

Impact of ICT on financial inclusion Benchmark of a sample of North African Countries using panel data for 2004-2022

تأثير تكنولوجيا المعلومات والاتصالات على الشمول المالي - معيار لعينة من بلدان شمال إفريقيا باستخدام بيانات اللوحة للفترة 2004-2022

Grari Sabrina¹, Kerdouci Marwa²

¹ Badji Mukhtar University - Annaba (Algeria), sabrina.grari@univ-annaba.org

² 8 may 1945 University - Guelma (Algeria), kerdouci.marwa1@univ-guelma.dz

1

Received: 09/03/2023

Accepted: 29/03/2023

Published: 15/06/2023

Abstract:

This study aimed at highlighting the impact of ICT on financial inclusion in a sample of 03 North African countries from 2004 to 2020, using methods of analysing the data of Panal Data CTs, where the Pooled Regression Model, Fixed Effects Model and Random Effects, based on independent variables representing ICT: Fixed-phone contributions per 100 inhabitants, mobile cellular contributions per 100 inhabitants and Internet user ratio based on ITU data, and finally financial inclusion as a subordinate variable representing the number of ATMs based on World Bank data. The study found that fixed telephone contributions, mobile cellular subscriptions per 100 population and the proportion of Internet users in the previous period had a positive and moral impact on the number of ATMs in the study sample.

Keywords: ICT; financial inclusion; North African countries; Panel.

JEL Classification Codes: F14,G2,G35,C23.

ملخص:

هدفت هذه الدراسة إلى إبراز أثر تكنولوجيا المعلومات والاتصال على الشمول المالي في عينة من 03 دول شمال إفريقيا خلال الفترة من 2004 إلى 2020، وذلك باستخدام أساليب تحليل بيانات السلاسل الزمنية المقطعية Panal Data، حيث تم تقدير النموذج التجميعي، نموذج التأثيرات الثابتة والتأثيرات العشوائية، استناداً على المتغيرات المستقلة التي تمثل تكنولوجيا المعلومات والاتصال: اشتراكات الهاتف الثابت لكل 100 نسمة، الاشتراكات الخلوية المتنقلة لكل 100 نسمة ونسبة مستخدمي الإنترنت وذلك بالاعتماد على بيانات الاتحاد الدولي للاتصالات، وأخيراً الشمول المالي كمتغير تابع والذي يمثل عدد أجهزة الصراف الآلي بالاعتماد على بيانات البنك الدولي. وقد توصلت الدراسة أنّ اشتراكات الهاتف الثابت، والاشتراكات الخلوية المتنقلة لكل 100 نسمة ونسبة مستخدمي الإنترنت في الفترة السابقة ذو تأثير موجب ومعنوي على عدد أجهزة الصراف الآلي في عينة الدراسة.

كلمات مفتاحية: تكنولوجيا المعلومات والاتصال، الشمول المالي، دول شمال إفريقيا، البانل.

تصنيفات JEL : F14، G2، G35، C23.

Corresponding author: Grari Sabrina, e-mail: sabrina.grari@univ-annaba.org

INTRODUCTION

Financial inclusion is one of the most recent topics that has emerged in the international arena, especially after the global financial crisis of 2008. It promotes access to financial services for all segments of society in order to support inclusive and sustainable economic development, meet the challenges of unemployment and achieve social justice. There is no doubt that current developments have clearly highlighted the great importance of financial inclusion and the need to promote digital financial service applications, sensitize and educate financial service users by developing ICT infrastructure as the most important ingredient of today's business environment that helps to devise new means and methods of providing banking services.

Attention to financial inclusion in Algeria and other developing countries, such as Tunisia and Egypt, has led to the involvement of many financial mechanisms and institutions, and has prompted the adoption of special strategies that include a number of measures to strengthen it and raise its levels in accordance with these countries' own financial environment.

Through the foregoing, this paper was designed to answer the following problem:

How has ICT affected financial inclusion in Algeria, Egypt and Tunisia?

To answer the problems of the study, we ask the following sub-questions:

- What are the most important indicators of financial inclusion?
- What are the most important ICT indicators?
- Is there a relationship between ICT and financial inclusion in Algeria, Egypt and Tunisia?

Study hypotheses

- There is no correlation between the study variables.
- Positive and moral impact of ICT indicators on financial inclusion in Algeria, Egypt and Tunisia.
- The negative and immoral impact of ICT indicators on financial inclusion in Algeria, Egypt and Tunisia.

Limits of study

- **Time limits:** Included the study on available time series on variables from 2004 to 2020.
- **Spatial boundaries:** the study is being conducted in Algeria, Egypt and Tunisia using quantitative economic data.

Study curriculum

To address this issue, the descriptive approach has been used in the theoretical aspect of ICT indicators and financial inclusion. It also uses the "results-based" methodology, the inductive approach of addressing data statistically and as a tool for observing economic conditions.

Study Structure

To achieve the desired purpose of the research we divided the study into the following axes:

- 1- Introduction to financial inclusion and ICT.
- 2- ICT's relationship to financial inclusion and mitigation of the effects of the COVID-19 pandemic.

3- A standard study of the impact of ICT on financial inclusion in Algeria, Tunisia and Egypt during 2004-2020.

Previous studies

Angella Faith Lapukeni 2015 study, Entitled: Financial Inclusion and the Impact of ICT: An Overview, examined an overview of global and African financial inclusion and discussed the impact of ICT on access to financially excluded individuals through mobile payments. Analysis of trends shows faster growth in mobile phone subscriptions than financial inclusion in Africa, providing an opportunity for ICT development to increase financial inclusion through mobile financial services. The paper also discusses the opportunity costs of increasing ICTs at both the micro and macroeconomic levels and concludes with a possible policy recommendation in promoting ICTs to increase financial inclusion. (Faith, 2015, pp. 495-500)

TimbiSézar&Abessolo Yves André Study 2020, Entitled: Is ICT Promoting Financial Inclusion in Sub-Saharan Africa?, The purpose of this study is to assess the impact of ICTs on financial inclusion in sub-Saharan Africa. The main contribution of this work is the application of Rogers' Innovation Diffusion Theory (2003) to explain access to financial services and the introduction of the financial inclusion index that we are developing after Sethi's work (2016). The methodology is based on the fixed impact model based on Chow's modified Gompertz Innovation Diffusion Model (1983) and Rogers' revision (2003). The sample includes 33 HSA countries and the study period 2004-2017. The study found that mobile phone and Internet have a positive and significant impact on financial inclusion, on the one hand, and fixed phone, on the other, negatively affects access to financial services. (Sézar & André, 2020)

Kangni R. Kpodar&MihasonirinaAndrianaivo Study 2011, Entitled: ICT, financial inclusion and growth: evidence from African countries, where this paper examines the impact of ICT, particularly mobile phone deployment, on economic growth in a sample of African countries from 1988 to 2007. Furthermore, check whether financial inclusion is one of the channels through which mobile phone development affects economic growth. using a wide range of ICT indicators, including mobile and fixed phone spread rates and the cost of local calls. Problems with homogeneity have been addressed using the system's Generalized Moment Method Estimator (GMM). Financial inclusion has been manifested in variables measuring access to financial services, such as the number of deposits or loans per capita. The study found that ICT, including mobile phone development, contributed significantly to African countries' economic growth. Part of the positive impact of mobile penetration on growth comes from increasing financial inclusion. At the same time, mobile phone development enhances the impact of financial inclusion on economic growth, particularly in countries where mobile financial services are entrenched. (Andrianaivo & Kpodar, 2011)

1- INTRODUCTION TO FINANCIAL INCLUSION AND INFORMATION AND COMMUNICATION TECHNOLOGY:

1.1- Definition and indicators of financial inclusion

1.1.1. Definition of financial inclusion

Financial inclusion is defined as "the proportion of individuals and companies with access to useful and affordable financial products and services that meet their needs (transactions, payments, savings products, credit facilities, loans and insurance services) and are provided in a responsible and sustainable manner". (Financial inclusion is a key enabler to reducing poverty and boosting prosperity., 2022)

Financial inclusion is also defined as: a process in which a person (or group or organization) lacks or is denied access to affordable, appropriate and fair financial products and services, thereby reducing his or her ability to participate fully in social and economic activities, increasing financial hardship and worsening poverty (measured by income, debt and assets). Addressing financial inclusion includes not only service delivery, but also capacity-building and structural change. (Burkett & Sheehan, 2009, p. 05)

Recognizing that financial inclusion is a key enabler, both in the fight against poverty and in achieving the goal of inclusive economic development, leads to a greater focus on financial inclusion policies and initiatives.

1.1.2 Financial inclusion indicators

Financial inclusion is measured by three dimensions: (i) access to financial services, (ii) use of financial services, and (iii) quality of products and service delivery. The core group, which addressed some of the key access and utilization indicators, hereby extends to the G-20's financial inclusion indicators, which cover the three dimensions and provide greater insight into access and use aspects. (G20 Financial Inclusion Indicators, 2022, p. 01) Today's mobile phone has become increasingly part of the idea of financial inclusion and can be understood by many indicators, mobile money has taken a big place in people's daily lives, especially in developing economies, and is now recognized as encouraging increased financial inclusion in these countries and deserves to be considered an indicator of inclusion. The following indicators of financial inclusion are shown in the following table:

Table (1): Financial Inclusion Indicators

Traditional indicators of financial inclusion	Mobile Money Indicators
Dimension of Access	
- Commercial bank deposit accounts per 1000 adults.	- Number of mobile cash accounts open to 1,000 adults.
- Number of commercial bank credit accounts per 1,000 adults.	- Number of active mobile financial accounts for 1,000 adults.
- Number of accounts of financial institutions as a percentage of the population above the age of 15.	- Number of mobile money accounts for residents aged over 15 or over 25.
Dimension of Availability	
- Number of commercial banks branches for 100,000 adults.	- Number of registered mobile phone money agents for 100,000 adults.
- The number of branches of microfinance	- Number of active mobile money

***Impact of ICT on financial inclusion Benchmark of a sample of north African countries
using panel data for 2004-2022***

institutions per 100,000 adults. - Number of ATMs per 100 thousand adults. (These indicators can be obtained for 1,000 km ²)	agents for 100,000 adults. (Also possible for 1000 km ²)
Dimension of Use	
- Credit as a percentage of GDP. Volume of deposits as a percentage of GDP. (These indicators can be obtained per 1,000 people)	- The value of mobile cash transactions as a percentage of GDP. - Send and/or receive funds through mobile phone or internet to access bank account.

Source: Prepared by the two researchers, based on: GPFI. (2022). G20 Financial Inclusion Indicators, Global Partnership for Financial inclusion.

<https://www.gpfi.org/sites/gpfi/files/G20%20Set%20of%20Financial%20Inclusion%20Indicators.pdf>

1.2- Definition and indicators of information and communication technology

1.2.1. ICT definition

Information and communications technology (ICT) is a comprehensive term encompassing any communications device or application, including: radio, television, cell phones, computer and network hardware and software, satellite systems, etc., as well as various associated services and applications, such as videoconferencing and distance learning. ICTs are often talked about in a particular context, such as ICTs in education, health care or libraries. (Rahman, 2009)

Also known as ICT, is any channel that can allow the creation, processing, storage and transfer of communications, in this context to the channel using the latest technologies. (Svetanoff & Aresty, 2022)

ICT also refers to technologies that provide access to information through telecommunications. This includes the Internet, wireless networks, mobile phones, other communication media and networked computers. (Thornton & Lang, 2014)

1.2.2. ICT indicators

The most important reliable indicators will be addressed in the establishment of electronic commerce, e-government, e-business and e-administration, so that the Arab world lags behind the high technology known to the developed world and given the importance of these indicators in the development of the digital economy and the promotion of digital financial inclusion. Which we summarize in the following table:

Table (2): ITU Key Indicators

Indicator	Concept
Mobile telephone subscriptions	Number of subscriptions to the public mobile service that provide access to the network using cellular technology. The indicator includes: future payments contributions and working prepaid accounts, i.e. used during the last three months. (The indicator applies to all mobile cellular subscriptions that provide voice communications, and excludes subscriptions via data cards or USB modems, subscriptions to general mobile data services, private mobile radio, phone calls, wireless recall and M2M).
Fixed telephone contributions	Indicates the total number of active fixed telephone lines. Indicator includes: analog fixed telephone lines, Internet Protocol (VoIP) subscriptions, fixed wireless local ring (WLL) subscriptions, Integrated Services Digital Network (ISDN) audio equivalent and fixed public telephones. (This indicator is previously called the main phone lines in operation).
Internet users	This indicator can include estimates and data corresponding to the proportion of individuals using the Internet based on the results of national household surveys. The figure must reflect the country's total population or individual population of at least 5 years and above.

Source: Prepared by the two researchers, based on: Vall, I. V. (2018). Telecommunication indicators. ICT Data and Statistics Division International Telecommunication Union. https://www.itu.int/en/ITU-D/Regional-Presence/ArabStates/Documents/events/2018/ICT-Statistics/Presentations/Session_5_7_ITU_admin_data.pdf

2- ICT's RELATIONSHIP TO FINANCIAL INCLUSION AND MITIGATION OF TO THE EFFECTS OF THE COVID-19 PANDEMIC

The COVID-19 pandemic has profoundly changed people's payment habits, with 60% of financial authorities seeing an increase in digital transactions. At the same time, the number of people receiving payments from their governments quadrupled in the first half of 2020 as the global pandemic continued. Nearly 70% of financial regulators worldwide view technology as a strong priority, as well as supporting the COVID-19 response with efforts to promote financial inclusion. (L'inclusion financière numérique (Financial inclusion Global Initiative), 2021, p. 10) Digital financial inclusion is already a priority before the COVID-19 pandemic, and is now a more pressing political goal.

Mobile cell phones, fixed and internet

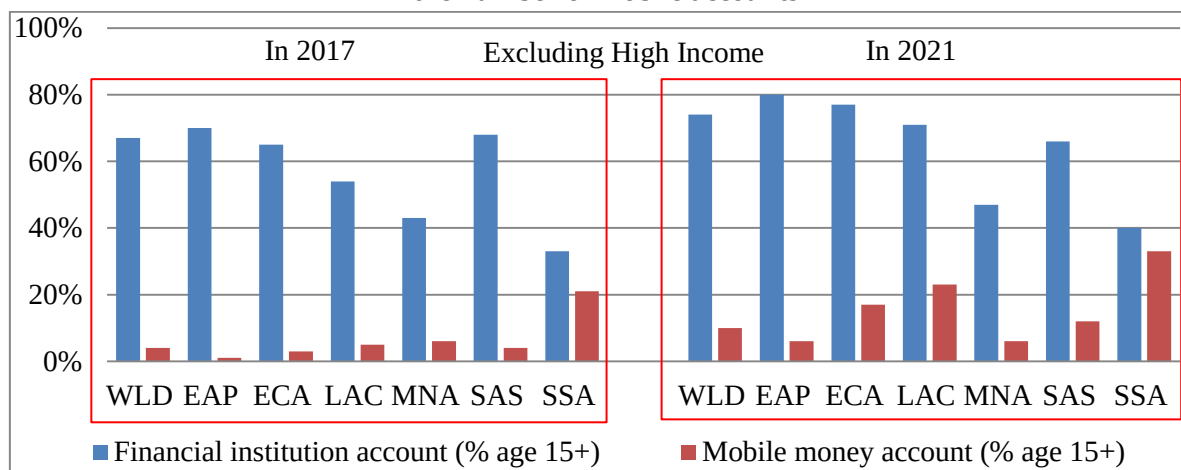
Low levels of banking are regarded as brakes on development. As ICT proliferates, new ways of accessing modern financial services are emerging. In the face of informal funding constraints, mobile money can offer solutions to previously excluded vulnerable groups from the formal banking system. (Philippe, Combarnous, & Eekhout, 2020, p. 28)

Mobile phone subscriptions allow expansion of and access to financial services for groups that have been underserved in developing countries. It reduces the costs of managing a supplier's physical bank branches and reduces the high costs of distance and time for the user. The increasing use of mobile phones in developing countries has contributed to the emergence

Impact of ICT on financial inclusion Benchmark of a sample of north African countries using panel data for 2004-2022

of branch-free banking services, improving financial inclusion. The next figure shows the upward trend of mobile funds between 2017-2021.

Fig (1): Comparison between the number of bank accounts in a bank or financial institution and the number of mobile accounts

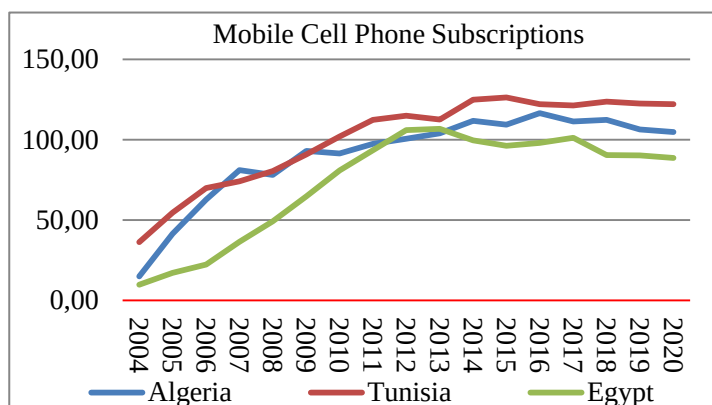


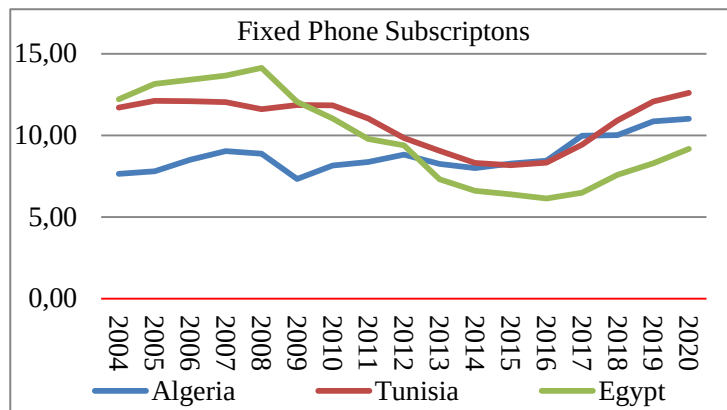
Source: Prepared by the two researchers, based on: data, F. (2021).

<https://www.worldbank.org/en/publication/globalindex/Data>

Based on the above format, in terms of digital financial inclusion, sub-Saharan Africa is the most advanced region, in 2021 33% of Africans had a mobile account. It should also be noted that mobile money has expanded markedly across the world, moving millions of households in low- and middle-income countries (LMICs), especially, from the informal monetary economy to a more inclusive digital economy. In 2012, there were 169 mobile money deployments in 71 countries, ten years later, the number of live deployments almost doubled to 316 and expanded to 98 countries worldwide. Through LMICs, people are increasingly living digital lives thanks to mobile money, dealing more often and for more reasons than ever. The COVID-19 pandemic accelerated this shift as people resorted to offline digital routes to buy everyday items, pay bills, receive government support payments and send money to the family. In 2021, this continued growth helped push the value of transactions to the trillion \$mark, a milestone that reached faster than anyone in the industry could have expected. (Aramé, Christopher, Andersson-Manjang, & Lindsey, 2021, p. 05)

Fig (2): Evolution of cell phone subscriptions for some North African countries during 2004-2020



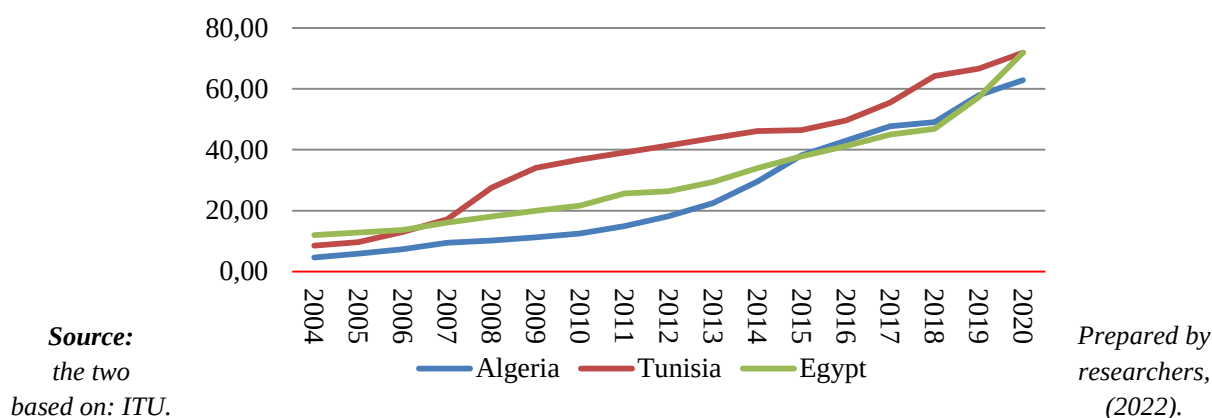


Source: Prepared by the two researchers, based on: ITU. (2022). Country ICT Data Indicator (Indicator).
<https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>

The prevalence of fixed telephone in the countries under consideration remains generally low, with the figure above (N° 02) We note that there was a significant discrepancy in fixed telephone contributions for 100 people during the years 2004-2020, due to monopolies that prevailed at the time and a weakness in fixed telephone infrastructure compared to the global average, as this weakness is noticeable in these low-income countries. It should also be noted that the reason for the increasing trend on mobile phones in Algeria may be due to the distinct services: the short-media service "MMS", the Internet service and the general radio service of the packages "GPRS", as the latter constitutes an essential part of the Internet and ICT infrastructure.

North African countries (Algeria, Egypt and Tunisia) have made progress and progress in mobile phone subscriptions, surpassing global access rates despite relative differences mainly related to market size and ability to cover the entire consumer segment. The growth of these services accelerated in parallel with the development and spread of 3G and 4G services. Egypt has seen a significant increase in the prevalence of mobile phone services during the period 2002-2013, as a result of the liberalization of the mobile telecommunications sector and thus increased levels of competition among companies operating in this sector. However, the latter saw a decrease in mobile phone subscriptions in 2014-2016, due to the deterioration of the security situation and poor governance. With regard to Algeria, from 2004 to 2017, the number of mobile cellular subscriptions had grown somewhat, since control of its costs had made its use accessible to all. Tunisia had outperformed Algeria and Egypt in mobile cellular subscriptions, as a result of significant investment in the continued deployment and improvement of fixed and mobile broadband infrastructure in both developed and developing economies.

Fig (3): Proportion of Internet users in North African countries during 2004-2020



Country ICT Data Indicator (Indicator). <https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx>

Through the above figure, Algeria, Egypt and Tunisia are characterized by a continuous increase in Internet usage. It is worth mentioning that at the end of 2013 Algeria saw the launching of 3G services, and then adopted 4G services to be marketed, which increased by 83.28% in 2016. (Autorité de régulation de la poste et des télécommunications - Rapport Annuel, 2016, p. 32) Both Tunisia and Egypt were races in this, improving the volume of e-commerce.

3- STUDY OF THE IMPACT OF ICT ON THE FINANCIAL INCULSION OF A SAMPLE OF NORTH AFRICAN COUNTRIES (USING PANEL DATA)

3.1- View study variables

To answer the problem of the study, Panal Data's data analysis methods were used by estimating the aggregate model, constant and random effects model. The sample includes three countries: Algeria, Egypt and Tunisia, i.e. $N = 3$, and the time limits are between 2004 and 2020, i.e. $T = 17$. Accordingly, the study model will be as follows:

$$ATM_t = \beta_0 + \beta_1 FTS_t + \beta_2 MCS_t + \beta_3 IU_t + \varepsilon_t$$

Where:

ATM_t : Number of ATMs

FTS_t : 100 population fixed phone subscriptions

MCS_t : Mobile cell phone subscriptions per 100 population

IU_t : Internet Users (%)

3.2- Estimate the model according to the data of the panel

Panel's three static data models were estimated: Pooled Regression Model (PME), fixed effects model (FEM) and random effects model (REM). The following table shows the results of the estimate using STATA 15.

Table (3): Aggregate Model Assessment (PME) Results, Fixed Effects (FEM) and Random Effects (REM)

Interpreted variables	Estimation Forms		
	Pooled Regression Model (PME)	Fixed Effects Model (FEM)	Random Effects Model (REM)
FTS	0.7597*	-0.6257***	0.7297*
MCS	0.0804**	0.0264	0.0804**
IU	0.27***	0.2420***	0.2761***
Constant	-10.1635*	8.9755***	-10.1635*
R ² (squared)	0.6622	0.8753	0.7297
F (statistic)	30.71	105.31	-
Prob-F	0.0000	0.0000	-
Number of obs	51	51	51

Source: Prepared by the two researchers, drawing on stata 15 outputs

Where:* Moral at 10%, * * Moral at 5%, * * * Moral at 1%.

The coefficients of the autonomous variables showed morale in their entirety, and the results of the F.stata test in the table showed that the three estimated models were statistically acceptable at the 5% indicative level, and we note that the R² correlation coefficient (squared) appeared with good values in the estimated model meaning that it was a high interpretive capability.

3.2.1. Trade-in tests between models

3.2.1.1. Restricted Fisher Test

The restricted F test will work to compare the compilation model with the fixed model, and the results in the next table:

Table (4): Restricted F.stata Test

F.stata	p-value
113.59	0.0000

Source: Prepared by the two researchers, drawing on stata 15 outputs.

We note from the table results above that they stipulated the morale of the F.stata test where morale was less than 0.05 and from which it can be said that the best model is the fixed effects model.

3.2.1.2. Breuch and Pagan-LMTest

This test is based on the differentiation between the Pooled Regression Model and Random Effects model, where:

- If the Random Effect model is the most appropriate model, we accept H₀
- If the Pooled Regression model is the most appropriate one, we accept H₁

Table (5): Test Breuch and Pagan-LM

Breuch and Pagan-LM	p-value
0.00	1.0000

Source: Prepared by the two researchers, drawing on stata 15 outputs.

The value of Chi-bar was 0.00 and the probability of p-value=1.0000 which means rejection of the zero hypothesis H₀ acceptance of the H₁ alternative hypothesis i.e. the compilation model is the best model.

3.2.1.3. Hausman Test

After we tested the restricted F and the Breuch and Pagan test, Hoseman's role is to test the differentiation between the fixed effects model and the random effects model, where its results appear in the following table:

Table (6): Hausman Test

Hausman	p-value
21.05	0.0001

Source: Prepared by the two researchers, drawing on stata 15 outputs.

We note from the table results above that the Hausman test statistical value is estimated at 21.05 and its probability value is estimated (p-value) at 0.0001 i.e. less than 0.05, from which the zero hypothesis is rejected and the alternative hypothesis is accepted i.e. the use of the fixed effects model is the appropriate model of the three models and this is back for both the F.stata test and the Hausman test.

3.3- Diagnostic tests of the model

The Panel Static Model is based on a number of hypotheses that ensure the validity of using the prediction process and testing the study hypotheses. These hypotheses are mainly the multiple correlation test between variables, the variation scales test and the subjective correlation of errors, so we applied these tests to the effects model. The results of these tests are as follows:

3.3.1. Multiple Correlation Test between variables(Multicollinearity)

Table (7): Multicollinearity Test

Variable	Vif	1/vif
Mcs	2.61	0.382520
Iu	2.21	0.51550
Fts	1.31	0.764768
Mean VIF	2.05	

Source: Prepared by the two researchers, drawing on stata 15 outputs.

Through Vif test results all variables exceed the value of 5 which means that the model does not suffer from multiple association.

3.3.2. Autocorrelation Test

The Wooldridge test is one of the best modern tests to measure the existence of aAutocorrelationto the static panel model, and its results in the catalogue table:

Table (8): Wooldridge Test

Wooldridge	p-value
24.173	0.039

Source: Prepared by the two researchers, drawing on stata 15 outputs.

The Wooldridge test shows that the probability value is less than 0.005, from which the test results are moral i.e. acceptance of the nowhere hypothesis acknowledging that there is no subjective correlation to the study model.

3.3.3. Contrast Stability Test (Heteroskedisticity)

The Breusch-Pagan/Cook-Weisberg test is based on the measurement of a persistence of variability to the static panel model, the results of which are in the following table:

Table (9): Heteroscedasticity Test

Breusch-Pagan / Cook-Weisberg	p-value
18.35	0.0000

Source: Prepared by the two researchers, drawing on stata 15 outputs.

Through the above table, the value of the Breusch-Pagan/Cook-Weisberg test was 10.526 and the statistical morale value was 0.0000, less than 0.05, i.e. zero hypothesis is accepted and no consistency is rejected.

We are supposed to adjust the inconsistency errors we will rely on the model estimation and only the PCSE method as DanialHoechle pointed out in The Stata Journal.

3.4- Estimate the corrective form according to Panal PCSE method

Table (10): Results of the corrective model assessment according to Panal PCSE method

Interpreted Variables	Corrective Form
	ModelPanal PCSE
FTS	0.7297**
MCS	0.0804***
IU	0.2761***
Constant	-10.1635**
R²(squared)	0.6622
Wald chi2	404.17
Prob-Wald	0.0000
Number of obs	51

Source: Prepared by the two researchers, drawing on stata 15 outputs.

* Moral at 10%, * Moral at 5%, * * Moral at 1%.

The above results show that the model has statistical morale as a whole The probability of testing Wald with Prob-Wald = 0.0000 was estimated at 5% morale level, The model also has a good explanatory capability, with a R²(squared) of 0.6622, i.e. the interpreted variables explain 66.22% of the changes to the dependent variable. The remainder, 44.78%, is due to other factors not included in the model's separate variables.

CONCLUSION

For the FTS variant has an acceptable positive and moral relationship at 4.7% where if it increases by one unit it increases the affiliate variable by 72.97%.

For the MCS variant has a very positive and morally acceptable relationship at 1% where if it increases by one unit it increases the affiliate variable by 8.04%.

For the IU variant has a very positive and morale-friendly relationship at 1% where if it increases by one unit, the affiliate variable increases by 27.61%.

ICT indicators studied positively and morally affect ATM activity in which it contributes to the creation of a broad area of payment, whether internal or external, Making it observe neither space nor time and access to more customers outside the branch's network as in smaller population centres, and in short time and effort and improved commercial performance through the quality of banking service, Reduce costs and achieve customer satisfaction, profitability of the bank, raise returns and provide more funds at low cost ATMs facilitate the deposit of savings for customers.

Impact of ICT on financial inclusion Benchmark of a sample of north African countries using panel data for 2004-2022

Bibliographie List:

- Andrianaivo, M., & Kpodar, K. (2011). ICT, Financial Inclusion, and Growth: Evidence from African Countries. *IMF Working Paper*.
- Aramé, A., Christopher, L., Andersson-Manjang, S. K., & Lindsey, D. (2021). *State of the Industry Report on Mobile Money (based on data collected from the Global Adoption Survey)*. Retrieved from https://www.gsma.com/sotir/wp-content/uploads/2022/03/GSMA_State_of_the_Industry_2022_ExecSummary_English.pdf
- (2016). *Autorité de régulation de la poste et des télécommunications - Rapport Annuel*.
- Burkett, I., & Sheehan, G. (2009). *From the margins to the mainstream : The challenges for microfinance in Australia*. Brotherhood of St Laurence and Foresters Community Finance.
- Faith, L. A. (2015). Financial Inclusion and the Impact of ICT: An Overview. (Reserve Bank of Malawi). *American Journal of Economics*, 5(5), pp. 495-500.
- Financial inclusion is a key enabler to reducing poverty and boosting prosperity*. (2022). Retrieved from The World Bank: <https://www.worldbank.org/en/topic/financialinclusion/overview>
- G20 Financial Inclusion Indicators*. (2022). Retrieved from GPFI: Global Partnership for Financial inclusion.: <https://www.gpfi.org/sites/gpfi/files/G20%20Set%20of%20Financial%20Inclusion%20Indicators.pdf>
- L'inclusion financière numérique (Financial inclusion Global Initiative)*. (2021). Retrieved from ITU: https://www.itu.int/en/itu/news/Documents/2021/2021-03/2021_ITUNews03-fr.pdf
- Philippe, B. J., Combarous, F., & Eekhout, T. (2020). *Les TIC : une réponse au défi du développement des micro et petites entreprises informelles en Afrique sub-saharienne ?* Retrieved from <https://hal.archives-ouvertes.fr/hal-02148324/document>
- Rahman, H. (2009). *Interactive Multimedia Technologies for Distance Education in Developing Countries*. (SDNP). Retrieved from <https://www.igi-global.com/chapter/interactive-multimedia-technologies-distance-education/17473>
- Sézar, T., & André, A. Y. (2020). Les Technologies De l'Information Et De La Communication (TIC) Promeuvent-Elles L'inclusion Financière En Afrique Sub-Saharienne ? *Global Journal of Human-social science: E Economics*, 20(02).
- Svetanoff, R., & Aresty, J. (2022). *The Technology of Peacebuilding: Empowering Youth With Dignity*. Retrieved from <https://www.igi-global.com/chapter/the-technology-of-peacebuilding/303477>
- Thornton, K., & Lang, M. (2014). *Ethical and Practical Issues Surrounding Access to ICT Education by Elderly Persons*. Retrieved from <https://www.igi-global.com/chapter/ethical-and-practical-issues-surrounding-access-to-ict-education-by-elderly-persons/111891>

-Appendices

➤ Supplement 01:

Pooled Regression Model

```
. regress atm fts mcs iu
```

Source	SS	df	MS	Number of obs	=	51
Model	2561.93801	3	853.979335	F(3, 47)	=	30.71
Residual	1306.88586	47	27.8060822	Prob > F	=	0.0000
				R-squared	=	0.6622
				Adj R-squared	=	0.6406
Total	3868.82387	50	77.3764774	Root MSE	=	5.2731

atm	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
fts	.7297156	.405538	1.80	0.078	-.0861217	1.545553
mcs	.0804997	.0385127	2.09	0.042	.0030222	.1579772
iu	.2761681	.0577967	4.78	0.000	.1598961	.3924402
_cons	-10.16356	5.517078	-1.84	0.072	-21.26249	.9353701

Fixed Effects Model

```
. xtreg atm fts mcs iu , fe
```

Fixed-effects (within) regression
Group variable: id

Number of obs = 51
Number of groups = 3

R-sq:

within = 0.8753
between = 0.9276
overall = 0.5609

Obs per group:

min = 17
avg = 17.0
max = 17

corr(u_i, Xb) = 0.1773

F(3,45) = 105.31
Prob > F = 0.0000

atm	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
fts	-.6257234	.1948216	-3.21	0.002	-1.018114	-.2333326
mcs	.026413	.0185872	1.42	0.162	-.0110235	.0638496
iu	.2420129	.0258711	9.35	0.000	.1899057	.29412
_cons	8.975542	2.753737	3.26	0.002	3.429231	14.52185
sigma_u	6.7101964					
sigma_e	2.1912215					
rho	.90363985	(fraction of variance due to u_i)				

F test that all u_i=0: F(2, 45) = 113.59

Prob > F = 0.0000

```
. xtreg atm fts mcs iu , re
```

atm	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
fts	.7297156	.405538	1.80	0.072	-.0651243	1.524556
mcs	.0804997	.0385127	2.09	0.037	.0050162	.1559831
iu	.2761681	.0577967	4.78	0.000	.1628886	.3894477
_cons	-10.16356	5.517078	-1.84	0.065	-20.97683	.6497149
sigma_u	0					
sigma_e	2.1912215					
rho	0	(fraction of variance due to u_i)				

F Test

➤ **Supplement 03:**

```
. xttest0
```

Breusch and Pagan Lagrangian multiplier test for random effects

$$\text{atm}[\text{id}, t] = \text{Xb} + \text{u}[\text{id}] + \text{e}[\text{id}, t]$$

Estimated results:

Test: $\text{Var}(u) = 0$

535

➤ **Supplement 04:**

Hausman Test

```
. hausman REM FEM
```

	Coefficients		(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
	(b) REM	(B) FEM		
fts	.7297156	-.6257234	1.355439	.3556763
mcs	.0804997	.026413	.0540867	.0337304
iu	.2761681	.2420129	.0341553	.0516831

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

```
chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
        = 21.05
Prob>chi2 = 0.0001
```

➤ **Supplement 05:**

Multicollinearity Test

```
. estat vif
```

Variable	VIF	1/VIF
mcs	2.61	0.382520
iu	2.21	0.451550
fts	1.31	0.764768
Mean VIF	2.05	

➤ **Supplement 06:**

Autocorrelation Test

```
. xtserial atm fts mcs iu
```

Wooldridge test for autocorrelation in panel data

H0: no first-order autocorrelation

```
F( 1, 2) = 24.173
Prob > F = 0.0390
```

➤ **Supplement 07:**

Heteroscedasticity Test

```
. hettest
```

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity

Ho: Constant variance

Variables: fitted values of atm

```
chi2(1) = 18.35
Prob > chi2 = 0.0000
```

**Impact of ICT on financial inclusion Benchmark of a sample of north African countries
using panel data for 2004-2022**

➤ **Supplement 08:**

Estimate the corrective form and only Panel PCSE method

```
. xtpcse atm fts mcs iu
```

Linear regression, correlated panels corrected standard errors (PCSEs)

```

Group variable:  id                      Number of obs   =       51
Time variable:  years                   Number of groups =        3
Panels:         correlated (balanced)   Obs per group:
Autocorrelation: no autocorrelation      min =       17
                                           avg =       17
                                           max =       17

Estimated covariances   =        6      R-squared       =    0.6622
Estimated autocorrelations =        0      Wald chi2(3)     =   404.17
Estimated coefficients   =        4      Prob > chi2     =    0.0000

```

atm	Panel-corrected					[95% Conf. Interval]
	Coef.	Std. Err.	z	P> z		
fts	.7297156	.3680147	1.98	0.047	.0084201	1.451011
mcs	.0804997	.0247136	3.26	0.001	.032062	.1289374
iu	.2761681	.0379726	7.27	0.000	.2017432	.350593
_cons	-10.16356	5.042567	-2.02	0.044	-20.04681	-.2803103

Descriptive analysis data

```
. summarize atm fts mcs iu
```

Variable	Obs	Mean	Std. Dev.	Min	Max
atm	51	12.99471	8.79639	1.27	33.85
fts	51	9.78504	2.102754	6.131492	14.13629
mcs	51	88.26135	31.30791	9.85916	126.2862
iu	51	32.27367	19.20121	4.634475	71.9142

Study Data

Years	Country	Id	Fts	Mcs	Iu	Atm
2004	Algeria	1	7.649049	15.01811	4.634475	1.27
2005	Algeria	1	7.804182	41.45245	5.843942	1.5
2006	Algeria	1	8.497952	62.80216	7.375985	2.39
2007	Algeria	1	9.029027	81.1054	9.451191	3.72
2008	Algeria	1	8.878149	78.19436	10.18	4.2
2009	Algeria	1	7.319475	92.99292	11.23	5.33
2010	Algeria	1	8.151224	91.42082	12.5	5.92
2011	Algeria	1	8.371756	97.46161	14.9	6.1

Grari Sabrina, Kerdouci Marwa

2012	Algeria	1	8.828002	100.717	18.2	6.21
2013	Algeria	1	8.244151	103.9905	22.5	6.51
2014	Algeria	1	7.994772	111.7079	29.5	7.61
2015	Algeria	1	8.263357	109.3176	38.2	8.35
2016	Algeria	1	8.440173	116.614	42.94553	8.57
2017	Algeria	1	9.969194	111.4475	47.69106	9.13
2018	Algeria	1	10.0196	112.4675	49.03847	9.54
2019	Algeria	1	10.85394	106.3696	57.9	9.64
2020	Algeria	1	11.01399	104.8422	62.9	8.9
2004	Tunisia	2	11.69359	36.29629	8.528818	8.31
2005	Tunisia	2	12.10471	54.68365	9.655087	9.68
2006	Tunisia	2	12.09954	70.00531	12.98641	11.05
2007	Tunisia	2	12.03483	74.12407	17.1	14.11
2008	Tunisia	2	11.6014	80.54174	27.53	15.72
2009	Tunisia	2	11.85542	90.84355	34.07	17.51
2010	Tunisia	2	11.83642	102.0114	36.8	20.36
2011	Tunisia	2	11.0381	112.283	39.1	21.12
2012	Tunisia	2	9.834037	114.9405	41.4416	22.26
2013	Tunisia	2	9.043835	112.496	43.8	23.14
2014	Tunisia	2	8.306933	124.9777	46.16	24.5
2015	Tunisia	2	8.164562	126.2862	46.49999	26.4
2016	Tunisia	2	8.3361	122.2188	49.59999	27.76
2017	Tunisia	2	9.424488	121.3576	55.50016	29.99
2018	Tunisia	2	10.91101	123.7706	64.19081	30.72
2019	Tunisia	2	12.0686	122.5883	66.7	32.21
2020	Tunisia	2	12.60737	122.1279	71.9	33.85
2004	Egypt	3	12.20827	9.85916	11.92	2.65
2005	Egypt	3	13.14715	17.23623	12.75	3.34
2006	Egypt	3	13.4041	22.32566	13.66	4.44
2007	Egypt	3	13.65728	36.60196	16.03	5.42
2008	Egypt	3	14.13629	49.24178	18.01	6.48
2009	Egypt	3	12.06132	64.73865	20	7.69
2010	Egypt	3	11.02333	80.98459	21.6	8.64
2011	Egypt	3	9.769373	93.52589	25.6	9.22
2012	Egypt	3	9.379068	106.0921	26.4	10.32
2013	Egypt	3	7.304611	106.7758	29.4	10.94
2014	Egypt	3	6.607136	99.71097	33.8946	12.06
2015	Egypt	3	6.380363	96.20599	37.81938	13.70
2016	Egypt	3	6.131492	98.0031	41.24807	15.69
2017	Egypt	3	6.48874	101.1483	44.9502	17.71
2018	Egypt	3	7.581673	90.40274	46.92434	18.72
2019	Egypt	3	8.294401	90.26838	57.28287	20.07
2020	Egypt	3	9.173516	88.73336	71.9142	22.06