JOURNAL OF DEVELOPMENT ECONOMICS AND FINANCE
Vol. 1, No. 2, 2020, 341-360
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URL : www.arfjournals.com

ICT and Economic Growth in Waemu's Countries: An Econometric Analysis

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Article History

Received : 6 October 2020
Revised : 20 October 2020
Accepted : 9 November 2020
Published : 30 December 2020

Key words

ICT; economic growth; WAEMU

JEL Classifications
O47- L96 - O55

Abstract: Considered as the main source of economic growth in the United States of America and other northern countries, Information and Communication Technologies (ICTs) are seen as a key factor that can boost Africa's development. They have proved to be very indispensable in recent years and especially in the management of the health crisis linked to the Coronavirus pandemic. That is why this paper has been set out to analyze their effects on economic growth. The originality of this paper lies on the one hand in the consideration of ICTs as endogenous variables and on the other hand in the econometric technique used. The estimates indicate three main results: (i) ICTs have a marginal, positive and significant influence on economic growth; (ii) ICT components do not individually influence economic growth. Their effect is only perceptible when they are grouped or semi-grouped; (iii) unlike ordinary goods and services, whose imports unbalance the trade balance, imports of ICT goods and services positively influence economic growth in WAEMU countries. These technologies are therefore intermediate goods and thus gross fixed capital formation, the wear and tear of which benefits national production. These results could improve if the countries under consideration develop ICT hardware producing sectors.

1. INTRODUCTION

The adoption and diffusion of Information and Communication Technologies (ICTs) have experienced an exceptional boom in recent years. These technologies are in great demand because of their usefulness in the different stages of the production, distribution and even consumption system (Cette *et al.*, 2004 ; Cariolle *et al.*, 2019 ;

Acemoglu and Restrepo, 2019b). Thus, apart from fixed-line telephone subscriptions, which stagnated at around 12.4%, mobile telephone and Internet subscriptions increased from 15.5% and 8.0% respectively in 2001 to 107.0% and 51.2% in 2018 at the global level (IUT, 2019). This growth in demand for ICTs shows how important these technologies are becoming, to the point of upsetting Maslow's[1] pyramid of needs. One of the undeniable proofs of these claims is the role that these technologies play in solving the health crisis linked to the coronavirus pandemic. Indeed, since the advent of this crisis, ICTs have been the lifeline for almost all daily activities and thus the engine of human existence. As a result, despite the containment imposed by this pandemic, students have continued to attend classes due to radio and television broadcasts and, above all, the Internet (online courses and videoconferences). The situation is the same to the sale and purchase of goods and services online and especially to the use of ICTs in medicine (telemedicine). These non-exhaustive uses of ICTs indicate the extent to which they could boost economic growth.

Nevertheless, « we see computers everywhere except in statistics ». This bitter observation, known as the Solow productivity paradox, is still relevant today, especially in developing countries such as those of WAEMU. Despite the significant adoption of ICTs, little work has analyzed their effects on economic growth. This is why this paper aimes to study the effects of these technologies on the economic growth of WAEMU countries. In so doing, it will help to remove the ambiguity on the economic influence of ICTs but also on the causal link between these technologies and economic growth in the WAEMU space.

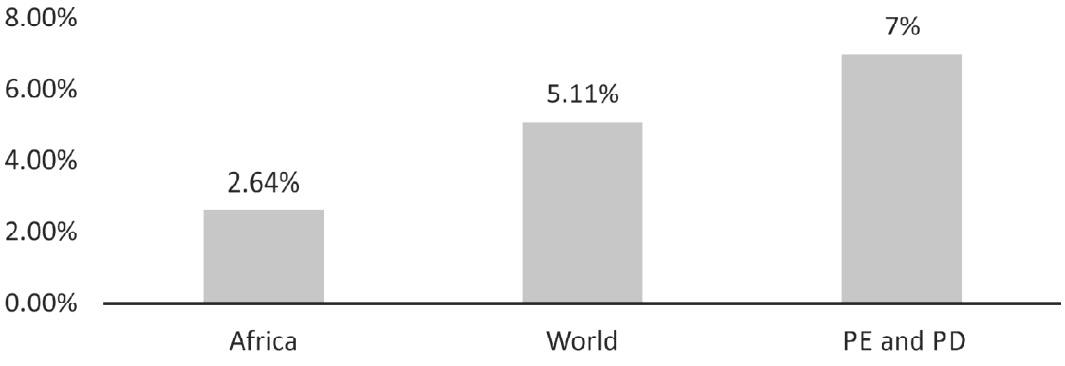
The various studies carried out on ICTs reveal that their adoption have many positive impacts. They generate benefits that correspond to productivity gains and more sustained growth (Cohen *et al.*, 2008 ; Jorgenson *et al.*, 2008a ; Youssef and M'Henni, 2004). These benefits are globally much higher than the direct and indirect costs induced by the acquisition and use of these technologies. This explains their strong correlation with economic development. Thus, over the last few decades, the direct effects of digital capital accumulation and their indirect consequences on aggregate factor productivity have accounted for about half of the growth observed in the United States and a little less than a quarter in France (Lemoine *et al.*, 2011). In Africa, on the other hand, the telecom penetration rate has reached the level of access to running water, i.e. 64%. This is higher than the rate of access to electricity (40%) and much higher than access to a bank account, which is 21% (IUT, 2019). Moreover, in low-income countries, including those of the WAEMU, nearly 8 out of 10 people have a mobile phone, 5 out of 10 businesses are connected to the

Internet and all UN member states have national websites allowing citizens to open a personal account online, declare their income taxes and register their businesses (OCDE, 2016).

Thus, digital development is growing strongly on the continent. Transitions in the field of the media through the automobile, tourism, health, agriculture and especially in international trade through E-commerce, show that the entire economy is going digital. In the field of trade, for example, these technologies have brought significant changes to the way goods and services are negotiated and acquired (Yushkova, 2014). Transactions between sellers and customers are now possible online, leading to new methods of banking based on the efficiency and flexibility of services offered to customers. The functions of banks have thus evolved with new services typically related to ICT. This boosts the process of monetary dematerialization through new money transfer systems such as e-money, mobile money etc.. Within companies, ICTs have revolutionized interpersonal communication techniques as well as production and distribution methods. All these transformations have led to improved productivity, increased sales and, by extension, improved economic growth (Azam, 2015 ; Wamba and Ndjie, 2019a).

World statistics on the adoption and diffusion of ICTs put Africa at the bottom of the league table. Indeed, according to the report of the International Telecommunication Union (ITU), the most digitized nation in Africa (Mauritius) ranks 49th in the world. Similarly, while the ICT Development Index (IDI) in developed and emerging countries is estimated at 7%, Africa has an average rate of 2.64%, about half the world average estimated at 5.11% (IUT, 2019).

Graph 1: The ICT Development Index



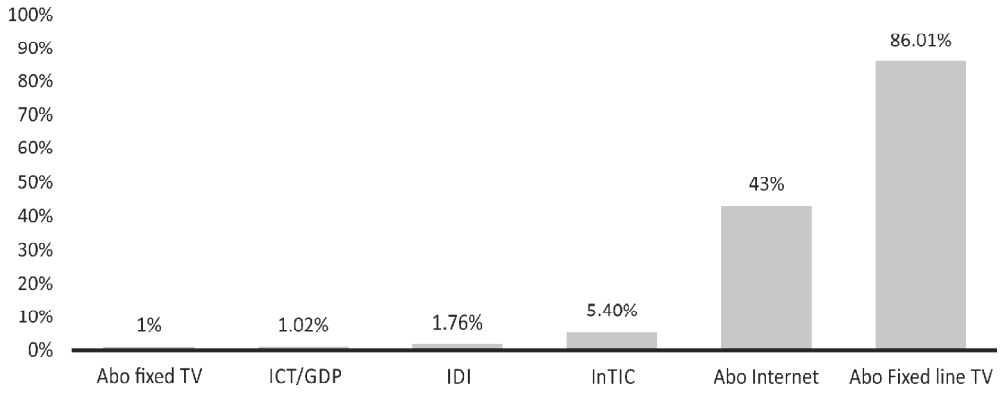
Source: ITU, 2019

It follows then that reducing the digital gap between the most connected and least connected countries remains a very important issue. In 2017, for example, the gap between the countries with the highest and lowest indices widened to 8.02 out of 10 points. In other words, the IDI growth rate is 0.15% in the least developed countries (LDCs) compared to 0.22% in developing countries; this shows that the digital revolution is slower in Africa.

WAEMU member states have not remained on the sidelines of this new technological revolution. They have also adopted and disseminated these digital technologies. However, these technologies have remained poorly developed and are limited only to the Post and Telecommunication subsector with their related uses. This subsector of post and telecommunications is booming in the Union with more or less brilliant statistics. Indeed, apart from the number of subscribers to fixed telephony which is stagnating at the turn of 1% of the population, the number of subscribers to mobile telephony and Internet is increasing and is estimated at 86.01% and 43% respectively in 2017. Investments in the sector are estimated at 5.40% of total investments and are growing at 23.39% per year. The share of ICT in GDP is still low and is estimated at 1.02% on average. The region also has a low ICT Development Index of around 1.76% (WDI, 2018 et ITU, 2019).

It is therefore easy to see that the adoption of ICTs in Africa and particularly in WAEMU is atypical: a sharp increase in mobile phone subscriptions when there is no industry producing these phones. Under these conditions, would the effect of ICTs on economic growth be identical to that observed in developed countries?

Graph 2: WAEMU ICT index



Source: ITU, 2019

The rest of this article is presented in four main points. First, we present a review of the literature on the link between ICT and economic growth. Second, the methodology adopted and the source of the data are decribed. Third, we analyze the result of the estimates. Finally, we conclude and present the policy implications.

2. DIGITAL TECHNOLOGIES AND ECONOMIC GROWTH: THE STATE OF THE LITERATURE

The theoretical debate about the impact of digital technology on economic growth grew very early on with the announcement of the famous productivity paradox: "We see computers everywhere, except in productivity statistics". The productivity surplus caused by computerization is, in fact, hardly perceptible, if not difficult to measure (Solow, 1998). The various positions this statement has risen have not denied the importance of ICTs in increasing the productivity and economic growth of nations. Rather, they have argued, based on evidence from the United States and some OECD countries, that these digital technologies enable increase of production (Cette *et al.*, 2002 ; Colecchia et Schreyer, 2002 ; Pilat, 2004 ; Besnard *et al.*, 2007 ; Berret, 2008 ; Acemoglu *et al.*, 2014 ; Jin et Cho, 2015). Indeed, contemporary economists have been attracted by the experience of the economic boom (high growth rate followed by low inflation and unemployment) observed in the United States during the second half of the 1990s. Several studies subsequently showed that this expansion of the US economy was mainly due to investment in ICT and its use in the production process (Papaioannou et Dimelis, 2007 ; Jorgenson *et al.*, 2008 ; Dimelis et Papaioannou, 2010). In general, it is widely accepted that ICT are important and can contribute to faster growth through accelerated productivity gains. But how and through which channel does digital technology influence the economy?

All the three digital sectors[2] have a positive effect on economic growth. These effects can be measured by the gains in Total Factor Productivity (TFP) resulting from the use of ICTs in production, distribution and even in purchasing and consumption decisions. In addition, these effects can also pass through five additional channels, namely: the multiplier effect due to investment in ICT; the deflator effect due to the fall in prices in the ICT sector, which implicitly spreads to other sectors; the capital-labour substitution effect; the quality effect reflecting the improvement in the quality of goods and services produced; and finally the Total Factor Productivity (TFP) effect following investment in ICT (Youssef et M'Henni, 2004 ; OCDE, 2014). Indeed, several studies have shown that there is a higher Keynesian investment multiplier for ICT hardware than non-ICT hardware (Acemoglu *et al.*, 2014). The

reason is that ICT equipments or hardwares are likely to be used in multiple ways and induces flexibility in the production system. They are therefore factors of production and also contribute to increasing the productivity of other factors. This multifactor productivity growth is most noticeable in ICT-producing industries, (Gu et Wang, 2004 ; Berrou and Mellet, 2020).

Empirically, Colecchia et Schreyer (2002b) conducted an OECD study that analysed the contribution of ICTs to economic growth in the G7[3] countries. The study covered the second half of the 1990s, the most important period in the history of ICTs in the United States and the G7. Over this period, the G7 countries accounted for nearly 60% of world output and an even larger proportion of investments in information technologies. Over the same period, economic growth in the G7 rebounded sharply because of considerable investments in information technologies (Jorgenson, 2005). Using the accounting decomposition of growth technique, these authors reached the following conclusions: (i) the economic growth recorded by the US and other G7 countries is due to the strong and sustained expansion of business investment in ICT. These investments accounted for almost two-thirds of total investment over the period and are growing at an annual rate of about 34%. (ii) The contribution of ICT capital to output has increased from a peak of 0.48 percent in 1995 to 0.86 percent in the year 2000. Several other studies have been carried out. Some have analysed the effect of ICT on individual developed countries (Cette *et al.*, 2002b ; Baldwin *et al.*, 2003 ; Pilat, 2004); others have benchmarked ICT adoption across developed countries and across major economic regions of the world (Van Ark *et al.*, 2002 ; Vu, 2011 ; Ridzuan and Ahmed, 2013 ; Brynjolfsson *et al.*, 2017 ; Niebel, 2018). From all these studies, it is noted that ICT has a positive effect on factor productivity and thus on economic growth. The intensity of this effect depends on the country's position as an ICT producer or importer (Pilat and Lee, 2001), its size, international specialization, initial factor endowments (Cheng *et al.*, 2020), and the presence or absence of complementary assets.

In Africa, on the other hand, the vast majority of ICT studies are conducted in the Maghreb countries. For instance, the work of Youssef et M'Henni (2004), analysed the effect of ICTs on Tunisia's economic growth. With a Cobb-Douglass type production function, these authors came up with three main results: investments in ICT capital represent 5.3% of total investments; the share of economic growth due to the ICT sector is 8.56%; and finally, the value added of the ICT sector in GDP is 2.9%. Despite the relevance of these results, the methodology used by these authors suffers from some shortcomings, notably the technique of sedimentation of ICT

capital from non-ICT capital and the use of OLS notwithstanding all the acknowledged limitations of this estimation technique. To compensate these shortcomings, other authors such as Albiman and Sulong, (2016a) ; Albiman and Sulong(2017) ; Wamboye *et al.*, (2015) have carried out the same studies on the case of all Sub-Saharan African countries but with non-linear models. The impact of ICTs on growth was found to be very marginal, about 0.03% of GDP.

In the West African sub-region, a few studies have also investigated the link between ICTs and economic growth. These include the work of Chabossou, 2017 which analysed the effect of ICTs on economic growth in Benin. The main finding of this study is that in both the short and long term, ICTs contribute about 0.08% to GDP. The study also concludes that there is a causal link from ICTs to economic growth. In other words, on the basis of available ICT capital, future gross domestic production can be predicted. This study was based on the study by Youssef et M'Henni, 2004, and is criticized for the same shortcomings.

It is therefore approved through the literature that Information and Communication Technologies have a positive effect on the economic growth of countries, whatever their level of development. However, the intensity of this positive impact depends on several intrinsic characteristics of the countries. It is therefore ideal to seek the effect of these technologies on less advanced countries, homogeneously united in an economic and monetary union. The results of such a study could further enrich the literature.

3. RESEARCH METHODOLOGY

Achieving the objective of this paper requires a good methodological approach. This requires a critical review of the methods previously used in the literature, the selection of a consistent model, and the presentation of the data source and estimation technique.

3.1. Brief methodological review and choice of model

At the outset, the contribution of ICT to growth was measured using the accounting decomposition method (Colecchia et Schreyer, 2002b ; Van Ark *et al.*, 2002; Lemoine *et al.*, 2011). This method assumes that ICT improves productivity via three mechanisms:

M1: ICT-producing sectors experience rapid gains in total factor of productivity and significantly influence economic growth;

M2: ICT investments increase the capital stock, which induces a multiplier effect on growth;

M3: the use of ICT increases efficiency gains and thus improves the level of production.

The main limitation of this method is the difficulty, if not the impossibility, of distinguishing the productivity gains brought by the adoption of digital technology from those of other productivity factors (management, market flexibility, innovation, etc.). It also does not make it possible to distinguish between two firms that invest as much in their computer equipment, but one uses its equipments to improve its competitiveness and the other leaves its computers off in a shed (Lemoine *et al.*, 2011).

Thus the econometric method appears to be the best technique for evaluating the effect of numerics on growth. Many researchers have used it (Youssef et M'Henni, 2004 ; Vu, 2011 ; Chabossou, 2017). They start from a Cobb-Douglas-type production function and subdivide the capital stock into "ICT capital" and "non-ICT capital".

$$GDP_{it} = AKICT_{it}^{\alpha}.KHICT_{it}^{\beta}.KHUM_{it}^{\gamma}$$

There are two fundamental problems with this approach : (i) distinguishing ICT capital from non-ICT capital, since gross fixed capital formation is global, and (ii) assuming the depreciation rate of ICT capital (around 12.5% (Youssef and M'Henni, 2004 p. 139 ; Chabossou, 2017 p. 63)). Moreover, this method does not allow to differentiate between the capital stock constituted and that actually used (Lemoine *et al.*, 2011).

It is to avoid these biases that we have chosen to conduct the analysis from a neoclassical perspective of endogenous growth theory (Romer, 1990 ; Barro, 1991). ICT (ICT investment; exports and imports of ICT goods and services; teledensity, etc.) are thus considered as factors that can influence economic growth. Thus, based on the work of (Farhadi *et al.*, 2012 ; Chavula, 2013 ; Evangelista *et al.*, 2014 ; Niebel, 2014 ; Albiman et Sulong, 2016), the model specified is as follows:

$$\mathbf{lnGDP_{it} = \beta_0 + \beta_1 lnICT_{it} + \beta_2 lnZ_{it} + \eta_{it} + \varepsilon_{it}} \quad (1)$$

With:

GDP_{it}: the dependent variable representing the Gross Domestic Production of country i at date t. This production can be influenced by several variables, including:

ICT_{it}: set of numerical predispositions (Computers, Telephones, Internet access, Investments in ICT, flows of ICT Goods and Services ...) that can have an

impact on the Gross Domestic Product. It is constructed as a composite variable using the Principal Component Analysis (PCA) method, the formula of which is as follows: $ICTit = \sum_{i=1}^{k} \zeta iXi$ With ζi the weighting coefficient linked to each of the variables

Z_{it} : represents the set of other control variables such as human capital (KHUM), financial development (Devf), degree of openness (Do), foreign direct investment (FDI) etc. çit is the set of unobservable variables and ηit is the error term.

3.2. Data Source and Estimation Techniques

The data use for analysis are obtained from the World Bank database (*http://data.worldbank.org/data-catalog/world-development-indicators*) and the International Telecommunication Union database (*http://www.itu.int/en/ITU-D/Statistics*). These data cover 18-year period (2000 to 2017) and concern the eight countries of the West African Economic and Monetary Union (WAEMU).

The models are estimated on STATA software using the panel data estimation technique since our data are both cross-sectional and time-sectional. Thus, specification tests were performed in order to choose the best model through the Hausman test. After this step, estimation was performed using the Ordinary Least Squares (OLS) technique with indicator variables. This allows to make the student t-values robust and to correct them for their heteroskedasticity by White's method (Goaied and Sassi, 2012 ; Kpodar, 2007). As sensitivity tests, the previous models are then estimated using non-linear techniques, notably Double Least Squares (DMC), to assess the relevance of the results obtained with OLS.

4. RESULTS AND DISCUSSIONS

After statistical tests were performed, the various estimations were carried out in three scenarios. Scenario (1) consists in capturing the overall effect of ICT on production. Scenarios (2) and (3) disaggregate the main variable and capture the individual effect of each of the numerical components of ICT. In addition to this, scenario (3) captures the semi-group effect of teledensity (fixed, mobile and Internet subscriptions) on total output.

Results of first estimation, preliminary tests, are that look for fixed or random effects in the data generating process, are summarysed in table 1.

Table 1: Specification test results

	Fixe-Effect Models			*Random effects Models*		
	(1)	*(2)*	*(3)*	*(1)*	*(2)*	*(3)*
LnICTit	0.005			0.006		
	(2.92)***			(2.15)**		
LnKHUMit	0.505	0.563	0.126	0.557	0.625	0.623
	(4.71)***	(4.99)***	(1.15)	(5.37)***	(6.41)***	(6.85)***
LnDoit	-0.006	-0.138	-0.049	-0.003	-0.061	-0.027
	(0.09)	(1.80)*	(0.82)	(0.06)	(1.32)	(0.60)
LnDevfit	0.020	0.072	0.026	-0.228	0.006	-0.039
	(0.39)	(1.37)	(0.60)	(4.07)***	(0.11)	(0.71)
LnTIit	0.100	0.230	0.221	0.224	0.277	0.221
	(1.10)	(2.58)**	(2.91)***	(2.25)**	(3.63)***	(2.56)**
LnRemSalit	0.043	-0.047	0.038	-0.051	0.103	0.227
	(0.52)	(0.53)	(0.57)	(0.54)	(1.09)	(2.78)***
LnDpTEducit	0.553	0.463	0.337	0.901	0.612	0.632
	(9.14)***	(7.18)***	(5.32)***	(15.29)***	(10.12)***	(10.22)***
LnIDEit	-0.040	-0.022	-0.005	-0.039	-0.055	-0.053
	(2.65**	(1.48)	(0.36)	(1.85)*	(3.44)***	(3.11)***
LnInv_ICTit		0.013	0.006		0.018	0.030
		(1.64)	(0.73)		(2.00)**	(3.12)***
LnXBS_ICTit		-0.004	-0.007		0.023	0.023
		(0.33)	(0.70)		(3.29)***	(3.24)***
LnMBS_ICTit		0.047	0.012		0.080	0.100
		(1.94)*	(0.53)		(2.83)***	(3.40)***
LnAboTelefixit		0.111			0.036	
		(1.47)			(0.60)	
LnAboTelemobit		0.001			-0.004	
		(0.34)			(3.40)***	
LnAboInterit		-0.015			-0.009	
		(2.85)**			(1.84)*	
LnTeledit			0.128			-0.050
			(5.25)***			(2.72)***
_cons	4.561	3.575	11.249	2.148	-0.235	-0.057
	(5.59)***	(3.48)***	(7.45)***	(2.97)***	(0.34)	(0.07)
R^2	0.98	0.98	0.98	0.99	0.99	0.99
N	77	77	77	77	77	77

* $p<0,1$; ** $p<0,05$ et ***$p<0,01$

Source: constructed by the authors from Stata15.1

Both fixed-effect and random-effect models show a significantly positive effect of ICT on economic growth. This puts us in a quandary since these tests should allow us to verify the homogeneity or heterogeneity of the data generating process (Doucouré, 2010). In other words, at the end of these tests, we should be able to know whether the theoretical model is perfectly identical for all countries or, on the contrary, whether there are specificities to each country. The Hausman test is then indispensable to discriminate between fixed and random effects in order to be able to conclude whether the estimation by fixed effects produces results that are significantly different from a random effects model. The result of this test is presented in the following table

Table 2: Summary of Hausman tests

	(1)	*(2)*	*(3)*
Prob>chi2	0.000	0.002	0.000

Source: constructed by the authors from Stata15.1

The chi2 probabilities are all less than 5%. This indicates that the fixed-effects model performs better in each of the three scenarios. The data used for this study are therefore perfectly identical for all countries. This result also indicates that our models contain endogenous variables. Therefore, as a sensitivity test, we will conduct regressions with instrumental variables to compensate for endogeneity biases.

We therefore retain the fixed-effects model, but to correct for the student t's heteroskedasticity by White's method, we estimate the models by OLS with individual dummy variables. The results of these estimates are presented in table 3:

Table 3: OLS Results with Indicator Variables

	(1)	*(2)*	*(3)*
LnICTit	0.005		
	(2.89)***		
LnKHUMit	0.505	0.563	0.126
	(4.37)***	(4.78)***	(1.20)
LnDoit	-0.006	-0.138	-0.049
	(0.11)	(1.75)*	(0.92)
LnDevfit	0.020	0.072	0.026
	(0.36)	(1.27)	(0.61)

contd. table 3

	(1)	*(2)*	*(3)*
LnTIit	0.100	0.230	0.221
	(1.01)	(2.38)**	(2.31)**
LnRemSalit	0.043	-0.047	0.038
	(0.50)	(0.48)	(0.55)
LnDpTEducit	0.553	0.463	0.337
	(7.93)***	(5.83)***	(5.26)***
LnIDEit	-0.040	-0.022	-0.005
	(2.59)**	(1.55)	(0.34)
LnInv_ICTit		0.013	0.006
		(1.41)	(0.71)
LnXBS_ICTit		-0.004	-0.007
		(0.31)	(0.68)
LnMBS_ICTit		0.047	0.012
		(2.65)**	(0.57)
LnAboTelefixit		0.111	
		(1.24)	
LnAboTelemobit		0.001	
		(0.33)	
LnAboInterit		-0.015	
		(2.96)***	
LnTeledit			0.128
			(6.59)***
_cons	4.561	3.575	11.249
	(4.99)***	(3.39)***	(7.83)***
R^2	0.99	0.99	1.00
N	77	77	77

* $p<0,1$; ** $p<0,05$ et *** $p<0,01$

Source: constructed by the authors from Stata15.1

These results indicate that ICTs positively influence economic growth in WAEMU countries. Indeed, when the adoption and diffusion of these technologies increase by 10%, gross domestic production grows by 0.05%. This positive and significant influence at the 1% threshold is consistent with the literature (Wamba and Ndjie, 2019; Chabossou, 2017; Albiman and Sulong, 2017; Youssef and M'Henni, 2004). The difference and especially the originality of our results lies in the value of the elasticity of the impact of ICT on GDP. This relatively low value (0.005%) is intuitively reasonable because of the scarcity of telecommunications infrastructure

and especially because of the virtual non-existence of industries producing these technologies in the WAEMU. This result is in line with the numerous studies that have shown that countries that have more digital infrastructure are those that experience higher growth of their gross domestic product (Kumar *et al.*, 2016 ; Jorgenson and Vu, 2005 ; Cette *et al.*, 2000 ; Cronin *et al.*, 1991). Despite the relatively high rate of adoption of digital technologies, WAEMU countries cannot benefit from their potential as it stands.

The results also show that the individual effect of most digital technologies remains insignificant. For example, ICT investment, exports of ICT goods and services, and fixed and mobile phone subscriptions do not individually have a significant effect on economic growth. Their effect is only noticeable when they are aggregated or semi-aggregated. This is the case for teledensity - a semi-bundling of fixed, mobile and Internet subscriptions - which has a positive influence on economic growth of 0.128%. This result is significantly better than that found by Chabossou, 2017 in the case of Benin (insignificant effect in both the short and long term) and Albiman and Sulong, 2017 for all sub-Saharan African countries.

Moreover, our results showed against all expectations that imports of ICT goods and services have a positive impact on economic growth. When they increase by 1%, gross domestic production grows by 0.047%. This means that, unlike ordinary goods and services, whose imports distort the balance of trade and the balance of payments, imported ICTs constitute a capital stock that contributes to gross domestic production (Colecchia and Schreyer, 2002b).

Another surprising but justifiable result is the negative effect of Internet subscriptions on economic growth in WAEMU countries. Indeed, until 2017, when Internet subscriptions increase by 1 per cent, domestic output declines by 0.015 per cent. In other words, the negative effects of Internet use outweigh the positive effects. The Internet is thus being misused, with the phenomenon of gay man (cybercrime); the abusive and non-productive use of social networks (sight-seeing on the web) and, above all, the effects of ICT on the environment (Avom *et al.*, 2020).

We then perform non-linear regressions to test the previously found results by correcting OLS for their ordinary biases of endogeneity and simultaneity.

The results of the estimations using the DLS method is similar to that obtained with OLS with a few differences. The elasticity of the ICT on economic growth is greater than that obtained with OLS. Here, when ICT increases by 1%, gross domestic product increases by 0.027%. This result is consistent with that obtained by Albiman

Table 4: Estimation by Double Least Squares (DLS)

	(1)	*(2)*	*(3)*
LnICTit	0.027		
	(2.19)**		
LnKHUMit	0.698	0.673	0.774
	(4.86)***	(4.46)***	(7.19)***
LnDoit	0.035	0.057	0.043
	(0.51)	(0.68)	(0.73)
LnDevfit	-0.298	-0.119	-0.074
	(4.31)***	(1.40)	(1.12)
LnRemSalit	-0.346	0.008	-0.035
	(1.81)*	(0.05)	(0.24)
LnDpTEducit	0.987	0.767	0.741
	(12.93)***	(7.76)***	(9.52)***
LnIDEit	-0.089	-0.117	-0.101
	(2.26)**	(3.15)***	(3.23)***
LnInv_ICTit		0.001	0.012
		(0.08)	(0.71)
LnXBS_ICTit		0.042	0.029
		(3.13)***	(3.12)***
LnMBS_ICTit		0.018	0.044
		(0.37)	(1.06)
LnAboTelefixit		-0.005	
		(0.05)	
LnAboTelemobit		-0.004	
		(1.94)*	
LnAboInterit		0.011	
		(1.03)	
LnTeledit			-0.064
			(3.10)***
_cons	2.112	1.225	-0.218
	(2.14)**	(0.95)	(0.22)
N	77	77	77

* $p<0,1$; ** $p<0,05$ et ***$p<0,01$

Source: constructed by the authors from Stata15.1

and Sulong (2017). The behaviour of the individual effects is almost the same in both cases. However, ICT investment, exports of ICT goods and services and Internet subscriptions positively influence economic growth.

The other variables in the model also have, in majority, expected effects. These are human capital, the degree of openness and education expenditure, all of which positively influence economic growth in WAEMU countries. The current level of financial development, foreign direct investment and wage compensation have negative effects on economic growth. The special case of FDI attracts our attention and deserves further analysis. Indeed, in the digital age, FDIs and especially multinational firms to be promoted must be those with highly numerical characters and must, above all, be aimed at installation and technology transfer.

Even though it is very marginal, the positive effect of ICTs on the economic growth of WAEMU countries is obvious. However, it is necessary to verify whether there is a causal link between these two magnitudes. It is therefore necessary to verify through a Granger test whether the level of economic growth can be predicted based on the values of ICT capital accumulation and vice versa. The null hypothesis of this test is H0: "variable X does not cause variable Y in the Granger sense". This hypothesis will be accepted if the probability associated with this test is greater than 5%. The following table presents the results of this test.

Table 5: Granger Causality Test

Test null hypothesis (X does not cause Y)		*Probability*	*Conclusion*
X	Y		
GDP	ICT	0.0469	GDP causes ICTs
ICT	GDP	0.4839	No causal relationship

Source: constructed by the authors from Eviews 9.1

This test thus reveals a unidirectional causality between GDP and ICT. It specifically indicates that it is GDP that causes ICTs at the 5% threshold. In other words, one can predict the amount of ICTs to be adopted given the current level of Gross Domestic Product. This result is contrary to that of Chabossou, 2017 for the specific case of Benin, and proves the extent to which WAEMU leaders do not have a rigorous ICT adoption policy. Indeed, ICTs are not really integrated into the production system as is the case in developed countries. That is why their adoption depends on the national wealth created rather than on them determining national production.

5. CONCLUSION

The increasing adoption of Information and Communication Technologies in the WAEMU space requires an in-depth analysis of their effects on economic growth.

This study is more important because of the extraordinary use of digital technologies in recent years and especially with the advent of the coronavirus pandemic. Thus, after a problem analysis and a review of the literature on the subject, we used a rigorous multi-stage methodology, including three different scenarios to capture the effect of these technologies. The first scenario measured the overall effect of ICTs by considering them as a composite variable. The second and third scenarios progressively disaggregated the ICT variable in order to capture the individual effects of its components. Three main results were obtained.

First, all regressions in this study showed a positive and significant effect of ICT on economic growth. The elasticity of this effect is 0.005% with OLS and 0.027% with BMD. Thus, regardless of the estimation technique used, the positive effect of ICT on growth is evident. This result is consistent with almost all previous work on the subject.

Second, our results show that the individual effect of most ICT components is not significant. Thus, ICT investment, exports of ICT goods and services, and fixed and mobile telephone subscriptions do not significantly influence economic growth. Their effect is only perceptible when they are aggregated or semi-aggregated. On the other hand, our results indicate that ICT goods and services have special characteristics. Indeed, unlike ordinary goods and services whose imports are harmful to the local economy, imports of ICT goods and services positively influence gross domestic production. These are therefore intermediate goods and thus gross fixed capital formation, the wear and tear of which benefits local production.

Thirdly, we note that in this digital age, FDI needs to be rethought. Indeed, the various estimation techniques have shown that FDI has a negative influence on economic growth because it does not acquire technology, which is an indisputable source of growth. The same applies to financial development, i.e. credit granted to the private sector, which is always poorly organised and insufficient to encourage the emergence of start-ups likely to have a positive influence on economic growth. In addition to all this, there is the Granger causality test which indicates a unidirectional causal link from production to ICTs, i.e. on the basis of the current level of production we can predict the quantity of ICTs to be adopted, which is contrary to the technology policies of developed countries.

These results call on the authorities of the sub-region to rethink the economic policies in force in the union and, above all, to take coherent initiatives to promote the highly beneficial adoption of ICTs. Firstly, there is a need to increase investment in ICTs to ensure strong and resilient digital infrastructure. Second, to make FDI

profitable in this digital age, our leaders must negotiate, demand and obtain technology transfer contracts with the multinational firms of the digital world, which until now have regarded WAEMU as a mere market or outlet for their products. Thirdly, the policy of financing private companies must be reinvented to enable them to make a significant contribution to national production.

Thus, ICTs are seen as a factor likely to reduce the wide gap between the countries of the South and those of the North. But they should not be taken as a miracle solution because their effects depend on several endogenous factors such as: the level of human capital; the level of financial development; economic, financial monetary and specifically industrial policies. This is why a reflection on the prerequisites for the beneficial adoption of ICTs in the WAEMU would be welcome.

Notes

1 Without the Internet, there is no access to search engines and their ocean of content. Without a connection, no possibility of communicating with one's family on another continent. Without an available network, no access to commercial sites or social networks. And tomorrow, without the Internet, will we be able to access social security, public transport, justice...? (Badevant, 2017)

2 Hardware producing sectors, ICT user sectors and sectors that cannot exist without digital such as e-business; e-commerce... (OECD, 2002; lemoine et al.: Arlandis et al, 2011).

3 Economic Cooperation Agreement between Canada, France, Germany, Italy, Japan, the United Kingdom and the United States

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To cite this article:

Dadegnon Aimé Kocou and Igue Charlemagne Babatoundé. ICT and Economic Growth in Waemu's Countries: An Econometric Analysis. *Journal of Development Economics and Finance,* Vol. 1, No. 2, 2020, pp. 341-360