The determinants of ICT: an empirical study for the G8

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Abstract

Information and communication technologies (ICT) are a rapidly growing area of the economy that are crucial to economic growth and present new opportunities. Using time series econometrics on a panel of G8 developing nations, this study illustrates how ICT affects economic growth.

The findings indicate that ICT and economic growth have a beneficial, long-term link. By demonstrating the existence of unidirectional causality, Granger causality analysis enables us to make the claim that investments in ICTs drive economic growth rather than the other way around. Therefore, the G8 nations have a chance to promote sustainable economic growth through the advancement of ICT.

Keywords: Economic growth, ICT, R&D, Causality, G8.

Introduction

Technology for information and communication (ICTs) is crucial to the "new knowledge economy." (Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Brynjolfsson and Hitt, 2011; Bassanini and Scarpetta, 2002; OECD, 2004; Timmer and van Ark, 2005; Holt and Jamison, 2009; Kretschmer, 2012; Biagi, 2017) Several studies have demonstrated the importance of ICTs, innovation, and technological change as determinants of productivity and national growth. ICT has a stronger effect on growth at the business level than at the industry and national levels, according to other studies (Lehr and Lichtenberg, 1999; Brynjolfsson and Hitt, 2000, 2003; Matteucci et al., 2005).

Product design, marketing, production, funding, and organization have all improved as a result of businesses using ICT (Hollenstein, 2004; Bloom et al., 2013). Additionally, by encouraging the development of new goods and services, ICT typically fosters innovation (Becchetti et al., 2003; Carlsson, 2004; Hollenstein, 2004).

These days, it is simple to understand how ICT determinants, especially R&D and education spending, affect the performance of enterprises in industrialized nations. Information and communication technologies are quickly expanding in poor nations, per a recent World Bank research. Information and communication technologies provide developing countries (DCs) with access to the knowledge domain and the ability to foster economic growth, according to a number of studies (Steinmueller, 2001; Lal, 2004; Basant et al., 2011; Tello, 2013; Calza and Rovira, 2011; Gutiérrez, 2012; Akomea-Bonsu, 2012).

Literature Review

An economy is built on the knowledge-based Information and Communication Technologies (ICT).

ICT, innovation, and technological change are seen by many researchers as factors that influence efficiency and growth (Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Brynjolfsson and Hitt, 2000; Bassanini and Scarpetta, 2002; OECD, 2004; Timmer and van Ark, 2005; Holt and Jamison, 2009; Kretschmer, 2012; Biagi, 2017). According to Lehr and Lichtenberg (1999), Brynjolfsson and Hitt (2000, 2003), and Matteucci et al. (2005), their influence on growth and productivity is stronger at the business level than it is at the industry and national levels.

Product creation, marketing, production, financing, and organization are all improved by the usage of ICT in businesses (Hollenstein, 2004; Bloom et al., 2012).

ICT, according to Becchetti et al. (2003), Carlsson (2004), and Hollenstein (2004), is synonymous with innovation And makes et easier t develop new goods and services.

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The performance of industrialized nations is undoubtedly impacted by ICT investment, especially when it is coupled with changes in organizational and human resources (Milgrom and Robert, 1995; Greenan et al., 2001; OECD 2003; Bloom et al., 2012; World Bank, 2016).

Empirical Study

The Im-Pesaran-Shin (IPS), Levine-Lin-Chu (LLC), Im-Pesaran-Chu (Im, Pesaran, and Shin, 2003), and Levine-Lin-Chu (Levine, Lin, and Chu, 2002) tests can be used to confirm the order of integration and identify the point at which the time series variable becomes stationary. Based on the ideas of the traditional Augmented Dickey-Fuller (ADF) test, the LLC and IPS approaches were both put into practice. While the IPS technique investigates intercept and slope coefficient variability, the LLC method examines intercept heterogeneity among group members. Both tests were applied by the ADF individual means statistic across section units.
The test follows the estimation using the following equation:

$$\Delta \mathbf{Y_t} = \boldsymbol{\mu_i} + \boldsymbol{\gamma_i} \mathbf{Y_{it-1}} + \sum_{j=1}^{pi} \boldsymbol{\beta_{ij}} \Delta \mathbf{Y_{it-j}} + \boldsymbol{\delta_i} \mathbf{t} + \boldsymbol{\varepsilon_{it}}$$

For all i and t, εit denotes normally and independently distributed random variables with zero means and finite heterogeneous variances (σ_i^2).
i = 1,2...N; t = 1,2...T; pi is the number of lags retained for the ADF regression; Δ is the first difference (1-L); and Yit is the series for country i in the panel over period t.
For the eight countries, Table 1 shows the potential for a long-term equilibrium relationship between ICT, research and development spending as a percentage of GDP (DepRDV), R&D researchers per million people (CherRDEV), public education spending, total as a percentage of GDP (DepEDUC), and military spending as a percentage of GDP (DepMIL). We shall discuss the presence of long-term associations below, as all variables are stationary in first difference.
Table 1: Unit root tests

	ICT	CHERRDEV	DEPEDUC	DEPMIL	DEPRDEV
At level (au niveau)					
Method					
Levin, Lin & Chu t*	-0.04043 (0.4839)	-1.41197 (0.0790)	-0.48355 (0.3144)	-9.59686* (0.0000)	-1.37979 (0.0838)
Im, Pesaran and Shin W-stat	-0.06770 (0.4730)	-0.92048 (0.1787)	0.13741 (0.5546)	-8.55293* (0.0000)	-1.64413 (0.0501)
ADF - Fisher Chi-square	19.5447 (0.3590)	25.4408 (0.1851)	19.0705 (0.5172)	103.917* (0.0000)	28.1249 (0.1065)
PP - Fisher Chi-square	29.2078 (0.0459)	21.4638 (0.3703)	13.5625 0.8520	122.533* (0.0000)	36.8897 0.0121
firstdifference (1er deffirence)					
Levin, Lin & Chu t*	-11.4079* (0.0000)	-10.8489* (0.0000)	-7.30969* (0.0000)	-15.6458* (0.0000)	-13.8300* (0.0000)
Im, Pesaran and Shin W-stat	-8.52880* (0.0000)	-10.7814* (0.0000)	-5.82153* (0.0000)	-14.6744* (0.0000)	-12.3422* (0.0000)
ADF - Fisher Chi-square	101.692* (0.0000)	125.542* (0.0000)	69.4351* (0.0000)	186.152* (0.0000)	149.588* (0.0000)
PP - Fisher Chi-square	102.193* (0.0000)	140.970* (0.0000)	91.9282* (0.0000)	968.332* (0.0000)	183.442* (0.0000)

Note: ** represents significance at the 1% of significance (bold entries). The null hypothesis is that the variable follows a unit root process*

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Cointegration analysis

Cointegration analysis, first introduced by Granger (1983) and Engle and Granger (1987), is regarded by many economists as one of the most significant new ideas in econometrics and time series analysis
This phrase describes the circumstance in which two or more non-stationary time series are connected in a way that prevents them from diverging over an extended period of time. After that, there are one or more stationary linear combinations of these integrated time series of order I(1) or 1(0). Cointegrating equations are what these combinations are known as.
One of the most interesting approaches for testing the cointegration of a group of time series is the maximum likelihood method proposed by Johansen (1988, 1991). This approach is based on the Vector Autoregressive (VAR) model and has the advantage of not being limited to two series, allowing us to test for the existence of multiple cointegrating relationships.
When figuring out the long-term correlations between variables, this is the most pertinent. The fundamental principle of this cointegration is straightforward: two non-stationary series are cointegrated if their differences are in the same order. The variables in two or more series can be seen as being in a long-term equilibrium relationship if they are cointegrated (Engle and Granger, 1987). In contrast, a lack of cointegration means that the variables have no long-run link; hence, in principle, the posited variables can arbitrarily move
The following is a model of Pedroni (2004) empirical cointegration test equation:

$$\boldsymbol{TIC_{it} = \varphi_{it} + \gamma_i^t + \varphi_{1t}\mathrm{TIC}_{it} + \varphi_{2t}\mathrm{CHERRDEV}_{it} + \varphi_{3t}\mathrm{DEPEDUC}_{it} + \varphi_{4t}\mathrm{DEPMIL}_{it} + \varphi_{5t}\mathrm{DEPRDEV}_{it} + \mu_{it}}$$

With i = 1,2, ..., n denotes each country in the panel, t = 1,2, ..., N and denotes the time period to be used in the panel.

These cointegration tests, which comprise three group statistics and four round statistics, make up the Pedroni panel cointegration test.

If these statistics are able to rule out the possibility of no cointegration, then there is cointegration between the variables. Table 4 provides specifics on the Pedroni cointegration test findings.

The null hypothesis that there is no cointegration relationship for our panel is rejected in the majority of tests based on the Pedroni test findings shown in Table2.
Table 2: Pedroni and Kao cointegration tests

PedroniResidualCointegration Test				
Series: ICT DEPMIL DEPEDUC DEPRDEV CHERRDEV				
Sample: 2000 2017				
Alternative hypothesis: common AR coefs. (within-dimension)				
			Weighted	
	Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	2.593580	(0.0047)	-0.165624	(0.5658)
Panel rho-Statistic	2.642300	(0.9959)	2.898061	(0.9981)
Panel PP-Statistic	-9.316459	(0.0000)	-1.677633	(0.0490)
Panel ADF-Statistic	-3.824973	(0.0001)	-0.467798	(0.3200)
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	3.766250	(0.9999)		
Group PP-Statistic	-12.96458	(0.0000)		
Group ADF-Statistic	-1.775344	(0.0379)		
Kao (1999)	ADF	-5.421379*	(0.0000)	

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Notes: *, ** indicate the rejection of the null hypothesis (H0) at 1%, 5%, where the H0 is that the variables are not cointegrated

Causal Analysis

Finding the causes of the phenomenon being studied is the goal of the causal analysis method. Here, the concept of causation is understood in a statistical context. A phenomenon that statistically favors the occurrence of effect e is called a cause.

In other words, the graphic shows that the existence of because c increases the frequency of consequence e, as demonstrated by a number of similar observations:

$$\Delta ICT_{it} = \alpha_{i1} + \sum_{p-1}^{k} \mu_{1ip}\,\Delta \mathrm{ICT}_{it-p} + \sum_{p-1}^{k} \beta_{1ip}\Delta \mathrm{CHERRDEV}_{it-p} + \sum_{p-1}^{k} \gamma_{1ip}\Delta \mathrm{DEPEDUC}_{it-p} + \sum_{p-1}^{k} \delta_{1ip}\,\Delta \mathrm{DEPMIL}_{it-p} + \sum_{p-1}^{k} \theta_{1ip}\Delta \mathrm{DEPRDEV}_{it-p} + \varphi_{1i} ECT_{it-1} + \varepsilon_{1it}$$

$$\Delta CHERRDEV_{it}\alpha_{i2} + \sum_{p-1}^{k} \mu_{2ip}\,\Delta ICT_{it-p} + \sum_{p-1}^{k} \beta_{2ip}\Delta CHERRDEV_{it-p} + \sum_{p-1}^{k} \gamma_{2ip}\Delta DEPEDUC_{it-p} + \sum_{p-1}^{k} \delta_{2ip}\,\Delta DEPMIL_{it-p} + \sum_{p-1}^{k} \theta_{2ip}\Delta DEPRDEV_{it-p} + \varphi_{2i} ECT_{it-1} + \varepsilon_{2it}$$

$$\Delta DEPEDUC_{it} = \alpha_{i3} + \sum_{p-1}^{k} \mu_{3ip}\,\Delta ICT_{it-p} + \sum_{p-1}^{k} \beta_{3ip}\Delta CHERRDEV_{it-p} + \sum_{p-1}^{k} \gamma_{3ip}\Delta DEPEDUC_{it-p} + \sum_{p-1}^{k} \delta_{3ip}\,\Delta DEPMIL_{it-p} + \sum_{p-1}^{k} \theta_{3ip}\Delta DEPRDEV_{it-p} + \varphi_{3i} ECT_{it-1} + \varepsilon_{3it}$$

$$\Delta DEPMIL_{it} = \alpha_{i4} + \sum_{p-1}^{k} \mu_{1ip}\,\Delta ICT_{it-p} + \sum_{p-1}^{k} \beta_{4ip}\Delta CHERRDEV_{it-p} + \sum_{p-1}^{k} \gamma_{4ip}\Delta DEPEDUC_{it-p} + \sum_{p-1}^{k} \delta_{4ip}\,\Delta DEPMIL_{it-p} + \sum_{p-1}^{k} \theta_{4ip}\Delta DEPRDEV_{it-p} + \varphi_{4i} ECT_{it-1} + \varepsilon_{4it}$$

$$\Delta DEPRDEV_{it} = \alpha_{i5} + \sum_{p-1}^{k} \mu_{5ip}\,\Delta ICT_{it-p} + \sum_{p-1}^{k} \beta_{5ip}\Delta CHERRDEV_{it-p} + \sum_{p-1}^{k} \gamma_{5ip}\Delta DEPEDUC_{it-p} + \sum_{p-1}^{k} \delta_{5ip}\,\Delta DEPMIL_{it-p} + \sum_{p-1}^{k} \theta_{5ip}\Delta DEPRDEV_{it-p} + \varphi_{5i} ECT_{it-1} + \varepsilon_{5it}$$

The lag order is established by the Schwarz information criterion, and the estimation parameters are α, μ, β, γ, δ, θ, ϑ, ρ, σ, ϕ a, ω, where is the difference operator and the error correction term from the long-run cointegration relationship.

In order to determine whether Granger causality extends from research and development expenditure (RDE) to information and communication technology (ICT), the null hypothesis is: β_1ip=0, for all (i) and (p); This hypothesis implies that the value of the previous (ICT) has a large linear predictive effect on the current value of (RDE) if it is rejected, that is, if β_1ip is different from zero. According to this theory, (ICT) Granger influences (RDE), and vice versa.

Information and communication technologies (ICT) and research and development expenditure as a percentage of GDP (DepRDV) are bidirectionally causative, with a 5% significant level in the short and long run, according to the estimation results shown in Table 5. Indeed, it is commonly acknowledged that internal and external R&D efforts

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are what propel technological advancement. Growth levels of R&D investment are regarded trustworthy measures of innovation capacity.
These findings also show that, although they depend on R&D spending and utilization, labor productivity levels are favorably correlated with technological innovation. Furthermore, the findings clearly indicate that organizational innovation is essential to productivity and R&D levels.
These findings also support the idea that improved value added across all industries should emerge from increased R&D spending in the ICT industry. When compared to research and development expenditure, the other study variables military and educational spending have no discernible effects. Additionally, at the 10% level, there is a unidirectional causal association between ICT and education spending. All things considered; the analysis shows that these kinds of nations have a lot of potential to boost ICT effectiveness to enhance their educational results.
Table 4: The VECM Granger causality analysis

Short- run (court terme)						Long - run
Excluded variables: block exogeneity (variables exogène)						
	ICT	CHERRDEV	DEPEDUC	DEPMIL	DEPRDEV	ECM_{t-1}
ICT	-	1.7391 (0.6283)	2.7880 (0.4255)	4.4983 (0.2124)	7.2726*** (0.0637)	-1.2736* [-6.8597]
CHERRDEV	0.1740 (0.9817)	-	5.7490 (0.1245)	1.6849 (0.6403)	0.7150 (0.8697)	-0.4309 [-1.2299]
DEPEDUC	6.2710*** (0.0991)	9.3330** (0.0252)	-	7.4224*** (0.0596)	5.4446 (0.1420)	0.0055 [0.3893]
DEPMIL	4.1845 (0.2422)	3.2218 (0.3587)	4.4896 (0.2132)	-	6.9263*** (0.0743)	-0.6622 [-1.3013]
DEPRDEV	17.896* (0.0005)	8.1271** (0.0435)	2.8295 (0.4187)	1.5531 (0.6701)	-	-0.5754* [-3.2380]

Notes: *ECT represents the coefficient of the error correction term. *, **, and *** indicate that the parameter estimates are significant at the 1%, 5% and 10% levels respectively.*

Conclusion

First, in the developed G8 nations, the majority of the ICTs under study are still in the early stages of adaption. Government assistance, in the form of ICT-facilitating programs, must to be prioritized and reinforced going forward.
Second, technical information also demands a modernized platform to advance high-tech technologies and enhance technological infrastructure, both of which positively affect the factors that determine ICT in G8 nations.
To be more precise, there are a number of factors that influence ICT, including R&D expenditures and researchers, public education spending as a percentage of GDP in industrialized nations, and military spending as a GDP percentage. These factors are first investigated theoretically, and then they are examined empirically in a study on the factors influencing ICT in industrialized nations.
In order to reap the most benefits, it is critical to make ICT more accessible and to create the methods needed to use it properly. Since acting on capacities and skills is required to properly profit from these new technologies, efforts must be taken in regards to access to the ICT platform.

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