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# Development of financial innovation and economic growth: An approach using the autoregressive method with staged lags

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## ABSTRACT
The objective of this article is to evaluate the effect of the development of financial innovation on economic growth in the CEMAC sub-region during the period 2000-2020. To achieve this objective, the study employed the autoregressive method with staggered lags in a dynamic panel, which is robust to autocorrelation, heteroskedasticity, and potential endogeneity issues. The estimation results revealed that financial innovation has a positive and significant effect on economic growth in the CEMAC zone. Moreover, the analysis of the nonlinear relationship indicates that there is a threshold of 43.15%, beyond which further expansion of financial innovation has a negative and significant impact on economic growth. This suggests a relationship resembling an inverted U-shaped curve between financial innovation and economic growth. Consequently, public authorities within the Economic and Monetary Community of Central Africa (CEMAC) should increase investments in financial infrastructure, such as expanding the number of banking agencies in countries like Gabon and Cameroon, to enhance proximity between ATM services and the population. They should also facilitate access to credit from financial institutions to encourage economic operators to invest in remote areas, thereby increasing access to financial services for impoverished populations. Finally, CEMAC leaders should consider policies that promote the use of mobile money for fund transfers and the expansion of ATM services across member countries, fostering greater financial inclusion and economic development.

**Contribution/Originality:** This work is the first to analyze the effect of innovation development on economic growth using the dynamic panel autoregressive method with staggered lags. This method is particularly robust against autocorrelation, heteroscedasticity, and potential endogeneity issues. Furthermore, it highlights the non-linear relationship between the two variables.

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## 1. INTRODUCTION

Economic activity today is being revolutionized by financial innovation, which strives to meet the demands of economic agents and the market, and to adapt to technological advances. The numerous ATMs, mobile phone services such as mobile money, the countless derivative products developed in recent years—particularly by banking institutions—and the new opportunities for accessing financial services are tangible examples. Financial innovation could therefore be defined not only as the development of new financial products but also as the entire informational, structural, and technical process through which banks aim to reduce costs by automating banking procedures, lowering the cost of collecting information and savings from customers, and ultimately reducing the risks associated with resource allocation. Since the 2000s, the Economic and Monetary Community of Central African States (CEMAC) has achieved substantial financial development characterized by increased population access to financial services, accumulation of financial assets, a broader range of financial instruments, greater diversity of financial institutions, improved efficiency, heightened competition in the financial sector, and an increase in innovative financial services based on mobile telephony (Mlachila, 2016).

According to the report of the Bank of Central African States (BEAC) dated December 31, 2019, twenty-one (21) banks were authorized to carry out the activity of issuing electronic money. There were sixty-eight thousand two hundred and twenty (68,220) service points available across CEMAC, representing an increase compared to fifty-three thousand three hundred and three (53,303) points at the end of 2018. The number of payment accounts associated with electronic money instruments experienced significant growth, rising from seventeen point eight (17.8) million registered accounts at the end of 2018 to twenty-four point seven (24.7) million twelve months later. Additionally, with the inclusion of new payment systems and services in the monitoring system, particular emphasis has been placed on enhancing financial and human resources. This focus aims to ensure the effective execution of the monitoring function and to mitigate all risks inherent in the operation of these payment systems and services.

In 2019, electronic money activity recorded eight hundred and eighteen million nine hundred and forty-one thousand seven hundred and seven (818,941,707) transactions, totaling eleven thousand three hundred and thirty-five billion (11,335,000,000) CFA francs. This represents an increase compared to 2018, which saw five hundred seventy-two million three hundred sixty-two thousand six hundred thirty-five (572,362,635) transactions, amounting to eight thousand two hundred ninety-six billion (8,296,000,000) CFA francs. Mobile money accounted for 96% of this total value, highlighting its dominant role in the electronic money sector during that year (Bank of Central African States, 2019).

It should be noted that in CEMAC countries, the banking sector dominates the financial sector, given the volume of transactions it carries out (Omankhanlen, 2012). As of December 31, 2019, the sub-region had 51 banks and 9 financial institutions operating within its borders. The distribution was as follows: Cameroon had 15 banks and 7 financial institutions; the Central African Republic had 4 banks; Congo had 11 banks; Gabon had 7 banks and 2 financial institutions; Equatorial Guinea had 5 banks; and Chad had 9 banks. In addition to the banking sector, microfinance has experienced rapid growth, providing various financial services such as loans, deposits, money transfers, and insurance to very low-income clients. This expansion has contributed significantly to financial inclusion and economic development in the region, addressing the needs of underserved populations and fostering local entrepreneurship.

This rapid growth of microfinance in Africa, in the years 2000 to 2013, shows that total assets increased by 427%, the number of borrowers by 204%, and loans by 504% (Yousuf & Masih, 2016). Despite the evolution of microfinance in the CEMAC sub-region, it has been dominated by mobile telephony, which has gained momentum in the countries of this sub-region. Thus, according to GSM (Global Association of Mobile Phone Operators), the penetration of mobile money usage was particularly strong in Gabon (43% of the population over the age of 15 had an account in 2017), but remains more discreet in the other countries of the sub-region, i.e., 16% of the adult population in the DRC in 2017, 15% in Cameroon and Chad, and 6% in Congo, according to the European Investment Bank (2017). Thus, it can be seen that the development of innovative financial services in the CEMAC sub-region is leading to strong economic growth.

For nearly two and a half centuries[1], economic growth has occupied the minds of economists. Smith (1776) opens a breach in a series of studies on the causes of the wealth of nations. From a conceptual point of view, economic growth refers to the sustained increase over one or more long periods of a dimension indicator, notably the real Gross Domestic Product (GDP). Perroux (1961), Mohamedi (2018), and Weil (2013), in turn define economic growth as an increase in the quantity of goods and services produced each year in an economy. Economic growth is therefore one of the most exciting phenomena in science.

Economic, because it allows us to understand the process of enrichment and the disparities in living standards between countries (Nshue, 2012; Randiki, 2016). Based on this fact, it should be noted that in the countries of the CEMAC sub-region, the level of wealth created has increased considerably since the beginning of the period of financial reforms. Thus, World Bank statistics show that real GDP per capita stands at nearly $4,489 in the CEMAC sub-region compared to $4,137 in the Southern African Development Community.

It is $800 in the West African Economic and Monetary Union (WAEMU) zone and $726 in the East African Community. At the regional level, income levels vary from one country to another. In the CEMAC region, for example, real GDP per capita ranges from $325.70 in the Central African Republic to $12,028.60 in Equatorial Guinea and $1,357.10 in Cameroon.

While the trajectory of real GDP is well known, that of economic growth is erratic. Economic growth rates in the subregion, although low and sometimes negative, have fluctuated with a downward trend. For example, the real GDP

[1] Some economists trace the first reflections back to the industrial revolution.

growth rate in the CEMAC subregion reportedly fell from -2.3% in 1993 to 4.1% in 2001 and from 3.3% in 2015 to -1.2% in 2016 (World Bank, 2018). However, due to the deterioration of its economic growth in recent years, CEMAC is currently one of the developing regions with the lowest growth rates. World Bank (2018) shows that on average, the real GDP per capita growth rate is -3.7% in CEMAC countries, compared to 1.1% in Sub-Saharan African (SSA) countries over the period 2010-2016.

This rate is lower than those of other regions in Africa, which respectively record rates of 2.1% in the Southern African Development Community, 4.6% in the East African Community, and 5.8% in the West African Economic and Monetary Union (WAEMU).

## 2. BRIEF LITERATURE REVIEW

The role of financial innovation development in economic growth has received little attention, given that financial activity is dominated by intermediation operations. Indeed, it appears that previously, financial innovation was not the preserve of the financial sector but rather of the real sector. This explains why the literature on the subject is not only late in emerging, but also has not experienced explosive growth. This state of affairs is criticized by Frame and White (2002), who denounce the lack of empirical research on the conditions under which the economic environment (financial regulatory policy, taxation, macroeconomic stability, technological maturity) can stimulate financial innovation, and the lack of empirical data on the subject.

As an illustration, Frame and White (2002) suggest that Cohen and Levin (1989) used 251 articles and books to conduct a survey on technological innovation, while for the same study on financial innovation, they had only 24 articles. In desperation, they advance: "Everybody talks about financial innovation, but (almost) nobody empirically tests hypotheses about it." Frame and White (2002). To say that "everyone talks about financial innovation, but almost no one empirically tests hypotheses about it."

Indeed, it must be emphasized that, since economic development depends on the financial system, the latter will have to innovate constantly to meet new economic demands and stimulate economic growth. Hence, the preponderant role of the financial sector is not only in the field of intermediation but also in financial innovation. Thus, since the 1980s, financial innovation has become essential to enable the financial sector to meet the demands of economic agents and markets, given the transformations in the macroeconomic environment.

As Frame and White (2002) so aptly point out: ".... A financial innovation represents something new that reduces costs, reduces risks, or provides an improved product/service/instrument that better satisfies participants' demands..."

Financial innovation leads banks not only to improve existing financial products, but also to create new products in order to optimally meet agents' demands, market needs, legal and institutional constraints, and, finally, changes in the macroeconomic environment. Thus, since financial innovation plays a key role in promoting venture capital, increasing liquidity and transferring risks, it would be an essential link in the process of economic growth, or to use the words of Van Horne (1985) the cornerstone of the financial system: "One of the bedrocks of our financial system is financial innovation, the life blood of efficient and responsive capital markets." Also, for Merton (1995), financial innovation is undoubtedly the machine that leads the financial system to improve the performance of the real sector. Tufano (2003) uses his words as follows: "Financial innovation is viewed as the engine driving the financial system towards its goal of improving the performance of what economists call the 'real economy'."

According to Abraham (1987), financial innovation is characterized by endogenous and embodied technical progress. It can be as disruptive as it is continuous, is driven by demand at least as much as by supply, saves labor, and increases capital intensity in the financial sector. He adds that when the cost reductions brought about by financial innovation are not retained within the financial sector, but passed on to customers, they influence economic activity if the macroeconomic and institutional environment is also favorable to other growth factors.

Furthermore, financial innovation can also be considered an integrated process that begins with invention and ends with diffusion.

This diffusion occurs, according to Miller (1986), following upheavals in the economic environment. It primarily involves inventions that achieve explosive success compared to existing products, leading to strong customer acceptance. Since financial innovation is the translation of industrial innovation into the banking sector, it meets the standards set by Schumpeter (1912). In this respect, financial innovation consists of creating new financial products or improving existing ones; this may correspond to the implementation of new payment methods (e.g., various electronic cards). to the creation and distribution of money through new circuits based on New Information and Communication Technologies (NICT), internet banking, telephone banking, home banking, etc. As an illustration, it can be noted that the financial innovations that have occurred in the mortgage market in recent years have been a determining factor in the strong growth recorded in the United States (Brender & Pisani, 2004). Indeed, the American financial system has changed profoundly with the rise of securitization. By closely linking the cost of mortgage credit to movements in the bond markets, securitization has made it possible to cushion the effects of successive shocks and to revive growth through household demand[2].

Financial innovations have historically attracted limited scholarly attention. The regulations enacted following the crisis of the 1930s, which remained in effect for over four decades, undoubtedly restricted financial changes and directed focus toward financial innovations as a driver of economic growth. Therefore, the concept of financial innovation was only introduced during the first half of the 1970s by Greenbaum and Haywood (1971) and Silber (1975).

[2] It should be noted, however, that this positive effect of financial innovation is very limited in time: the recent subprime crisis speaks volumes about the potential excesses of excessive, poorly controlled and poorly regulated financial innovation.

These authors highlight the theory of innovation induced by the demand for new characteristics and the theory of innovation induced by institutional constraints.

According to Abraham (1987) and Bhatt (1988), financial innovation is essential for economic growth since it has been used to contain the explosion of costs in the financial sector and then to open up new project possibilities in an environment characterized by restrictive regulations, a more diversified demand from customers and finally a reduction in intermediation margins given the exacerbation of banking competition. Financial innovation, according to Bhatt (1988), is also the creative adaptation of banking technology to the economic environment. For Schumpeter (1912), bank credits are essential for economic growth and the banker must stimulate innovation (process of creative destruction) by financing entrepreneurs with the best chance of succeeding in their projects. Chen (1995), for his part, believes that financial innovation plays an important role in the economy by reducing transaction costs, providing better risk sharing, and generating financial gains.

The above statements are not unanimously agreed with that of Pesendorfer (1995), who believes that the efficiency of financial innovation has a "redundancy" effect, meaning that new securities are combinations of existing securities and do not always improve the utility of economic agents. He also shows that complementarity between existing financial innovations and financial intermediaries can lead to inefficiency in the level of financial innovation. According to this author, efficiency is achieved if there is a single type of intermediary or if operating costs are zero. Merton (1995) predicts that the future of financial innovation will not be characterized by new product introductions, but rather by structural and institutional changes. With the arrival of the theory of endogenous growth with financial innovation, the relationship between financial innovation and growth will find a true theoretical conception and return to the forefront. In this wake, financial innovation influences economic growth by acting on three factors: households, the financial sector, and firms. Chou and Chin (2004) and Eggoh and Vilieu (2009) are the authors of the pioneering models of this theory of endogenous growth with financial innovation.

Other studies show that the relationship between the development of financial innovation and economic growth is positive and that there is a bidirectional causality between the two dimensions in most countries. This is the pioneering study conducted by Hassan, Sanchez, and Yu (2011), who used multivariate time series models with six financial innovation proxies to examine the relationship between the development of financial innovation and real sector growth in 168 developing countries. The studies by Valverde, Paso, and Fernández (2014), in turn, used panel data for the period 1990–2011 and applied various econometric methods to study the link between financial innovation and economic growth in seven Latin American countries. The results of their study showed no evidence that the development of financial innovation had an effect on economic growth during the period.

A few authors have also studied the relationship between financial innovation and economic growth in developing economies, particularly in Africa. One of the pioneering studies in this context was conducted by Gakure and Ngumi (2013), who applied multiple regression analysis to assess the relationship between financial innovation and economic growth in Nigeria. Financial innovation was proxied by ATMs, credit cards, electronic banking, and mobile phone transfers. The results of their study showed that economic growth was moderately influenced by financial innovation products. The study by Simiyu, Kilonzo, and Mwangi (2014) estimated the impact of financial innovations on market size in South Africa. They used the co-integration test and employed quantitative data from 200 respondents. The correlation results suggested, on the one hand, no significant relationship between the various channels of financial innovation used and market size, and on the other hand, a significant relationship between the various market needs and the innovative financial products developed.

The authors suggest using financial innovations to increase customer satisfaction and value on the one hand, and to increase market size on the other. The divergences in effects demonstrate the multitude of problems associated with the evaluation of the relationship between the development of financial innovation and economic growth.

In light of these controversies and considering the contextual facts presented above, this study examines the leverage effect that the development of financial innovation can have on the dynamics of the real sector of the economies within the CEMAC sub-region. The objective of this work is to determine the impact of financial innovation development on economic growth in the countries of the CEMAC sub-region. The study is structured into several sections: Section III discusses the methodology, Section IV presents and discusses the results, and Section V concludes the study.

## 3. METHODOLOGY

### *3.1. Data Sources*

To achieve the objectives of our study, we utilized data from two sources. Data on financial innovation were provided by the International Financial Service (2020). This database supplied information on two variables: ATM services in each country and the volume of electronic transfers. Data on the economic performance of countries were obtained from the World Bank (2020) databases. These databases offer information on six countries within the CEMAC sub-region, namely Cameroon, Gabon, Central African Republic, Chad, Equatorial Guinea, and Congo, covering the period from 2000 to 2020.

### *3.2. Model Specification*

To determine the relationship between financial innovation and economic growth, we drew inspiration from the work of Dontsi (2023) and Eggoh and Vilieu (2009), who used mobile money and ATM services (ADAB) as variables to measure financial innovation. However, to address the issue of omitted variables, a set of control variables from the literature was included in each model.

The economic growth measure chosen for this study is inspired by the work of Gaies (2018), Petkovski and Kjosevski (2014), Booysen (2013), Kpodar (2006), and Levine (1997). The annual growth rate of the gross domestic product (AGRP) is a key economic indicator. This variable, when compared to the current GDP, offers the advantage of not being limited to a specific situation and effectively captures the variation in GDP from one year to the next. By integrating these different variables, the overall model's functional form is presented as follows.

$$TCPIB_{it} = \alpha 0 + \alpha 1 MMit + MM^2 it + \alpha 2 DPCGit + \alpha 3 FBCFit + \alpha 4 SDABit + \mu i + \delta t + it \quad (1)$$

Where:

- $TCPIB_{it}$ is the economic growth indicator of country $i$ at date $t$.
- $\mu_i$ represents individual fixed effects (Country-specific effects).
- $\delta_t$ represents time-specific effects.
- $MM_{it}$ it is the Mobile Money indicator of country $i$ at date $t$.
- $\boldsymbol{\alpha_j}$ are the coefficients to be estimated.
- $i = 1, 2, 3, 4, 5, ;$ $t = 1, 2, 3, \ldots\ldots, 20.$

In Equation 1, the variable $MM_{it}^2$ is used to assess the existence of mobile money in an economy, and its extent is strongly correlated with the rate of mobile phone penetration in the economy. The development of this service increases the demand for money for transaction purposes and therefore, increases the velocity of money circulation and the level of activity of economic agents. In this work, financial innovation is captured by the rate of use of "Mobile Money". It is measured by the ratio between the number of active accounts and the number of open accounts (World Bank, 2020). This indicator is commonly used in the literature, notably Dontsi (2023). In addition, financial innovation can also be represented by a dummy variable that takes the value 1 if it is possible to carry out financial transactions via mobile phones, and 0 otherwise (Avom & Mvogo, 2020). In this work, we do not use the dummy variable to capture financial innovation, because we want to verify whether there is also a non-linear relationship between financial innovation and economic growth.

The variable $SDAB_{it}$ is approximated in this study by the number of ATMs. This indicator is known as the measure of the financial depth of an economy. It reflects the degree of financial maturity of the financial system. Financial literature recognizes that the provision of financial services is positively correlated with the size of the financial system such that a country with a large financial system offers economic agents a more extensive and diversified range of financial services (Cezar, 2012). This increases the velocity of circulation of money and the level of economic activity.

### *3.3. Estimation Technique*

The objective of this section is to describe the analytical methods used to determine the effect of financial innovation on economic growth. To accomplish this, we selected the ARDL (Autoregressive Distributed Lags) method.

This method was adopted in this study for several reasons. First, it is appropriate for addressing two common econometric issues in financial data: endogeneity and periodic correlation. It is argued that endogeneity and periodic correlation can be corrected if the ARDL model is adopted with a sufficient number of lags. Furthermore, Yaoxing (2010) notes that the use of appropriate lags in ARDL models corrects for periodic correlation between residuals and resolves endogeneity problems in regression. Second, this latter method has the advantage of allowing the joint estimation of short-term and long-term parameters, as well as the incorporation of variables that can be integrated of different orders, namely I(0) and I(1).

In addition, this technique allows for relatively more efficient results in the presence of small samples (Banerjee, Dolado, & Mestre, 1998). Finally, this technique takes heterogeneity into account, unlike the traditional panel (Jun, 2012).

Following the ARDL cointegration technique, the relationship between financial innovation and economic growth in the CEMAC subregion is analyzed.

$$y_{it} = \mu_i + \vartheta_t + \sum_{i=1}^{N} \gamma_{it} p y_{it-j} + \sum_{i=0}^{N} \beta_i X_{it-j} + \varepsilon_{it}\, q_j \quad (2)$$

Where $i$=1 … indicates the countries t=1… T indicates the number of periods, $\mu i$ is the individual fixed effect $p$ the number of lags of the dependent variable and q the number of lags of the explanatory variables, $yit$ the dependent variable (the growth rate) and $Xit$ the vector of explanatory variables.

In the case of cointegration of the variables, the term $\varepsilon it$ is stationary.

Equation 1 can be rewritten with an error correction formula, yielding the following Error Correction Model (ECM).

$$\Delta Y_{it} = \delta_0 + \sum_{j=m}^{n} b_j \Delta Y_{it-j} + \sum_{j=m}^{n} c_j \Delta X1_{it-j} +$$

$$\sum_{j=m}^{n} d_j \Delta X2_{it-j} + .. + \sum_{j=m}^{n} n_j \Delta Xn_{it-j} + \beta_1 Y_{it-m} + \beta_2 X1_{it-m} + \beta_3 X2_{it-m} +$$

$$\cdots .. + \beta_{n+1} Xn_{it-m} + \varepsilon_{it} \quad (3)$$

Where:

$\Delta Y_{it}$ is the dependent or explained variable $\delta_0$ the constant, $Y_{it-m}$, the lagged dependent variable, $X1_{it-m} X2_{it-m}$ ……$Xn_{it-m}$, are the independent or explanatory variables $b_j\, c_j\, d_j$ …… $n_j$ are the short-term parameters, $\beta_1 \beta_2 \beta_3$ …… $\beta_{n+1}$, are the long-term parameters and $\varepsilon_{it}$ the error term.

The overall model described above is written as follows: (4)

$$\Delta TCPIB_{it} = \delta_0 + \sum_{j=m}^{n} b_j \Delta TCPIB_{it-j} + \sum_{j=m}^{n} c_j \Delta MM_{it-j} + \sum_{j=m}^{n} d_j \Delta MM^2_{it-j} + \sum_{j=m}^{n} e_j \Delta DPCG_{it-j} + \sum_{j=m}^{n} f_j FBCF_{it-j} + \sum_{j=m}^{n} g_j \Delta SDA_{it-j} + \varphi_i (\beta_1 TCPIB_{it-m} + \beta_2 MM_{it-m} + \beta_3 MM^2_{it-m} + \beta_4 DPCG_{it-m} + \beta_5 FBCF_{it-m} + \beta_6 SDAB_{it-m}) + \varepsilon_{it} \quad (4)$$

The ARDL panel cointegration technique is based on three estimators: the Mean Group (MG), the Pooled Mean Group (PMG), and the Dynamic Fixed Effect (DFE).

a) The MG estimator, proposed by Op. Cit., is the unweighted average of the coefficients from different individual regressions. It accounts for the variability of the coefficients in both the long and short term. The estimator is obtained by independently estimating N regressions and then averaging the resulting coefficients. This approach demonstrates that the MG estimator is a consistent estimator of the mean of the parameters.

b) The PMG and DFE were developed by Pesaran, Shin, and Smith (1999). The PMG combines both averaging and pooling methods. The latter imposes an equality constraint on the long-term coefficients and allows the short-term coefficients to differ across groups. The fundamental difference between the MG and the PMG models lies in the fact that the MG estimator does not consider the possibility that some parameters within the group may be identical. The PMG estimator is effective when the imposed restrictions are valid; however, if heterogeneity exists, this estimator can be biased. The DFE model is similar to the PMG but differs in that it assumes all slope coefficients and short-term error variances are identical, allowing only the individual effects to vary between groups. The choice of the best estimator between these three estimators involves a compromise between consistency and efficiency through the Hausman (1978). Estimators that impose restrictions tend to be more efficient when used with heterogeneous models, provided that the restrictions are valid. For example, if the long-term coefficients are identical across countries, the Pooled Mean Group (PMG) estimator will be both consistent and efficient, whereas the Mean Group (MG) estimator will be consistent but not efficient. Conversely, if the long-term restrictions are imposed incorrectly, the PMG estimator will lose its consistency, while the MG estimator will still provide consistent estimates of the average long-term coefficients across countries.

## 4. PRESENTATION OF RESULTS AND DISCUSSION

The presentation of the results of this study was organized around two main points: the description of the variables and the outcomes of the regression model estimation.

### *4.1. Descriptive Statistics*

The following paragraphs are dedicated to presenting and describing the model variables, including descriptive statistics, the correlation matrix, and a graph that summarizes the relationship between financial innovation and economic growth.

Table 1 summarizes the model variables using several indicators. This table indicates that the average percentage of active mobile money accounts in CEMAC countries is 7.07%, while the average for ATM services is 3.60%. This suggests that the financial system within the CEMAC sub-region remains in its early developmental stages. However, this average conceals certain disparities among the countries in the sub-region. For example, in Gabon in 2020, the ratio of active accounts to open accounts was 64.33%, highlighting significant variation in financial inclusion levels across different nations within the region.

This shows the lead that this country has over others in terms of financial innovation. As for the gross domestic product variable, it has an average of 3.97% over the last two decades. This rate remains low compared to the economic growth potential of the countries in this sub-region.

**Table 1.** Descriptive statistics of the variables.

| Variable | Obs. | Mean | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|
| pib | 126 | 3.978 | 9.541 | -36.392 | 63.38 |
| mm | 126 | 7.078 | 13.215 | 0 | 64.334 |
| dpcg | 126 | 11.586 | 5.256 | 167 | 29.118 |
| fbcf | 126 | 26.308 | 12.985 | 5.31 | 79.401 |
| Sdab | 126 | 3.607 | 4.518 | 0 | 18.935 |
| infl | 126 | 7.169 | 15.612 | -29.547 | 70.191 |
| trade | 126 | 90.125 | 48.512 | 33.21 | 252.827 |
| exdebt | 126 | 30.254 | 32.784 | -33.118 | 165.97 |

As for the correlation matrix, it is shown in Table 2. Analysis of this matrix reveals two main pieces of information. The first observation is that the correlation coefficient between the model's explanatory variables is less than 87%, which demonstrates that our model does not suffer from the multicollinearity problem. Based on the correlation between financial innovation and economic growth, we will uniquely determine the contribution of financial innovation to economic growth.

Thus, the relationship between the correlation coefficient and the coefficient of determination is as follows.

$$\rho_{xy} = \sqrt{R^2} \rightarrow R^2 = \rho_{xy}^2 \rightarrow R^2 = -0{,}1793^2$$

= 0,0321 = 3,21%.

With:

$\rho_{xy}$ : The correlation coefficient.

$R^2$ : The determination coefficient.

The results of this relationship show that the coefficient of determination measures the contribution of financial innovation to economic growth in the CEMAC sub-region. This contribution is 3.21%.

**Table 2.** Correlation matrix between variables.

| Variable | PIB | MM | DPCG | FBCF | SDA | INFL | TRADE | EXDEBT |
|---|---|---|---|---|---|---|---|---|
| PIB | 1.0000 | | | | | | | |
| MM | -0.1793 | 1.0000 | | | | | | |
| DPCG | -0.5654 | 0.0497 | 1.0000 | | | | | |
| FBCF | 0.2715 | -0.0706 | -0.0790 | 1.0000 | | | | |
| SDA | -0.2877 | 0.6289 | 0.5338 | -0.0003 | 1.0000 | | | |
| INFL | 0.0458 | 0.1449 | -0.1654 | 0.0654 | -0.0184 | 1.0000 | | |
| TRADE | 0.3107 | -0.1206 | -0.0457 | 0.6814 | 0.0588 | -0.0087 | 1.0000 | |
| EXDEBT | -0.0167 | -0.1737 | 0.1596 | -0.1416 | -0.2230 | -0.0486 | -0.0954 | 1.0000 |

**Source:** Authors using Stata 12 software.

Table 3 records the results of Pesaran (2004) cross-sectional dependence test. The purpose of this test is to distinguish between unit root tests used to analyze the stationarity of different variables. When a variable exhibits cross-sectional dependence, second-generation tests are appropriate for analyzing its stationarity. Conversely, if a variable exhibits cross-sectional independence, first-generation tests are suitable. The null hypothesis of Pesaran (2004) test states the absence of cross-sectional dependence. Based on the P-values, only the gross fixed capital formation variable shows cross-sectional independence, while the other variables exhibit cross-sectional dependence.

**Table 3.** Pesaran (2004) cross-sectional dependence test.

| Variable | CD-test | p-value | corr | abs(corr) |
|---|---|---|---|---|
| pib | 2.29 | 0.022 | 0.129 | 0.212 |
| mm | 14.72 | 0.000 | 0.829 | 0.829 |
| dpcg | 2.75 | 0.006 | 0.155 | 0.307 |
| fbcf | 1.06 | 0.287 | 0.060 | 0.299 |
| sda | 17.05 | 0.000 | 0.961 | 0.961 |

**Source:** Authors using Eviews 9 software.

### *4.2. Estimation Results and Discussion*

The results are presented in the various tables below. Table 4 presents the results of the effect of financial innovation on economic growth in the CEMAC sub-region using the ARDL method, also known as the PMG (Pooled Mean Group) method. Table 5 presents the specific short-term analysis of the effect of financial innovation on economic growth in each country of the CEMAC sub-region. Finally, Table 6 presents a robustness analysis by reproducing the estimates from Table 1 with additional control variables.

**Table 4.** Effect of « Mobile money » on economic growth in the CEMAC sub-region using the ARDL Method.

| Long-term | 1 | 2 | 3 |
|---|---|---|---|
| MM | 0.2589*** (0.00) | 0.2409*** (0.00) | 0.3272** (0.02) |
| MM2 | -0.0030** (0.01) | -0.0027** (0.03) | -0.0036** (0.01) |
| DPCG | -0.9798*** (0.00) | -1.0356*** (0.00) | -0.9232*** (0.00) |
| FBCF | | 0.0309 (0.4) | 0.0103 (0.08) |
| SDAB | | | -0.3162 (0.3) |
| Court-terme | | | |
| Cointeq | -1.0601*** (0.00) | -1.0252*** (0.00) | -0.9794*** (0.00) |
| D(MM) | -4.5940 (0.2) | -4.3451 (0.3) | -4.8622 (0.3) |

| Long-term | 1 | 2 | 3 |
|---|---|---|---|
| D(MM²) | 10.4242<br>(0.3) | 11.4452<br>(0.3) | 12.7520<br>(0.3) |
| D(DPCG) | -1.3185*<br>(0.09) | -1.2286*<br>(0.08) | -1.3577**<br>(0.04) |
| D(FBCF) | | 0.0879<br>(0.5) | 0.1352<br>(0.3) |
| D(SDAB) | | | -1.8673<br>(0.5) |
| Cons | 17.7691***<br>(0.00) | 17.1519***<br>(0.00) | 16.1066***<br>(0.00) |

**Note:** NB: ***; ** and * significance at 1%, 5% and 10%. Values in parentheses represent probabilities.

### *4.2.1. Analysis of the Impact of Financial Innovation on Economic Growth in the CEMAC Sub-Region using the PMG Method*

Using the autoregressive method with staggered lags, robust to autocorrelation, heteroscedasticity of errors, and a possible endogeneity problem, shows that the coefficient of the restoring force is negative and significant for the three columns of Table 4. This indicates that there is a long-term relationship between economic growth and its fundamentals.

The analysis of the restoring force in column 3 (-0.97) shows that it takes 9.7 years for economic growth to return to its steady state (equilibrium) following a deviation caused by a financial innovation shock. This suggests that it takes about 10 years for the effects of a financial innovation shock in the CEMAC sub-region to completely disappear and for the real GDP growth rate to return to its equilibrium level. Thus, the return to equilibrium is not immediate, particularly due to the lack of convergence of CEMAC countries on financial intermediation. Furthermore, the variables mobile money and mobile money squared, as well as general government consumption expenditure, are significant in the long run.

Although panel analysis allows us to assess the overall behavior of a phenomenon, it should be noted that it has limitations in that it does not take into account disparities within the countries that make up this panel. For this reason, we extend the analysis in Table 5 to deduce the short-term relationship between financial innovation and economic growth in each CEMAC country, the aim being to highlight disparities between countries.

**Table 5.** Specific short-term analysis of the effect of mobile money on economic growth in each CEMAC country.

| | CMR | COG | RCA | GE | TCHAD | GABON |
|---|---|---|---|---|---|---|
| Cointeq | -0.5903***<br>(0.00) | -1.3036***<br>(0.00) | -0.7667***<br>(0.02) | -1.0808***<br>(0.00) | -0.9233***<br>(0.00) | -1.2119***<br>(0.00) |
| D(MM) | 0.1396**<br>(0.01) | 0.0400 (0.97) | 2.5933<br>(0.8) | -29.0136<br>(0.9) | -3.1140<br>(0.3) | 0.1815**<br>(0.02) |
| D(MM²) | -0.0106***<br>(0.00) | -0.1170***<br>(0.00) | -0.3776<br>(0.3) | 77.0700<br>(0.9) | -0.0387***<br>(0.00) | -0.0135***<br>(0.00) |
| D(DPCG) | 0.0603<br>(0.9) | 0.1507<br>(0.5) | -1.5487**<br>(0.04) | -2.2348<br>(0.2) | -4.1167<br>(0.1) | -0.4572*<br>(0.05) |
| D(FBCF) | 0.1071<br>(0.3) | -0.0075<br>(0.2) | 0.8842<br>(0.1) | -0.0843<br>(0.7) | -0.1329***<br>(0.00) | 0.0450<br>(0.3) |
| D(SDA) | 2.5969<br>(0.5) | 1.9702<br>(0.47) | -0.1639<br>(0.9) | -2.3078<br>(0.8) | 18.3411<br>(0.8) | 5.0414<br>(0.2) |
| Cons | 7.9779<br>(0.5) | 22.9118<br>(0.4) | 7.4555<br>(0.7) | 26.1671<br>(0.6) | 15.1911<br>(0.2) | 16.9360<br>(0.4) |

**Note:** **NB**: ***; ** and * significance at 1%, 5% and 10%. Values in parentheses represent probabilities.

### *4.2.2. Specific Short-Term Analysis of the Effect of Financial Innovation on Economic Growth in Each Country of the CEMAC Sub-Region*

The short-term results of the relationship between financial innovation and economic growth are documented in Table 5. This table indicates that Cameroon and Gabon are the CEMAC countries where financial innovation has a positive and significant impact on economic growth, with a higher contribution in Gabon compared to Cameroon, since a one-unit increase in the mobile money usage rate promotes an increase in economic growth of 18.15% and 13.96%, respectively. This demonstrates that financial innovation through the use of mobile money is well developed in these countries. Furthermore, the inverted U-shaped relationship between financial innovation and economic growth is confirmed in these two countries. In conclusion, financial innovation in the CEMAC sub-region is driven by two countries: Gabon and Cameroon. Moreover, analysis of the error correction coefficient (speed of adjustment or restoring force) reveals that it takes nearly six years in Cameroon and 12 years in Gabon for economic growth to return to its steady state following a financial innovation shock in the CEMAC sub-region. This demonstrates that financial policy is not convergent in the CEMAC sub-region.

*4.2.3. Sensitivity Analysis*

To analyze the sensitivity of our results, we retained the ARDL/PMG method by alternating the explanatory variable of interest. We substituted the « *Mobile Money* » variable with the variable for ATM services. The results of this analysis are reported in Table 6.

**Table 6.** Analysis of the effect of ATM services on economic growth.

| | 1 | 2 | 3 |
|---|---|---|---|
| SDA | -3.2919*** (0.00) | -3.7603*** (0.00) | -2.5155** (0.01) |
| SDA2 | 0.2484*** (0.00) | 0.2871*** (0.00) | 0.2508*** (0.00) |
| DPCG | -1.0735*** (0.00) | -0.9358*** (0.00) | -1.1126*** (0.00) |
| FBCF | | 0.0900* (0.06) | 0.1093** (0.03) |
| M2 | | | -0.2728* (0.06) |
| COINTEG01 | -0.8079*** (0.00) | -0.8546** (0.00) | -0.7968*** (0.00) |
| D (PIB (-1)) | -0.0225 (0.8) | 0.0154 (0.9) | 0.0001 (0.9) |
| D(SDA) | 4.8347 (0.2) | 5.4067 (0.1) | 0.2534 (0.9) |
| D(SDA2) | -2.8166 (0.1) | -2.2731 (0.2) | -1.5207* (0.08) |
| DPCG | -1.0101* (0.06) | -0.7472** (0.04) | -0.7148 (0.17) |
| FBCF | | 0.1226 (0.4) | 0.3405 (0.3) |
| M2 | | | -0.1918 (0.6) |
| Cons | 16.16947** (0.02) | 13.7113** (0.02) | 16.6367** (0.01) |

**Note:** **NB**: ***; ** and * significance at 1%, 5% and 10%. Values in parentheses represent probabilities.

Analysis of this table indicates that ATM services have a negative and significant impact on economic growth in the CEMAC subregion in the long term. Specifically, a 1% increase in ATM services results in a 2.51% decrease in economic growth. This can be attributed to the current insufficiency of ATMs to effectively stimulate economic activity. Conversely, the ATM squared variable exhibits a positive and significant effect on economic growth, suggesting a U-shaped relationship between ATM services and economic growth. By setting the first derivative of GDP with respect to ATM services to zero, the threshold for ATM services compatible with positive growth is identified at 5.02%. This finding aligns with the research of Berthelemy and Varoudakis (1994), who established a U-shaped relationship between financial intermediation and economic growth. Overall, the relationship between ATM services and economic growth is nonlinear, emphasizing the importance of considering threshold effects in policy formulation.

## 5. CONCLUSION

Financial innovation, through the use of mobile money and ATM services, gradually took root in the CEMAC sub-region in the early 2010s. It has the advantage of allowing the general population and middle-income populations, who constitute the majority of the rural workforce and are largely excluded from the banking system, to access this technology, with the only constraints being the possession of a mobile phone and a good connection to the communications network.

Theoretically, our research shows that the use of mobile money has a positive impact on economic growth, as predicted by Levine (1997) functional theory on the relationship between financial development and economic growth. Empirically, using data from the International Financial Services, World Development Indicators, and Global Findex 2020 databases, and employing the PMG/ARDL method over the period 2000-2020, it reveals that financial innovation has a positive and significant influence on economic growth in the CEMAC sub-region. Furthermore, our results show that there is a threshold at which an expansion of financial innovation has a negative effect on economic growth, thus reflecting an inverted U-shaped relationship between financial innovation and economic growth. This threshold is 43.15%.

Furthermore, the specific short-term analysis using the same estimation method revealed that Cameroon and Gabon are the two CEMAC countries whose financial innovation positively and significantly impacts economic growth, with a higher contribution in Gabon compared to Cameroon (because a one-unit increase in the mobile money usage rate promotes an increase in economic growth of 18.15% and 13.96%, respectively, for Gabon and Cameroon). This

demonstrates that financial innovation through the use of mobile money is well developed in these countries. Moreover, the inverted U-shaped relationship between financial innovation and economic growth is confirmed in these two countries.

Ultimately, it is clear that financial innovation in the CEMAC sub-region is driven by two countries: Gabon and Cameroon. Therefore, public authorities must lower customs duties on mobile phones to allow the poorest populations to acquire them at low prices, enabling access to "Mobile Money." In addition, public authorities must invest more in financial and telecommunications infrastructure to improve not only the quality of the connection but also to encourage economic operators to invest in the most remote areas; this will increase access to their services for poor populations. On the other hand, financial institutions must also increase the number of branches in these countries (Gabon and Cameroon) to facilitate proximity between ATM services and the population.

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