Macrothink Institute™

International Journal of Accounting and Financial Reporting
ISSN 2162-3082
2024, Vol. 14, No. 1

The Effect of ICT on the Development of Bank Branches in the WAEMU Zone: An Application of Negative Binomial Regression

PRAO Yao Séraphin (Corresponding author)

Associate Professor at Alassane Ouattara University (Bouaké)

LAMPE- Laboratory of Economic Policies' Analysis and Modeling, Ivory Coast

E-mail: praoseraph@gmail.com

https://orcid.org/0000-0002-7782-8442

OUATTARA Tanmantchin Brice-Wilfried

Ph.D. Student at Alassane Ouattara University (Bouaké)

LAMPE- Laboratory of Economic Policies' Analysis and Modeling, Ivory Coast

E-mail: tanmantchinouattara@gmail.com

https://orcid.org/0009-0005-4626-6909

Received: February 7, 2024 Accepted: March 12, 2024 Published: March 22, 2024

doi: 10.5296/ijafr.v14i1.21792 URL: https://doi.org/10.5296/ijafr.v14i1.21792

Abstract

The main objective of this study is to analyze the effect of ICT on the number of bank branches in the WAEMU. Based on the total of eight (08) member countries of the union, from 1995 to 2022, it employs the negative binomial (BN) regression method for the estimations. The results of the study show that among the ICT variables selected, only mobile and fixed-line telephone subscriptions have a statistically significant and positive effect on the number of bank branches in the union. The Internet and the number of ATMs have no significant effect on the number of branches, although they remain negatively correlated with the number of bank branches. On the other hand, the number of banking institutions and the size of these banks encourage the opening of new bank branches.

Keywords: Number of bank branches, TIC, Negative binomial regression, WAEMU

JEL: A13; G21; G41; O33

1. Introduction

Banking institutions serve as the primary financial intermediaries, bridging the gap between agents and those with the ability to provide funding and meeting their daily finance needs. They have a significant role in human civilization as a result of their economical efficiency, and the wide range of services they provide has already demonstrated their worth.

Therefore, risk management and the capacity to expand the branch network to satisfy public demands and expectations were the banking institutions' instant performance levers. Because it shows how close a bank is to the public, the branch network has emerged as one of the most important metrics for evaluating banking performance. We call this banking accessibility. The opportunity to bring the bank closer to its customers is the driving force behind the desire to expand the branch network, as noted by Vernon (1966) and Dunning (1988). Expanding the branch network stood out as a major challenge for banks conscious of operating costs and profitability targets. However, the trend at the time was to increase the number of bank branches in many countries, given the prevailing paradigm at the time.

Nonetheless, the emergence of information and communication technologies (ICT) appears to be revitalising this perspective while concurrently endorsing remote banking, which presents benefits concerning the opportunity costs it mitigates. The organisation of work has changed as a result of the widespread use of ICTs, particularly in banking. The primary factor contributing to these services' success is their capacity to offer financial services in real time and remotely to the communities they serve (Hernando et al., 2007). Because these services are more affordable and easier to use, they have gained popularity quickly, often at the expense of banking services. ICTs improve bank performance in addition to these public advantages by lowering operational costs and gathering and processing customer data (Musiime et al., 2010). According to Daniel (1999) and Irechukwu (2000), the number of bank branches has drastically decreased as a result of the use of ICTs (mobile and internet) in financial activities.

As such, the notion that growing the branch network—despite the initial costs associated with doing so—is a crucial component of banks' overall success now evokes ideas supporting contactless banking. For instance, the penetration rate of bank branches in the euro zone decreased from 54.9% in 2009 to 39.6% in 2018. This pattern has also persisted in France, Italy, the Netherlands, Germany, and Spain; in the latter country, the biggest decrease occurred from 96.1% in 2009 to 56.1% in 2018, a 40% decrease (Statista, 2020).

In contrast to the observed decrease trend, the number of bank branches in the West African Economic and Monetary Union (WAEMU) and across the African continent is still increasing despite the full growth of information and communication technology. Between 1996 and 2018, the rate of mobile penetration increased from 0.034% to 102.09%. Similarly, the rate of Internet use rose by around 22.49%, from 0.0005% in 1996 to 22.5% in 2018. For fixed-line telephone subscriptions, the number of users emerged at 165,949.5 versus 50,329.86 over the same period. However, the number of bank branches increased by 311 points from 58 in 1996 to 369 in 2018 (WDI, 2020). This trend thus runs counter to

theoretical predictions observed outside the WAEMU region, raising questions about the effect of ICT on banking activity.

Therefore, the primary goal of this research is to examine how ICT has impacted the growth of bank branches inside WAEMU. More precisely, we'll ascertain how fixed telephone service affects the quantity of bank branches, then investigate the impact of mobile phone penetration on branch counts, and lastly look into the impact of the Internet on branch counts in the WAEMU.

The interest of this study lies in the fact that it allows us, firstly, to reinforce the literature, especially the empirical literature, relating to the effect of NICTs on banking activity as a whole, and then in the specific context of developing countries, notably the WAEMU. Indeed, at the empirical level, ICTs have been the subject of several works on banking performance (Appiahene et al., 2019; Angioha et al. 2020). However, few have addressed the issue of the number of bank branches, especially, in the WAEMU. Our study will therefore attempt to bridge this gap by mobilizing a more appropriate econometric approach. Finally, it will enable us to refute or confirm postulates concerning the role of ICT in the development of bank branches. The study is structured in two parts: the first deals with the literature review, while the second sets out the methodological approach leading to the results of our study.

2. Literature Review

This literature review is divided into two parts. The first is dedicated to the theoretical review, while the second deals with the empirical review.

2.1 Review of Theoretical Literature

First, we look at the determinants of the number of bank branches in financial intermediation theory, and then at the effects of ICT on banking development.

Regarding the factors that determine the number of bank branches, it should be mentioned that financial intermediation theory suggests that the growth of multinational corporations is predicated on the pursuit of new markets in the framework of the branch network's or banks' expansion. According to Dunning (1988), businesses conduct a portion of their business internationally in order to reduce the expense of market failures. Thus, one of the primary drivers of agency network expansion is the pursuit of new markets, which leads to an expansion of supply. In addition, opening new bank branches abroad is an important diversification strategy for banks. However, improved portfolio diversification, regulatory and tax arbitrage opportunities, access to markets offering better growth prospects, the search for higher profit margins and the internalization of existing customer-bank relationships are some of the reasons put forward to explain higher levels of internationalization (Focarelli and Pozzolo, 2005). These diversification activities are supported by a theoretical literature that emphasizes the weight of risk.

Indeed, modern portfolio theory, developed in 1952 by Markowitz, shows how rational investors use diversification to optimize their portfolios. For some proponents of the theory, opening new branches diversifies risk. Yet, according to classical portfolio theory,

geographic expansion will reduce a bank's risk if it involves adding assets whose returns are imperfectly correlated with existing assets. Earlier studies argue that only small, inefficient local banks are the main beneficiaries of banking regulation limiting geographic risk by protecting them from increased competition (Kane, 1995). In addition, Boyd and Prescott (1986) point out that diversified banks benefit from a cost-effectiveness that can improve stability. If diversification makes a bank "too big to fail", then implicit or explicit government guarantees can reduce the risk of investing in the bank (Groppb et al., 2011).

On the other hand, other theories point out that expansion increases bank risk. Indeed, agency-based models of business expansion (Jensen, 1993; Berger and Ofek, 1995) reveal that banks may expand geographically to take advantage of private benefits, even if this reduces loan quality and increases fragility. Furthermore, Brickley et al (2003) and Berger et al (2005) point out that distance can impair the ability of a bank's head office to monitor its subsidiaries, which can have negative effects on asset quality. Furthermore, to the extent that diversification increases complexity, it may impair banks' ability to monitor loans and manage risk (Winton, 1999).

In addition to diversification, profitability is also seen as an explanatory factor for banks' geographical expansion. Indeed, higher levels of geographic diversification can reduce exposure to idiosyncratic local shocks (Goetz et al. 2016), with improved economies of scale, scope and management (Berger and DeYoung, 2001). However, these difficulties associated with managing a larger, geographically diverse organization can lead to diseconomies of scale and scope.

Regarding the effects of NICTs on banking development, the spread of information and communication technologies (ICTs) is leading to the replacement of labor-intensive bank branches with automated processes. Indeed, technology is reducing the banking sector's overheads (De Young, 2005; Hernando and Nieto, 2007 and Daniel (1999). Banks are therefore replacing traditional banking methods with online banking. The market is seeing an increase in the number of ATMs, online banking, telephone banking and mobile banking. ICT has thus revolutionized the conventional banking business model, enabling banks to break out of their comfort zones and traditional value chain. The main reasons for this are reduced overheads and, above all, reduced distance due to low transport costs (DeYoung, 2005; Delgado et al., 2006). Thus, DeYoung et al (2007) see online banking as a process of innovation that functions as a relay to physical branches for the provision of banking services.

Concerning the link between NICTs and the development of banking agencies, the literature has not insisted on this relationship but rather on the link between NICTs and banking performance. In addition to these theoretical lessons, other reasons, also relevant, are provided to us by the empirical literature.

2.2 Review of Empirical Literature

Numerous studies have looked into how NICTs affect banks and businesses. Shirley and Sushanta (2006) investigated how information technologies affected bank profitability in this

particular research setting. These authors demonstrate, using a panel of 68 US banks spanning more than 20 years, that while IT can result in cost savings, increased IT spending can have network effects that lower bank earnings.

In Asia, Dinh and Le (2015) assessed the impact of internet banking on bank performance in Vietnam. Over a period from 2009 to 2014 and using fixed and random effect models, they find that internet banking positively impacts bank profitability. These results are similar to those of Le et al, (2022) who sought to examine the impact of ICT development on the operational efficiency of the banking sector in Vietnam, over the period 2007-2019. They find that the contribution of ICTs to banks is positive, as they positively influence the efficiency of Vietnamese banks.

In Africa, more specifically in Nigeria, Idowu (2002) has similarly analyzed the impact of ICT on the banking sector. Based on primary data collected from the customers of five major banks, the results of his study underline that ICTs are making a major contribution to the growth of the banking sector in Nigeria and to the improvement of services. For their part, with annual data from eleven banks over the period 2001 to 2011 and using fixed and random effects models, Muhammad et al. (2013) find that the use of ICT in the banking sector increases return on equity in Nigeria. These results were confirmed by the work of Peace et al. (2018), who point out that the adoption of a variety of ICTs by banks has highly impacted the quality of their operations, their performance and more specifically engendered the increase in their return on equity, over the period from 2006 to 2015. In contrast, Ugwuanyi and Ugwuanyi (2013), find that ICT exerts no effect on bank performance, or even a negative effect on bank returns in Nigeria. Such a result is similar to that of Mahboub (2018) who finds using Ordinary Least Squares (OLS) that the effect of ICT on banking performance is not statistically significant, for a sample of 50 Lebanese banks over the period 2009 to 2016.

More recent works such as Njoroge and Mugambi (2018), Del Gaudio et al. (2021), Appiahene et al. (2019), and Angioha et al. (2020), have also proven the positive effect of ICT on banking performance.

According to the work of Njoroge and Mugambi (2018), mobile banking, while increasing banks' market share in Kenya, makes their core financial services more accessible, reducing their overheads and transaction costs. For their part, Gaudio et al. (2019) studied the effect of information and communication technologies (ICT) on profits and the risk of financial distress in the EU 28 banking sector over the period from 1995 to 2015, in Europe. The results obtained using the Generalized Moment Method (GMM) underline that ICT plays a key role in improving bank performance. Furthermore, the overall financial stability of the banking sector is enhanced by the intensive adoption of IT and financial technologies, which increase the distance to default. Appiahene et al (2019), using the two-stage DEA approach applied to 444 Ghanaian bank branches, reveals that IT has a significant impact on banks' overall performance, as a good number of them (78.82%) were efficient in their overall operations, despite their respective deposit and investment inefficiencies. Finally, Angioha et al (2020), examined the extent to which the information technology predictor variables, information technology knowledge, management support for information technology use,

frequency of information technology use and access to information technology can influence the productivity of commercial bank employees. The study, conducted using primary data from a sample of 400 employees from 8 banks in Cross River State and multiple regression analysis, indicates a statistically significant joint influence of all predictor variables (IT knowledge, management support for IT use, frequency of IT use and IT access) on commercial bank employee productivity.

Overall, empirical studies in Africa have very often focused on the link between NICTs and banking development and not on the development of banking agencies. The major contribution of this study is to fill this gap. Indeed, in order to increase financial inclusion and the banking rate, NICTs can promote rapprochement between banks and populations, through banking agencies.

3. Study Methodology

We first present the specification of the basic model of the study, and then our approach leading to the estimation of the model parameters.

3.1 Specification of the Basic Model

Our model to be estimated in this study is mainly based on the work of Sawalha and Sayed (2006) and Vasechko et al., (2009). The choice of variables is guided by the study by Zhang et al (2020) on the determinants of the number of bank branches in India. Our study model is presented as follows:

$$P(Y = y_i/X_i) = \frac{\Gamma(y_i+v)}{\Gamma(y_i+1)\cdot\Gamma(v)} \cdot \left(\frac{v}{v+\lambda_i}\right)^v \left(\frac{\lambda_i}{v+\lambda_i}\right)^{y_i} \quad (1)$$

Where $P(Y = y_i/X_i)$ designates the probability that Y takes the value y_i;

Setting $v = 1/\alpha$, the mathematical expectation and the variance are obtained respectively by:

$$E(y_i/X_i) = \lambda_i = e^{x\beta} \quad \text{and} \quad Var(y_i/X_i) = \lambda_i(1 + \alpha\lambda_i) \quad (2)$$

With α the overdispersion or underdispersion parameter. Thus, for $\alpha = 0$,, the model boils down to that of poison counting for an underdispersed model and for $\alpha > 0$, reflecting overdispersion, the model refers to that of negative binomial regression.

In model 1, we have:

NAGCEB = f(TUintnet, ABTF100, ABTM100, NbrBanq, TxcePIB, NbrATMp, Urban)

In model 2, we have:

NAGCEB = f(TUintnet, Taille, ABTM100, NbrATMp, Urban)

In model 3, we have:

NAGCEB = f(Taille, NbrBanq, TxcePIB, NbrATMp, Urban, Poplt)

In model 4, we have:

$$NAGCEB = f(TUintnet,\ ABTF100,\ ABTM100,\ NbrBanq, TxcePIB, Urban,\ Poplt)$$

The description of the variables of the four models is made in the following lines.

3.2 Study Variables and Data Sources

Table 1 below summarizes these variables while taking into account their sources and their expected effects (signs) on the number of bank branches.

Table 1. Summary of study variables and expected signs of the variables

Variables	Definition of Variables	Source	
NAGCEB	The number of bank branches	WDI	Expected sign
NBRBANQ	The number of banking institutions	BCEAO	+
TAILLE	The size of the banks	BCEAO	+
ABTF100	The rate of fixed telephone subscribers per 100 inhabitants	WDI	-
ABTM100	The rate of mobile telephone subscribers per 100 inhabitants	WDI	-
TUINTNET	Internet usage rate	WDI	-
NBRATMP	The number of permanent counters	BCEAO	-
TXCEPIB	GDP growth rate	WDI	+
URBAN	The rate of urbanization	WDI	+
POPLT	Population aged 15 to 64 (growth rate)	WDI	+

Source: Authors, from the literature.

Indeed, our study includes a single endogenous variable: the number of banking agencies (NagceB). This variable gives the total number of functional bank branches in a country for a given year. According to the literature and consistent with previous work, the number of bank branches is determined by several factors, of which those retained in this work are: ABTF100, the rate of fixed telephone subscribers per 100 inhabitants; ABTM100, the mobile telephone subscription rate per 100 inhabitants; TUintnet, the internet usage rate; NbrATMp, the number of permanent ATMs. These four variables were used as ICT proxies and to these variables, we associated three other so-called control variables, namely: NbrBanq, the number of banking institutions in the given country for a year; Size, the size of banks

measured by total assets; TxcePIB, which corresponds to the growth rate of Gross and Urban domestic product which quantifies the rate of urbanization of countries. POPLT is the population growth rate which is in percentage. On a methodological level, the estimation of the different models undergoes a certain number of tests, the most important of which are the following.

4. Validation Tests

We initially run the econometric tests listed below, as they emphasise the unique aspects of the data that influence the estimation method choice. The results of these tests will be provided in the following phase, enabling the selection of the estimating technique.

4.1 Homogeneity Test

The homogeneous specification or heterogeneity of the data generating process is an important element, guaranteeing the quality of the estimation results. With this in mind, we carry out the homogeneity test which amounts to testing the equality of the coefficients of the study model in the individual dimension and to verify if there are potential specific effects specific to each country under the alternative hypothesis of the test (H_1: Heterogeneous Panel) or that all countries are the same in the individual dimension under the null hypothesis (H_0: Homogeneous Panel). A dependency test is then carried out.

4.2 Interindividual Dependence Test

Many processes can lead to interindividual dependence, including missing and observed common effects, spatial spillovers, unobserved common effects, and general residual interdependence that may persist even after accounting for all observed and unobserved common effects. Due to its ease of use and widespread usage in literature, the study's interindividual dependence test (Pesaran and Weiner, 2004) is utilised more frequently than the Lagrange Multiplier (LM) created by Breusch-Pagan.

Following the interindividual dependence test, we will conduct the unit root test in order to verify the presence or absence of a unit root in our series. There are also two categories: first generation tests and second generation tests. First-generation unit root tests are only appropriate when the dependence test reveals interindividual independence. Conversely, second generation ones are recommended.

4.3 Presentation of Unit Root and Cointegration Tests

We start with the unit root tests and end with the cointegration test.

4.3.1 Unit Root Tests in Panel Data

Several tests are proposed for carrying out this stationarity or unit root test. For the first category, these are the tests of Harris and Tzavalis (1999) and Levin, Lin and Chu (2002) which admit homogeneity of the autoregressive root under the alternative hypothesis and those of Maddala and Wu (1999), Hadri (2000), and Im Pesaran and Shin (2003) who admit the heterogeneity of the autoregressive root (Hurlin and Mignon. 2006). For second-generation tests, we can cite those of Bai and Ng (2001), Choi (2002), Phillips and Sul (2003), Pesaran

(2007) and Moon and Perron (2004) as described by Hurlin and Mignon (2006). The null hypothesis of these tests assumes that all series are non-stationary. The results of the independence test will determine the type of test to be carried out.

In addition to these tests, it is also necessary to check the possible presumption of a long-term relationship between the series of the study via a cointegration test, in the case of integrated series of different orders.

4.3.2 Cointegration Test

Cointegration refers to the joint evolution of the study variables over time and over the long term. The use of the cointegration technique in panel data makes it possible to test the presence of long-term relationships between the integrated variables. One of the advantages of cointegration tests on panel data is the increase in gain in the power of the test. For this test, we can refer to the tests of Pedroni (1995, 1997, 1999, 2004), Kao (1999) and Westerlund (2007).

Pedroni (1995, 1997) proposed various two-step cointegration tests aimed at understanding the null hypothesis of no intra-individual cointegration for both homogeneous and heterogeneous panels. In the presence of a single regressor in the cointegration relationships, Pedroni (1999, 2004) proposes an extension to the case where the cointegration relationships include more than two variables and develops seven (7) tests based on the estimation of the residual of the model long term. Pedroni tests take into account heterogeneity through parameters that may differ between individuals.

As for the Kao cointegration test, it assumes the cointegration vectors are all homogeneous between individuals and is also only valid for a bivariate system (when only one regressor is present in the cointegration relation). And like Pedroni, Kao offers two tests but only the one from 1999 remains valid for the panel series. This test postulates under the null hypothesis the absence of cointegration in accordance with the Dickey-Fuller type and Augmented Dickey-Fuller type tests.

The results of these preliminary econometric tests will ultimately lead us to the choice of the appropriate estimation method.

5. Results of Econometric and Estimation Tests

We successively present the results of the statistical tests, the correlation matrix and the preliminary tests.

5.1 Descriptive Statistics

Here we provide information on our data based on the descriptive statistics of the variables. Table 2 summarizes the information relating to our study series.

Table 2. Descriptive statistics

Variables	Mean	Standard deviation	Min	Max	Observations
NAGCEB	2.591	1.634	0.136	6.084	
NBRBANQ	11.919	6.098	2	29	
ABTF100	3.068	8.325	0.011	35.154	
ABTM100	43.436	44.120	0	174.025	N = 224
TUINTNET	8.011	12.227	0	58.054	n = 8
NBRATMP	197.495	208.087	1	1201	T = 28
TXCEPIB	4.314	3.766	-28.099	15.376	
URBAN	1173.83	660.91	133.14	2981.95	
POPLT	15.436	0.804	13.225	16.575	

Source: Authors, based on data from the World Bank (WDI, 2022) and the BCEAO (2022).

From the statistics recorded in this table 2, we note that in the WAEMU zone, over the period from 1995 to 2021, the average number of bank branches (NagceB) available per 100 inhabitants is approximately 3 (2.591) with a standard deviation of 1.634 indicating a variance of 2.671 slightly above the mean. This observation implies the over-dispersion of Banking agencies in the union. The maximum number of agencies available for a workforce of 100 inhabitants is 6. Furthermore, WAEMU has on average 12 banks per country (11.919) of which the maximum number is estimated at 29 with a minimum number of 2 banks by country during the period. We also notice a strong dispersion in the number of banks in the union with a variance of 37.195 against the average of 11.919 banks.

Concerning the penetration of information and communication technologies (ICT), the average subscription rate for mobile telephony during the period far exceeds that for fixed telephony, i.e. 43.43% compared to 3.06%. , notwithstanding the late development of this technology. As for the average rate of internet usage, it amounts to 8.01% over the same period. Concerning permanent ATMs, during the period (1995-2021), there was an average number of 197 ATMs (i.e. 197.495), with an increasing number of 1201 ATMs. In addition, the urban area of the union is estimated at 1173.83 km2, on average. The minimum being 133.14 km2 compared to 2981.95 km2, for the maximum area. Finally, the average GDP growth rate over the period is 4.31%.

Following the synthetic description of the variables, we now analyze the existing correlation between them.

5.2 Correlation Matrix

With the main aim of ruling out the potential problem of multi-collinearity of the series, we pay attention to this analysis. This table 3 summarizes these correlations.

Table 3. Variable Correlation Matrix

	NAGCE	NBRBANQ	ABTF100	ABTM100	TUINTNET	NBRATMP	TXCEPIB	URBAN	POPLT
NAGCEB	1.000								
NBRBANQ	0.664	1.000							
ABTF100	0.121	-0.273	1.000						
ABTM100	0.844	0.663	0.183	1.000					
TUINTNET	0.673	0.610	0.124	0.785	1.000				
NBRATMP	0.605	0.763	-0.195	0.692	0.622	1.000			
TXCEPIB	0.130	0.136	-0.071	0.099	0.089	0.135	1.000		
URBAN	0.376	0.819	-0.371	0.452	0.383	0.585	0.112	1.000	
POPLT	0.348	0.730	-0.515	0.338	0.254	0.582	0.206	0.771	1.000

Source: Authors, based on data from the World Bank (WDI, 2022) and the BCEAO (2022).

The analysis of the results of the correlation matrix shows that all the explanatory variables are positively correlated with the number of bank branches. Furthermore, between them, we observe a relatively high correlation as between the number of banks and the urbanization rate. Likewise, the variables of mobile penetration and the number of bank branches have a strong positive correlation between them.

Following this analysis and as introduced above, we now present the results of the econometric tests carried out.

5.3 Results of Econometric Tests

The tests performed consist of tests of homogeneity, interindividual dependence, unit roots and cointegration.

5.3.1 Results of the Homogeneity Test

Table 4 presents the results of the homogeneity test for our four study estimation models.

Table 4. Homogeneity Test

	Model 1	Model 2	Model 3	Model 4
F(7. 216)=	124.89***	137.26***	116.10***	103.28***
Prob > F =	0.000	0.000	0.000	0.000

Source: Authors, based on data from the World Bank (WDI, 2022) and the BCEAO (2022).

Note: (***) represent the level of significance at the 1% level.

The results of the Fisher homogeneity test performed here indicate the heterogeneity of the study panel. Indeed, as presented in Table 4, the static F associated with the test of each model are all significant at the 1% threshold. This requires us to reject the null hypothesis of the absence of specific effects. The Hausman test is then conducted to clarify whether these specific effects are fixed or random. The results of this second test are recorded in table 5.

Table 5. Results of the Hausman test

	Model 1	Model 2	Model 3	Model 4
chi2(5)= (b B)'[(V_b-V_B)^(1)](b-B)=	14.73**	21.72***	77.88***	123.72***
Prob>chi2 =	0.039	0.005	0.000	0.000

Source: Authors, based on data from the World Bank (WDI, 2022) and the BCEAO (2022).

Note: (***) represent the level of significance at the 1% level.

As indicated by the probabilities associated with the test of each model (Prob > chi2 = 0.000 < 1%), the chi2 statistics of the tests are therefore all significant at the 1% level. There is therefore the presence of individual fixed effects. We then present the results of the dependence test below.

5.3.2 Result of the Interindividual Dependence Test

The null hypothesis of the test admits interindividual independence. The results obtained from the Pesaran and Weiner (2004) test are recorded in Table 6.

Table 6. Results of the Dependency Test

	CD-test	p-value	Corr
Model 1	-3.03***	0.002	-0.108
Model 2	-2.80***	0.005	-0.100
Model 3	-2.39**	0.017	-0.085
Model 4	-3.81***	0.000	-0.136

Source: Authors, based on data from the World Bank (WDI, 2022) and the BCEAO (2022).

Note: (***) represent the level of significance at the 1% threshold.

The results of this test confirm the presence of interindividual dependence since the probability accompanying the test of each model is less than 1%. Therefore, the type of unit root test to perform is second generation. The results of this test are provided below.

5.3.3 Results of the Unit Root Test

This test is preliminary to the estimates and makes it possible to deduce the order of integration of the variables. Since here the type of test to be carried out is that of second generation, we conducted the Pesaran (2003) and Pesaran (2007) tests. The results are summarized in Table 7. The test results reveal that except the GDP growth rate (TxcePIB), the number of bank branches (NagceB) and the urbanization rate (Urban), all our variables are stationary in first difference. They are then all integrated of order I(1) except these three variables which are integrated of zero order I(0). This result reveals the presumption of a long-term relationship between our series.

A cointegration test is therefore carried out for greater precision. We present the results of this test in Table 7.

Table 7. Unit Root Test Result

	Stationarity at level and in first difference						
	Stationarity at level			Stationarity in first difference			
Variables	CIPS	CADF	*Decision.*	CIPS	CADF	*Decision*	O,I
NAGCEB	-2.146** (0.016)	-2.496** (0.016)	*S*	-	-	-	I(0)
NBRBANQ	-1.134 (0.128)	-2.149 (0.128)	*N*	72.907*** (0.000)	-3.716*** (0.000)	*S*	I(1)
ABTF100	0.639 (0.739)	-1.332 (0.894)	*N*	69.429*** (0.000)	-4.561*** (0.000)	*S*	I(1)
ABTM100	-2.207 (0.418)	-1.695 (0.575)	*N*	57.479*** (0,000)	-2.453** (0.022)	*S*	I(1)
TUINTNET	-0.087 (0.465)	-0.683 (0.999)	*N*	53.571*** (0.000)	-2.984*** (0.000)	*S*	I(1)
NBRATMP	1.756 (0.998)	-1.924 (0.880)	*N*	79.859*** (0,000)	-2.732*** (0.002)	*S*	I(1)
TXCEPIB	-8.147***(0.000)	-3.686***(0.000)	*S*	-	-	-	I(0)
URBAN	-5.838***(0.00)	-1259*** (0.000)	*S*	-	-	-	I(0)
POPLT	-0.287 (0.387)	-2.108 (0.730)	*N*	-3.328*** (0,000)	-3.638 ***(0.000)	*S*	I(1)

Source: Authors, based on data from the World Bank (WDI, 2022) and the BCEAO (2022).

Note: (***), (**) indicate the level of significance at the 1% and 5% threshold respectively.

5.3.4 Result of the Cointegration Test

The results of the Pedroni (1999) cointegration test carried out are recorded in Table 8.

Table 8. Results of the Pédroni Cointegration Test (1999)

	Model 1	**Model 2**	**Model 3**	**Model 4**
Modified Phillips-Perron t	2.387*** (0.008)	2.119** (0.017)	2.541*** (0.005)	3.512*** (0.000)
Phillips-Perron t	-1.991** (0.023)	-1.600** (0.054)	-1.770** (0.038)	3.222*** (0.000)
Augmented Dickey-Fuller t	-1.985** (0.023)	-2.055** (0.019)	-2.200** (0.013)	3.293*** (0.000)

Source: Authors, based on data from the World Bank (WDI, 2022) and the BCEAO (2022).

Note: (***), (**) indicate the level of significance at the 1% and 5% level, respectively.

We reject the null hypothesis that there is no cointegration link since all of the probabilities related to the test statistics are less than 5%. As a result, the dependent variable (the total number of bank branches) and the explanatory variables have a long-term connection. The specificity of these results recommends the application of the DOLS method for our estimates. However, due to the cardinal nature of our dependent variable (the number of bank branches), the appropriate estimation methods in this study framework are those of counting including that of Poison or Negative Binomial regression (Vasechko et al., 2009). Thus, we use the Poison method when the variance of the series is approximately equal to its mean. For an over-dispersed series where the variance is greater than the mean, the appropriate regression method is Negative Binomial (BN) regression. Which characteristic agrees with our study variable, hence our choice of the negative binomial regression method for our estimations.

6. Presentation of the Estimation Results and Interpretations

Table 8 summarizes the estimation results obtained. The results reveal the significance of several factors.

Table 8. Estimation results using negative binomial regression

	Negative Binomial Regression (BN)			
Variables	Model 1	Model 2	Model 3	Model 4
NBRBANQ	1.042*** (0.000)	-	0,013 (0,595)	0.029 (0.203)
ABTF100	0.026** (0.011)	-	-	0.041*** (0.000)
ABTM100	0.006*** (0.001)	0.0058*** (0.008)	-	0.006*** (0.002)
TUINTNET	-0.003 (0.484)	0.0016 (0.725)	-	-0.003 (0.496)
NBRATMP	-2.3e-4 (0.556)	-0.00032 (0.407)	-1.92e-4 (0,644)	-
TXCEPIB	0.011 (0.418)	-	5.7e-3 (0.693)	0,013 (0.288)
URBAN	-2.8e-4 (0.128)	-5.3e-4***(0.002)	-4.79e-4* (0.088)	-3.8e-4 (0.133)
POPLT	-	-	0.362 (0.607)	0.727** (0.043)
TAILLE	-	1.048*** (0.000)	1.378*** (0.002)	-
CONST	14.861 (0.964)	10.747 (0.967)	4.683 (0.987)	-10.569* (0,052)

Source: Author, based on data from GFDD (2022), ADB and the World Bank (2022).

Note: (***) (**) (*) represent the level of significance at the threshold of 1%, 5% and 10%.

Indeed, the number of banks, fixed and mobile telephone subscriptions, the size of banks as well as the growth of the adult population (15 years and over) significantly and positively influence the number of bank branches in the WAEMU zone. However, the use of the Internet and the number of permanent ATMs have a statically negative but not significant effect on the number of bank branches, relative to our analysis period. Furthermore, urbanization seems to slow down the number of bank branches in our study area and over the

period considered. Indeed, urbanization has a statistically significant and negative correlation with the number of bank branches at the 1% and 10% thresholds as indicated by the results of estimations 2 and 3.

Regarding interpretations, we start with our variable of interest, namely ICT, and end with the control variables. This will involve providing an explanation for the effect of each of these variables on the number of banking branches in the West African Economic and Monetary Union (WAEMU).

Regarding the effect of ICT on the number of bank branches in the WAEMU zone, the results indicate that ICT has a significant effect on the number of bank branches in the WAEMU. Indeed, subscription to fixed and mobile telephony encourages growth in the number of bank agencies in the union. Such results could be explained by the fact that fixed and especially mobile telephone subscriptions lead to the use of other types of financial services that are even more accessible and adapted to a larger portion of the population. The use of these new inclusion channels could thus encourage an increase in the banking rate, the management and maintenance of which leads to the need to open other banking agencies. In addition, the proximity of these new financial services leads banks to follow suit given their high rate of adoption and use.

On the other hand, the use of internet technology and the number of permanent ATMs seem to reduce the number of these agencies. However, even if the latter two technologies have a negative correlation with the number of bank branches, their effects remain statistically insignificant. Such a result could be explained by the fact that the use of the Internet and ATMs relies mainly on the banks' already existing clientele. The contactless possibilities offered by these services to carry out transactions, purchases and payments, then to save, limit the primary need to resort to bank agencies. Thus, the rationality of agents and banks in terms of opportunity costs can therefore justify the strong reliance of customers on these services for their daily operations and also the reduction in the number of agencies. This result also seems to clarify that only internet and ATM technologies remain the main ICTs which reconcile the needs of banking customers while allowing banks to save the costs of setting up new branches. These results are similar to those of Kim (2021) highlighted in the United States according to which a greater number of internet connections leads to the closure of bank branches in the United States.

Regarding how bank sizes affect the number of bank branches in the WAEMU zone, the quantity of banks in each nation as well as their sizes have a positive impact on the quantity of bank branches. In fact, the WAEMU banking network's dynamism suggests financial rivalry, with accessibility serving as a crucial component in determining market share. It goes without saying in this environment of competition that a bank's chances of attracting clients and making money are positively correlated with its accessibility. Furthermore, in their perpetual quest for profit, banks are led to increase their size, allowing the distribution of fixed costs over a larger number of assets and the reduction of their average costs. As a result, the increase in size of a bank contributes to the diversification of its activities and the extension of the agency network, which has a positive impact on profit. This result is contrary

to that of Chen and Strathearn (2020) who find that the size of the banking sector has a negative influence on the density of bank branches in Canada.

As for the effect of demographic and urban growth on the number of bank branches in the WAEMU zone, the results indicate that the growth of the adult population positively influences the number of bank branches. This result would be an efficient response to demand which, with the growth of the adult segment, would experience a greater volume, which could cause congestion in agencies. The creation of new branches therefore becomes necessary for the provision of better banking services. However, the negative effect of urbanization on the number of bank branches is counterintuitive. In accordance with the literature, urbanization should favor the expansion of the bank branch network. On the other hand, this counterintuitive result could be explained, in the context of our developing countries, not only by the process generating urbanization, but also by its disorderly nature. In Africa, urbanization is not necessarily linked to the development of the rural world but to the movement of an impoverished class in search of better well-being in the city. As a result, urbanization does not necessarily rhyme with increased income. However, banks operate like a business, looking for profit. For banks to open branches, city residents would have to be solvent, which is not always the case.

In summary, the study shows that ICT has a significant effect on the number of bank branches as well as certain macroeconomic variables such as the growth of the adult population, the size of banks and urbanization.

7. **Conclusion**

The main objective of this study was to analyze the effect of ICTs on the number of bank branches in the eight (08) member countries in the WAEMU zone over the period from 1995 to 2021. After an econometric analysis of the preliminary tests, the counting estimation methods were found to be suitable for our estimates. Thus, by applying the negative binomial (BN) regression method, the study leads to four important results:

1. Among the ICT variables selected, only mobile and fixed-line telephone subscriptions have a statistically significant and positive effect on the number of bank branches in the union.

2. Internet and ATMs have no significant effect on the number of branches, although they remain negatively correlated with the number of branches.

3. The number of banking institutions and bank size favor the opening of new bank branches.

4. Urbanization seems to explain the decline in the number of bank branches in the WAEMU zone.

Such results suggest two major lessons. Banks need to develop more services using mobile telephony in order to profit while offering quality services to the population. As far as fixed-line telephony is concerned, it can be an instrument enabling banks to get closer to their

customers. In this way, banks will not only be able to obtain information from their customers, but also to offer them suitable products.

In view of these results, banks need to make better use of the Internet and ATM channels. This would reduce their operating costs and, in turn, boost their profits. In this way, banks will be able to offer new products to different types of customer, given the relatively high penetration rate in the WAEMU zone. Fixed telephony can help reduce the distance between the population and banks in the zone. As Internet access is expensive for the majority of the population, mobile telephony could enable banks to offer more mobile services.

Finally, financial education also remains a major challenge. On the other hand, the results of this study could be enriched with explanatory variables from studies capturing the "usage" dimension of these technologies and the diversification of banking services.

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