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Full Modified Ordinary Least Square Analysis of the Relationship between New Technologies of Information, Financial Development and Growth in WAEMU Zone

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Abstract

This paper aims to study the relationship between financial development, information, and communication technology (ICTs) diffusion and economic growth by examining the effects of interactions between finance and ICT on economic growth. The study covers eight West African Economic and Monetary Union (WAEMU) countries and spans the period from 2000 to 2018. The empirical results, after applying the fully modified ordinary least squares (FMOLS) estimator can be generalized as follows. First, regardless of the financial development indicator used, the empirical results show that financial development negatively influences economic growth in the WAEMU. This counter-intuitive relationship may be related to many phenomena, but there are no clear explanations in the literature yet. Second, ICTs diffusion improves economic growth in the zone. This implies that WAEMU countries should strengthen their ICTs policies and improve the use of new information and communication technologies. Finally, the interaction between ICTs diffusion and financial development is positive and significant in explaining growth. This implies that the economies of the WAEMU region can only benefit from financial development once a level of ICTs development is reached.

Keywords: ICTs; Financial development; Economic growth; FMOLS; WAEMU.

1. Introduction

The relationship between financial development and economic growth has been one of the most debated issue as to whether the financial sector contributes to the financing of the real sector in the economic development process. Schumpeter (1911), opines that finance helps to increase economic performance by targeting the most productive sectors of the economy and channeling investment to these sectors. In this way, the effectiveness of finance on economic growth is ensured as advanced by King and Levine (1993) and Levine *et al.* (2000). In contradiction to this theory, some authors attribute this to the financial sector an almost non-existent role in explaining growth. Robinson (1952), contradicts the active role of finance in the economic growth process. According to this author, financial development is a fruit of economic growth and the determinants of the latter lies in other sectors than finance. In agreement with Robinson and Lucas (1988) argues that finance is overestimated in growth. Other authors like Gregorio and Guidotti (1995) found a negative effect of financial development on economic growth. Despite these contradictions, finance could not be dismissed when it comes to analyzing economic growth.

The first strand of the literature highlights the relationship between ICTs and economic growth. However, in the earlier literature, ICTs development was seen as a concern for developed economies, because these economies were able to mobilize resources to promote the sector (Kenny and Qiang, 2003). Indeed, the research showed evidence of growth effects through network externalities, particularly relevant to telephone services and Internet. This assertion is explained by Grace *et al.* (2003). According to these authors, due to network effects, the number of users connected to the system exponentially increases the value of telephone line. Similarly, once a threshold of users is reached, an explosive growth is registered. This explains why it was thought that developed economies benefited from ICTs development. Furthermore, Röller and Waverman (2001) find that ICTs can only positively influence economic growth beyond certain threshold. According to their study, economic growth is affected when the ICTs penetration rate reaches 40 lines per 100 inhabitants. But other authors believe that the positive effects of ICTs can be just as important in developing countries because ICTs are comparable to public services such as water, electricity and transport Andrianaivo and Kpodar (2011), Waverman *et al.* (2005), (Datta and Agarwal, 2004), Lewin and Sweet (2005), Tcheng *et al.* (2007). Thus, the introduction of mobile banking is seen as an

innovation that enabled the diversification of banking services and their decentralization within economies. Thus, ICTs improve the productivity of firms by allowing them to adopt flexible structures and locations see also Andrianaivo and Kpodar (2011), Kenny and Qiang (2003), Sridhar and Sridhar (2004), Andrianaivo and Kpodar (2011) and Grace *et al.* (2003). Then, in recent years, authors have focused on the joint effects of financial development and ICTs diffusion on economic growth. In this respect, Sassi and Goaied (2013) added the interaction effects of ICTs and financial development in the economic growth model and found it to be positively significant. Das and Seaborn (2018) also consider the interaction effect in setting up an economic growth model. They reported that interaction effect of ICTs and financial development can improve economic growth in low-income countries, but not in middle-income countries.

The second strand of empirical literature highlights that the financial sector, together with better telecommunications infrastructure, improves economic growth in the long run. Using panel data from 61 countries between 1990 and 2002, empirical results showed that mobile phone subscribers and internet users can increase financial depth, which is an important factor for economic growth. For example, Cronin *et al.* (1991) confirms the existence of two-way causal relationship in US between investment in telecommunications infrastructure and economic growth. However, Beil *et al.* (2005) perform Granger-Sims causality tests for 50-year time series in the US and found one-way causality from economic growth to investment in telecommunications. (Dutta, 2001) also applied Granger causality tests to representative sample of 30 developing and industrialized countries, and found two-way causality for developing and industrialized countries. Salomon and Perkins (2005) also identified bidirectional causality in South Africa. Asongu (2012), examined the effects of mobile phone technology, knowledge creation and diffusion on inclusive human development in 49 sub-Saharan African countries from the period 2000-2012 using the Tobit model and reported that the information technology sector enables several industries to maintain a competitive advantage in global market through certain innovation services. Likewise, this argument is supported by Chowdhury (2006) who focused his study on the state of ICTs capital investment and economic performance of small and medium enterprises in Kenya and Tanzania. Using ordinary least squares (OLS), the study found out that 1% increase in Internet users contributes to 40% reduction in the impact of inflation, which explains how communication technology improves the economic environment. Another study was conducted by Faris *et al.* (2019) on the issue in Gulf Cooperation Council (GCC) countries over the period of 2000 and 2016. These results showed that information and technological communication are the drivers of financial development in the GCC economies. Moreover, ICTs contributes to growth by increasing productivity. But besides this direct role, recent economic literature shows that ICTs would contribute to enhancing the effect of financial development on economic growth. However, in practice, policy makers in these countries do not know exactly to what extent ICTs influences the link between financial development and economic growth, which poses a problem in defining economic policy for better economic growth. What drives research in this area?

Two important contributions can be drawn from this study. First, in recent decades, the link between financial development and economic growth has attracted the attention of many authors in the WAEMU (Aka, 2010; Diang, 2015). However, the weakness of their studies is that they have not considered the effect of ICTs and their interactions with financial development on economic growth. Therefore this study fills the gap in the case of these countries and at the same time helps governments to better steer their economic policies to reap the benefits of ICT diffusion. Second, the methodological level, the estimation method chosen is the fully modified ordinary least squares (FMOLS) method. This estimation method is based on non-parametric approach that takes into account the effect of serial correlation while solving the endogeneity problem of the regresses. In addition, this method produces reliable estimates on small samples and provides robust results (Phillips, 1995).

The paper is based on sections. In Section 2, the researcher presents the model specification. In section 3 the study elucidates the methodology applied, the description of the variables and the data sources. Section 4 is devoted to the empirical results and finally conclusions and remarks in section 5.

2. Empirical Analysis

2.1. Model Specification

This paper aims to assess information, communication technologies and financial development on economic growth in WAEMU countries. Therefore, researcher used the extended Cobb-Douglas production function as:

$$Y_{it} = F(A_{it}, L_{it}, K_{it}) = A_{it} K_{it}^{\alpha} L_{it}^{\beta} \text{ with } 0 < \alpha < 1 \text{ and } 0 < \beta < 1 \quad (1)$$

Whereas Y_{it} is real gross domestic production level in the country i at time t, K_{it} represents the capital, L_{it} the labour level and A_{it} is depicted by the global productivity factors which reflects the technology and the economic efficiency. L_{it} and A_{it} are assumed to grow at exogenous rates (n) and (g) respectively.

$$L_{it} = L_0 e^{nit} \text{ and } A_{it} = A_0 e^{git} \quad (2)$$

Many authors have shown that increased productivity can be the result of a well-functioning financial system and the use of ICTs Kenny and Qiang (2003), Datta and Agarwal (2004), Lewin and Sweet (2005), Andrianaivo and Kpodar (2011), Asongu (2012), Abdinoor and Mbamba (2017) and Faris *et al.* (2019). The study also

adopted the model proposed by Keho (2009) and incorporated the new technologies as technologies factors. Then technological factor can be written as:

$$A_{it} = G(Df, ICT) = A_0 e^{\theta_{zit}} \quad (3)$$

Where TIC represents new technologies of information and Df financial development indicator. New technologies of information condition the effect of financial development on economic activity, researchers introduce an interaction variable between these variables:

$$z_{it} = (Df_{it}, Df_{it} * ICT) \quad (4)$$

Where $(Df_{it} * ICT)$ highlights $ICTs$ interaction of financial development on economic activity. By combining equations (1) and (3) and taking the logarithms, we get the following equation (5), we have:

$$Y_{it} = \alpha_0 + \alpha k_{it} + \beta l_{it} + \theta z_{it} + \mu_{it} \quad (5)$$

Whereas y, l and k represent the log of Y, K and L, respectively and μ_{it} the error term. The researcher assumes that the accumulation of physical capital follows a process of the form thus:

$$k_{it} = (1-\delta)k_{it-1} + i_{it} \text{ with } k_{it} = (1-\gamma L)^{-1} i_{it} \quad (6)$$

Whereby δ is the depreciation rate of capital and i_t the investment level[1]. By substituting (6) in (5) and assuming that labor force grows at constant rate, we obtain the evolution of real growth per capita as:

$$Y_{it} = \alpha_0(1-\gamma) + \gamma Y_{it-1} + \alpha i_{it} + \varphi t + \beta_2 Df_{it} - \gamma\beta_2 Df_{it-1} + \gamma\beta_3 Df_{it-1} * ICT_{it-1} + \mu_{it}' \quad (7)$$

However, some adjustments have been made to the variables taking into account the availability of data and the particularity of our study environment but, above all, the review of the literature carried out in section 2. The non-linear models can be presented by the following equations (8) and (9):

$$LY_{it} = \beta_0 + \beta_1 LDF_{it} + \beta_2 ICT_{it} + \beta_3 (LDF * LICT)_{it} + \beta_4 LPA_{it} + \beta_5 LFCF_{it} + \beta_6 LIPC_{it} + \beta_7 LCOR_{it} + \omega_{it} \quad (8)$$

$$LY_{it} = \beta_0 + \beta_1 LCSP_{it} + \beta_2 ICT_{it} + \beta_3 (LCSP * LICT)_{it} + \beta_4 LPA_{it} + \beta_5 LFCF_{it} + \beta_6 LIPC_{it} + \beta_7 LCOR_{it} + \varepsilon_{it} \quad (9)$$

Where in the logarithm operator, (Y) gross domestic product, Information and Communication Technology (ICT), (DF) financial development, (CSP) credit extended by the financial system to the private sector, ($LDF * LICT$) interaction term between financial development and ICT. ($FBCF$), (PA), (TO), (IPC) and (COR) represent the gross fixed capital formation, active population, trade openness indicator, consumer price index and level of corruption in different countries of the union.

3. Applied methodology

3.1. Cross-Sectional Dependence Test

Due to the activities, countries in the same geographic zone may interact together. For instance, activities such exports, imports and economic integration can create a possibility of cross-sectional dependence between them. Also, common shocks or spurious specification of the model can lead to cross-sectional dependence (Chudik and Pesaran, 2013). In the panel data analysis, cross-sectional dependence should be checked in order to avoid biased and non-robust estimators (Breusch and Pagan, 1980; Pesaran M., 2004; Phillips and Sul, 2003). Further, Breusch and Pagan (1980) proposed the Langrage Multiplier (LM) test to control the cross-dependence in panel data. Therefore we write a panel data regression as follows:

[11]The financial sector acts as intermediary between savings and investment. As in Pagano (1993), it is assumed that only a portion of household savings s can be used for productive investment i. We assume that the fraction of savings lost in the intermediation process is a deadweight loss for households, but it could be reintroduced into their budget constraint as a lump-sum transfer, without any change in the model. In fact, this model assumes that financial intermediation does not require capital (see Berthelémy and Varoudakis, 1994 for a similar assumption).

$$Y_{it} = \alpha_i + \beta_{it} X_{it} + \varphi_{it} \quad (10)$$

Where X_{it} depicts $k \times 1$ vector of regressor, t represents the temporal dimension $(t = 1, 2, ..., T)$ and each country in panel is indicated by i $(i = 1, 2, ..., N)$. Thus the LM test is specified in equation (11) below.

$$LM = T \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \hat{\rho}_{ij} \quad (11)$$

Where the null hypothesis is that: $H_0 : Cov(\varphi_{it}, \varphi_{jt}) = 0$ exhibits no cross-sectional dependence and $H_1 : Cov(\varphi_{it}, \varphi_{jt}) \neq 0$ the alternative hypothesis when the cross-sectional dependence occurs. To adjust bias, Pesaran M. (2004) proposed the LM test modification expressed by the equation (12).

$$CD = \sqrt{\frac{2T}{N-1}} \sum_{i=i}^{N} \sum_{j=1+i}^{N} \frac{(T-k)\hat{\rho}_{ij}^2 - \left[(T-k)\hat{\rho}_{ij}^2\right]}{\text{var}\left[(T-k)\hat{\rho}_{ij}^2\right]} \quad (12)$$

3.2. Slope Homogeneity Test

When cross-sectional dependence exists, this situation signifies that countries in panel can interact with each other due to common effects such as shocks, social network… etc. In these conditions, slope heterogeneity can appear. Thus this phenomenon should be checked in order to obtain robust estimator Swamy (1970), Hsiao (1986), Breitung (2005) and Pesaran and Yamagata (2008). Therefore, we check the hypothesis of slope homogeneity against alternative hypothesis of slope heterogeneity for big panel. Pesaran and Yamagata (2008) suggested panel data model taking into account fixed effects and heterogeneous slopes. In so doing, they considered the specification written below:

$$Y_{it} = \alpha_i + \beta' x_{it} + \varepsilon_{it} \text{ with } i = 1, ..., N \text{ ; and } t = 1, ..., T \quad (13)$$

We can therefore test the following hypothesis, $H_0 : \beta_j = \beta$ for all i (slope homogeneity,) and $H_1 : \beta_i \neq \beta_j$ and for all $i = j$ (slope heterogeneity).For a smaller sample, Fisher proposed statistics associated with the overall homogeneity test as:

$$H_0^1 : \beta_i = \underset{(K;1)}{\beta} \text{ ; } \alpha_i = \alpha \text{ ; } \forall_i \in [1, N] \quad (14)$$

Thus, if the realization of the Fisher statistics for the sample under consideration is above the theoretical level at $\alpha\%$ then the null hypothesis of homogeneity is rejected. For this study, the researcher adopted the Fisher homogeneity test for data analysis.

3.3. Unit Root Test (Panel)

As the involvement of macroeconomic applications in the panel data analyses has been growing recently, the Dickey-Fuller and Augmented Dickey-Fuller tests are required to be extended for testing stationarity in panel data analysis. According the literature, two groups of test exist. The first group, called the first generation test, is based on the assumption of inter-individual independence of the residuals (Baltagi and Kao, 2000; Banerjee *et al.*, 2000; O'Connell, 1998; Phillips and Sul, 2003; Strauss and Yigit, 2003). On the other hand, the more recent second generation test tends to lift this hypothesis of independence as advanced by Quah (1994), & Bai and Ng (2004), Moon and Perron (2004), Choi (2002), Pesaran (2003) and Chang (2002;2004). As a result, researcher adopted the second generation which takes into account the hypothesis of cross-sectional such as the Phillips-Perron Fischer and Phillip Perron Choi tests. These tests are specified as:

$$Y_{it} = \alpha_i + \theta_i + \nu_{it} \text{ with } \nu_{it} = \sum_{j=1}^{p_i} d_{ij} \nu_{t-j} + \varepsilon_{it} \quad (15)$$

Where ε_{it} is iid $(0, \sigma_{\varepsilon,i}^2)$. The temporal effect θ_t represented by stationary process. In model (15), we test the hypothesis of unit root in idiosyncratic component ν_{it} for individuals in panel. So the null hypothesis $H_0 : \sum_{i=j}^{p_i} d_{ij} = 1$; $\forall_i = 1, ..., N$ is tested again in the alternative hypothesis $H_1 : \sum_{i=j}^{p_i} d_{ij} < 1$.

3.4. Panel Test Cointegration

Pedroni (1995;1997) proposes various tests aimed at taking the hypothesis of absence of intra-individual cointegration for both homogeneous and heterogeneous panels. As critical values in these works relate to the presence of a single regressor in the cointegrating relationships, Pedroni (1999a;2003) adds an extension to the case where the cointegrating relationships include more than two variables. The implementation of the tests requires first approximating the long-run relationship:

$$Y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1it} + \beta_{2i} x_{2it} + ... + \beta_{Mi} x_{Mi} + \varepsilon_{it} \text{ ou } i = 1,...,N \text{ ; } t = 1,...,T \text{ et } m = 1,...,M \quad (16)$$

Among seven tests proposed by Pedroni, four are based on the within dimension and three on the dimension (Hurlin and Mignon, 2006). Kao (1999), has also proposed tests of the hypothesis of no cointegration. Unlike Pedroni's tests, Kao considers the special case where the cointegrating vectors are assumed to be homogeneous between individuals. The ideal test would be the Pedroni (1999b) test. But given the large number of variables (more than 7), we cannot use this test. Therefore, we will use the Kao test. By the same token, the presence of cross-sectional dependence, we can use the Westerlund (2007) cointegration test to check the existence of long-term relationship.

3.5. Estimation of the Long-Term Panel

The Fully Modified (FM) method is a model initially proposed by Phillips and Hansen (1990), then extended by Phillips (1995) to the vector case (VAR) integrating both stationary and non-stationary explanatory variables in the long-term relationship. Thus, we consider the following model:

$$\underset{(n,1)}{Y_t} = \underset{(m,1)}{\beta X_t} + \underset{(n,1)}{\mu_{0t}} \quad (17)$$

Where β is a matrix $m = m_1 + m_2$. We now distinguish two types of regresses in the main cointegration relation according to the respective degree of integration.

$$\underset{(m_{1,1})}{X_{1t}} = u_{1t} \quad (18)$$

$$\underset{(m_{2,1})}{\Delta X_{2t}} = u_{2t} \quad (19)$$

The cointegration relation can be written as a function of these two components of the regressed space.

$$Y_t = \beta_1 x_{1t} + \beta_2 x_{2t} + \mu_{0t} \quad (20)$$

We suppose that $u_t^{'} = (\mu_{0t}, \mu_{1t}, \mu_{2t})$ in the invertible Vector Moving Average (VMA) process is defined by:

$$\underset{m+n,1}{u_t} = \underset{(m+n,m+n)}{C(L)} \underset{(m+n,1)}{\varepsilon_t} \quad (21)$$

Where ε_{it} is iid $(0, \sigma^2_{\varepsilon,i})$ and the coefficients of the matrix $C(L)$ satisfy the standard summability assumptions. In addition, the explanatory variables are assumed to be stationary, μ_{1t} at any date in the residual of the cointegrating relationship μ_{0t}. The Fully Modified estimation procedure of the parameter vector β can be decomposed into two steps (Hurlin *et al.*, 1998).

3.6. Variables Definition and Data Description

The data derived from four different sources. Macroeconomic data are from World Bank, International Monetary Fund (IMF) and (BCEAO, 2019) database. By account, the data (ICT) is from the International Communications Union (UIT). Our endogenous variable in the study is gross domestic product (Y). The exogenous variables are composed of three variables of interest, Information and Communication Technology (ICT), Financial Development (DF) and credit extended by the financial system to the private sector (CSP). We include the interaction term ($DF * ICT$) to test the joint effect of financial development and (ICT) on economic growth. Our control variables are four in number, namely gross fixed capital formation ($FBCF$), the labor force (PA), the trade openness indicator (TO) and the consumer price index (IPC). We also introduced an institutional control variable corruption (COR) which reflects the level of corruption in the different countries of the union. All variable definitions and their sources are recorded in Table 1 below.

Table-1. Summary of Expected Variables and Signs

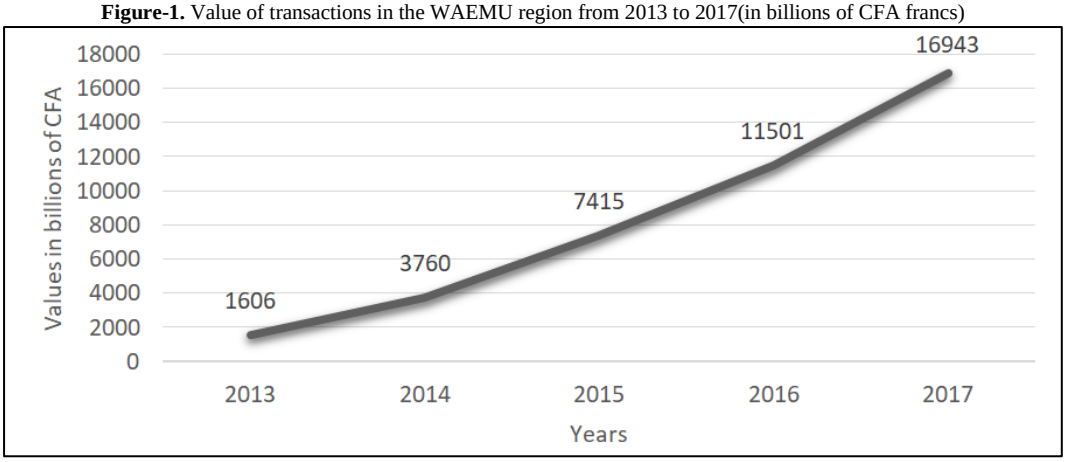
Variables	Description	Source	Expected sign
Y	Gross domestic product.	BCEAO (2020)	
DF	Financial development Capturing the level, breadth, depth and accessibility of financial services in the union	FMI (2016)	(+)
CSP	Credit for the private sector	WDI (2020)	(+)
ICTs	Information and technologies. This variable is captured here by the number of mobile phone subscribers.	IUT (2019)	(+)
PA	The total labor force include persons aged 15 years and above.	WDI (2020)	(+)
FBCF	Gross fixed capital formation.	WDI (2020)	(+)
TO	Opening rate.	WDI (2020)	(+)
IPC	Consumer price index	BCEAO (2020)	(-)
COR	Corruption control. It is scored in the range 0 to 1: A score close to 1 indicates a fairly corrupt system and a score close to 0 indicates a less corrupt system.	V-Dem (2017)	(-)

Source: Author, based on the economic literature (Note that in this study we have used the IMF's synthetic financial development (FD) indicator (IMF, 2016).

Similarly, the descriptive statistics for all variables are described in Table 2 below. The average growth rate in the WAEMU is very low (1.407%) over the period between 2000 to 2018. However, there is a maximum value of 12.047%. In addition, the rate of growth of credit to the private sector is around 15.549%, with a standard deviation of 8.127. On average 6 million people in the union use a mobile phone. It can also be observed that on average, the member countries of the union achieved 29.42% of their trade with the outside world.

Furthermore, in Figure 1 below, there is a general upward trend in the number of mobile phone transactions between 2013 and 2017. The volume of transactions in 2017 amounted to 16.943 billion CFA francs against 11.501 billion in 2016; 7.415 billion in 2015. Thus, about 5.442 billion transactions were processed between 2016 and 2017 by all the existing mobile payment platforms in the Union. Overall, the financial transactions carried out in the UEMOA zone via mobile phones show the importance of this sector in the financial aspect of the Union.

Figure-1. Value of transactions in the WAEMU region from 2013 to 2017(in billions of CFA francs)



Source: Author, based on BCEAO data (2018)

Table-2. Descriptive Statistics of Variables

Variables	Observations	Mean	SD	Minimum	Maximum
Y	152	1,407	2,799	-7,110	12,047
CSP	152	15,549	8,127	0,402	41,156
DF	152	0,110	0,026	0,042	0,208
TIC	152	6020488	7385252	0	3,38e+07
PA	152	2,699	0,417	2,164	3,874
FBCF	152	18,312	6,096	5,885	32,430
TO	152	29,419	8,976	15,184	56,380
IPC	152	88,543	15,403	0	105,6
COR	152	0,651	0,173	0,157	0,924

Source: Author, based on data from (BCEAO, 2019), WDI (2019), ITU (2019)

The Pearson correlation coefficient matrix is summarized in Table 3. Indeed, it indicates the direction of correlations between endogenous variable (Y) and exogenous variables. Except for the trade openness indicator and the consumer price index, the correlations between the explained variable and the other explanatory variables are in line with our predictions.

On the other hand, overall we observe low and moderate correlations between the explanatory variables. Moreover, the strongest correlation observed is between private sector credit (CSP) and financial development (DF) which stands at 0.662. This is due to the fact that these two variables both reflect the level of financial development of an economy. The low degree of correlations between the explanatory variables (less than 0.8) allowed us to remove the doubt of the likely existence of multicollinearity that would bias our regressions. Therefore, the impact of multicollinearity is not significant and all explanatory variables in the model can be retained for analysis.

Table-3. Correlation matrix

	Y	*CSP*	*DF*	*TIC*	*PA*	*FBCF*	*TO*	*IPC*	*CORR*
Y	1,000								
CSP	0,212*	1,000							
DF	0,228*	0,662*	1,000						
TIC	0,287*	0,521*	0,563*	1,000					
PA	0,121	0,208*	0,060	0,386*	1,000				
FBCF	0,348*	0,472*	0,447*	0,277*	0,211*	1,000			
TO	-0,035	0,567*	0,420*	0,131	-0,012	0,077	1,000		
IPC	0,239*	0,427*	0,346*	0,548*	-0,026	0,250*	0,063	1,000	
COR	-0,259*	-0,370*	-0,287*	-0,374*	-0,522*	-0,436*	0,107	-0,072	1,000

Note: * denotes the significance of the correlation at the 5% level. Source: Author, using data from BCEAO (2019), WDI (2019), ITU (2019)

4. Empirical Results

The estimation of our model starts first by testing the hypothesis of cross-sectional. The study opted for the (Breusch and Pagan, 1980) dependence test to test the hypothesis of non-dependence between individuals. The results of the Breusch-Pagan test performed on our model are presented in Table 4. The results of this test show that the p-value associated with the test statistic is less than 1%, so the hypothesis is rejected. Therefore, the individuals in the study are dependent on each other.

Next, the researcher used the Fisher test to test the hypothesis of process heterogeneity. The results reported in Table 5 show that the p-value associated with the Fisher test statistic is less than 1%, thus the hypothesis of no specific effects is rejected at 1% level. The process is therefore homogeneous with a fixed effect.

Now, given the presence of dependence between individuals, it seems obvious to apply the second generation stationarity tests such as Choi (2002) and Pesaran (2003), which take into account the possible correlations between individuals. The results of second generation stationary tests are reported in Table 6 below. The results of unit root test of series shows that, at 5% threshold, the null hypothesis confirming the presence of a unit root cannot be rejected for the variables at level. Indeed, out of the nine variables, only two are stationary at level. The PP-Choi and PP-Fisher Chi-square statistics thus suggest that all the variables in the study are stationary in first difference. When the variables are taken as first differences, they are all stationary. Therefore, there is presumption of co-integrating relationship between the different variables.

Table-4. Result of the dependency test

Test	**Statistic**	**d.f.**	**Prob.**
Breusch-Pagan LM	57,878	28	0,000
Pesaran scaled LM	3,992		0,000

Source: Author, based on data from BCEAO (2019), WDI (2019), ITU (2019)

Table-5. Result of the homogeneity test

Test	**Statistics**	**P-value**
	8.21	0.000

Source: Author, based on data from BCEAO (2019), WDI (2019), ITU (2019)

Table-6. Result of the stationarity test

	Level		First difference		Decision
Tests	PP-Fisher	PP-Choi	PP-Fisher	PP-Choi	
Variables	Chi-square	Z-stat	Chi-square	Z-stat	
Y	32,331(0,009)	-2,517 (0,005)	-	-	I(0)
CSP	-0,610(0,270)	-0,610(0,270)	110,465(0,000)	-8,12(0,000)	I(1)
DF	186,223 (0,000)	-0,610 (0,270)	110,465(0,000)	-8,12 (0,000)	I(1)
TIC	186,223(0,000)	-11,469 (0,000)	-	-	I(0)
PA	8,851 (0,919)	-11,469 (0,000)	74,023(0,000)	-6,093(0,000)	I(1)
FBCF	3,615 (0,999)	3,436(0,999)	74,023 (0,000)	-6,093(0,000)	I(1)
TO	21,760 (0,151)	2,826 (0,997)	74,023(0,000)	-6,093(0,000)	I(1)
IPC	22,738(0,120)	-0,094 (0,462)	9,008 (0,001)	0,767(0,000)	I(1)
COR	19,357 (0,250)	0,852 (0,802)	84,506 (0,000)	-6,917 (0,000)	I(1)

Source: Author, based on data from BCEAO (2019), WDI (2019), ITU (2019)

To test the presence of long-term relationship between the variables in the model, the study opted for cointegration test of Kao (1999). The results were analyzed in table 7. According to the data analysis, all the five statistics are in favor of long term relationship between the variables. Therefore, the variables are cointegrated. The results of FMOLS estimation are summarized in table 8. Also, Hausman test was applied to the choice between the random effect model and fixed effect model. The probability of the test is under 5% threshold, so the null hypothesis of a random effect cannot be retained. Thus, we keep a fixed effect model.

Table-7. Results of the cointegration test by Kao (1999)

	Statistics	P-value
Modified dickey-Fuller t	-9,438**	0,000
Dickey-Fuller t	-10,208**	0,000
Augmented Dickey-Fuller t	-4,194**	0,000
Unadjusted modified Dickey-Fuller t	-12,737**	0,000
Unadjusted Dickey-Fuller t	-10,666**	0,000

Note: ** means rejection of the unit root hypothesis at the 1% threshold. Source: Author, using data from BCEAO (2019), WDI (2019), ITU (2019)

Table-8. Result of the long run estimation (**FMOLS**)

	Equation 1 (DF)			Equation 2 (CSP)		
Dependent variable *LY*	**Coeff.**	**S.E**	**P-value**	**Coeff.**	**S.E**	**P-value**
LDF	-13,388	4,486	0,003*	-	-	-
LCSP	-	-		-0,466	0,215	0,030*
LTIC	0,054	0,028	0,056*	0,098	0,043	0,023*
*LDF*LTIC*	2,444	0,687	0,000*	-	-	-
*LCSP*LTIC*	-	-	-	0,069	0,039	0,077**
LPA	0,947	0,029	0,000*	0,996	0,047	0,000**
FBCF	-0,011	0,001	0,000*	-0,011	0,002	0,000*
TO	0,002	0,000	0,008*	0,003	0,001	0,076**
LIPC	-1,270	0,184	0,000*	-1,235	0,331	0,000*
LCOR	-2,414	0,172	0,000*	-2,361	0,340	0,000*
CONS	6, 341	0,464	0,000*	5,757	0,759	0,000*
adjusted R^2		0,56			0,70	
Joint Hausman test(Fixed effect ,Random effect)=**0.000**						

Note: *(**) denotes the significance of the variable at 5% and (10%). **Source**: Author, constructed from Stata 14

The researcher conducted estimation using two separate equations (1) and (2). In the first equation the study used the IMF (2016) synthetic financial development index for the explanation of economic growth. To consolidate the results, credit to the private sector (equation 2) as an indicator of financial development to understand the real effect of the financial sector on economic growth was also used. However, equation 1 is the main equation of our study. The estimation results indicate that 56% of economic growth is explained by the variables in the model (Equation 1). Indeed, all the variables used in the study are significant. The study also observed a positive relationship between ICT, the active population, the openness rate and economic growth. Then, financial development, price index and gross fixed capital formation show a negative relationship with growth. There is also an inverse relationship between private sector and economic growth, indicate the inability of

financial sector to stimulate growth in the union. This negative relationship between financial system and growth is mitigated when ICTs is included in the financial sector.

The study results reveal significant and positive effect of ICTs on economic growth in WAEMU, in particular mobile telephony. Indeed, 1% increase in the number of ICT users generates a 0.042% increase in GDP. This is due to the important role that mobile phones play in the economic environment of these countries. In addition, ICTs are ubiquitous in most sectors of activity, finance and administration inclusive. Moreover, ICTs can affect government revenues through corporate and employee income taxes, VAT and social security contributions due to their large deployment in the area. These results are in line with that of Tcheng *et al.* (2007) who observed that in Africa, incomes from telecommunication services represent about 5% of GDP.

Thus, as noted above, ICTs can only influence economic growth positively beyond a certain threshold. Therefore, there is an urgent need for WAEMU policy makers to develop more security measures to safeguard the interest of customers and ensure better communication between partners. We have seen that the effect of mobile phone penetration in the financial system has mitigated the negative effect of financial development. Therefore, once the negative effect is mitigated by the action of mobile phone services, the financial sector then becomes significant and positive for economic growth, financial sector could be the channel through which mobile phone penetration really influences growth.

These results are also confirmed when the financial development index is replaced by private sector credit. Although the financial development index and private sector credit appear to be negatively correlated with growth, the terms of their interaction with mobile phone penetration are positive and significant, countries are well developed in mobile phones tend to grow faster. Consistent with previous results and the literature, this effect appears intensely in countries where mobile financial services are available and used. These results are based on economic theory. Gurley and Shaw (1961) opine that financial innovation, which accompanies financial development, reduces the risk attached to investment and the costs of financial intermediation and stimulates savings.

In the UEMOA region, these results can be explained by the fact that mobile financial services, also offered by mobile phones, belong to the category of branchless banking, which allows banks to provide financial services at a distance to their customers and the unbanked. Also these branchless banking services are in addition to the services already offered to existing customers. In this sense, they are considered an add-on to the traditional banking system, as they are not specifically designed for customers with only low access to financial services but to the entire financial structure in general. These results confirm that mobile phone penetration can foster economic growth by facilitating and consolidating the impact of financial inclusion on economic growth. Therefore it is appropriate to think about the development of financial system by lowering the cost of financial services and decentralizing financial activities beyond the major cities, and above all by integrating ICT into the management of financial services in order to allow access to people excluded from these services because of their complexity.

5. Conclusion and Policy Implications

The overall objective of the study was to examine the relationship between financial development, ICT diffusion and economic growth by considering the interconnection between financial development and ICT. The first objective was to analyze the effect of financial development on economic growth. Objective two verified the effect of ICT development on economic growth, and finally, the third objective was to analyze the joint effect of ICT and financial development on economic growth in the WAEMU. At the empirical level, the researcher was interested in the eight WAEMU countries, over the period between 2000 and 2018, when we were entering a new era with the mobile phone. Moreover, the study methodology relied on estimators of FMOLS in a dynamic panel.

Overall, the results indicated that financial development has negative effect on economic growth in these countries. In contrast, ICTs positively influences economic growth. The results also indicated that the negative effect of financial development is mitigated when combined with ICT. In fact, the financial system in union, the performance of banking sector, has failed to be an engine for economic growth. The financial sector in the UEMOA zone is weighing in economic growth. Either it fails to provide economy with appropriate products or financial support is not sufficient. Although the deployment of mobile banking services is in its infancy, the results show that countries where financial services are available, combined effect of financial system and diffusion of mobile telephony benefits from economic growth.

The main findings of this study highlight three lessons. First, formal financial system in the union is still underdeveloped to meet the challenge of dynamic economic growth and deserves a large-scale innovation. Secondly, the study results found out that mobile telephony, through its service offers, particularly mobile banking, is a formidable lever for the banking of unbanked workers in the informal sector. Finally, the two joint sectors (ICTs and financial sector) can be a powerful lever for achieving the objectives of financial sector development in the Union if this convergence of sectors (finance and telecommunications) is well regulated. These factors together with the results of the analysis allow recommendations to be made. In order to deepen financial sector, political authorities of WAEMU countries should apply security measures aimed at increasing the protection of mobile banking operations with a view to their development, in order to assure the population of the safety of these offers. In addition, they should strive to lower the cost of financial services, strengthen the institutional framework by ensuring that corruption is controlled, and intensify the development of mobile banking and its integration into the banks.

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