Analyzing the Role of Electronic Payment Systems in Fostering Economic Growth in Algeria using ARDL models during the period (2007–2022)

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Summary: This study aims to identify the extent of the impact of electronic payment systems on increasing economic growth in Algeria during the period 2007–2022. Using the cointegration property according to the autoregressive-distributed lag (ARDL), the study revealed the existence of a short- and long-term balanced relationship between economic growth and electronic payment systems. The study results are as follows:
• Electronic payment systems have a positive impact on economic growth in Algeria in the short term and a positive equilibrium relationship in the long term.
• The electronic gross settlement system and the electronic clearing system have a positive and significant impact on the economic growth rate in the short term, and a positive but non-significant effect on the economic growth rate in the long term.
• The error correction mechanism is present in the error correction model, indicating that the economic growth rate function in the short term converges toward its long-term equilibrium. The error correction coefficient is negative and significant.
The study recommends increasing awareness of the culture of using electronic payment systems and their benefits in society by promoting various products and innovating new technologies. To improve customer confidence in electronic payment methods, mechanisms to reduce digital fraud should be developed.
Keywords: electronic payment systems, electronic gross settlement system, electronic clearing system, economic growth, ARDL model, Algeria.
Jel Classification Codes : C22, E42, F43.

I- Introduction :

Since the last quarter of the previous century, information technology has advanced significantly, and this has significantly transformed the banking industry, as banks and their customers can now conduct their banking operations through various digital platforms. Most banking systems have shifted towards using electronic payment systems, which have evolved rapidly with advances in telecommunications. These advances create optimal conditions for comprehensive payment systems, facilitating the transition from traditional to digital payment methods.

Electronic payment systems are a key indicator of an economy's progress and development. This has led banks worldwide to realize that developing and modernizing payment methods is a top priority, as traditional payment methods are no longer relevant. In an era where speed is crucial for processing deals and transactions, and cash transactions are being reduced, electronic payments can help formalize Algeria's informal sector. Technological advancements have enabled the development of electronic payment methods, making them increasingly affordable.

Real-time payment processing has become one of the most crucial factors for the effective performance of banks and financial institutions, and modern economies are seeking to integrate it into their banking systems. Algeria is not immune to these developments and has been trying to adapt to them since 2006. As part of its strategy to modernize its banking system, Algeria began using

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instant settlement systems and electronic clearing systems to leverage the synergies between instant payment methods and other electronic banking technologies.

The importance of this study lies in clarifying the relationship between electronic payment tools and economic growth by examining Algeria's gross domestic product development. The research topic focuses on the urgent need to keep pace with the global economy, particularly after the shift to electronic transactions following the information technology revolution. Electronic payment systems and tools have become essential to facilitate transactions in the new economic context. This study aims to analyze the development of electronic payment systems and gross domestic product in Algeria. It also aims to measure and analyze the short- and long-term relationship between economic growth and electronic payment systems in the Algerian economy from 2007 to 2022, using econometric models.

The research problem has centered on the following key question:

To what extent does the development of electronic payment systems affect the increase in economic growth in Algeria during the period 2007–2022?

To answer the problem raised, we formulated the following hypotheses:

Hypothesis 1: There is a significant relationship between the systems of electronic payment and Algeria's short-term economic growth.

Hypothesis 2: There is a positive long-term joint integration relationship between Algeria's electronic payment systems and economic growth.

To address the problem raised and test the validity of the hypotheses, a descriptive approach was employed to analyze the development of economic growth and electronic payment systems, drawing on the theoretical aspects of the most important studies that have addressed the subject. As for the applied aspect, the study relied on a standard approach to test the relationship between economic growth and electronic payment systems, using joint integration according to the autoregressive distributed lag model (ARDL) using the Eviews 12 program for the period 2007-2022.

II- Literature review :

The study by Imane Bouguerra (2018) examined the impact of electronic payment systems on economic growth in Jordan between 2003 and 2015. Using a simple linear regression model to analyse the relationship, the study found a statistical relationship between electronic payment systems and economic growth in Jordan during the specified period. It also concluded that the electronic payments sector in Jordan has witnessed significant development in payment and settlement systems, including high-value payment systems, retail payment systems, and retail payment instruments.

A study of Abdulmumin (2020) investigates the role of e-payment systems on economic growth in Nigeria from 2010 to 2018. In particular, the study utilized the volume and value of e-payment transactions to analyze how e-payment systems affect economic growth. For models 1 and 2, the study calculated the value of real GDP, POS, ATM, mobile, and online transactions, in addition to the volume of these transactions, from quarterly time series data. The findings of the multiple regression analysis for models 1 and 2 suggest that while there is a negative but not significant association between point-of-sale transactions and real GDP in Nigeria, there is a positive insignificant relationship between ATM and internet transactions and economic growth. Additionally, the study demonstrates that while the value of mobile transactions in Nigeria is directly but not significantly correlated with economic growth, the volume of mobile transactions has a significant positive correlation with it.

The study Aldaas (2021) examines the relationship between electronic payment systems and economic growth using data from a sample of international nations, including Saudi Arabia, the United Kingdom, India, Malaysia, Jordan, Canada, the United States, and Australia. The analysis

employed the gross domestic product (GDP) as the dependent variable and independent variables (number of ATMs, payment cards, etc.). By using regression analysis and correlation coefficients on a five-year time series of data (2014–2018), no conclusive evidence is discovered to support or refute the hypothesis that electronic payment systems and economic growth are related, which suggests that the relationship might be country-specific, requiring further investigation within individual contexts.

The study Andrea, Udeh, & Allison (2022) examines the influence of electronic payment systems on Nigeria's GDP. The analysis focuses on three variables: automated teller machine (ATM) payment systems, point-of-sale (POS) payment systems, and mobile app payment systems. Using a sample of five (5) telecom companies and the ARDL model suitable for time series data analysis, the study finds that all three payment systems significantly impact Nigeria's economic growth. To enhance security. The study recommends that banks continually update their hardware and software to improve security whenever new features become available.

A study Haruna, Nneka Maurie, & Zac (2023) examines the influence of the electronic payment system on Nigeria's economic growth. Gross domestic product was designated as the dependent variable for economic growth, while transactions using point of sale, web pay, and mobile payment channels were the independent variables. Data for quarterly time series were collected from 2012 Q1 to 2021 Q4. The findings, acquired through regression using dynamic ordinary least squares, showed that while web payment channels have an insignificant effect on Nigeria's economic growth, mobile payment channels and points of sale significantly contribute positively to economic growth.

The study Al-Tufayli (2023) aims to clarify the relationship between electronic payment methods and macroeconomic variables in the sample countries (Saudi Arabia, Bahrain, and Iraq) for the period 2011–2021. Using the ARDL model, the results of the econometric analysis showed that electronic payment methods in Saudi Arabia have a positive effect on some macroeconomic variables to varying degrees in the short term, with ATMs having the biggest impact. In the long term, it was found that the largest and most positive impact is for electronic clearing. The results showed that electronic settlement and electronic clearing systems have a positive influence in Bahrain in the short term, with ATMs again having the greatest impact. In the long term, the settlement system positively affects economic growth. However, the effect of electronic payment methods on some macroeconomic variables in Iraq is unclear for reasons such as the nature of the Iraqi economy, banking habits, social culture, and the recent experience of using electronic payment methods. Therefore, from an economic standpoint, the econometric analysis results are either insignificant or illogical, likely due to Iraq's dependence on oil resources as a main source of economic growth.

A review of the existing literature indicates a notable lack of Algerian empirical studies addressing the impact of electronic payment systems on economic growth. In addition, the majority of prior research has relied on narrow indicators and relatively basic analytical approaches, offering only a partial understanding of the substantial structural transformations that the electronic payment sector in Algeria has undergone between 2007 and 2022. Therefore, the research gap stems from the absence of a comprehensive, methodologically robust investigation employing the ARDL model to quantify the effect of electronic payment systems on economic growth in Algeria over this period—a gap that the present study aims to bridge.

III. Analysis of the development of electronic payment systems and their impact on economic growth in Algeria:

Before defining electronic payment systems, we must first address the concept of electronic payment, which refers to this process of transferring money (mainly the price of a good or service) digitally and sending data via telephone lines, the network, or any other method of sending data (Al-Zain, 2019, p. 488). It is also known as a system of integrated systems and programs designed to enhance secure electronic payment operations, ensure the confidentiality and protection of purchasing procedures, and ensure the provision of services (Boudlal, 2018, p. 218).

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In electronic payment systems, researchers have provided a set of definitions, the most important of which are: electronic tools, transfer methods, and devices issued by banks and institutions as means of payment, such as bank cards, electronic money, electronic checks, and smart cards (Al-Zain, 2019, p. 147).

An electronic payment system is a means of conducting transactions or paying for goods and services electronically without using checks or cash. It is also called an electronic or online payment system.

Electronic payment systems have grown over the past few decades as online banking and shopping have become increasingly popular. As the world advances in technology, many electronic payment systems and payment processing devices have been developed to increase, improve, and secure electronic payment transactions while reducing the use of checks and cash. The electronic payment economy does not mean eliminating cash transactions; rather, it means keeping them to a minimum. (Afaha, 2019, p. 72)

III.1- Analysis of the development of electronic payment systems in Algeria

III.1.1- Analysis of the development of the electronic gross settlement system in Algeria during the period (2007-2022):

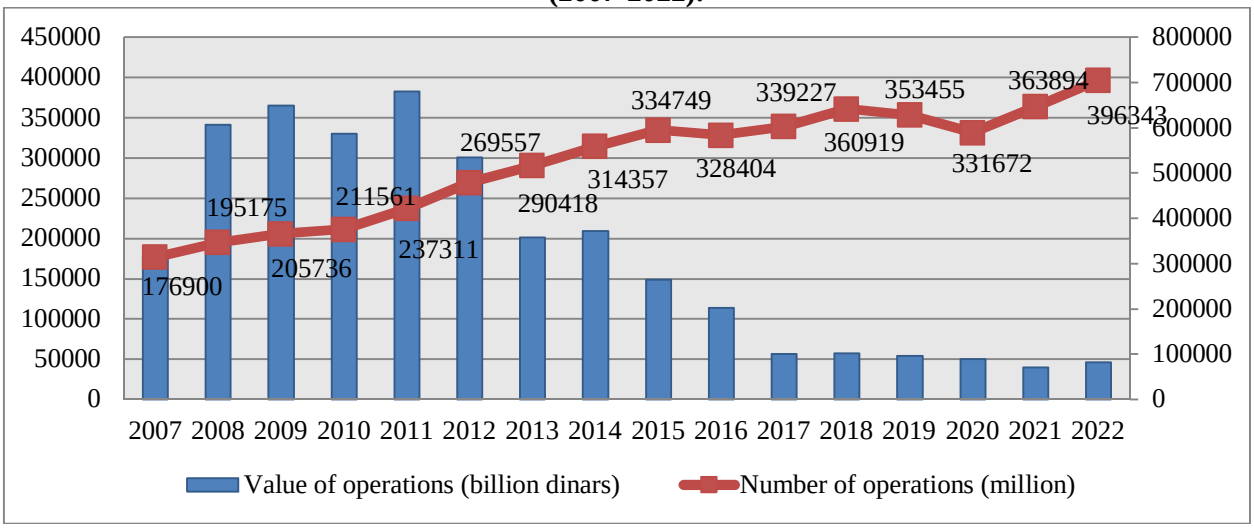
The Bank of Algeria introduced the Electronic Gross Settlement System in February 2006 to modernize the banking system. Used exclusively for dinar transfers, the Electronic Gross Settlement System includes all banks and financial institutions with accounts at the Bank of Algeria. The Electronic Gross Settlement System processes transfers continuously, immediately, and without delay on an aggregated basis (Algerian Republic Official Newspaper, 2006).

It offers a real-time view of instant aggregate settlement. The final settlement occurs immediately upon completion of the payment instructions and upon sufficient funds being available in the sending bank account. The Electronic Gross Settlement System project aimed to achieve several objectives (Moati, 2012, p. 66):

Meet the diverse needs of electronic payment users.
Reduce the total cost of payments.
Bring Algeria's payment system up to international standards for the timely settlement of bank card operations and other payment methods.
Shorten the settlement cycle.
Encourage the use of bank cards.
Strengthen interbank relations.
Attract foreign banks.

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Figure No. 01: The development of the electronic gross settlement system in Algeria during the period (2007-2022):



Source: Prepared by the researchers using data from the following reports:
(Bank of Algeria, 2023, p. 77) (Bank of Algeria, 2022, p. 75) (Bank of Algeria, 2021, p. 68) (Bank of Algeria, 2020, p. 83) (Bank of Algeria, 2019, p. 71) (Bank of Algeria, 2018, p. 70) (Bank of Algeria, 2017, p. 74) (Bank of Algeria, 2016, p. 82) (Bank of Algeria, 2015, p. 88) (Bank of Algeria, 2014, p. 87) (Bank of Algeria, 2013, p. 93) (Bank of Algeria, 2012, p. 87) (Bank of Algeria, 2011, p. 90) (Bank of Algeria, 2010, p. 129) (Bank of Algeria, 2009, p. 119) (Bank of Algeria, 2008, p. 116)

According to available data, at the end of 2008, the electronic gross settlement system recorded approximately 195175 reconciliation transactions in the Central Bank's books. For an estimated total of 607138 billion dinars, compared to 313373 billion dinars in 2007, through 176900 million operations, an annual increase of 10.3% and an annual rise of 93.7% in value. Since then, the system has grown year on year, with volatility in value, particularly in 2012 and 2013.

Although the volume of transactions via the electronic gross settlement system increased by 10823 million from 2016 to 2017, the value of transactions fell by almost half, from 201692,278 billion Algerian dinars in 2016 to 99896,266 billion Algerian dinars in 2017. This decline occurred amid the economic situation, the austerity crisis, and other factors affecting Algeria during that period.

Furthermore, the COVID-19 pandemic impacted the electronic gross settlement system, leading to decreases in both transaction volume and value between 2019 and 2020. However, in 2021, volume recovered to 363894 million operations, driven by improved economic and customer conditions. Despite this, the value remained lower 71 090,145billion dinars. The electronic gross settlement system's future growth is directly linked to the banking industry's progress in digital transformation and its ability to provide necessary technologies.

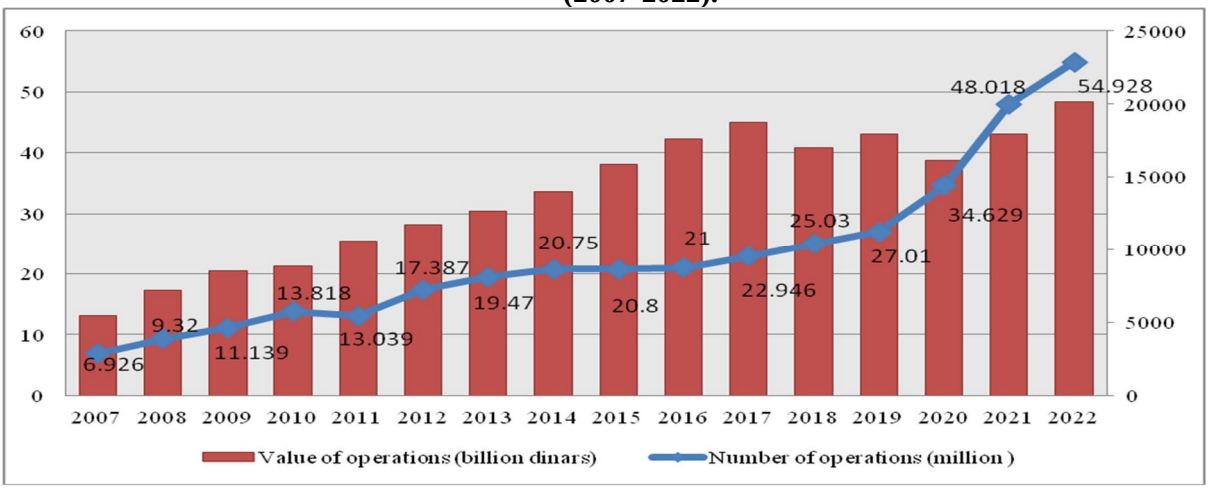
III.1.2- Analysis of the development of the electronic clearing system in Algeria during the period (2007-2022):

Algeria's electronic clearing system, ETCI Algérie Télécompensation Interbancaire, came into force on May 15, 2006, initially processing certain payment instruments and expanding by the end of 2006 to include all remaining payment types. The system processes payments by exchanging digital data and images of payment instruments. The system allows the exchange of all payment instruments (cheques, automated transfers, cards, and commercial bills of exchange) under the supervision of the Interbank Clearing Centre, based on multilateral payment instructions, then transferring the net settlement balances to the ARTS system at a predetermined time. The Bank of Algeria's system also includes a phase for continuously exchanging payment instructions throughout the trading day, the calculation phase of each participant's multilateral net positions before the end

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of the trading day, and the deposit phase where net balances are placed in participants' settlement accounts that are accepted by the ARTS system. Importantly, net positions are only settled if they are fully covered by available funds in the settlement account, following an "all or nothing" principle.

Figure No. 02: The development of the electronic clearing system in Algeria during the period (2007-2022):



Source: Prepared by the researchers using data from the following reports:
(Bank of Algeria, 2023, p. 79) (Bank of Algeria, 2022, p. 76) (Bank of Algeria, 2021, p. 69) (Bank of Algeria, 2020, p. 84) (Bank of Algeria, 2019, p. 72) (Bank of Algeria, 2018, p. 71) (Bank of Algeria, 2017, p. 75) (Bank of Algeria, 2016, p. 84) (Bank of Algeria, 2015, p. 90) (Bank of Algeria, 2014, p. 89) (Bank of Algeria, 2013, p. 95) (Bank of Algeria, 2011, p. 92) (Bank of Algeria, 2010, p. 132) (Bank of Algeria, 2009, p. 122) (Bank of Algeria, 2008, p. 117)

The clearing process is considered one of the most essential banking operations. With the emergence of digital technology, electronic clearing was adopted as the volume of operations in Algerian banks continued to increase from 2007 to 2022. Due to increasing interest in digital transformation and the implementation of necessary measures, transaction volumes reached 48.018 million in 2021 and 54.928 million in 2022. Transaction values fluctuate from year to year due to the economic conditions that characterize the study period. In 2008, electronic clearing systems processed approximately 9.32 million transactions, compared with 6.926 million in 2007. The total in 2008 amounted to approximately 7188.255 billion dinars, compared to 5452.188 billion Algerian dinars in 2007 (the monthly processing volume in 2008 was about 777000 transactions), a rate of 34.6%. Operations continued to grow in 2010, with the volume of payment transactions reaching approximately 13.818 million at the end of 2010, compared to 11.139 million in 2009. With a total of 8878.1 billion Algerian dinars, the volume increased by approximately 24% and the value by approximately 4%. The monthly processed transaction volume reached 1.152 million. At the end of 2014, the electronic clearing system recorded approximately 20.75 million transactions, with a total value of roughly 13989 billion Algerian dinars, an increase of about 6.6% compared to the end of 2013, when it recorded approximately 12661.6 billion Algerian dinars, representing an increase of 10.4%. Most of the transactions were between public banks, as they have multiple agencies and branches at the national level.

III.2- Analysis of the development of the gross domestic product in Algeria during the period (2007-2022):

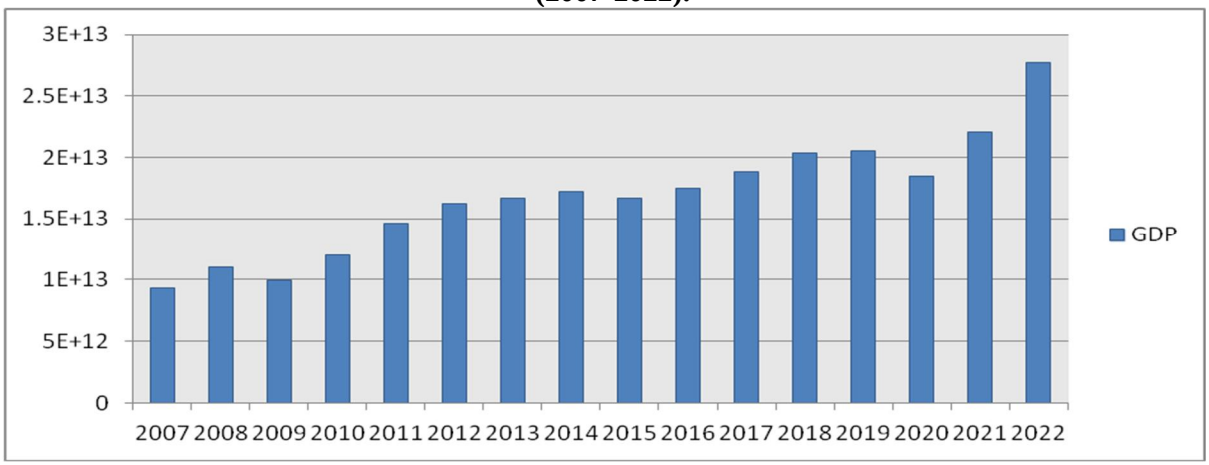
There are many definitions of economic growth, but most agree that it is linked to positive changes in a given economy's gross domestic product (GDP) and that this growth leads to improved living standards. Economic growth can also be seen as a permanent increase in per capita gross income within an economy, or as a quantitative increase in national income and production. In this sense, economic growth is a quantitative phenomenon characterized by sustained increases in population and production, and by the gradual transformation of the economy through increased welfare and production. Economic growth is quantitatively reflected in statistics but may not

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necessarily lead to significant improvements in living conditions, as it is essentially a quantitative concept. (Jamani, 2019, p. 3)

GDP best measures economic growth because it provides information on the economy's size and performance (HALLER, 2012, p. 66). GDP is the total monetary or market value of all manufactured goods and services produced within a country within a specified period. As a broad measure of overall economic activity, GDP serves as a comprehensive scorecard of a country's economic health. Isibar (2018) believes that calculating a country's GDP includes all private and public consumption, government spending, and investment. (Haruna, Maurie, & Zaccheaus, 2023, pp. 41- 42)

Figure No. 03: The development of the gross domestic product in Algeria during the period (2007-2022):



Source: Prepared by the researchers using data from the following source: (World Bank Group, 2023)

From Figure No. (02) Algeria's gross domestic product rose from 9352.886 billion dinars in 2007 to 20500.2 billion dinars in 2019, with a slight decline in 2009 and 2015. This growth is due to expansion in sectors outside hydrocarbons, especially in the activity sector (industry, marketed and non-marketed services), in addition to the improvement in the agricultural sector, which also benefited from favourable climatic conditions and increased growth in the areas of construction and public works. The growth rate in 2020 decreased to 18476.9 billion dinars compared to 2019 (20500.2 billion dinars) due to the impact of the COVID-19 pandemic. After that, there was an increase in 2021 and 2022, reaching 22079.3 billion dinars and 27688.8 billion dinars, respectively, driven by a significant recovery in the health situation and growth in the fuel sector. The recovery in 2022 is due to an increase in sectors other than hydrocarbons.

IV-Studying the impact of electronic payment systems on economic growth in Algeria during the period 2007–2022, using the ARDL model:

This section examines the relationship between electronic payment systems (the Electronic Total Settlement System and the Electronic Clearing System) and economic growth (GDP) in Algeria from 2007 to 2022.

IV.1-Research Methodology

IV.1.1-Study variables:

To define the study variables, we conducted a review of previous studies and the research problem. This review helped identify both the dependent and independent variables that serve the research objectives:

- **The dependent variable:** Economic growth, measured by the Gross Domestic Product (GDP).
- **The independent variables:** Electronic payment systems, specifically the Electronic Gross Settlement System (ARTS) and the Electronic Clearing System (ATCI).

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Data for these variables were obtained from reports of the Bank of Algeria and the World Bank, covering the period from 2007 to 2022, and the logarithm of the variable values was used for analysis.

IV.1.2-Definition of model:

We use the ARDL distributed lag model proposed by Pesaran et al. (1997–2001). The ARDL model accounts for the time lags between variables, and the explanatory variables are distributed over periods. The ARDL model integrates these variables into distributed lag parameters that correspond to the number of explanatory variables, since explanatory economic factors require time to influence the dependent variable, with effects distributed across short-term and long-term periods, and the model is written as follows (zerbout & Rezazi, 2022, p. 231):

IV.2-Empirical Findings:

IV.2.1- Descriptive study of the study variables:

Table 1 shows the statistical measures for the study variables in the period 2007-2022

Table No. (1): Descriptive statistical indicators

	GDP	ARTS	ATCI
Mean	13.20872	14.31123	13.11183
Median	13.22965	14.40038	13.17348
Maximum	13.44230	14.83259	13.30463
Minimum	12.97095	13.42184	12.73657
Std. Dev.	0.129304	0.438002	0.169163
Skewness	-0.370540	-0.347436	-0.818323
Kurtosis	2.479454	1.955025	2.559741
Jarque-Bera	0.546778	1.049879	1.914958
Probability	0.760797	0.591591	0.383859
Sum	211.3395	228.9797	209.7892
Sum Sq. Dev.	0.250792	2.877687	0.429240
Observations	16	16	16

Source: Prepared by the researchers based on Eviews 12

The table shows that the GDP (measured by the logarithm of GDP) during the study period had a mean of 13.208, with values ranging from 12.97 to 13.44 and a standard deviation of 0.978%, with a median of 13.229.

IV.2.2-The nature of the linear relationship between the study variables:

In Table No. 2, which shows the linear correlation matrix between the study variables, the following can be read: With probability values of 0.0041 and 0.0000, both less than 0.05, the results indicate a linear relationship between gross domestic product and the electronic gross settlement system (ARTS), showing an inverse correlation of 67% and a positive correlation of 94% with the electronic clearing system (ATCI).

Table No. (2): Linear correlation matrix

Correlation			
Probability	**GDP**	**ARTS**	**ATCI**
GDP	1.000000		

ARTS	-0.675626	1.000000	
	0.0041	-----	
ATCI	0.940953	-0.721590	1.000000
	0.0000	0.0016	-----

Source: Prepared by the researcher based on Eviews 12

IV.3-Measuring the impact of ARTS and ATCI on GDP in the long and short term using ARDL models:

We will attempt to answer the research question by assessing the impact of both the Electronic Gross Settlement System (ARTS) and the Electronic Clearing System (ATCI) on gross domestic product (GDP). Using the cointegration methodology for autoregressive distributed lag (ARDL) models allows for assessing long-term and short-term relationships and determining the dynamics by which the estimated short-term deviation from the long-term equilibrium is corrected.

IV.3.1-Time series stability tests:

We use one of the most important known unit root tests to determine the stationarity of each time series and verify the previous condition, which is the Phillips-Perron (PP) test. Table 3 summarizes the results of the stationarity tests for the time series of GDP, ARTS, and ATCI

Table No. (3): PP Stability Test for GDP, ARTS and ATCI Time Series :

UNIT ROOT TEST TABLE (PP)				
Null Hypothesis : GDP has a unit root				
Variables	**Formulas**	$H_0: \lambda = 0$ ***(Prob)***	$H_0: b = 0$ ***(Prob)***	$H_0: C = 0$ ***(Prob)***
GDP	*At Level*			
	With Constant & Trend	0.5499	0.0598	0.0434
	With Constant	0.8767	-	0.4440
	Without Constant & Trend	0.9995	-	-
	At First Difference			
	With Constant & Trend	0.1903	0.7284	0.6054
	With Constant	0.0307	-	0.0774
	Without Constant & Trend	0.0163	-	-
ARTS	**Null Hypothesis : ARTS has a unit root**			
	At Level			
	With Constant & Trend	0.0278	0.0054	0.0015
	With Constant	0.4499	-	0.1065
	Without Constant & Trend	0.4303	-	-
ATCI	**Null Hypothesis : ATCI has a unit root**			
	At Level			
	With Constant & Trend	0.3917	0.2881	0.0344
	With Constant	0.0139	-	0.0039
	Without Constant & Trend	0.9976	-	-

Source: Prepared by the researcher based on Eviews 12

a) Time series stability test for GDP:

The premise of stability is accepted by rejecting the unit root hypothesis (H_0: λ=0) in the gross domestic product (GDP) time series across three model specifications according to the known unit root test methodology. Table 3 presents the Phillips-Perron (PP) test results for the GDP time series.

The table shows the following results:

At the original level, we accept the hypothesis of the existence of a unit root in all three specifications (p-values: 0.54, 0.87, and 0.99). Therefore, the GDP time series is not stable at the original level.

After taking the first difference, according to the unit root testing methodology, the trend coefficient in the first specification is not statistically significant (prob = 0.728). Therefore, we proceed to the second specification with only a constant term, where we also find no statistical significance for the constant (prob = 0.077). Consequently, we estimate the third specification without a constant or trend coefficient and reject the hypothesis of a unit root. We can conclude that the GDP time series is stationary after the first difference and is therefore integrated of order one, I(1).

$$GDP \sim I(1)$$

b) Time series stability test for ARTS:

Table 3 summarizes the stability tests for the time series of the electronic gross settlement system (ARTS). The he results of estimating the first model with the general trend coefficient and constant term indicate statistical significance for the general trend coefficient (p-value = 0.0054). Therefore, this model is optimal for testing the unit root hypothesis. With a p-value of 0.0278, we reject the

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null hypothesis of a unit root at the original level. Therefore, we conclude that the time series is stationary and integrated of order zero I(0).

$$\text{ARTS} \sim I(0)$$

c) Test the stability of ATCI's time series:

The first formula in the table 3 shows that there is no statistical significance for the general trend coefficient, which leads us to examine the second formula, whereby the probability value (p = 0.039) is the statistical significance of the constant, corresponding to the rejection of the hypothesis of a unit root (p = 0.139). Therefore, we accept the stability of the ATCI series at the original level.

$$\text{ATCI} \sim I(0)$$

The previous results of the stability tests demonstrate the possibility of using ARDL models to measure the impact of the relationship between the two variables.

IV.3.2- Estimate the ARDL model for the impact of ARTS and ATCI on GDP. The format of the ARDL form is as follows:

$$GDP_t = a_0 + \sum_{i=1}^{p} \theta_i GDP_{t-i} + \sum_{l=0}^{q_1} \beta_l \, ARTS_{t-l} + \sum_{l=0}^{q_2} r_l \, AICI_{t-l} + \varepsilon_t$$

$$GDP_t \sim ARDL\left(p;\ q_1; q_2\right)$$

In this context, P, q1, and q2 represent the lag orders of the variables GDP, ARTS, and ATCI, respectively.

a) Determine optimal slowing degrees:

By estimating all possible ARDL models, the optimal lag orders give the best results, with the lowest values for the information criteria AIC, BIC, and HQ, and the highest value for the adjusted R-squared, as shown in the following table.

Table No. (04): Best Estimated Formulas for ARDL Model

Model Selection Criteria Table						
Dependent Variable: GDP						
Date: 02/25/24 Time: 00:36						
Sample: 2007 2022						
Included observations: 13						
Model	LogL	AIC*	BIC	HQ	Adj. R-sq	Specification
1	74.089308	-9.552201	-9.030709	-9.659391	0.998907	ARDL(3, 3, 3)
17	72.449754	-9.453808	-8.975774	-9.552066	0.999297	ARDL(2, 3, 3)
2	63.253665	-8.039025	-7.560991	-8.137283	0.997106	ARDL(3, 3, 2)
18	61.667167	-7.948795	-7.514218	-8.038120	0.997538	ARDL(2, 3, 2)
33	54.567186	-6.856490	-6.421914	-6.945815	0.992659	ARDL(1, 3, 3)
34	51.872476	-6.595766	-6.204647	-6.676158	0.991666	ARDL(1, 3, 2)
35	43.056789	-5.393352	-5.045691	-5.464812	0.974121	ARDL(1, 3, 1)
19	43.072090	-5.241860	-4.850741	-5.322253	0.967727	ARDL(2, 3, 1)
3	43.602851	-5.169669	-4.735093	-5.258994	0.960344	ARDL(3, 3, 1)
48	25.625393	-3.326984	-3.153153	-3.362714	0.789938	ARDL(1, 0, 0)
16	27.490989	-3.306306	-3.045560	-3.359901	0.797305	ARDL(3, 0, 0)
47	26.303554	-3.277470	-3.060182	-3.322132	0.787093	ARDL(1, 0, 1)
32	26.219368	-3.264518	-3.047230	-3.309181	0.784318	ARDL(2, 0, 0)
36	28.049316	-3.238356	-2.934153	-3.300884	0.782987	ARDL(1, 3, 0)
4	29.890463	-3.213917	-2.822799	-3.294310	0.754776	ARDL(3, 3, 0)
15	27.731836	-3.189513	-2.885310	-3.252041	0.772124	ARDL(3, 0, 1)
44	25.684840	-3.182283	-2.964995	-3.226946	0.765831	ARDL(1, 1, 0)
20	28.618920	-3.172141	-2.824480	-3.243601	0.761433	ARDL(2, 3, 0)
31	26.535145	-3.159253	-2.898507	-3.212848	0.765195	ARDL(2, 0, 1)
12	27.515027	-3.156158	-2.851955	-3.218686	0.764395	ARDL(3, 1, 0)
46	26.410830	-3.140128	-2.879382	-3.193723	0.760661	ARDL(1, 0, 2)

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43	26.317838	-3.125821	-2.865075	-3.179416	0.757212	ARDL(1, 1, 1)
28	26.245899	-3.114754	-2.854008	-3.168349	0.754510	ARDL(2, 1, 0)
39	27.154249	-3.100654	-2.796450	-3.163181	0.750948	ARDL(1, 2, 1)
45	27.105621	-3.093172	-2.788969	-3.155700	0.749078	ARDL(1, 0, 3)
30	26.830429	-3.050835	-2.746632	-3.113363	0.738227	ARDL(2, 0, 2)
40	25.783150	-3.043562	-2.782816	-3.097157	0.736396	ARDL(1, 2, 0)
14	27.752813	-3.038894	-2.691233	-3.110354	0.727430	ARDL(3, 0, 2)
11	27.731837	-3.035667	-2.688006	-3.107127	0.726549	ARDL(3, 1, 1)
27	26.649405	-3.022985	-2.718782	-3.085513	0.730834	ARDL(2, 1, 1)
23	27.606143	-3.016330	-2.668668	-3.087790	0.721210	ARDL(2, 2, 1)
8	27.553965	-3.008302	-2.660641	-3.079762	0.718963	ARDL(3, 2, 0)
29	27.510941	-3.001683	-2.654022	-3.073143	0.717096	ARDL(2, 0, 3)
24	26.480229	-2.996958	-2.692755	-3.059486	0.723736	ARDL(2, 2, 0)
42	26.414912	-2.986910	-2.682706	-3.049437	0.720946	ARDL(1, 1, 2)
41	27.212685	-2.955798	-2.608137	-3.027258	0.703813	ARDL(1, 1, 3)
38	27.154432	-2.946836	-2.599175	-3.018296	0.701146	ARDL(1, 2, 2)
7	28.096283	-2.937890	-2.546771	-3.018282	0.676824	ARDL(3, 2, 1)
26	26.933749	-2.912884	-2.565223	-2.984345	0.690826	ARDL(2, 1, 2)
13	27.897081	-2.907243	-2.516124	-2.987636	0.666766	ARDL(3, 0, 3)
10	27.753032	-2.885082	-2.493963	-2.965474	0.659299	ARDL(3, 1, 2)
22	27.651186	-2.869413	-2.478294	-2.949806	0.653919	ARDL(2, 2, 2)
25	27.516265	-2.848656	-2.457537	-2.929049	0.646660	ARDL(2, 1, 3)
37	27.343095	-2.822015	-2.430896	-2.902407	0.637120	ARDL(1, 2, 3)
6	28.096498	-2.784077	-2.349500	-2.873402	0.569113	ARDL(3, 2, 2)
9	27.915672	-2.756257	-2.321681	-2.845582	0.556957	ARDL(3, 1, 3)
21	27.721466	-2.726379	-2.291803	-2.815704	0.543520	ARDL(2, 2, 3)
5	28.099197	-2.630646	-2.152612	-2.728903	0.353937	ARDL(3, 2, 3)

Source: Prepared by researchers, using the EViews.12 programme

The previous table shows the best possible models of the estimated ARDL of the studied relationship, where the optimal formulas by AIC, BIC, HQ, and determination coefficient are the model ARDL (3, 3, 3), i.e., **($p = 3, q_1 = 3, q_2 = 3$).**

IV.3.3-Estimate the optimal ARDL model of the GDP relationship by ARTS and ATCI

Appendix No. 1 shows the model estimation outputs, where the ARDL equation for the relationship under study can be written as follows:

$$GDP_t = 2.737006 + 0.947561\ GDP_{t-1} + 0.149606\ GDP_{t-2} - 0.021810 GDP_{t-3} + 0.055424\ ARTIS_t + 0.020281\ ARTIS_{t-1} - 0.0473\ ARTIS_{t-2} - 0.1404\ ARTIS_{t-3} + 1.48409\ ATCI_t + 1.2665\ ATCI_{t-1} - 0.2599\ ATCI_{t-2} - 0.1197\ ATCI_{t-3} +$$

This equation represents the best formula for the ARDL model to explain the GDP in Algeria in terms of ARTS and ATCI. Through this model, GDP is related to the values of the current series and the values of the previous three years for each of GDP, ARTS, and ATCI according to the following:

- GDP positively correlates to the ARTS values of the current series and the values of the previous year (with a unit change of 0.0554 and 0.0202, respectively) and inversely to ARTS two or three years ago.
- GDP has a positive correlation with ATCI in the same current year and is inversely related to the value of ATCI for the previous three years.

From Appendix 1, we note that the coefficient of determination (R^2) is 0.999909, which is acceptable, as the explanatory variables account for 99.99% of the variation in the dependent variable, indicating a strong correlation between GDP and its explanatory variables. The value of F-statistic (998.2800) with a significance level of 0.024682 is below the 5% significance level, indicating that the model is statistically significant at the 5% level. The goodness-of-fit test also confirms, with a coefficient of determination of 99.89%, that the change in GDP is due to the variables included in the model (ARTS and ATCI). The remaining 0.11% of the change in GDP is attributed to other factors not included in the model.

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IV.3.4-Bounds test for joint integration :

Using the bounds test, we examine the existence of a long-term cointegration relationship for the variables under study. However, we must first verify that the classical error assumptions of the ARDL model are satisfied to avoid estimation problems. Appendix 5 presents the residual test results for the estimated model. The conditions for applying the bounds test to examine the cointegration hypothesis are as follows:

- **The hypothesis of normal distribution of residual:** The Jarque-Bera test (Appendix 2) yields a p-value of 0.814406 (> 0.05), confirming the normal distribution of residuals in the ARDL model.
- **The hypothesis of homogeneity of error variance:** The ARCH test (Appendix 2) shows p-values of 0.8788 for the F-statistic and 0.8641 for the Lagrange multiplier, both exceeding 0.05, confirming homoscedasticity.

These diagnostic tests confirm the validity of the ARDL model for detecting long-term cointegration relationships using Pesaran's (2001) bounds test to evaluate the null hypothesis H0: no cointegration. The F-statistic is calculated based on the integration order of the time series, number of variables, ARDL specification, and sample size, then compared to the critical bounds.

Table No. (05): F-Bounds Test Results

F-Bounds Test		**Null Hypothesis: No levels relationship**		
Test Statistic	**Value**	**Signif.**	**I(0)**	**I(1)**
			Asymptotic: n=1000	
F-statistic	170.8541	10%	2.63	3.35
K	2	5%	3.1	3.87
		2.5%	3.55	4.38
		1%	4.13	5
Actual Sample Size	13		**Finite Sample: n=35**	
		10%	2.845	3.623
		5%	3.478	4.335
		1%	4.948	6.028
			Finite Sample: n=30	
		10%	2.915	3.695
		5%	3.538	4.428
		1%	5.155	6.265

Source: Prepared by the researcher based on Eviews 12

This test was conducted using the Autoregressive Distributed Lag (ARDL) methodology, as shown in Table 5 above. The results indicate that the calculated F-statistic value of 170.8542 is greater than the upper limit I(1) at each of the significance levels (10%, 5%, and 1%), which are equal to 3.62, 4.33, and 6.028, respectively. Based on the results, we reject the null hypothesis H0, that states there is no joint integration (null hypothesis: no-level relationship). We accept the hypothesis of long-run joint integration of GDP across ARTS and ATCI.

IV.3.5-Estimating the error correction model or the speed of correcting the imbalances between the two terms:

Previous results support the idea of a long-term equilibrium between GDP, ARTS, and ATCI. Through the error correction model, this relationship can be estimated and accessed quickly in the short term.

a) Estimating the long-term equilibrium relationship

Table No. (06) shows a long-term relationship between GDP and the explanatory variables.

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Table No. (06): The Impact of ARTS and ATCI on GDP in the Long-Term

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
ARTS	1.487358	1.416878	1.049744	0.4846
ATCI	2.150625	1.285873	1.672502	0.3431
C	-36.32074	36.87653	-0.984928	0.5048
EC = GDP - (1.4874*ARTS + 2.1506*ATCI - 36.3207)				

Source: Prepared by the researcher based on Eviews 12

From the table, the long-term equilibrium relationship can be written in the following form:

$$\mathbf{GDP_t = - 36.32074 + 1.487358\ ARTS + 2.150625\ ATCI}$$

Based on the above estimated equation, we observe that the ARTS variable has a positive impact on GDP in the long term. Increasing ARTS by 1 unit leads to 1.487358 -unit increase in GDP, indicating a positive correlation consistent with economic theory. However, this relationship is not statistically significant at the 5% level, as the probability value for the parameter is 0.4846. Similarly, the ATCI variable positively affects GDP in the long term. A one-unit increase in ATCI results in a 2.150625-unit rise in GDP, aligning with economic theory. However, this relationship is also not statistically significant at the 5% level.

These relationships illustrate the long-term equilibrium effects of ARTS and ATCI on GDP. Any imbalance between the two sides of the equation represents the error term (e), which was denoted as EC in the previous table.

$$\mathbf{EC = GDP_t –(- 36.32074 + 1.4873\ ARTS + 2.1506\ ATCI)}$$

b) Estimating the error correction equation ECM:

The error correction model is based on the premise of a long-term equilibrium relationship in which the equilibrium value is determined by its determinants. However, the estimated values in the model may deviate from their equilibrium values, resulting in an equilibrium error that can be corrected over the long term. Therefore, the error correction model assumes two types of relationships between GDP (the dependent variable) and ARTS and ATCI (the explanatory variables): a long-term relationship measured by the levels of the variables and a short-term relationship measured by their period-to-period changes (Al-Abdeli, 2007, p. 18). Appendix No. 3 explains the error correction equation in detail.

This model explains the short-term dynamic relationship between these variables that leads to equilibrium. The error correction equation can be expressed as follows:

$$\Delta GDP_t = -0.1277\,\Delta GDP_{t-1} + 0.0218\,\Delta GDP_{t-2} + 0.055\,\Delta ARTIS_t + 0.1877\,\Delta ARTIS_{t-1} + 0.1404\,\Delta ARTIS_{t-2} + 1.4840\,ATCI_t + 0.3796\,ATCI_{t-1} - 0.1197\,ATCI_{t-2} + 0.075357 e_{t-1}$$

The first part of the ECM equation explains the short-term response of GDP to changes in ARTS and ATCI. A dynamic positive correlation exists between the change in GDP and the change in ARTS in the same year and the previous two years. Similarly, changes in GDP also positively correlate with shifts in ATCI over the current and the last two years. In the short term, all variables exhibit significance levels between 5% and 10%. As an explanatory variable, ARTS positively impacts GDP by 5.54%, aligning with economic theory. The ATCI variable is even more influential, positively affecting short-term economic growth by 148.41%, consistent with economic theory. The equilibrium error in period (t-1), multiplied by the error correction factor, constitutes the 0.075357 component of the equation. This term describes the short-term error-correction mechanism that works to achieve equilibrium after one period.

The results also showed that the short-term dynamic relationship between GDP and the explanatory variables is due to the negative and statistically significant estimated error. The value of this error was CoinEq(-1) = -0.075357, which measures the percentage of imbalance in the dependent variable that can be corrected from one period to another. In other words, 7.53% of GDP can be rectified from one period to another, and the negative sign supports the existence of a long-term equilibrium relationship between the variables.

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IV.4- Economic interpretation of findings within the Algerian context

IV.4-1- Economic interpretation of the econometric results (Econometric Interpretation)

The results obtained using the ARDL model carry profound economic implications that go beyond mere statistical significance, and they can be stated as follows:

IV.4-1-1-Interpretation of the "Error Correction Term" (ECT = -0.075):

Empirical finding: The parameter is negative and statistically significant, which confirms the existence of a mechanism that corrects deviations and restores equilibrium.

Economic interpretation: The speed of adjustment is relatively slow (only about 7.5% of the disequilibrium is corrected in each period/year). This reflects structural rigidity in the Algerian economy. In other words, despite the development of payment systems (technological shocks), the response of Gross Domestic Product (GDP) and its return to long-run equilibrium is constrained by other factors (such as excessive dependence on oil rents, bureaucracy, and weak productive flexibility). The financial system is modernizing, yet the real economic structure remains slow to respond.

IV.4-1-2-The clearing system (ATCI) has a stronger short-run effect than the real-time gross settlement system (ARTS):

Empirical finding: The ATCI coefficient (1.48) is much larger than the ARTS coefficient (0.055).

Economic interpretation: The electronic clearing system (ATCI) processes mass payment instruments (cheques and mass transfers) that more directly affect wages, supplier payments, and commercial transactions of small and medium-sized enterprises—hence, it has a more direct linkage with the real economy. Accelerating these operations increases the velocity of money, which is immediately reflected in current economic activity.

By contrast, the ARTS system mainly concerns large-value settlements among banks (interbank) and large firms. It is more closely associated with bank liquidity management and does not necessarily generate immediate productive value added, which explains its weaker responsiveness compared with the clearing system.

IV.4-1-3- "Short-run significance" versus "long-run non-significance":

Empirical finding: The effect is positive and statistically significant in the short run, but statistically insignificant in the long run (despite a positive sign).

Economic interpretation (the Solow paradox): This indicates that payment systems in Algeria function as facilitators rather than growth drivers in the long run.

In the short run, easing a liquidity constraint or speeding up cheque processing can resolve a firm-level bottleneck and thus raise output.

In the long run, however, Algeria's economic growth is primarily shaped by other, more structural determinants (oil prices and public investment) rather than by financial system efficiency alone. Payment-system technology is a necessary condition for modern growth, but it is not sufficient unless accompanied by genuine economic diversification.

IV.4-2-Linking the results to Algeria's reality

IV.4-2-1-Formal money supply and cash-based circulation:

Despite the improvements in ARTS/ATCI highlighted by the study, the Algerian economy is characterized by a pronounced cash preference, whereby a substantial share of broad money (M2) circulates outside the banking system (currency in circulation outside banks).

This helps explain the lack of long-run significance: a considerable portion of economic activity (especially in the informal sector) takes place outside the effective coverage of ARTS and ATCI. Thus, while payment systems have modernized, financial inclusion has not expanded at the same pace to integrate the informal economy.

IV.4-2-2-The role of crises and shocks (2014 and 2020):

The sample period (2007–2022) includes two major shocks: the 2014 oil price crisis and the 2020 COVID-19 pandemic.

In 2020, despite the economic contraction, reliance on electronic payment systems increased out of necessity. This may create a temporary inverse pattern that can blur econometric identification; however, the positive results found in the study suggest that payment systems acted as a shock absorber, sustaining a minimum level of economic activity during lockdowns—otherwise, the contraction would likely have been deeper.

IV.4-2-3-Infrastructure modernization (2006) and delayed effects:

Reforms started in 2006, and the results point to an accumulated positive impact. Nevertheless, electronic banking in Algeria remained, for a long time, largely limited to cash withdrawals (ATMs) rather than genuine electronic payments (POS terminals/TPE and internet payments). This helps explain the limited growth effect, as the payment cycle remained incomplete (money exits banks and returns to the informal cash economy), weakening the transmission mechanism.

V. Conclusion:

This study aimed to assess the extent to which the development of electronic payment methods and systems contributed to economic growth in Algeria during 2007-2022, using joint integration within the autoregressive distributed lag (ARDL) framework. The study reached a set of results, the most important of which are:

- After conducting unit root tests to determine the stability of the data, the results showed that the GDP variable is stable at the first difference, i.e., integrated at the first degree. In contrast, the two explanatory variables, ARTS and ATCI, remained stable at their original levels, i.e., integrated of order zero I(0).
- The results of the joint integration boundary test showed the existence of a long-term equilibrium relationship between the explanatory variables (electronic gross settlement system and electronic clearing system) and the dependent variable (economic growth rate).
- The best model according to the AIC, BIC, and HQ criteria is the ARDL (3,3,3) model to measure the impact of electronic payment systems (electronic gross settlement system and electronic clearing system) on the economic growth rate during the study period.
- The results of the analysis showed that the electronic gross settlement system and the electronic clearing system have a positive impact on the economic growth rate in the short term and that the parameters are significant at the 0.05 level. This is consistent with Al-Tufayli's (2023) findings are based on empirical analyses in Saudi Arabia and Bahrain.
- The results of the analysis showed that the electronic gross settlement system and the electronic clearing system have a positive impact on the economic growth rate in the long term. However, the parameters are not significant at the 0.05 level. This is consistent with Al-Tufayli's (2023) findings based on empirical analysis results in Iraq.
- The results of the error correction model analysis showed that there is an error correction mechanism in the model, that the economic growth rate function in the short run tends to equilibrium in the long run, and that the error correction coefficient is negative and significant.
- The results of the diagnostic tests showed that the estimated model is free from measurement problems.

Based on the above results, the following hypotheses can be confirmed or rejected:

Hypothesis 1: There is a significant relationship between the systems and means of electronic payment and Algeria's short-term economic growth. This hypothesis has been validated by the finding that both the electronic gross settlement system and the electronic clearing system are significant at the 0.05 level and have a positive impact on the short-term economic growth rate.

Hypothesis 2: There is a positive long-term joint integration relationship between Algeria's electronic payment systems and economic growth. The bounds test for cointegration established a long-term equilibrium relationship, thereby validating the hypothesis.

The study recommends the following:

- There is a need to develop the infrastructure for electronic payment technologies and systems, and develop legislation and laws to enhance their reliability.
- Strengthen electronic payment systems by raising awareness and promoting the adoption of electronic payment systems through various products, innovating new technologies, and ensuring compliance with cashless payment policies.

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- Governments should work to develop mechanisms to reduce digital fraud and increase customer confidence in dealing with electronic payment tools.
- Keep pace with developments in financial technology, and international expertise in the field of digitising financial services should be utilised. In addition, efforts should be made to develop competent human resources capable of using information technology.

Appendices:

Appendix 1: ARDL model estimation results for the studied relationship

Dependent Variable: GDP				
Method: ARDL				
Sample (adjusted): 2010 2022				
Included observations: 13 after adjustments				
Maximum dependent lags: 3 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (3 lags, automatic): ARTS ATCI				
Fixed regressors: C				
Number of models evalulated: 48				
Selected Model: ARDL(3, 3, 3)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
GDP(-1)	0.947561	0.074694	12.68592	0.0501
GDP(-2)	0.149606	0.037646	3.973970	0.1569
GDP(-3)	-0.021810	0.040719	-0.535634	0.6869
ARTS	0.055424	0.004897	11.31725	0.0561
ARTS(-1)	0.020281	0.006980	2.905499	0.2110
ARTS(-2)	-0.047355	0.005366	-8.825284	0.0718
ARTS(-3)	-0.140431	0.004085	-34.37323	0.0185
ATCI	1.484093	0.061585	24.09811	0.0264
ATCI(-1)	-1.266511	0.049993	-25.33355	0.0251
ATCI(-2)	-0.259910	0.044260	-5.872337	0.1074
ATCI(-3)	-0.119736	0.057766	-2.072769	0.2862
C	2.737006	0.604179	4.530126	0.1383
R-squared	0.999909	Mean dependent var		13.25591
Adjusted R-squared	0.998907	S.D. dependent var		0.088382
S.E. of regression	0.002922	Akaike info criterion		-9.552202
Sum squared resid	8.54E-06	Schwarz criterion		-9.030710
Log likelihood	74.08931	Hannan-Quinn criter.		-9.659392
F-statistic	998.2800	Durbin-Watson stat		2.395647
Prob(F-statistic)	0.024682			
*Note: p-values and any subsequent tests do not account for model selection.				

Appendix No. 2: Diagnosing residuals for the ARDL model

Tests		**Stat_Value**	**Prob**
Heteroskedasticity Test: ARCH	**F-statistic**	0.024469	0.8788
	Obs*R-squared	0.029291	0.8641
Normal distribution test		0.410592	0.814406

Appendix No. 3: Error correction model estimation

ARDL Error Correction Regression
Dependent Variable: D(GDP)
Selected Model: ARDL(3, 3, 3)
Sample: 2007 2022
Included observations: 13

ECM Regression
Case 2: Restricted Constant and No Trend

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Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	-0.127795	0.011794	-10.83559	0.0586
D(GDP(-2))	0.021810	0.012463	1.750019	0.3305
D(ARTS)	0.055424	0.001397	39.67373	0.0160
D(ARTS(-1))	0.187787	0.002474	75.91620	0.0084
D(ARTS(-2))	0.140431	0.001810	77.60279	0.0082
D(ATCI)	1.484093	0.018247	81.33374	0.0078
D(ATCI(-1))	0.379646	0.012472	30.43930	0.0209
D(ATCI(-2))	0.119736	0.011972	10.00121	0.0634
CointEq(-1)*	0.075357	0.001441	52.28447	0.0122

R-squared	0.999602	Mean dependent var	0.034130
Adjusted R-squared	0.998807	S.D. dependent var	0.042292
S.E. of regression	0.001461	Akaike info criterion	-10.01374
Sum squared resid	8.54E-06	Schwarz criterion	-9.622621
Log likelihood	74.08931	Hannan-Quinn criter.	-10.09413
Durbin-Watson stat	2.395647		

* p-value incompatible with t-Bounds distribution.

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