpodar & Andrianaivo) found no evidence of non-linear effect from the use of mobile phones, Internet penetration and fixed telephone lines in the SSA region. Recent study of (Albiman & Sulong, 2017)on the disaggregate income groups within SSA region in 27 countries find positive linear effect and non-linear effect of ICT on economic growth.

More new studies, of the impact of ICT on economic growth such like (Girijasankar , Tapan , & Pradhan, 2018) study, which used the co-integration method and the on PANEL data for G20 countries between 2001 and 2012 years results of a positive correlation between ICT infrastructure and economic growth. Other study of (Appiah-Otoo , 2021), employed, a panel of 123 countries consisting of high-income countries and middle-income countries, with low-income countries. Over the period of 2002 to 2017, they find that, ICT increases economic growth in the high and middle-income countries, however, poor countries tend to gain more from the ICT revolution. The study of (Kumari & Kumar Singh, 2023) study, they used a (GMM) method in a sample of 85 countries: 27 low-income countries and 58 high-income countries in the period of 2000–2019. The results of joint effect conclude that in the low-income context, the joint effect of

ICT infrastructure, FD, and TO positively affects EG, but the results reversed in the high-income context. The findings are important for the policy implications, especially in countries with highly required ICT infrastructure. Also the study of (Biswanath & Anasuya, 2024) which used a panel of 13 emerging country over the period 2000 to 2020. Explored the direct and indirect effect of ICT on economic growth in those nations. The study found that ICT use has a positive effect on (EG).

4. Empirical findings and discussion

4.1. Preliminary analysis

Table presents the descriptive statistics of our data. The average of GDP is 4.069029, ranging from -13.12673 to 15.19350, with a negative skewness value (-0.671268) and a standard deviation of 3.911177. Moreover, we found that the average of GFCF is 24.58284, ranging from 10.53234 to 44.51877, with a positive skewness value (0.748181) and a standard deviation of 7.079499. This confirms that these countries are truly developing countries over the study period .Moreover, the average of INT is 28.86672, ranging from 0.00 to 100.0000, with a standard deviation of 30.89571. In addition, the average of MCS is 62.42442, ranging from 0.00 to 212.4529, with a standard deviation of 56.05810 which shows that these countries are keeping pace with technological development. A comparison of the averages for INT and MCS show to us that the average for INT is 28.86672, while for MCS it is 62.42442. Additionally, the standard deviation for MCS is 56.05810, resulting in a coefficient of variation (calculated as (Standard deviation/mean)*100) of 89.80%. For INT, the standard deviation is 30.89571, leading to a coefficient of variation of 107.03 %. These figures indicate a marked shift in the use of information and communications technology, reflecting the significant strides these countries have made in this direction in recent years. Finally, the Jarque-Bera test outcomes fail to accept the null hypothesis of normality in all the series.

The Table presented the correlation matrix results, this matrix Provide a first impression on the nature of the associations between GDP and the other variables. We observe that all coefficients were significant at a 1 % significance level (SL), indicating a significant

link between these variables and GDP. Clearly, INT, and MCS showed an inverse correlation with GDP. On the other hand, GFCF exhibited a positive correlation. However, the result of VIF confirms no Multicollinearity.

Table 02 : Descriptive statistics.

Variable	GDP	INT	MCS	GFCF
Mean	4.069029	28.86672	62.42442	24.58284
Median	4.302367	15.40084	61.04360	23.56572
Max	15.19350	100.0000	212.4529	44.51877
Min	-13.12673	0.000000	0.000000	10.53234
Std.Dev	3.911177	30.89571	56.05810	7.079499
Skewness	-0.671268	0.750482	0.295212	0.748181
Kurtosis	4.704899	2.212192	1.711979	3.226202
Jarque Berra	116.5498	71.12003	49.68802	56.68411
Prob	0.000000	0.000000	0.000000	0.000000
Observation	594	594	594	594

Source: Prepared by researchers using STATA 17

Table 03 : Correlation matrix

Variables	GDP	INT	MCS	GFCF	VIF
GDP	1.0000				
INT	-0.1936*** (0.0000)	1.0000			4.00
MCS	-0.1729*** (0.0000)	0.8661*** (0.0000)	1.0000		4.00
GFCF	0.3516*** (0.0000)	0.0354 (0.3895)	0.0294 (0.4748)	1.0000	1.00

Significance levels: *** p<0.01, ** p<0.05, * p<0.1. (.) Indicates the p-value.

Source: Prepared by researchers using STATA 17

4.2. Cross section dependence

To test the null hypothesis of no cross sectional dependence (CSD) in the variables, we use 4 different tests that are the (pesaran m. , 2004) (PCD) test and (pesaran m. , 2015) (CD) test, (juodis & reese, 2021) (CD_W) test, (fan, liao, & yao, 2015) (CD_{W+}) and (pesaran & xie, 2021) (CD*) test. The outcomes showed in Table . Appears the refusal of the null hypothesis in all variables at 1 % SL. This result suggests that any shock capable of affecting a certain variable within a nation will transmit to same variable in the other nations in the sample, owing to the interconnectedness among them. Hence, this outcome puts us in the context of adopting unit root and co-integration tests of the second and third generation in order to avoid any inaccurate results.

4.3. Slope homogeneity

Prior to conducting the unit root and co-integration scrutiny, it is crucial to accomplish a fundamental test that permits us to consider the authentication of the Slope homogeneity hypothesis within the sample. Accordingly, two tests will be relied upon that are (pesaran & yamagata, 2008) and (blomquist & westerlund, 2013) tests. The outcomes in

Table Appears clearly the refusal of the null hypothesis of homogeneity in the slope across the nations. Therefore, it is important to consider the heterogeneity constraints on the slope in order to ensure robust results in estimation technics.

Table 04 : CSD issue results

Variables	PCD (pesaran m. , 2004)	CD (pesaran m. , 2015)	CD_W (juodis & reese, 2021)	CD_{W+} (fan, liao, & yao, 2015)	CD* (pesaran & xie, 2021)
GDP	21.62210***	21.62***	-0.78	270.52***	-3.54***
INT	66.56179***	66.56***	10.04 ***	822.71***	-0.36
MCS	67.71612***	67.72***	-3.03***	834.57***	-2.69***
GFCF	8.938313 ***	8.94***	-2.01**	359.11***	14.6***

***, ** and * denotes the significance at 1, 5 and 10 SL respectively

Source: Prepared by researchers using STATA 17

Table 05 : Slope homogeneity tests findings

(pesaran & yamagata, 2008) **test**		
Delta tilde $\tilde{\Delta}$	2.960***	0.003
Modified delta tilde $\tilde{\Delta}_{adj}$	3.213***	0.001
(blomquist & westerlund, 2013) **test**		
$\tilde{\Delta}$HAC	1.834**	0.067
($\tilde{\Delta}$HAC)adj	1.991**	0.047

***, ** and * significance at 1, 5 and 10 % SL respectively.

Source: Prepared by researchers using STATA 17

4.4. Unit root tests and Co-integration

In the Table we find the results of the unit root tests. This table Showed that the variables are mixed integrate between I(0) and I(1). Whereas the variable GDP are naturally stationary, the explanatory variables are stationary after the first difference. Also the (ditzen, karavias, & westerlund, 2021) Detect the presence of two structural break in 1998 and 2002. The study check the existence of a long-term co-evolution of the variables with (Westerlund, 2007), the Table 07 presented the results of the test .As a result, both Gt and Pt statistics show significant values at 5 % SL. As stated by (jahanger, et al., 2023), the rejection of null hypothesis with Gt and Pt statistics provide sufficient evidence to accept the hypothesis of co-integration between series.

Table 06 :n Integration order findings

Variables	**CIPS test**	**Pesaran's CADF**	**Herwartz-Seindenburg**	**Demetrescu-Hanck**	**Herwartz,-Maxand-Walle**	**DKW (2021)** Coef T-stat break date
GDP	-4.697***	-4.789***	-1.5291*	-0.9584	0.0237*	F(1|0) 2.02 1998
D(GDP)	-6.256***	-7.441***	-1.8447**	-1.8291**	-2.1693**	F(2|1) 6.64*** 2002
INT	-1.629	3.704	1.2862	1.1917	2.5155	F(3|2) 1.58
D(INT)	-3.842***	-0.787	-3.0746***	-1.8329**	-2.3573***	F(4|3) 1.56
MCS	-2.762**	-2.564***	1.5620	2.6869	2.5111	F(5|4) 3.90
D(MCS)	-4.089***	-3.544***	-2.4420***	-1.9183**	-1.5494*	
GFCF	-2.715**	-1.819**	0.9186	1.7679	0.4339	
D(GFCF)	-5.041***	-6.611***	-2.2001**	-3.0163***	-2.4861***	

***, ** and * significance at 1, 5 and 10 % SL respectively. D denotes the first differences operator. Critical values for CIPS test are -2.63; -2.71and -2.85 at 10, 5 and 1 % SL respectively.

Source: Prepared by researchers using STATA 17

Table 07 : Co-integration analysis findings

Statistics	Value	Z-value	p-Value	Robust p-value
Gt	-4.308	-7.815	0.000	0.000
Ga	-11.014	2.383	0.991	0.210
Pt	-14.832	-4.655	0.000	0.000
Pa	-10.238	1.075	0.859	0.130

***, **, * signifies the rejection of the null hypothesis at 1, 5 and 10 %, respectively.

Source: Prepared by researchers using STATA 17

4.5. Long run elasticities examination

After confirming the CSD issue, slope heterogeneity, I (0) and I (1) integration, and the presence of a co-integration relationship, the next stage used the PMG-ARDL procedure to estimate the long-run elasticities.

Table present the results. Column 1 are specific to the coefficient of the ICTs variables with gross fixed capital formation (GFCF) as a control variable. The results in the column 4, which are, consistent with findings from similar studies (lars-hendrik & leonard, 2001) (Štefan & emre, 2012) (mohammad & jef, 2016)show the statistically significant relationship between economic growth (GDP) and the internet users (INT) the same column shown that the mobile subscriptions variable are not statistically significant. Some earlier studies find the same result (Freeman & Soete, 1997) (Aghion & Howitt, 1998) (Wamboye, Tochkov , & S Sergi , 2015) . The output elasticities of internet are 0.03%.

The coefficient of gross fixed capital formation (GFCF) are positive and statistically significant at the 1%. The output elasticities of GFCF are 0.10%, which aligns with what was expected. This result validates the role, which plays as a major consideration in driving economic growth in developing countries.

The error correction term (ECT) is correct; found to be negative and statistically significant for all model specifications. The speed of adjustment (ECM) ranges from the

lowest value of approximately 102.05%; both of MCS and GFCF are positive and statistically significant in the short-run.

The diagnostic tests showed that the homogenous constraint in long-term equilibrium at the 5% statistical level according to Hausman test, and this result indicates that the PMG-ARDL estimator is suitable for estimating the long-run coefficients. The outcomes of the residual-based cross section dependence test suggests the absence of CSD problems between residuals and the appropriateness of the PMG-ARDL estimator.

4.6. Robustness check

The Cross-Sectional ARDL (CS-ARDL), which exhibit greater consistency compared to PMG-ARDL techniques due to their consideration of the CSD issue. The outcomes presented in

Table . The CS-ARDL findings are near to PMG-ARDL estimator results.

Both of ICTs indicators are statistically significant and has a negative coefficient at the 5% level the same is for GFCF. The output elasticities of INT and MCS are 0.17% and 0.11% respectively. For the Gross fixed capital formation (GFCF) are 0.58%.

The error correction term (ECT) is correct; found to be negative and statistically significant for all model specifications. The speed of adjustment (ECM) ranges from the lowest value of approximately 102.05%; all the variables INT, MCS and GFCF are negative and statistically significant in the short-run.

Table 08 : PMG-ARDL estimation results

Variables	Coefficient	Std. error	t-student	Probability
		Long-run		
INT	-0.0306159	0.0089308	-3.43	0.001
MCS	0.0019016	0.0047041	0.40	0.686
GFCF	0.1090785	0.0300551	3.63	0.000
		Short-run		
ECT	-1.020478	0.0684778	-14.90	0.000
D.INT	-.0217068	0.0396372	-0.55	0.584
D,MCS	.0447788	0.0201084	2.23	0.026
D.GFCF	.8504898	0.1996668	4.26	0.000
		Diagnostic tests		
Hausman test		1.43 (0.6990)		
Residual-based CSD CD* (pesaran & xie, 2021)		-0.79 (0.429)		

Source : Prepared by researchers using STATA 17

Table 09 : CS-ARDL estimation results

Variables	Coefficient	Std. error	t-student	Probability
		Long-run		
INT	-0.1701667	0.0802262	-2.12	0.034
MCS	-0.1063991	0.0495201	-2.15	0.032
GFCF	-0.5802959	0.1665782	-3.48	0.000
		Short-run		
ECT	-1.090408	0.0626673	-17.40	0.000
D.INT	-0.1632013	0.073665	-2.22	0.027
D,MCS	-0.0826675	0.0430503	-1.92	0.055
D.GFCF	-0.563903	0.1562837	-3.61	0.000

Source: Prepared by researchers using STATA 17

4.7. Causality analysis

The last step of the empirical analysis consists of conducting a causality analysis especially from our independent variables to GDP. For this reason, we rely on the modern non-Granger causality test presented by (Juodis, Karavias , & Sarafidis , 2021) panel data causality test. The findings reported in Table 1, and summarized in Figure 3 .Reveal the existence of a causality link running from the ICTs indicators (INT and MCS). This result provides compelling evidence of the viability of using these variables to stimulate and predict future values of GDP, given their substantial influence on driving the latter. Nevertheless, the results confirm the absence of a causal connection from GFCF to GDP. Those results matching with the findings of (rudra, mak, & neville, 2015), (rudra, girijasankar, & tapan, 2018) studies.

Table 10 : Causal Relationship analysis outcomes

Direction of causality		From			
	Variables	GDP	INT	MCS	GFCG
To	GDP	/	6.4658**	39.2734***	3.5237
	INT	9.2908***	/	146.7247***	29.2192***
	MCS	4.8543*	68.4292***	/	0.8301
	GFCF	12.8530***	26.9054***	26.8785***	/

*** and **,* denote the statistical significance at 1 and 5,10%, respectively.
Source: Prepared by researchers using STATA 17

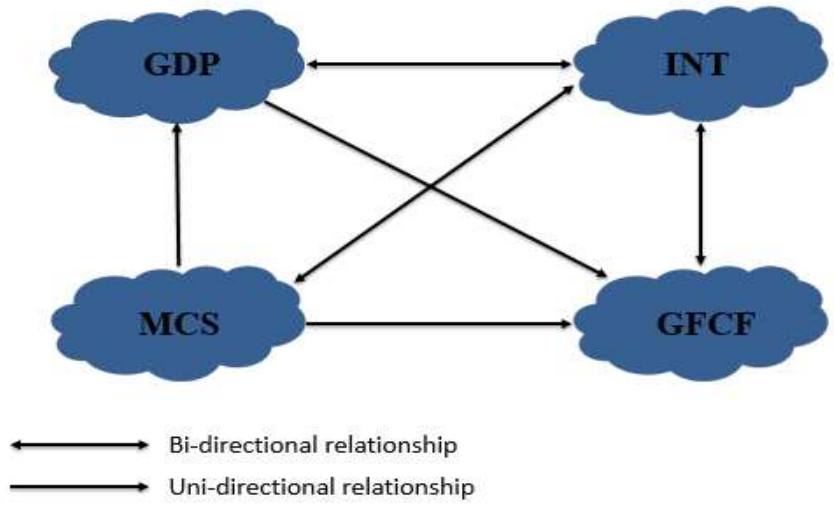

Figure 3 .Causal Relationship associations.

5. Conclusion

This study used a panel of eighteen developing countries over 33 years from 1990 to 2022 to find the effect of ICT on economic growth. The findings indicate the existence of both of slope heterogeneity and cross-sectional dependence. Moreover, to find the integral degree of the variables the second-generation panel unit root tests was used, this tests confirmed that the variables are mixed integrate between I (0) and I (1). To look for any structural breaks, this study used the third-generation of panel unit root test. This one detected that there is two breaks in 1998 and 2002 .To find this effect the study used The PMG-ARDL methodology. The results of this procedure showed that only the internet and GFCF have an effect on GDP. This effect are negative in the long-term. In the other hand, to check the robustness of the previous model outcomes, this study used the CS-

ARDL estimator, which confirmed that both of ICT indicators (INT and MCS) and GFCF have a negative effect on GDP. These countries suffer from poor internet and mobile phone infrastructure, which reduces the potential economic returns. In addition, the weak energy infrastructure, which is a key driver of these technologies, limits the possibility of using and benefiting from them. In addition, access to these networks is uneven for the population, as some remote and rural areas suffer from the lack of these networks, in addition to the fact that not everyone in these countries can afford these services. The lack of the necessary skills and technology has limited the use of these technologies in developing countries to personal use, such as entertainment and socializing, which do not provide any economic return. Integration between the IT sector and other service and economic sectors is almost non-existent. In addition, investments directed to this sector are scarce, as most of the imports of ICT, goods are imported. In addition, there is a lack of capital flow to these countries to invest in the ICT sector.

The findings from the causality analysis indicate that there is a bidirectional causal relationship between the internet users and MCS, GFCF and GDP. The causality outcomes indicates a unidirectional causal relationship from GDP to GFCF and MCS to GDP, GFCF.

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