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CAUSAL LINKS BETWEEN ICT, HDI, AND ECONOMIC GROWTH: EVIDENCE FROM MENA

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Abstract This paper examines the causal links between ICT, HDI, and economic growth in the MENA region's high-income, middle-income, and low-income countries from 2002 to 2019. These panel data will be studied by using several tests such as the unit root test, Pedroni cointegration test, Kao cointegration test, and ECM test. This link will put a great load on the governments to invest more in both human capital and ICT infrastructure. This policy should be applied in both the short and long run to enhance sustainable growth and development. Therefore 17 countries were chosen from MENA depending on six variables depending on the panel ECM test. This paper ends with the significance of ICT and economic growth in the MENA region in the both short run and long run. Also, this result applies to all countries in the region whether with high-income or middle-income, or low-income countries. Also, these results show some bidirectional or unidirectional between these variables that differ according to the income level of the country.

***Keywords**: HDI, ICT, economic growth, MENA*

***JEL Codes:** J24, O33, O47, O55*

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Introduction:

Economic growth becomes one of the most attractive topics that most economists and researchers. They try to link it with the different changes around us especially after the technological invasion happens all over the world. The neoclassical school was the first the link economic growth with natural and human resources such as land, labour, and also capital as known in the endogenous growth model (Lucas, 1988). All countries depend on the exploitation of natural resources besides the use of human capital in applying economic growth. The relationship between economic growth and investment in human capital attracted the attention of many researchers (Diebolt & Hippe, 2022; Bawono, 2021; Vinod & Kaushik, 2007; Asteriou & Agiomirgianakis, 2001). These were considered old economic theories (Majeed & Ayub, 2018) but modern theories gave a huge contribution to the socio-economic factors of economic growth in the context of ICT and R&D.

Nowadays, ICT becomes one of the pillars of economic growth in all countries as ICT affects individuals, firms, and the overall economy which leads to a "production paradox" (Vu, et al, 2020). Also (WB, 2016) calls for the role of ICT in eliminating information barriers and especially in paving the way for inclusion and efficiency in applying knowledge economy.

In many works of literature, this relationship was obvious in developed countries as ICT and economic growth are positively significant (Draca, et al, 2009). Furthermore, (WB, ICT for Greater Development Impact, 2012) set some goals for applying ICT in any economy that alleviates poverty, and economic growth, and increases productivity. There are many reasons behind the difference in applying ICT in developed, and developing countries. The lack of human capabilities that ICT depends on in developing countries or R&D expenses needed (Keller, 2004). Also, using ICT efficiently will decrease transaction costs and increase knowledge creation (Pilat, 2004). Also, the relationship between ICT, HDI, and economic growth, (Kowal & Pękosz, 2017) found that there is a strong link between HDI, ICT, and GNI per capita in emerging and developing countries.

The selection of the MENA region can be justified due to many reasons as the variety of income levels, the huge size of human capital, and the recent developments in ICT. Therefore the objective of that paper is to study the causal links between ICT, HDI, and economic growth in the

MENA region. Furthermore, the study will divide the MENA region into three main categories according to the world bank division according to income level: high, middle, and low-income countries.

Therefore this paper will be divided into four sections as the first will be a theoretical examining the literature review. This literature review covers the theoretical framework besides the empirical studies. the second part will introduce the methodology, while the third will present the results. Finally, it will end with a conclusion and references.

Literature review:

As there is a huge debate on the relationship between ICT, and economic growth, these studies will be divided into two main groups according to the type of countries; developed countries or developing countries, or according to regional divisions such as ASEAN or OPEC for example. This part will be divided into three main parts the first will review the literature on the relationship between ICT and economic growth. While the second part will deal with the literature tackling the relationship between HDI, ICT, and economic growth. Finally, the third part will deal with the literature dealing with that relationship in the MENA region.

ICT and economic growth:

The relationship between ICT and economic growth was studied firstly in both developed and developing countries many works of literature come with different results. (Qiang, 2009) examined 120 developed and developing countries and found that the impact of ICT is higher in high-income countries than the middle and low-income countries. While (Madden & Savage, 2000) studied 43 developed and developing countries and concluded with a positive relationship between ICT, human capital, and economic growth.

As the fruits of ICT were sought in most of the developed countries in the mid of 1990s, ICT has a positively significant relationship with economic growth in advanced economies with an only acceleration of labour productivity in the USA (Jalava & Pohjola, 2002). But in comparing this relationship between the USA and Europe, the impact of ICT is greater in the USA than in Europe due to the adaptation of liberalization in the USA faster than in Europe (Inklaar, et al, 2007). (Aschauer, 1989) Studied the relationship between ICT and economic growth in the USA depending on

Cobb Douglas function that concluded with a positive relationship between them. Therefore (Saidi & Shebli, 2018) found that there is a bidirectional short-run relationship between ICT and R&D, and a long-run relationship between education and ICT, as both education and R&D, are drivers of economic growth in high-income countries.

Other literature contradicts that assumption of a positive relationship in developed countries and found a negative relationship as (O'Mahony & Vecchi, 2005) reached a negative relationship between ICT and economic growth in the UK due to a lack of the needed skills. Japan has no relationship between ICT and economic growth in japan but it resulted in reducing energy consumption (Ishida, 2015).

Regarding the developing countries, (Hawash & Lang, 2010) concluded that this relationship was significant and leads to an increase in productivity in 33 developing countries. The empirical relationship between HDI, ICT, and economic growth was studied in many regions (Zhang & Danish, 2019) studied this relation in developing Asian countries and concluded that only high-income and middle-income countries in Asia have a positive relationship while no relation for low-income countries. When trying to link the landline and mobile lines to the relationship between ICT and economic growth, (Lee, et al, 2009) this positive relationship happens in Sub-Saharan countries (SSA) when mobile lines were introduced instead of landlines.

In linking R&D with ICT and economic growth, (Sağlam, 2018) concluded that there is a bidirectional relationship between ICT and economic growth in 34 countries of OECD with no effect on the R&D expenses or employment. Other literature linked ICT with economic growth in the context of landline and mobile lines in developing countries to reduce the digital divide and enhance economic growth (Waverman et al, 2005; Sridhar & Sridhar, 2008). (Aschauer, 1989) Studied the relationship between ICT and economic growth in the USA depending on Cobb Douglas function that concluded with positive relationships between them. (Nasab & Aghaei, 2009) found that there is a positive significant relationship among OPEC countries.

HDI and economic growth

GDP per capita is considered an important indicator in measuring economic growth. When it comes to economic development, HDI is the most reliable in most literature. The human development index (HDI) is a composite indicator. It is used to measure the quality of life for humans in the sense of education, health, and standard of living. Most of the literature concluded that there is a positive relation between HDI and economic growth as (Elistia & Syahzuni, 2018) studied the impact of HDI on economic growth and found that there is a positive impact of HDI on economic growth in 10 ASEAN countries. Also, (Meyer, et al, 2017) examined this relationship in South Africa and found that there is a short-run and long-run significant relationship between it, especially in alleviating poverty. However (Abraham & Ahmed, 2011) studied how HDI can affect economic growth in Nigeria. They concluded that human development affects economic growth only in the long,-run not in the short run. That is due to the policies aiming at accelerating the alleviation of poverty. moreover (Girma, et al, 2005) in their study investigated the economic growth and development in Sub-Saharan Africa (SSA) from 1970 to 1997 and found that there is a positive relationship between aid on growth and development. Finally

ICT, HDI, and economic growth in MENA

Concerning the studies on the MENA region, few studies linked the three variables – GDP per capita, HDI, and ICT- together. The studies were divided into 2 main topics; the relationship between ICT and economic growth, or between HDI and economic growth in the MENA region. (Lechman, 2022) studied these relationships in MENA aa s whole regardless of the differences according to income levels. The positive relationship between these variables was studied only by (Nour, 2002) but with application to only 7 Arab countries in the Gulf region. ICT was used as a substitute for corruption in enhancing economic growth in MENA (Mim & Jeguirim, 2021). Other literature examined the relationship between financial development, ICT, and economic growth in the MENA region and reached a result of a negative relationship between financial development and economic growth, and a positive relationship between ICT and economic growth (Sassi & Goaied, 2013).

The previous presentation of literature presented the following two gaps: the first is the small amount of literature dealing with the MENA region in the context of HDI, ICT, and economic growth. The second gap is the lack of studies that deal with different income levels in the MENA region.

Methodology

Data

The data used in the paper were extracted from two main sources; World Bank and UNDP as shown in table 1. Regarding HDI, UNDP was regarded as the only source for it, while all other data were from World Bank. All data were on an annual basis from 2002 to 2019 for 17 countries only from MENA due to a lack of information for other countries. These variables were used in logarithms forms to decrease heterogeneity.

Table 1: variables used (2002-2019)

Variable	Symbol	Units	Source
GDP per capita growth rate	GDP	Percentage	World Bank
Fixed broadband per 100	FBRD	Percentage	World Bank
percentage of individuals using the internet	INT	Percentage	World Bank
Human development index (HDI)	HDI	Decimal	UNDP

In choosing the countries in the MENA region, the author was willing to apply the study to all countries of MENA but some problems hindered that. One of these problems is the lack of data available in some countries, while the second problem is the delay in applying ICT in many economies. Therefore the result is those 17 countries that overcome these problems. According to World Bank classifications, these countries were categorized into three main categories; high income, middle income, and low income. That paper uses 7 countries as high-income countries that were Saudi Arabia, United Arab Emirates, Qatar, Kuwait, Israel, Kuwait, Bahrain, and Cyprus. Also, Egypt, Iran, Iraq, Jordan, and Kuwait are considered middle-income countries compared to Yemen, Lebanon, Algeria, Morocco, and Tunisia which are regarded as low-income countries.

Proposed Model

As the main aim of the paper is to test the relationship between HDI, ICT and economic growth in the MENA region, the author divided this region into three categories that reflect the differences between these countries in the aspect of income and infrastructure needed to apply digitalization.

Therefore the model proposed will be as follows;

$GDP = f(HDI, FBRD, INTRT)$ ……equation 1

Then to express the function –expressed in equation 1- in the econometric model, the equation will be as follows:

$ln\ ln\ GDP = \propto + \beta 1 lnINTRT + \beta 2 lnFBRD + \beta 3 lnHDI + \varepsilon$

…….. Equation 2

Where GDP indicates GDP per capita, INTRT indicates the access to the internet, FBRD indicates fixed broadband per 100 habitants, and HDI indicates the human development index. $\beta 1$, $\beta 2, and\ \beta 3$ are the slope of parameters and α is the fixed effect of the parameters.

The unit root test adopted was Im, Pearsan, and Shim (IPS) as it helps in studying the time series and individual effects, and common time effects (Maddala & Wu, 1999). To measure the relationship between the variables, the author used Pedroni cointegration and Kao cointegration tests to test the relationships in the long run and the short run. Also, a substitution between the variables has occurred to test the different effects of them whether they were bilateral or unilateral direction relationships.

Also in adopting the error correction model, the basic structure of the equation used in it is shown as follows in equation 3:

$\Delta y_t = \propto + \Delta a x_{t-1} + EC_{t-1} + \varepsilon_t$ …… equation 3

Where EC denotes the error correction and is used to measure the speed of various variables. Δy_t is the change in GDP per capita growth, while x denotes the variables in the model and t is the change in time.

Results

The descriptive data show that the high-income countries scored the maximum values for HDI, GDP, FBRD, and INT. then the middle-income countries come in second place and low-income countries are last. The mean for the GDP per capita in middle-income countries exceeds those in the other two groups.

Table 2: descriptive data results

Variable	High income				Middle income				Low income			
	Mean	Std, dev	Min	Max	Mean	Std, dev	Min	Max	mean	Std, dev	Min	max
LogGDP	0.235	4.29	-15.15	15.988	2.096	3.32	-6.02	9.5	1.2	4.87	-24	9.13
LogFBRD	11.98	10.4	0.035	36.77	4.52	4.64	9.47	17.05	3.26	3.31	0	18
LogHDI	0.835	0.038	0.74	0.919	0.714	0.051	0.62	0.82	0.97	-0.65	0.52	0.52
LogINT	59.48	27.8	6.384	99.70	30.75	21.34	0.93	77.77	31.13	0.4	1.59	1.59

Source: authors` calculations

Unit root

To test the heterogeneity of the data, IM, Pearson, and shin (IPS) will be reliable. This will be applied to the three income groups of the MENA region at the level and first difference. The results computed in table 4 show that there are mixed results at different levels whether I (0) or I (1). The MENA countries are stationary at all levels for GDP only, while there were stationary at the first level.

Table 3: unit root results

	High income				Middle income				Low income			
	Level		1st difference		Level		1st difference		level		1st difference	
	No trend	Trend	No trend	trend	No trend	Trend	No trend	Trend	No trend	trend	No trend	Trend
DP	3.76991***	3.66568***	6.27917***	4.33926***	2.00981**	2.04931**	4.94255***	3.65615***	1.9066**	2.566***	7.7959***	6.1609***
BRD	1.07048	1.35854*	2.16715**	0.86707	.39729	.18274	0.11225	.43503	.6637	.0446	1.475*	1.4657*
DI	.95240	.25105	4.05122***	2.98027***	0.59013	0.44572	2.5524***	1.79259**	2.185**	0.7966	1.3670*	0.47267
NT	.08100	.32780	3.93190***	3.92768***	.13319	.41712	1.22121	2.3467***	.9634	.3425	0.6884	.0461

Note: the unit root test is recognized at *** 1%, **5%, and * 10%
Source: author`s calculations

These results can be accepted to support that the data for the three categories of countries are stationary and there will be no 2nd difference for the unit root test (Khalil, et al., 2016). So it shows the existence of a long-run relationship between the variables used in the model that leads to the application of Pedroni and Kao cointegration tests.

Cointegration

To reach the links between ICT and economic growth, various cointegration tests were conducted. The author depends on only these two tests of cointegration because Johansen's test is not consistent with panel data.

Table 4: Pedroni cointegration test

	All	High income	Middle income	Low income
	Statistic	Statistic	Statistic	Statistic
Panel v statistic	-0.574403	1.104274	0.557631	-1.622417
Panel rho statistics	0.772563	-0.383917	-0.454357	1.295816
Panel PP statistic	-4.734090***	-3.399717***	-5.526187***	-0.283977
Panel ADF statistic	-4.19545***	-2.236699**	-2.444526***	-3.12836***
Panel v statistic (weighted)	-0.476514	-0.861538	-0.302372	-1.313523
Panel rho statistics (weighted)	0.288732	-0.102039	-0.303009	0.034916
Panel PP statistic (weighted)	-5.749334***	-5.381726***	-4.043434***	-3.77915***
Panel ADF statistic (weighted)	-4.419008***	-4.025947***	-2.367327***	-3.63870***
Group rho statistic	0.695451	1.044631	0.681964	0.187582
Group PP statistic	-12.67325***	-8.903046***	-8.888698***	-6.4396***
Group ADF statistic	-4.1199***	-4.598847***	-3.913582***	-3.2448***

Source: author`s calculations

The findings began with the Pedroni panel and then Kao tests were used to test the long-run relationships. Table 4 shows the significance of all variables whether for the regions of MENA as a whole or each category of the case studies at 1% with exception of rho and v statistics. This ends with a strong rejection of the null hypothesis of no cointegration between ICT

and GDP at 1% for all variables. Therefore we can conclude that ICT and economic growth are correlated and integrated in the long run.

Kao test found that all variables are correlated at all levels at 1% which also found that there is a strong long-run relationship between these variables. The probability of these categories is 0.0000 except for the middle-income countries which were 0.0125 which is considered also as 5% as shown in table 5.

Table 5: Kao cointegration test

	All	**High income**	**Middle income**	**Low income**
	Statistic	Statistic	Statistic	Statistic
ADF	-3.2031***	-3.480327***	-2.242199**	-4.034246***

Source: author`s calculations

Then the short-run and long-run results are explained in table 6 as tables 4 and 5 showed that the variables are integrated in the first order. Then a granger causality test of the error correction model was conducted. The results show that there is a huge difference in the relationship between ICT and GDP in the countries of the MENA region, especially when dividing these countries according to income levels- whether high or middle, or low. The high-income countries have a significant relationship between ICT and GDP with regard to all variables except HDI. But in the short run, FBRD is bidirectional significant only with INTRT. Also, there is a unidirectional significant relationship between HDI and FBROD from one side, and FROD and HDI. Finally, although these countries have some different variables between them as HDI and INTRT, all MENA countries have significant relationships between GDP and other variables.

Table 6: ECM results

	High income					Middle Income					Low income				
Dependent variable	D(GDP)	D(INTRT)	D(FBRD)	D(HDI)	ECM	D(GDP)	D(INTRT)	D(FBRD)	D(HDI)	ECM	D(GDP)	D(INTRT)	D(FBRD)	D(HDI)	ECM
D(GDP)	-	0.046225	0.046255	-0.02397	-0.297703***	-	-0.095001	0.028452	74.02309**	-0.851133***	-	0.023796	0.076383	-99.07051**	-0.675749***
D(INTRT)	0.265361	-	0.977379***	100.5168	0.418759***	-0.100812	-	2.781707***	108.5773	0.025149	0.108527	-	-	1.476152***	82.42333*	-0.011351
D(FBRD)	-0.044244	0.133236***	-	100.7745***	0.023328	-0.001127	0.078948***	-	35.01993***	0.008935	0.00422	0.121438***	-	-6.098936	0.055214
D(HDI)	-0.000200	-0.00000955	0.0003733***	-	0.319273***	0.000360	0.000278	0.003976***	-	-0.025069	0.00063	0.000635**	-0.000570	-	-0.027378

Source: author`s calculations

Discussion

The results of the study show the significance of the relationships between ICT and GDP in the MENA region that can be applied by investing more in telecommunications infrastructure. This was clear in the results of high-income countries in the region that the ICT indicators were significant with GDP in the long run compared with low and middle-income countries with low-quality of ICT infrastructure.

The findings show a bidirectional relationship between the use of the internet and fixed broadband per 100 in high-income countries which affects economic growth in the long run (Czernich, et al, 2011; Farhadi, et al, 2012; Castaldo, et al, 2015).

One more important result that can be explained is the bidirectional relationship between HDI and GDP per capita in low-income countries as more investment in human capital as education and health will result in more human development that will conclude with more economic growth. Also, the investment in human capital will enhance the use of ICT which affects positively the economic growth in the MENA region. This implies that the investment in human capital and research and development "R&D" should be increased as the MENA region is one of the world`s highly invested in energy (Saidi, et al, 2018).

Finally, To enhance economic growth, economic development should be presented in the aspects of technology and how to use it in different fields besides education and health.

Conclusion

From the empirical analysis, there is cointegration between ICT, HDI, and economic growth in the MENA region regardless of the income level of the countries. The study ignored the use of fixed line subscribers, and mobile lines subscribers that were used in many other studies because those are available for most citizens in MENA. Therefore the core variable that the author assumed to be significant is the use of the internet and fixed broadband.

For further study, the availability of more data on the low-income countries in the MENA region will be beneficial in any other study related to ICT, and economic growth as the lack of transparency of data acts as a huge obstacle in the study. Regarding the policy implications, the government should give more attention to investments in the ICT infrastructure besides the techniques of ICT know-how.

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