The Relationship Between Information and Communication Technology, Financial Development, Electricity consumption and Economic Growth in OECD countries: A Panel Investigation

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INTRODUCTION

Over the past few decades, the Information and Communication Technology (ICT) sector has been growing rapidly across the globe. ICT is a general term that encompasses all means of collecting, storing, editing and communicating (Kundishora, 2010). The ICT sector is quite extensive, covering various technologies by which signals can be stored, received or transmitted electronically. ICT plays a very vital role which cannot be overstated in global development. Its contributions range from provision of new methods of communication to innovations that have given rise to new industries. For example, according to Salahuddin and Alam (2016), the United Nations Development Program (UNDP) agrees that internet use improves market efficiency, creates economic opportunities, enhances productivity and promotes political participation; they therefore suggested that access to internet should be viewed as a basic human right in our contemporary society.

There is an abundance of literature on the relationship between ICT and its effects on economic growth (Colcchia et al, 2001; Iskandarani, 2015; Chavanne et al, 2015; Hofman et al, 2016). The increased interest in this area is as a result of the significant rise in ICT use and its resultant effect on the economic growth of countries all over the world (Chavanne et al, 2015). ICT has been shown to tremendously contribute to improvements in productivity and energy efficiency (Erdmann & Hilty, 2010; Shahiduzzaman & Alam, 2014; Ishida, 2015).

In the same vein, several studies exist that have also investigated the relationship between ICT use and electricity. According to Van Heddeghem et al, (2014), electricity consumption caused

by ICT products and services has greatly increased. And pressure on domestic demand for electricity consumption is attributed to the rapid growth in the use of ICT. And many of these studies show that the continuous rise in ICT usage puts some pressure on domestic demand for electricity consumption (Salahuddin & Alam 2015; Salahuddin, Alam & Ozturk, 2016). Yet, it is generally believed that the benefits of ICT far outweigh its disadvantages. This is the main reason why governments invest extensively in ICT use (particularly internet use) in spite of the pressure it places on electricity consumption. A typical example is the case of OECD countries over the past two decades (Zhang, 2013).

Past consideration has been given to the effect of ICT on electricity consumption, carbon-dioxide emission, productivity as well as gross domestic product per capita among many others (Salahuddin, Alam & Ozturk, 2016), (Salahuddin & Alam, 2014, 2015, 2016).

This particular study deviates from previous studies in terms of examining to what extent ICT use impacts and is impacted by variables which includes electricity consumption, financial development and economic output in OECD countries. The position of ICTs in the financial sector development should not be overlooked as it plays significant role in the enhancement of financial sector infrastructure as well as information delivery. The current study intends to fill the gap in the literature by giving consideration to the inclusion of financial development in the variables of consideration among many others. Therefore, the study seeks to investigate how the use of ICT is affected by electricity consumption, financial development and economic growth. The study queries the interaction among the variables under review. This study will be the first, to the author's best knowledge, to investigate the relationship between these variables in the

context of OECD countries in a panel framework. And consideration will be given to the periods between 1990 and 2014.

The organization of this paper is as follows. The next section is on the literature survey. Section 3 dwells on the methodology and econometrics procedure. Section 4 gives the empirical findings and sections 5 finally presents the conclusion and policy implications emanating from the study.

LITERATURE REVIEW

It is not news that the world is a global community especially as it exposes us to different cultures and ways of life. This exposure is made possible with the aid of information and communication technologies (ICTs). This has led several economies to accept new order of governance and even adjustment to demand as a necessity. We cannot overemphasize the level of impact that ICT has on any economy in this modern time. According to Marshall, Taylor and Yu (2003), ICTs relate economic and social development efforts at the regional level with promising opportunities in areas not limited to electronic commerce, community and civic networks and telecenters, electronic democracy and online participation, self-help and virtual health communities, but also advocacy, cultural enhancement, and others. Iskandarani (2008) pointed out that the world is connected in several ways especially by internet, earning it the popular term “global village”. This allows for multi facet interdependence and relationship among others for growth and development.

Information and communication technologies (ICT) have a wide array of effects on the global systems (Moyer and Hughes, 2012). According to Shahiduzzaman and Alam (2014), the rapidity in the use and expansion of technologies have significantly contributed to increase in productivity and boosting of economic growth.

In the study of the contribution of investment on Information and Communication technology by Vu (2011) is an evaluation which involves a division into two streams which includes employment of growth accounting in the estimation of the contribution of ICT investment to GDP growth in one, and the use of cross country regression techniques in the assessment of the effects of ICT on economic growth in the other. For United States, this study is consistent with the works of Jorgenson (2001), Jorgenson and Stiroh (2000), Oliner & Sichel (2000), while for United Kingdom in agreement with the work of Oulton (2002); for Finland, the work is in agreement with Jalava and Pohjola (2002); in accordance with Jorgenson and Motohashi (2005) for Japan; in harmony with the works of Colecchia and Schreyer (2001), Daveri (2002), Timmer, Ypma & Van Ark (2003), and Van Ark, Melka, Mulder, Timmer & Ypma (2002) for EU economies; compatible with the work of Jorgenson (2003) for the G7 economies; and as well as Jorgenson and Vu (2007) for 110 countries.

Other views in line with these popular ones which have also gained convincing evidence on the growth effect of investments in ICT can be found in the panel data analysis done by Dewan and Kraemer (2000) involving thirty-six countries with consideration given to the years between 1985 – 1993, the result showed a significant and positive relationship between IT and investment in developed countries and statistically insignificant for developing countries. Similar analysis was carried out by Pohjola (2002) who considered a sample of 44 countries between the years 1985-1999 and the result showed no significant correlation between ICT investment and growth. Another analysis done by Jacobsen (2003) who considered a sample of 84 countries between the years 1990–1999, established a positive and significant relationship between mobile phone and growth but did not reveal any significant growth effect from computer penetration. However, Hofman, Aravena & Aliaga (2016) has it in their investigation that the gap in ICT capital which

works against the enhancement in human capital in the Latin-America can be linked to the persistent gap in labor productivity, therefore main source of growth can be attributed to the contribution of capital in fastest growing industries and developing countries.

According to Mohammad and Khorshed (2015), literature investigating the relationship between electricity consumption and economic growth is quite enormous.

Yoo (2006) looked into causality between real GDP and electricity consumption considering four ASEAN countries between the periods of 1971 and 2002, the result revealed a unidirectional and bidirectional relationship in Indonesia and Thailand, and as well as Malaysia and Singapore respectively. Wolde-Rufael (2006) engaged Toda-Yamamoto Granger causality, the findings showed that GDP per capita Granger-causes electricity consumption for six countries out of 17 African countries. In the study done by Sadorsky (2012), the use of GMM techniques was employed and it was found that there is a positive and statistically significant relationship between ICT and electricity consumption. Ozturk and Acaravci (2011), in their study of most of the countries among MENA countries within the period of 1971 and 2006, found no evidence of support for positive relationship between electricity consumption and economic growth. Among all is the work on the investigation of internet usage, electricity consumption and economic growth in Australia between the years 1985 and 2012 done by Mohammad and Khorshed (2015), which revealed that internet usage and economic growth stimulate electricity consumption. Also, the work of Salahuddin, Gow & Ozturk (2015) on the investigation of long run and short run relationship between economic growth, electricity consumption, carbondioxide emissions and financial development with consideration given to GCC countries between the periods of 1980 and 2012, showed that electricity consumption and economic growth stimulate CO_2 emissions in GCC countries while financial development reduces it.

Shamim (2007), the pioneer who provided empirical evidence that the component of financial sector developed by better telecommunication infrastructure is positively associated with long run economic growth, found out that an increase in mobile phone subscribers and internet users affect financial depth positively. This finding is in line with the conclusion of Claessens *et al*. (2002) that developing countries need to promote ICT sector and exploit opportunities for leapfrogging. The works of Jacobsen (2003) and Ozturk & Acaravci (2011) call for further inquiry into the effect of ICT penetration on growth and relationship between electricity consumption and economic growth, and ICT and financial development with more recent data.

METHODOLOGY

This study utilizes panel econometrics to investigate the dynamic nexus between ICT, financial development, electricity consumption and economic growth for 16 OECD[1] countries in a balanced panel framework. The number of the countries investigated is restricted because of data availability. The variables for this study are; individuals using internet, electricity power consumption (kwh per capita), domestic credit to private sector and real GDP per capital (measured at constant 2010 US$). The current study data spans from 1990 to 2014 on an annual frequency. Data were retrieved from World Development Indicator (WDI). This study leverages after the studies of Narayan (2010) and Salahuddin & Alam (2015). The study models ICT as a function of electricity consumption, financial development and economic growth.

Model Specification

The functional form relationship to investigate the theme under consideration is given below as;

[1] The list of the countries investigated in the current study are; Australia, Canada, Chile, Denmark, Iceland, Israel, Japan, Korea, Mexico, New Zealand, Norway, Poland, Switzerland, Turkey, the United Kingdom, and the United States.

$$ICT = f(ELC, FD, RGDPC) \qquad eqn.1$$

Here, ICT indicate the variable for internet usage, FD is financial development, and RGDPC is real gross domestic product per capita.

$$ICT_{it} = \alpha + \beta_1 \ln ELC_{it} + \beta_2 \ln FD_{it} + \beta_3 \ln RGDPC_{it} + \varepsilon_{it} \qquad eqn.2$$

Here, i=1, 2….N and t=1, 2….T. Also α is constant while $\beta_{1,}\beta_2, \beta_3$ are partial slope co-efficient and ε_{it} is the stochastic term which is expected to be ~N (IID)

EMPIRICAL RESULTS

This paper proceeds with summary statistics of the variables under review as presented in Table 1. The low standard deviation in the series implies that the data are evenly dispersed around the mean. All series are not normally distributed with the rejection of Jarque P-value. This is validated by the negative skewedness observed among the series. However, further estimation is carried out on the series.

Table 1: Descriptive statistics

		Mean	Median	Max	Min	Std. Dev.
Australia	ELC	9938.133	10213.04	10972.89	8522.159	844.8679
	FD	94.99616	91.48595	129.2011	60.0984	24.74719
	GDPC	45110.11	45626.62	54293.79	34967.52	6610.222
	ICT	42.81945	43.88329	84	0.585095	31.13211
Canada	ELC	16326.69	16385.4	17235.41	15269.57	574.5956
	FD	127.9608	124.4069	188.7536	89.15883	33.90226
	GDPC	43298.07	44883.83	50080.03	35108.52	5189.165
	ICT	47.56879	61.5933	87.12	0.361	33.80286
Chile	ELC	2651.252	2738.479	3911.649	1240.661	855.698
	FD	72.89816	74.94107	108.3908	41.05306	22.78415
	GDPC	10305.35	9852.834	14701.95	5947.765	2605.195
	ICT	22.85588	22.1	61.11	0	21.3956
Denmark	ELC	6399.872	6490.093	6824.746	5858.802	252.1963
	FD	114.8676	140.0954	201.2587	30.26378	68.37508
	GDPC	54427.84	56190.81	61174.55	44569.01	5393.196
	ICT	50.72176	64.25	95.99	0.097277	38.81383

Iceland	ELC	31264.4	27666.39	54799.17	15931.14	14516.98
	FD	116.2547	98.01272	312.1179	41.51396	74.29087
	GDPC	37754.55	37512.27	46695.21	29421.01	5862.973
	ICT	56.51227	79.12	98.16	0	38.51715
Israel	ELC	6031.443	6502.74	7184.502	3981.208	971.4348
	FD	66.85928	67.9378	79.87204	49.03475	8.452844
	GDPC	27075.35	26947.44	32661.29	21141.3	3347.576
	ICT	28.29557	19.59339	75.01775	0.110774	27.66394
Japan	ELC	7960.316	8020.274	8710.026	6805.54	517.1598
	FD	189.4113	186.361	221.2885	172.9017	14.26699
	GDPC	42561.54	42239.11	46466.12	37906.16	2477.384
	ICT	42.18534	46.5942	89.10683	0.020294	34.12143
Korea	ELC	6509.697	6673.938	10496.51	2373.214	2721.647
	FD	96.73018	109.7758	148.3405	49.52033	38.4513
	GDPC	16494.7	16734.85	24323.57	8464.937	4963.365
	ICT	46.11455	59.4	87.55683	0.023265	36.87307
Mexico	ELC	1735.969	1796.77	2187.228	1165.399	318.276
	FD	21.25354	20.92488	30.91462	13.4464	5.15592
	GDPC	8457.791	8494.839	9492.991	7257.931	712.9225
	ICT	14.26336	11.9	44.39	0	15.22398
New Zealand	ELC	9269.443	9360.949	9700.091	8636.634	300.2217
	FD	111.88	107.6445	144.4081	73.01237	24.04539
	GDPC	30462.37	31233.91	36006.02	23782.89	3965.73
	ICT	46.08322	59.08075	85.5	0	32.3118
Norway	ELC	24286.49	24214.11	25590.69	22999.93	688.8173
	FD	90.23524	97.57389	128.8608	53.5152	29.46619
	GDPC	80343.51	83732.94	91617.28	60268.66	10046.92
	ICT	54.8233	72.84	96.3	0.707299	37.93816
Poland	ELC	3401.956	3272.302	3971.8	2961.396	324.8563
	FD	29.79749	25.2342	52.33029	12.89473	13.72861
	GDPC	9324.595	8814.267	14088.75	5509.9	2806.382
	ICT	26.80027	21.15	66.6	0	26.23409
Switzerland	ELC	7787.754	7845.635	8360.576	7155.486	381.4036
	FD	152.1	149.2616	169.165	140.5609	7.814404
	GDPC	68570.32	67860.24	76410.86	61602.79	5386.633
	ICT	47.93797	61.4	87.4	0.595714	34.51654
Turkey	ELC	1828.815	1667.423	2854.566	929.6999	619.2823
	FD	27.21106	18.4862	63.79106	14.13509	15.27178
	GDPC	9076.786	8244.497	13312.02	6708.881	1974.071
	ICT	16.37777	11.38	51.04	0	18.2051
United Kingdom	ELC	5775.176	5815.828	6270.984	5129.528	340.1307
	FD	4267.73	130.6635	103469.7	97.99168	20667.1

	GDPC	35658.04	37077.65	41050.41	28291.92	4540.882
	ICT	44.51333	56.48	91.61	0.087355	36.37275
United State	ELC	13009.29	13046.61	13704.58	11713.33	547.1989
	FD	163.6259	171.0911	206.3028	114.4757	29.51548
	GDPC	44458.64	45428.65	50881.11	35803.87	5111.439
	ICT	44.75363	58.7854	75	0.784729	29.02368

Source: Authors computation

Estimation procedures

The empirical procedure of this study is given as;

First, cross-sectional dependency test which is done to check the presence of cross- sectional dependence across the panel. Cross-sectional dependency is detected by Pesaran (2004) CD test.

Second, stationarity test to ascertain stability and stationarity features of the series. This current study relies on Pesaran (2007) unit root rest that account for cross sectional dependency.

Third, to verify the long-run equilibrium relationship among series, bootstrap panel technique advanced by Westerlund and Edgerton (2007) is used.

Finally, learn about the path of causality between the variables, Dumitrescu & Hurlin (2012) Granger causality test is engaged.

The presence of cross-sectional dependency among the series in the study suggests the employment of the second generation panel econometrics techniques. This dependency is informed by the some interaction between unobserved factors among the variables of the paneled countries.

Table 2: Pearson 2004 Cross Sectional Dependency Results

Variable	CD-test	p-value	corr.	abs(corr.)
ELC	27.96*	0.000	0.510	0.585
FD	21.80*	0.000	0.398	0.568
GDPC	51.69*	0.000	0.944	0.944
ICT	51.72*	0.000	0.944	0.944

*Note: H_0: Cross-sectional independency CD ~N (0, 1); * significant at 1%*

The table 2 above reveals the presence of cross-sectional dependency, which exposes the common unobserved effect of the variables under review.

Table 3: Pesaran 2007 Panel Unit root Test

		Critical value (%)		
Variable	CIPS-statistics	10	5	1
ELC	-1.365	-2.07	-2.15	-2.32
GDPC	-1.686	-2.07	-2.15	-2.32
ICT	-2.013	-2.07	-2.15	-2.32
FD	-0.723	-2.07	-2.15	-2.32

Note: All variable were non-stationary at level.

The stationarity of the variable of interest is presented in table 3 above. The need to know the other of integration is pertinent to avoid the trap of spurious regression with no explanatory power. The table reveals that all variables are stationary after first differencing. That is all series are integrated of order one ~I(1).

Table 4: Westerlund & Edgerton (2007) bootstrapping cointegration test

Statistic	Value	Z-value	P-value	Robust P-value
Gt	-1.640	4.887	1.000	0.970
Ga	-4.735	5.372	1.000	1.000
Pt	-3.210	7.059	1.000	0.900
Pa	-3.423	4.593	1.000	0.740

Note: The simulation was carried with bootstrapping regression with 1000 repetitions .Here Gt and Ga test represents the cointegration for each country individually, while Pa and Pt test cointegration of the panel as a whole

Our study proceeds with investigation for long-run equilibrium relationship. Thus, we employ the Westerlund & Edgerton, 2007 cointegration test with null hypothesis of no cointegration against an alternative of cointegration. Table 4 presents the cointegration simulation. Our study fails to find support for cointegration relationship among the variable under review. Thus, this paper proceeds with causal interaction among the series as next test.

Table 5: Dumitrescu Hurlin Panel Causality Tests

Null Hypothesis:	W-bar	Zbar	Prob.
ELC does not granger cause ICT	4.2821	9.2832*	0.0000
ICT does not granger cause ELC	2.8519	5.2380 *	0.0000
FD does not granger cause ICT	3.0795	5.8818*	0.0000
ICT does not granger cause FD	5.7941	13.5596*	0.0000
GDPC does not granger cause ICT	4.5320	9.9900*	0.0000
ICT does not granger cause GDPC	2.6992	4.8062*	0.0000
FD does not granger cause ELC	2.1854	3.3528*	0.0008
ELC does not granger cause FD	2.9647	5.5571*	0.0000
GDPPC does not granger cause ELC	4.5287	9.9807*	0.0000
ELEC does not granger cause GDPC	1.6284	1.7775***	0.0755
GDPC does not granger cause FD	4.8208	10.8067*	0.0000
FD does not granger cause GDPC	1.1463	0.4139	0.6790

**significant at 1%, ** significant at 5%, ***significant at 10%*

The need for causal relationship is also very important to this current study. To do this, the Dumitrescu Hurlin Panel Causality test is conducted. Table 5 reveals a unidirectional causality running from gross domestic product per capita to financial development. This outcome meets the *apriori* expectation, that gross domestic product per capita is a better predictor of financial development. Furthermore, the Dumitresu & Hurlin (2012) Granger causality test has the following revelations: A bi-directional causality running from EPC to ICT, EPC to FD, GDPC to ICT and ICT to FD. The study explains by extension that electricity consumption, gross domestic product per capita and financial development better explain information and communication technology. These feedback causality seen draw attention of policymakers and stakeholder to take decisive actions.

CONCLUSION AND RECOMMEDATION

This study examined the interaction between information and communication technology, financial development and economic growth in selected OECD countries for a period of 1990 to 2014 in a balanced panel framework. The study seeks to investigate the long-run bond among the variables of interest as well as causal relationship. The study employed the bootstrap panel technique advanced by Westerlund and Edgerton (2007) to test for long-run equilibrium relationship among series and Dumitrescu Hurlin (2012) causality tests as estimation techniques.

The study set out first with cross-sectional dependency test among the panel bloc and the result suggests the use of second generation panel econometrics techniques. Hence Pesaran 2007 unit root test for panel data analysis was employed and it is revealed that all variables under investigation are stationary after first differencing. The results of the cointegration test reveals the existence no cointegration relationship among these variables, that is, financial development, electricity consumption and economic growth and ICT all have no long-run equilibrium path for the region under review (OECD). However, for causality interaction, this study show bi-directional causality running from EPC to ICT, EPC to FD, GDPC to ICT and ICT to FD is indicative to policymakers and stakeholders, in the sense that if information and communication technology is enhanced, its multiplier effect would influence electric power consumption and the economy at large given that there is also causality from information and communication technology to financial development.

All these revelation from the causality and empirical outcome come with couple of implications, among which are what decision and policy makers should pay attention to. The OECD region is very strategic in the European Union region. There is a positive but short-run equilibrium

relationship between the variables considered, therefore even though these countries considered still have to explore more in the expansion and use of ICT. Empirical finding from this study is informative to policymakers and stakeholder to strengthen drivers of growth as ICT, electricity and financial development is reliant on economic growth. Therefore, the government should fortify other growth drivers like institutions (Acemoglu & Robinson, 2005; Robinson & Acemoglu, 2012). This by extension translates into improvement in investment and productivity not only in the short-run but also in the long-run.

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