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THE LONG-RUN RELATIONSHIP BETWEEN ICT INDICATORS AND STOCK MARKET INDEXES FOR G7 AND E7 COUNTRIES

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ABSTRACT

Since the late 1990s, information and communication technology (ICT) has caused changes in all fields, particularly in the stock markets. By using ICT technology, stock market investors had a chance to get information, reduce the trading cost and make optimal investing decisions. This study aims to examine the long-run relationship between stock market indexes and ICT indicators for G7 and E7 countries. The stock market indexes are taken as dependent and ICT indicators as independent variables, for the period between 2003 and 2019. We included three ICT indicators which are fixed telephone subscriptions, mobile telephone subscriptions, and internet users (individuals using the internet percentage of population). The panel cointegration tests which are Pedroni and Kao, and the Fully Modified Least Squares (FMOLS) method are used in this paper. The results imply that ICT indicators which are mobile telephone subscriptions and individuals using the internet have a positive impact on stock markets and their significance.

Keywords: *Stock market, ICT, Panel cointegration, Fully modified least squares method.*

INTRODUCTION

Information and communication technologies (henceforth ICTs) include a mobile telephone, personal computer, internet hosting service. Nowadays, the of influences the ICT sector are perceived all around the world and are estimated to be significantly groundbreaking in the following years as technology infiltrates and poses important changes in all sectors and aspects of life (Jorgenson & Vu, 2016). Among the fields that have been tremendously affected by ICT are the development of the stock market in particular and the world in general terms (Igwilo, 2020).

In the late1990's ICT, particularly computers and the internet began spreading all over the World, which marked the beginning of the capital market's transition to an automated trading system. In capital markets, access to accurate and timely information is the most important thing. Therefore, ICT provides the opportunity to have this accurate and timely information in the operations of a capital market (Mwalya, 2010). Nowadays, ICT is changing the capital market each day owing to the electronic trading system.

Based on the World Bank Statistics Global Data, we can see the performance of three important ICT indicators, which are the total number of fixed telephones, mobile telephone subscriptions,

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and Internet users in the world. The number of fixed telephone subscriptions increased by 35% between 1995 and 2019, the mobile telephone subscription increased by 90 million to 8,1 billion in the world. As shown in **Figure 1**, the mobile telephone subscriptions trend grew more rapidly than fixed telephone subscriptions. Another indicator of ICT is individual use of the internet calculated by a percentage of the general population. Even if the internet users indicator constituted only 0,68% of the world population in 1995, it rose to 50,76% in 2018, according to **Figure 2**.

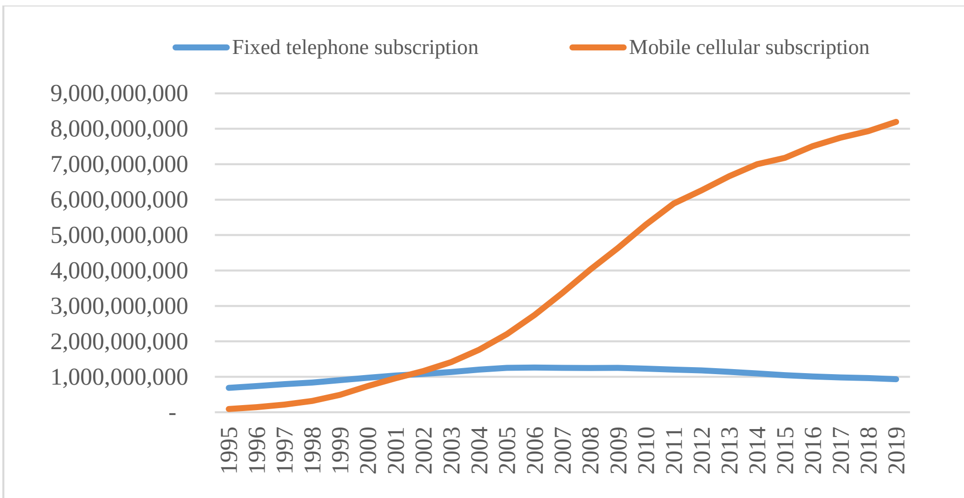

Figure 1. Total number of fixed and mobile telephone subscriptions in the world (1995-2019). Source: (WorldBank, 2020)

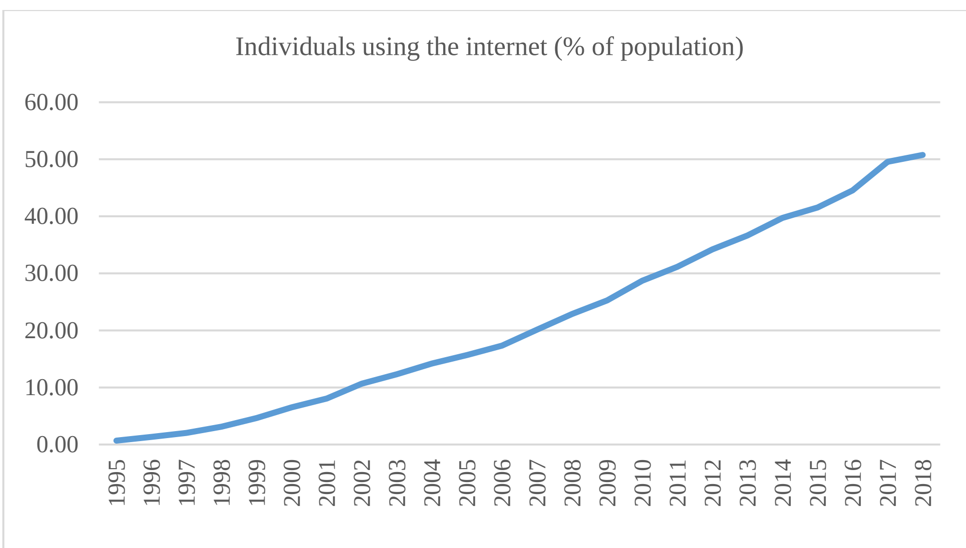

Figure 2. Total number of individuals using the Internet (% of the population) in the world (1995-2018). Source: (WorldBank, 2020)

In literature, the impact of ICT on the capital market has been a subject of study since the 2000s. It is also still controversial whether ICT has a positive impact on the financial markets. There are two types of views in previous papers.

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The first view, suggested by most of the authors like (Ngassam & Gani, 2003; Chinn & Fairlie, 2006; Erzirim *et al.*, 2009; Mwalya, 2010; Bhunia, 2011; Friday & OsonduMary, 2014) is that financial markets are motivated and affected by ICT. Some of them suggest that the increasing use of the internet and developing exchanges are creating a borderless global trading platform. Furthermore, this is allowing investors to access the international financial market with lower transaction costs (Bhunia, 2011). Also, Fama and French stated that the capital markets become more efficient by making sure that all participants can get the information of exchange as quickly as they want. All the results of ICT developments are creating new products and instruments in the financial markets (Fama & French, 1988). Another view, (Ajit *et al.*, 2001) indicates that the systematic relationship between stock market development and ICT development indicators has not been discovered yet.

This paper aims at investigating the long-run association between capital market indexes and ICT indicators, which are fixed telephone subscriptions and mobile telephone subscriptions and internet users, for G7 and E7 countries. The analysis spans a period from 2003 to 2019, using the Unit Root tests for stability and Pedroni and Kao panel tests, as well as panel cointegrating Fully Modified Ordinary Least Square Method for the long-term relationship between variables. Below is the organization of the paper: The following section investigates important literature reviews related to the association between ICT indicators and capital markets. The third section deals with data collection and analysis methods while the fourth section gives place to conclusion and recommendation.

Literature Review

Previous studies since the 2000s were reviewed. A few of the studies were on the effect of ICT on stock market development and performance, particularly in developed and emerging economies. On the other hand, the majority of the authors dealt with ICT on economic growth and some other aspects of socio-economic development (Okwu, 2015).

In recent years, ICT impact on economic growth was analyzed by many researchers. Some of them were (Kallal *et al.*, 2021; Usman *et al.*, 2021) studied the effect of ICT on economic growth and consumption in a periphery country and South Asian countries (Cheng *et al.*, 2021). Examined the relationship between ICT diffusion, economic growth and financial development based on panel data covering 72 countries. Adding to this (Niebel, 2018) studied the impact of ICT on economic growth in developing emerging and developed countries. Also, (Hwang & Shin, 2017; Sawng *et al.*, 2021), analyzed the impact of ICT on economic growth in Korea. Another paper was studied by (Haftu, 2019) on Sub-Saharan Africa's economic growth (Edquist *et al.*, 2018). Investigated diffusion of mobile broadband's effect on economic development for 135 countries. Furthermore (Zhang, 2021) investigated the relationship between broadband and economic growth in China (Appiah-Otoo & Song, 2021). Addressed the impact of ICT on economic growth by comparing rich and poor countries (Vu *et al.*, 2020). studied 208 academic papers that examine the link between ICT and economic growth (Pradhan *et al.*, 2018). Investigated the impact of ICT on per capita real GDP for G20. Another paper (Adeleye & Eboagu, 2019), studied ICT on economic growth covering 54 countries (Hussain *et al.*, 2021). Examined ICT penetration on economic growth for South Asian countries (Solomon & van Klyton, 2020). studied the usage of digital technology on economic growth for 39 African countries applying the GMM model. Some studies which have been addressing the effect of ICT on productivity (Pieri *et al*., 2018; Tang & Wang, 2020; Kim *et al*., 2021; Nakatani, 2021). Another study (Atsu *et al*., 2021) examined the relationship between ICT, energy consumption and carbon dioxide emissions for South Africa. Similar to this study (Nguyen *et al*., 2020; Lahouel *et al*., 2021), investigated the role of ICT in driving emissions and economic growth.

Having reviewed studies on the relationship between ICT indicators and financial market indicators, different results were found in the context of analysis methods and period variables. One of the earliest studies that analyzed the relationship between ICT and capital markets was published in 2001 by (Ajit *et al*., 2001). They analyzed the effect of ICT on capital markets with a multivariate analysis involving 63 countries and the period from 1990 to 1999. Study findings did not indicate a significant systematic relationship between indicators of stock market development and ICT development. The relationship between ICT and stock market development including high-income and middle-income economies was analyzed in another study carried out in 2003 (Ngassam & Gani, 2003). The paper analyzed the period from 1990 to 1999 with the least squares dummy variable models. The study revealed that two ICT variables, personal computer and internet host, had a significant positive effect on stock market development. In a close contest with the previous paper (Erzirim *et al*., 2009), investigated the effect of ICT on the growth of the capital market in Nigeria. The modified Gompertz technology diffusion model was used for the period from 1998 to 2007. The findings revealed that ICT contributed to the growth of the Nigerian Capital Market. Similarly (Mwalya, 2010), used a different method, Comparison Period Return Approach (CPRA), to analyze stock movement following the launching of a company website on the stock market. Results were obtained by using an official corporate website on the profitability of 45 companies that were listed at Nairobi Stock Exchanges (NSE) for the period 2005-2010. According to the findings, the market was very sensitive to the adoption of ICT at NSE. Similar to the previous paper findings (Bhunia, 2011), studied the growth of the Indian Stock Exchanges as a result of the effect of ICT with a modified version of the Gompertz technology diffusion model. The paper covered the period between 2001 and 2011. The empirical findings showed that ICT contributed to growth in the Indian capital market. In addition to this (Chaiboonsri & Chaitip, 2013), studied the relationship between Thailand's stock market index (SET) and stock prices of ICT firms True, DTAC, and AIS. Maximum Entropy Bootstrap (MEB) was used in the study to test the time series econometric models for the period between 2008 and 2012. The study findings indicated a significant relationship between variables with the powerful tool Maximum Entropy than conventional statistics.

Also (Friday & OsonduMary, 2014), evaluated the effect of information technology on some selected developed and emerging markets, using a simple percentage and multiple regression analysis for the period from 2001 to 2010. The findings revealed that ICT development indicators were all correct and positively signed. In another study (Okwu, 2015), analyzed the effect of ICT on the Nigerian and Johannesburg Exchange, which were stock markets related to the African continent. The panel data analyzing method was used for the period from 1995 to 2014 in this study. The findings showed that ICT adoption had heterogeneous effects during the study period. Also (Anyiam *et al*., 2015), analyzed the effect of Information Technology on the Global capital markets operation. The samples included 10 developed markets and 10 emerging markets. A simple percentage and multiple regression analyses were used in the study for the period from 2001 to 2010. Study findings showed that there was a positive relationship between existing variables and information technology, which contributed to the growth of the Global equity markets. Most recently (Pradhan *et al.*, 2018), studied the interaction between the diffusion of mobile phones, financial development, foreign direct investment, ICT goods imports, and economic growth using panel data analysis. The study involved the G-20 countries for the period from 1990 to 2014. The results showed that there was a network of short-run and long-run causal relationships between variables. The paper mentioned to decision-makers in the G-20 nations who are willing to invigorate the dissemination of mobile phones in the long term should have as a priority for impelling their economic development, as well as procuring inflows of foreign direct investment and improving the financial sector.

MATERIALS AND METHODS

Materials

The goal of this study is to analyze the long-run relationship between the capital market index and ICT indicators in G7 and E7 countries. Our analysis is based on panel co-integration which uses cross-section panel data annually for the period from 2003 to 2019. This paper gives place to secondary data obtained from The World Federation of Exchanges (WFE) and The World Bank.

As following we take capital market indexes as the dependent variable. We also take ICT indicators as the independent variables, which are fixed telephone subscriptions, mobile telephone subscriptions, and individuals using the internet.

- Stock market indexes- The stock market index is one of the measurements of stock market performance. The analysis covers the following indexes which are G7 for S&P/TSX composite (Canada), CAC40 (France), DAX (Germany), FTSEMIB (Italy), Nikkei225 (Japan), FTSE 100 (United Kingdom), S&P500 (United States). E7 for Shanghai Composite index (China), S&P BSE SENSEX index (India), Jakarta Stock Exchange Composite index (Indonesia), Bovespa 50 IBRX (Brazil), IPC index (Mexico), RTS index (Russia), BIST 100 (Turkey).
- Fixed telephone subscription- Fixed telephone subscription is defined as the sum of an active number of analog fixed telephone lines, voice-over-IP subscription, fixed wireless local loop subscriptions, ISBN voice-channel equivalents, and fixed public payphones (WorldBank, 2020).
- Mobile telephone subscription- Mobile cellular telephone subscription is subscriptions to a public mobile telephone service that provides access to the PSTN using cellular technology (WorldBank, 2020).
- Internet users- Internet users are individuals who have used the Internet (from any location) in the last 3 months. Individuals using the internet are a measured percentage of the population(WorldBank, 2020).

Fixed Telephone Subscription

Table 1 below presents descriptive statistics and correlation analysis for G7 and E7 countries. Stock market indexes range between 183.25 to 49354.42 with the lowest value of the index at 183.25 which is the value of BIST 100 in Turkey in 2003, while the highest value of the capital market index at 49354.42 which is the value of the IPC index in Mexico in 2017. Internet users range between 1.69 and 94.90 percent of the population. The lowest value of internet users is 1.69, that of India in 2003, while the highest value of internet users at 94.90, that of the United Kingdom in 2018. The highest value of fixed telephone and mobile telephone subscriptions belongs to China in 2019.

Table 1. Data's descriptive statistics and Correlation analysis

	INDX	FTEL	MTEL	NET
Mean	10291.95	44967174	2.25E+08	53.73
Median	6207.65	25719739	98359300	60.20
Maximum	49354.42	4.49E+08	1.75E+09	94.90
Minimum	183.25	140362	13291000	1.69
Std. Dev.	10924.85	63451379	3.12E+08	27.75
Skewness	1.62	3.58	2.71	-0.37
Kurtosis	5.14	18.71	10.207	1.82
Jarque-Bera	150.10	2957.81	807.99	19.28
Probability	-	-	-	-
Sum	2449484	1.07E+10	5.35E+10	12788.47
Sum Sq. Dev.	2.83E+10	9.54+17	2.30E+19	182626.8
Observations	238	238	238	238

Notes: The sample period is from 2003 to 2019. The capital market index is taken as a dependent variable and fixed telephone subscription, mobile telephone subscription, and internet users (individuals using the internet computed percentage of population) as independent variables.

Methods

Our empirical analysis begins with an explanation of the regression equation, followed by a theoretical explanation of Panel Unit Root Test, Panel Co-integration tests, and Panel Fully Modified Least Squared Method. Then, we revealed the results of the analysis.

As we mentioned, consider a regression model as:

$$\gamma_{it} = \alpha_{it} + \beta_{1i}X_{1it} + \beta_{2i}X_{2it} + \beta_{3i}X_{3it} + \dots + \cdots \beta_{ki}X_{kit} + \varepsilon_{it} \quad (1)$$

Where: α, β_1, β_2, β_3 are unknown parameters that need to be calculated

γ = Stock market index as a dependent variable

i= 1, 2, … N indicates each country in the panel

t= 1, 2, … T refers to the time period in the panel

X_1 = Fixed telephone subscription as the independent variable

X_2= Mobile telephone subscription as the independent variable

X_3 = Individuals using the Internet (percentage of population) as the independent variable

ε_i = Error term for the observation

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Unit Root Test

First, (Abuaf & Jordion, 1990) employed a panel unit root test for the real exchange rate. The researchers began to examine this test in various sectors around the world. Nowadays, the panel unit root test has contributed to theoretical and empirical literature as well (Akarsu, 2013). To carry out a co-integration test, the stationary of the variables should be considered. The following four-unit root test can be conducted; Levin, Li, and Chu (Common root); Im, Pesaran Shin (Individual root); Fisher-ADF (Individual root), and Fisher-PP (Individual root). In this paper, we used four of them to test the stability of variables.

Table 2. Summary of Unit Root test for stability

	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*	Statistic	Prob*
Method	Index		Ftel		Mtel		Net	
Levin, Lin and Chu	-0.686	0.246	-1.403	0.08	-4.665	0.00	0.739	0.77
Im, Pesaran and Shin W-stat	1.223	0.889	1.818	0.965	-3.055	0.00	2.871	0.99
ADF- Fisher Chi-square	28.25	0.450	25.037	0.625	58.02	0.00	30.403	0.34
PP- Fisher Chi square	34.46	0.185	9.284	0.999	158.102	0.00	63.980	0.00
Unit root test variables expressed in logarithms								
	Statistic	Prob**	Statistic	Prob**	Statistic	Prob**	Statistic	Prob**
Method	Index		Ftel		Mtel		Net	
Levin, Lin and Chu	-4.870	0.000	-14.375	0.000	-17.399	0.000	-8.138	0.000
Im, Pesaran and Shin W-stat	-1.909	0.028	-6.657	0.00	-12.482	0.000	-4.692	0.000
ADF- Fisher Chi-square	41.847	0.040	198.110	0.00	404.343	0.000	73.459	0.000
PP- Fisher Chi square	71.209	0.00	538.38	0.00	937.656	0.000	151.37	0.000

Note The lag length selection is based on Akaike Info Criterion (AIC). Maximum number of lag is range between 1 to 3 for all variables. In addition prob * stands for the level of significance at 5%. ** An asymptotic Chi-square distribution is used when probabilities for the Fisher test are estimated. All other tests consider asymptotic normality.

As shown in **Table 2**, all the tests reject the null hypothesis that variables are stable, except internet users. In the panel cointegration test, all the variables should be stable for the same level. Therefore we need to express all the variables in logarithms. As highlighted above the **Table 2** indicated that the result of the unit root test after variables expressed in logarithms. To conclude, variables are stable. Based on panel unit root tests, one can use panel co-integration analysis to get the result of the long-run association between capital market and ICT indicators.

Panel Cointegration Tests

Engle and Granger first presented the view of co-integration in time series econometrics (Engle & Granger, 1987). Then other researchers extended it with various co-integration test approaches such as residual-based, error correction-based. Also, unbalanced panels, cross-section, and methods are important points when analyzing panel co-integration (Verbeek, 2004). Types of panel co-integration tests are Pedroni (Engle-Granger based), Kao (Engle-Granger based), and Fisher (combined Johansen). In this paper, we used two of them: Pedroni and Kao tests.

Pedroni (Engle-Granger Based) Cointegration Tests

(Pedroni, 1999) computed the regression residuals from the hypothesized cointegrating regression. In the most general case, the following regression form is taken (Pedroni, 1999).

$$y_{it} = \alpha_i + \delta_{it} + \beta_{1i}X_{1it} + \beta_{2i}X_{2it} + \beta_{3i}X_{3it} + \beta_{Mi}X_{Mit} + \epsilon_{it} \quad (2)$$

For t = 1, …, T; i = 1, … N; m = 1, …, M

Where T represents the number of observations over time, N refers to the number of individual members, and M refers to the number of regression variables. Present that the slope coefficients $\beta_{1i}, \beta_{2i}, \beta_{3i}, \ldots, \beta_{Mi}$ are permitted to vary across individual members of the panel. The parameters α_i is the member-specific intercept, or fixed-effects parameter which is allowed to vary across individual members. Also, some applications include deterministic time trends which are specific to individual members of the panel and are captured by the term δ_{it} (Pedroni, 1999). The general approach is to obtain residuals from Equation (2).

$$\epsilon_{it} = \rho_i \epsilon_{it-1} + u_{it} \quad (3)$$

or

$$\epsilon_{it} = \rho_i \epsilon_{it-1} + \sum_{j=1}^{p_i} \varphi_{ij} \Delta\epsilon_{it-j} + u_{it} \quad (4)$$

A consequence of distinction arises in the terms of the autoregressive coefficient y_i of the estimated residuals under the alternative hypothesis of cointegration.
For the within-dimension statistics the test for the null of no cointegration implemented as a residual-based test of the null hypothesis H₀ : $y_i = 1$ for all i, versus the alternative hypothesis H₁: $y_i = y < 1$ for all i, so that it presumes a common value $y_i = y$. By contrast, for the between-dimension statistics the null of no cointegration is implemented as a residual-based test of the null hypothesis H₀ : $y_i = 1$ for all i, versus the alternative hypothesis H₁ : $y_i = y < 1$ for all i, so that it does not presume a common value for $y_i = y$ under the alternative hypothesis (Pedroni, 1999). As shown in Appendix, the Pedroni test present seven statistics which four are based on within-dimension and three are based on between-dimension.

Kao test (Engle-Granger) Cointegration Tests

Kao test derived from residual-based tests of cointegration like the Pedroni tests. But, the difference of Kao test is that it examines the fixed effect model that Pedroni does not focus on. Also, Kao deals with the bivariate process with a zero mean vector and the long-run covariance in the model (Kao, 1999). In Kao tests following equations we have,

$$y_{it} = \alpha_i + \beta X_{it} + \epsilon_{it} \quad (5)$$
For $y_{it} = y_{it-1} + u_{it}$ (6)
$$X_{it} = X_{it-1} + \epsilon_{it} \quad (7)$$

for $t = 1, \ldots, T$; $i = 1, \ldots, N$.

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According to the Kao test, the limiting distributions of residual-based cointegration are derived from Dickey-Fuller tests and Augmented Dickey-Fuller when using the model (Kao, 1999). The DF test can be applied;

$$\epsilon_{it} = \rho\epsilon_{it-1} + u_{it} \tag{8}$$

or the augmented version of the pooled specification,

$$\epsilon_{it} = \hat{\rho}\epsilon_{it-1} + \sum_{j=1}^{\rho} \varphi_i \Delta\epsilon_{it-j} + u_{it} \tag{9}$$

Under the null of no cointegration, Kao shows that following the statistics,

$$DF_p = \frac{T\sqrt{N}(\hat{\rho}-1) + 3\sqrt{N}}{\sqrt{10.2}} \tag{10}$$

$$DF_t = \sqrt{1.25}t_p + \sqrt{1.875N} \tag{11}$$

$$DF^*{}_p = \frac{\sqrt{NT}(\hat{\rho}-1) + 3\sqrt{N\hat{\sigma}^2{}_v \,/\, \hat{\sigma}^2{}_{ov}}}{\sqrt{3 + 36\hat{\sigma}^4{}_v/(5\hat{\sigma}^4{}_{ov})}} \tag{12}$$

$$DF^*{}_t = \frac{t_p + \sqrt{6N\hat{\sigma}_v/(2\hat{\sigma}_{ov})}}{\sqrt{\hat{\sigma}^2{}_{ov}/(2\hat{\sigma}^2{}_v) + 3\hat{\sigma}^2{}_v/(10\hat{\sigma}^2{}_{ov})}} \tag{13}$$

and for p > 0 (i.e. the augmented version),

$$ADF = \frac{t_p + \sqrt{6N\hat{\sigma}_v/(2\hat{\sigma}_{ov})}}{\sqrt{\hat{\sigma}^2{}_{ov}/(2\hat{\sigma}^2{}_v) + 3\hat{\sigma}^2{}_v/(10\hat{\sigma}^2{}_{ov})}} \tag{14}$$

where $\hat{\sigma}^2{}_v$ and $\hat{\sigma}^2{}_{0v}$ are consistent estimates of $\sigma^2{}_v$ and $\sigma^2{}_{0v}$.
Converge to N(0, 1), where the estimated variance is
$\hat{\sigma}^2{}_v = \hat{\sigma}^2{}_u - \hat{\sigma}^2{}_{u\epsilon}\sigma^{-2}{}_\epsilon$ with estimated long-run variance $\hat{\sigma}^2{}_{0v} = \hat{\sigma}^2{}_{0u} - \hat{\sigma}^2{}_{0u\epsilon}\hat{\sigma}^{-2}{}_{0\epsilon\epsilon}$.
The covariance of $w_{it} = \begin{pmatrix} u_{it} \\ \epsilon_{it} \end{pmatrix}$ is estimated $\sum = \begin{pmatrix} \hat{\sigma}^2{}_u & \hat{\sigma}_{u\epsilon} \\ \hat{\sigma}^2{}_{u\epsilon} & \hat{\sigma}^2{}_\epsilon \end{pmatrix} = \frac{1}{NT}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{w}_{it}\hat{\acute{w}}_{it}$ and the long-run covariance is:

$$\aleph = \begin{pmatrix} \hat{\sigma}^2{}_{ou} & \hat{\sigma}_{ou\epsilon} \\ \hat{\sigma}^2{}_{ou\epsilon} & \hat{\sigma}^2{}_{o\epsilon} \end{pmatrix} = \frac{1}{N}\sum_{i=1}^{N}\left[\frac{1}{T}\sum_{t=1}^{T}\hat{w}_{it}\,\hat{\acute{w}}_{it} + \frac{1}{T}\sum_{t=1}^{l}\varphi_{\tau l}\sum_{t=\tau+1}^{T}(\hat{w}_{it}\hat{\acute{w}}_{it-\tau} + \hat{w}_{it-\tau} + \hat{\acute{w}}_{it}\right] \tag{15}$$

Where $\varphi_{\tau l}$ is a weight function or a kernel. Usually, kernels are truncated by the bandwidth parameter / so that $\varphi_{\tau l} = 0$ for τ>1 (Kao, 1999).

Table 3. Result of Pedroni and Kao tests for panel cointegration

Alternative hypothesis:	common AR coefs (within-dimension)			
Pedroni test	Statistic	Prob	Weighted Statistic	Prob

Panel v-Statistic	-1.767928	0.9615	-2.440842	0.9927
Panel rho-Statistic	0.492091	0.6887	0.402599	0.6564
Panel PP-Statistic	-5.443676	0.0000	-5.931486	0.0000
Panel ADF-Statistic	-3.576876	0.0002	-4.558607	0.0000

Alternative hypothesis:	individual AR coefs (between-dimension)	
	Statistic	Prob
Group rho- Statistic	2.040020	0.9793
Group PP-Statistic	-10.79117	0.0000
Group ADF- Statistic	-4.349994	0.0000

Kao test	t-Statistic	Prob.
ADF	-2.072992	0.0191

Residual variance	0.078977
HAC variance	0.040167

As shown in **Table 3** related to Pedroni co-integration tests, four of the seven test statistics reject the null hypothesis, there is no cointegration relationship between dependent and independent variables. Therefore, we can conclude that there is a long-term relationship between capital market indexes and ICT indicators. The result of the analysis indicated the association is both homogeneous and heterogeneous. According to the Kao test that we use for the panel co-integration test, the test rejects the null hypothesis, that there is no co-integration. Therefore; it also accepts the alternative hypothesis that there is co-integration between variables.

Fully Modified Ordinary Least Square Method

In panel co-integration analysis, two different methods, FMOLS (Fully Modified Ordinary Least Square) test and Panel DOLS (Dynamic Ordinary Least Square) test, can be used for research. In this paper, we use the Panel Fully Modified Least Squares (FMOLS) method to get a long-term equation for coefficient.

$$Ln(indx) = \alpha_{it} + \beta_{it} + \beta_1 Ln(Ftel) + \beta_2 Ln(Mtel) + \beta_3 Ln(Net) + \varepsilon_{it} \quad (16)$$

Where α_{it} is country-specific fixed effects, and β_{it} is country-specific time trends, ln(index) is the log of the stock market index, ln(Ftel) is the log of fixed telephone subscription, ln(Mtel) is the mobile telephone subscription, ln(Net) is the individuals using the internet (percentage of population), ε_{it} is implying that no relevant integrated variables are omitted (Herzer & Vollmer, 2012).

Method of Fully Modified Least Squared Method Hypothesis

H0: There is an absence of a significant long-term relationship between the stock market index and ICT indicators.

H1: There is a significant long-term relationship between the stock market index and ICT indicators

Table 4. Result of Panel Fully Modified Least Squared Method

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNFTEL	-0.071927	0.022124	-3.251143	0.0013
LNMTEL	0.492034	0.013581	36.22997	0.0000
LNNET	0.114707	0.019722	5.816106	0.0000

R-squared	0.949884	Mean dependent var	8.660741
Adjusted R-squared	0.945934	S.D. dependent var	1.206461
S.E. of regression	0.280528	Sum squared resid	15.97531
Long-run variance	0.045282		

As shown in **Table 4**, using the panel FMOLS method, we found that the values of two independent variables were significant. It indicates a significance level of 0.0000 for two independent variables. Furthermore, the Prob value is less than 0.05 significant level ($P < 0.05$), thus, we reject the null hypothesis (H0), and accept the alternative hypothesis (H1) for two variables. Based on the analysis above, we can conclude that ICT indicators, which are mobile telephone subscriptions and individuals using the internet, have a significant effect on stock market indexes for G7and E7.

Equation of Fully Modified Least Squared Method:

$$LNINDX = -0.07192*LNFTEL + 0.49203*LNMTEL + 0.11470*LNNET \quad (17)$$

As can be seen in the equation above, the Panel FMOLS result indicates that a 1% increase in fixed telephone subscription leads to a 0.07 % decrease in the capital market index. A 1% increase in mobile telephone subscriptions leads to an increase in the capital market index by 0.49%. In response to a 1% increase in internet users, the capital market index increases by 0.11%. In detail, we also employ the FMOLS method for G7 and E7 separately.

Table 5. Result of Panel Fully Modified Least Squared Method for G7 and E7

Dependent Variable: G7 LINDX					Dependent Variable: E7 LINDX				
Variable	Coefficient	Std. Error	t-Statistic	Prob.	Variable	Coefficient	Std. Error	t-Statistic	Prob.
LFTEL	-0.233586	0.035849	-6.515.796	0.0000	LFTEL	0.043380	0.038365	1.130.713	0.2608
LMTEL	0.670467	0.012095	5.543.540	0.0000	LMTEL	0.311030	0.025357	1.226.626	0.0000

LNET	-0.315836	0.026549	-1.189.631	0.0000	LNET	0.219330	0.027578	7.952.964	0.0000
R-squared	0.912531	Mean dependent var		8.859.024	R-squared	0.956232	Mean dependent var		8.396.290
Adjusted R-squared	0.907548	S.D. dependent var		0.914541	Adjusted R-squared	0.952370	S.D. dependent var		1.427.417
S.E. of regression	0.278074	Sum squared resid		1.221.738	S.E. of regression	0.311522	Sum squared resid		9.898.705
Long-run variance	0.053966				Long-run variance	0.053882			

$$LINDX = -0.233586014192*LFTEL + 0.670467237661*LMTEL - 0.315835646005*LNET \quad (18)$$

As can be seen in the **Table 5**, FMOLS model result has shown for G7 and E7. According to the FMOLS method for G7 countries, all the variables significantly cause of Prob value less than 0.05. Based on the analysis result, we reject the null hypothesis (H0) and accept the alternative hypothesis (H1). We conclude that fixed telephone subscriptions, mobile telephone subscriptions, and the number of individuals using the internet have a significant effect on G7 stock market indexes. For the representation of method Equation (18), mobile telephone subscription has a positive effect while fixed telephone and internet users have a negative effect on stock market indexes for G7.

$$LINDX = 0.0433803549292*LFTEL + 0.311029719532*LMTEL + 0.21932976163*LNET \quad (19)$$

According to the FMOLS method above for E7, the null hypothesis (H0) is rejected and the alternative hypothesis (H1) is accepted. In particular, ICT indicators which are mobile telephone subscriptions and internet users have a significant effect on stock market indexes. We conclude that all the variables have a positive effect on stock market indexes for E7.

CONCLUSION

The goal of this study is to investigate relationship between the stock market index and ICT indicators, which are fixed telephone subscription, mobile telephone subscription, and internet users (individuals using the internet percentage of population). The study data involves the period from 2003 to 2019 for G7 and E7 countries. In analysis, the stock market indexes are taken as a dependent variable, and ICT indicators are taken as independent variables. We used panel co-integration tests, Pedroni and Kao, to analyze the long-run relationship between the stock market index and ICT indicators in all the countries. In addition, we used the panel co-integrating Fully Modified Least Square method to support the Pedroni and Kao test results and get coefficients for a long-term relationship between variables.

To carry out the panel co-integration tests, we analyzed the stability of variables beforehand by using Unit Root tests, the Levin, Li, and Chu (Common root); Im, Pesaran Shin (Individual root); Fisher-ADF (Individual root), and Fisher-PP (Individual root). According to the results of the stability tests, we found that all the variables needed to differ except mobile telephone subscriptions and internet users. Therefore, all the variables are taken as Logarithms in the analysis.

After that all the variables instability at the same level, we examined the Panel Pedroni and Kao tests. Regarding the panel tests, we found that the null hypothesis was rejected, that there was no co-integration relationship. Therefore, an alternative hypothesis that a co-integration relationship existed between stock market indexes and ICT indicators was accepted. We used panel co-integration Fully Modified Least Squared method to get coefficient for the long-term relationship between variables and support the result of panel co-integration tests. According to the FMOLS method results, especially mobile telephone subscriptions and individuals using the internet had a significant and positive effect on the stock market in G7 and E7. The coefficients were revealed for a long-term relationship between variables as shown in Equation 170. We also used the method by a group. Analysis results of G7s indicate that the mobile telephone subscriptions have a positive effect and other variables negative. Analysis results of the E7 group show that all the ICT variables have a significant effect and the variables are significant except fixed telephone subscriptions.

It is recommended that the effect of ICT indicators on the stock market be studied in the context of different sectors.

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