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Impact of E-Government Indicators on Tax Revenues in Algeria: Econometric Study for the Period 2003–2025

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Abstract. *This study measures the impact of e-government indicators—namely the E-Government Development Index (EGDI), the Online Service Index (OSI), and the Human Capital Index (HCI)—on tax revenues in Algeria over 2003–2025. Using an ARDL model, the study uses annual time-series data. The bounds testing approach confirms a long-run cointegration relationship among the variables. The error correction term is estimated at -0.51, which is negative and statistically significant, indicating that about 51% of short-run disequilibrium is corrected within one period toward long-run equilibrium. In the short run, the Human Capital Index (HCI) shows a positive and significant effect on tax revenues. In the long run, all three indicators—EGDI, OSI, and HCI—exhibit positive and significant effects, with a 1% increase in each leading to a 0.15%, 0.14%, and 0.45% increase in tax revenues, respectively. Diagnostic tests confirm the model is free from autocorrelation, heteroskedasticity, and specification errors, with stable parameters and normally distributed residuals. These results confirm that e-government development, improved digital services, and human capital investment enhance tax administration efficiency, broaden the tax base, and increase tax compliance, thereby supporting fiscal sustainability in Algeria.*

Keywords: *e-government, tax revenues, ARDL model, cointegration, error correction, fiscal sustainability*

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Elektron hökumət göstəricilərinin Əlcəzairdə vergi daxilolmalarına təsiri: 2003–2025-ci illər üzrə ekonometrik tədqiqat

Zəhra Abbas[1*], Əsma Xəlil[1], Cəmilə Menidjel[2]

Xülasə. *Bu tədqiqat 2003–2025-ci illər ərzində Əlcəzairdə elektron hökumət göstəricilərinin — xüsusilə elektron hökumətin inkişafı indeksi (EGDI), onlayn xidmətlər indeksi (OSI) və insan kapitalı indeksi (HCI) — vergi gəlirlərinə təsirini qiymətləndirir. Tədqiqatda illik zaman sıraları məlumatlarından və ARDL modelindən istifadə olunur. Sərhəd testi (bounds testing) yanaşması dəyişənlər arasında uzunmüddətli kointeqrasiya əlaqəsinin mövcudluğunu təsdiqləyir.*

Səhvlərin düzəldilməsi əmsalı -0,51 olaraq müəyyən edilmişdir; mənfi və statistik cəhətdən əhəmiyyətli olan bu göstərici qısamüddətli tarazsızlığın təxminən 51%-nin bir dövr ərzində uzunmüddətli tarazlıq istiqamətində düzəldildiyini nümayiş etdirir. Qısamüddətli dövrdə insan kapitalı indeksi (HCI) vergi gəlirlərinə müsbət və əhəmiyyətli təsir göstərir. Uzunmüddətli dövrdə isə hər üç göstərici — EGDI, OSI və HCI — müsbət və əhəmiyyətli təsirə malikdir; belə ki, hər bir göstəricidəki 1%-lik artım vergi gəlirlərində müvafiq olaraq 0,15%, 0,14% və 0,45% artıma səbəb olur. Diaqnostik testlər modelin avtokorrelyasiya, heteroskedastiklik və spesifikasiya xətalarından azad olduğunu, həmçinin sabit parametrlərə və normal paylanmış qalıqlara malik olduğunu təsdiqləyir. Bu nəticələr təsdiqləyir ki, elektron hökumətin inkişafı, rəqəmsal xidmətlərin təkmilləşdirilməsi və insan kapitalına investisiyalar vergi inzibatçılığının səmərəliliyini artırır, vergi bazasını genişləndirir və vergi öhdəliklərinə riayət olunmasını gücləndirir, bununla da Əlcəzairdə fiskal dayanıqlığa dəstək verir.

Açar sözlər: *elektron hökumət, vergi gəlirləri, ARDL modeli, kointeqrasiya, səhvlərin düzəldilməsi, fiskal dayanıqlıq*

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1. Introduction

Tax revenue plays a crucial role in government spending. It provides an indigenous source from which the government can collect funds for social and fiscal policies as well as government spending. Tax revenues are not only a function of the levels of taxation but also depend on the coverage and effectiveness of a taxation system. For example, information collection, monitoring of declarations, timely collection and coverage of taxpayers are factors in tax effectiveness. Thus, better tax administration is increasingly reliant on tools that enhance compliance while reducing compliance costs and tax evasion. Furthermore, domestic revenue mobilization has also been found to play a key role in decreasing reliance on external financing as well as in funding development, especially in developing countries (Tolossa & Melese, 2024).

E-government has altered the relationship between a government and the general public. Through the transition to digital services, information dissemination has improved, paper usage has been reduced, and the number of services that can be delivered has also increased. In taxation, digitalization has occurred through information integration, electronic filing, electronic payments and the use of digital information in monitoring and compliance. E-government has also transitioned from service delivery over a distance to information utilization and information generation within decision-making. In taxation, the speed and quality of information can have an influence on compliance and effective monitoring. High-quality and timely information may allow risk targeting and non-compliance to be identified effectively (Zídková et al., 2024).

Digitalization can have an influence on the economy through reducing compliance costs associated with taxation. When information is accessible, payments and filing are simplified, and compliance costs are reduced. Digital information may also help in cross-checking information from multiple sources and may

help in the identification of underreporting and misreporting. Therefore, e-government can be applied in two forms: on the taxpayer through enhanced compliance and on the side of tax administration through enhanced monitoring. A study using 1,677 country-year data from 2006 to 2017 found that digitalization of government services can reduce tax evasion, and the diffusion of information and communication technologies (ICT) to individuals can enhance this relationship (Uyar et al., 2021).

Digitalization is not guaranteed to lead to an enhancement in tax revenues. The influence of digitalization may also be influenced by the institutional quality of government institutions, by the digital capacities of institutions and taxpayers or by available infrastructure. A study using country-year data for up to 159 countries from 2004 to 2021 found that digitalization does not necessarily have a direct influence on the non-resource revenue-to-GDP ratio. However, digitalization may have a larger influence when combined with enhanced institutional quality, especially with regard to regulatory and accountability quality. This highlights the influence of institutional quality on the relationship between digitalization and revenue mobilization (Lee, 2025).

Another influence of digitalization may be in reducing the difference between taxes paid and taxes collected. Zídková et al. (2024) used the E-Government Development Index to measure the relationship between the level of e-government and VAT collection in EU countries. This is relevant because it links digitalization to a specific measure of tax revenue (VAT gap). The study also found a positive relationship between e-government and VAT collection. This supports the influence of digitalization on tax administration through enhanced information and services (Zídková et al., 2024).

Tolossa and Melese (2024) used the E-Government Development Index as an explanatory variable and attempted to determine factors that influence the mobilization of tax revenue in 30 Sub-Saharan African countries between 2003 and 2022. The study also found that, in addition to economic variables, the e-government index can explain tax effort in a PCSE model.

This is important for developing countries because digitalization is now one of many variables that can be used to explain domestic revenue mobilization, and not only an issue related to administration but also a policy issue (Tolossa & Melese, 2024).

There have also been some studies that question the relationship between digitalization and tax revenues and whether it is only a linear relationship between digitalization and increased tax revenue. Hanrahan (2026) used panel data of OECD governments between 1995 and 2018 and a digitization index based on IP data to investigate the influence of digitalization on the composition of government tax revenue. The study found that digitalization influenced the composition of tax revenue. This may indicate that the influence of digitalization depends on the property being taxed. Alternatively, digitalization may influence compliance or revenue collection but not the composition of revenue (Hanrahan, 2026).

Digitalization of a taxation system may also influence taxpayer behavior. Recently, Bi et al. (2026) utilized a quasi-natural experiment that involved the implementation of the “Internet Plus Government Services” program in China and found that as e-government expanded, there was a decline in corporate tax evasion and an increase in the effective tax rate. This supports the influence of e-government on taxpayer behavior because digital government services have been shown to increase the monitoring capacity of the tax administration while also increasing the cost to engage in economic activity while hiding it from the tax administration (Bi et al., 2026).

Digitalization is seen as having an important influence on tax improvement. However, the size and persistence of this influence are mixed. Some studies have found a positive influence of digitalization on

tax revenue collection or reduced tax evasion (Kuzey et al., 2025; Uyar et al., 2021). However, other studies have found that the influence of digitalization may depend on institutional quality or may not influence all aspects of a tax system. Additionally, the influence of digitalization may also depend on the index used to measure digitalization. For example, some studies use tax administration digitalization, ICT diffusion, diffusion of e-government services or the E-Government Development Index (Uyar et al., 2021; Zídková et al., 2024; Hanrahan, 2026).

There is therefore a research gap. While there is an increasing amount of international research that links digitalization to revenue mobilization, more empirical research is needed to test this relationship in Algeria over a long time period. Additionally, different indicators are used to measure e-government across international research, and the relationship between e-government and revenue mobilization also differs. This is especially important for the Algerian economy because the influence of digitalization may also differ from a country with more established digital and institutional capabilities. This study will examine the relationship between e-government indicators and tax revenues in Algeria using cointegration analysis. The statistical significance of e-government indicators will also be tested, and the time period will cover 2003 to 2025.

Based on this gap, the research problem centers on the following main question:

To what extent do e-government indicators affect tax revenues in Algeria over the period 2003–2025?

The following sub-question branches from this main question:

Is there a cointegration relationship between e-government indicators and tax revenues in Algeria over 2003–2025, and is there a statistically significant impact between e-government indicators and tax revenues in Algeria over the same period?

This study provides relevant connections between two rapidly converging domains within the contemporary public finance literature: digitalization of the state and the mobilization of resources from taxation. It also evaluates the connection between e-government and tax revenue in a developing country across different stages of e-government development. From a research point of view, this study tries to test this causal relationship in a developing economy using data that also spans varying degrees of e-government. From a policy point of view, this study will also facilitate evaluation of whether or not implementation of digitalization has helped enhance the ability of the government to mobilize tax revenues or whether further regulatory and institutional reforms are necessary to enhance this relationship.

This study aims to evaluate the effect of e-government indicators on tax revenues in Algeria over the period 2003 to 2025. Furthermore, this study aims to estimate the statistically significant effect of e-government indicators on tax revenue. It also tries to identify the long-run linkages among the variables and whether there exists a cointegration relationship among the variables. This study will attempt to evaluate the economic relationship between e-government and tax revenue using econometric methods rather than just the dynamics between the variables.

Annual data are used from the year 2003 to 2025. The dependent variable is tax revenue, and the independent variables are e-government indicators. Initially, the characteristics and stationarity of the data are examined. Next, a test for cointegration among the variables is conducted. Based on the characteristics of the data, appropriate econometric methods are used to estimate both the short-run and long-run relationships. An important objective of this study is to differentiate between short-run and

long-run relationships. This is particularly important when dealing with slowly evolving economic variables.

This study has three areas of relevance that are closely related to one another. Firstly, this study provides up-to-date empirical evidence on the Algerian context extending up to the year 2025. Secondly, this study uses e-government through indicators rather than using a general definition of digitalization in the government. Finally, this study utilizes testing of effects and testing for cointegration. This enables identification of whether changes in e-government indicators are only related to tax revenue in the short run or whether there exists a longer-run economic relationship. This study therefore aims to address some of the evidence gap on the relationship between digitalization and tax performance in Algeria.

Based on the above, the study proceeds from the following two hypotheses:

- First Hypothesis: There is a cointegration relationship between e-government indicators and tax revenues in Algeria over the period (2003–2025), at a significance level of $\alpha \leq 0.05$.
- Second Hypothesis: There is a statistically significant impact between e-government indicators and tax revenues in Algeria over the period (2003–2025), at a significance level of $\alpha \leq 0.05$.

2. Methods

Recent empirical studies have increasingly used statistical and econometric techniques to examine relationships between economic variables and provide evidence on both short- and long-run dynamics of the studied phenomena. This study examines the relationship between e-government indicators and tax revenues in Algeria using the Autoregressive Distributed Lag (ARDL) model over the period 2003 to 2025. ARDL is used because it allows the short-run and long-run relationships to be determined, as well as the dynamic relationship between the variables in the model. Data on Algeria were obtained from the World Bank, the International Monetary Fund (IMF) and the Organization for Economic Co-operation and Development (OECD) for the period 2003 to 2025. These sources are globally accepted and reliable. The variables are relevant to the relationship between e-government and tax revenues, and the data cover Algeria over the study period.

The study intends to use this methodology to examine the contribution of e-government reforms to changes in tax revenue in Algeria, while also considering the long-run and dynamic relationship between the variables. Based on economic theory, past research conducted on this subject and the nature of the Algerian economy, the independent variables, e-government indicators (EGDI, OSI, HCI), will be used to explain the dependent variable, tax revenues (TAXREV_GDP). The appropriate model for the dependent variable will be identified based on the data used and the study's assumptions. We will use EViews 13 for estimation. A linear model will be employed because it aligns with the research problem and economic theory.

We obtain the Autoregressive Distributed Lag (ARDL) model with the following equation for the dependent variable, tax revenues (TAXREV_GDP):

TAXREV_GDP = f (EGDI, OSI, HCI) T = 2003–2025

The explicit linear form of the proposed model is:

$$\Delta TAXREV_GDP = \alpha_0 + \Sigma_{i=1}^{p} \beta_{1i} \Delta TAXREV_GDP_{t-i} + \Sigma_{j=0}^{\varphi} \beta_{2j} \Delta EGDI_{t-j} + \Sigma_{k=0}^{r} \beta_{3k} \Delta OSI_{t-k} + \Sigma_{l=0}^{s} \beta_{4l} \Delta HCI_{t-l} + \alpha_1 EGDI_{t-1} + \alpha_2 OSI_{t-1} + \alpha_3 HCI_{t-1} + \varepsilon_t$$

Where:

- Δ denotes first differences.
- p, q, r, s represent the maximum lag lengths for the dependent and independent variables.
- β_1, β_2, β_3, β_4 are short-run coefficients (error correction model).
- α_1, α_2, α_3 are long-run coefficients.
- EGDI: E-Government Development Index (independent variable)
- OSI: Online Service Index (independent variable)
- HCI: Human Capital Index (independent variable)
- TAXREV_GDP: Tax revenues (dependent variable)

3. Results and Discussion

3.1 Stationarity Test of Time Series

Stationarity of a time series is tested based on the presence of a unit root. If a unit root is present, the series is non-stationary because of spurious trends, which is undesirable in econometric analysis. Various tests can be used to test for stationarity. One such test is the Augmented Dickey-Fuller (ADF) test. EViews automatically selected the appropriate number of lags for stationarity testing.

Table 1

Results of stationarity tests for study variables

Variable	At Level: Trend & Intercept	Result	At First Difference: Trend & Intercept	Result	Integration
EGDI	-1.83 (0.65)	Non-stationary	-3.37 (0.00)	Stationary	I(1)
OSI	-1.79 (0.66)	Non-stationary	-4.40 (0.01)	Stationary	I(1)
HCI	-2.98 (0.15)	Non-stationary	-3.60 (0.04)	Stationary	I(1)
TAXREV_GDP	-2.26 (0.43)	Non-stationary	-5.50 (0.00)	Stationary	I(1)

Source. Prepared by the researchers based on outputs from EViews 13.

In Table 1, the ADF test results indicate that all the study variables (EGDI, OSI, HCI and percentage of tax revenues to GDP, TAXREV_GDP) are non-stationary in levels. This is because all variables have p-values greater than 0.05 (5%). However, as all p-values are smaller than 0.05 (5%), all variables become stationary after taking first differences, so we reject the unit-root null hypothesis for all variables. This indicates that every variable under investigation is integrated of order one, I(1), and there is no evidence that any variable is integrated of order two, I(2). This satisfies the ARDL bounds-testing approach's stationarity condition.

Optimal Lag Length Selection

Based on the AIC criterion, we selected the optimal lag structure. The ARDL (1,0,1,0) model was found to be the best, as shown in the following figure:

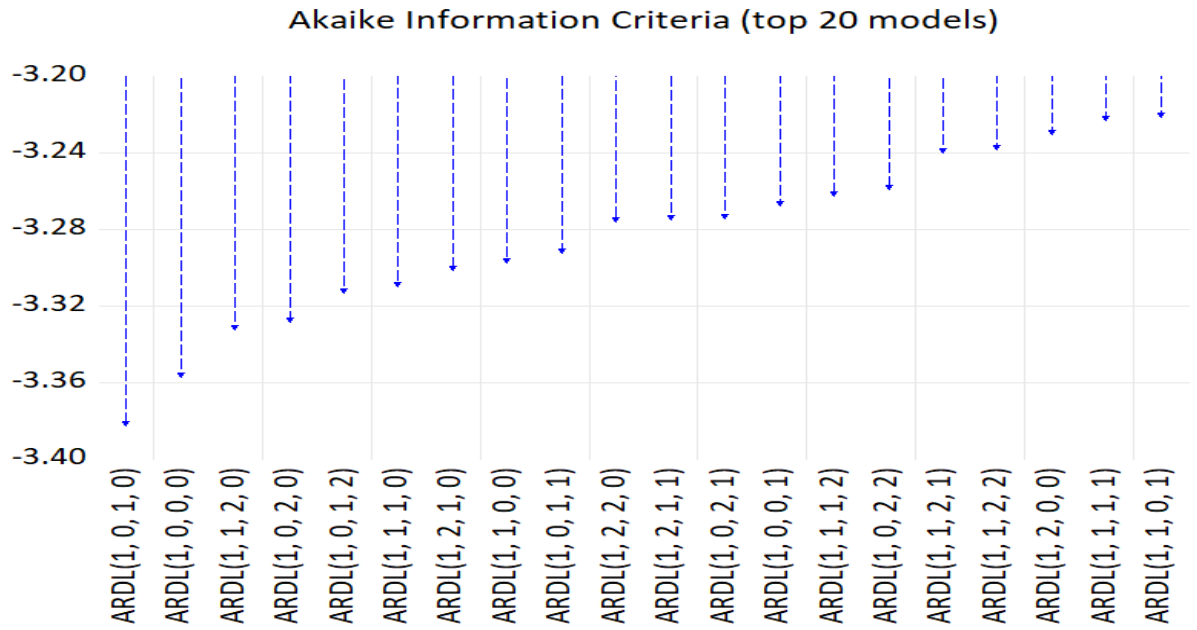


Figure 1
Optimal lag length selection results

Source. Prepared by the researchers based on outputs from EViews 13.

Figure 1 depicts the output of selecting the optimal ARDL model using the Akaike Information Criterion (AIC). The top 20 models were selected according to their AIC values. The analysis showed that the ARDL(1,0,1,0,1) model best captured the relationship among the study variables, as it had the lowest AIC value (approximately -3.38) compared with the other models. This is because a smaller AIC value indicates a better balance between model complexity and estimation performance. Therefore, the ARDL(1,0,1,0,1) model was selected to estimate short- and long-term relationships and conduct cointegration analysis.

3.2 Bounds Test for Cointegration

Table 2
Bounds test for cointegration

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
		Asymptotic: n=1000		
F-statistic	5.034821	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.5%	3.15	4.08
		1%	3.65	4.66
Actual Sample Size	22	Finite Sample: n=35		
		10%	2.618	3.532
		5%	3.164	4.194
		1%	4.428	5.816

Source. Prepared by the researchers based on outputs from EViews 13.

Table 2 presents the cointegration test results using the Bounds Testing approach. In this test, the F-statistic value is found to be equal to 5.034821, which is greater than the upper bound critical value at I(1) for finite samples at the 5% and 10% levels, which are 4.194 and 3.532, respectively. Therefore, we accept the alternative hypothesis of cointegration and reject the null hypothesis of no long-run cointegration among the study variables. This implies that a long-run relationship exists between e-government indicators (OSI, HCI, EGDI) and tax revenues (TAXREV_GDP). Therefore, using the ARDL model to analyze both short- and long-run relationships is justified.

3.3 Estimation of the Study Model Parameters for the Dependent Variable Tax Revenues (TAXREV_GDP)

After confirming the existence of a cointegration relationship among the variables, we estimated the following model:

Table 3
Study model estimation using ARDL(1,0,1,0)

Dependent Variable: TAXREV_GDP
Method: ARDL
Date: 06/26/26 Time: 19:22
Sample (adjusted): 2004 2025
Included observations: 22 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (2 lags, automatic): OSI HCI EGDI
Fixed regressors: C
Number of models evalulated: 27
Selected Model: ARDL(1, 0, 1, 0)
Note: final equation sample is larger than selection sample

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
TAXREV_GDP(-1)	0.482100	0.207836	2.319622	0.0339
OSI	0.488965	0.220197	2.220577	0.0412
HCI	0.400863	0.581440	0.689433	0.5004
HCI(-1)	-0.790069	0.562672	-1.404138	0.1794
EGDI	-0.494494	0.212388	-2.328257	0.0333
C	0.487078	0.250421	1.945040	0.0696

R-squared	0.720254	Mean dependent var	0.255719
Adjusted R-squared	0.632834	S.D. dependent var	0.063575
S.E. of regression	0.038523	Akaike info criterion	-3.448133
Sum squared resid	0.023744	Schwarz criterion	-3.150576
Log likelihood	43.92947	Hannan-Quinn criter.	-3.378038
F-statistic	8.238957	Durbin-Watson stat	2.311405
Prob(F-statistic)	0.000517		

*Note: p-values and any subsequent tests do not account for model selection.

Source. Prepared by the researchers based on outputs from EViews 13.

In Table 3, the ARDL(1,0,1,0) model estimation has significant explanatory power, as evidenced by an R^2 value of approximately 0.72. This indicates that the explanatory variables explain approximately 72.02% of the variation in TAXREV_GDP, while the remaining variation is attributed to other unaccounted factors. Adjusted R^2 is approximately 0.6328, which is also relatively large given the number of variables in the model and indicates a good fit.

The overall model appears significant and captures some of the dynamics in the study variables. The model's F statistic is around 8.23, with a p-value of 0.00 at the 5% significance level. Moreover, the error terms show no significant autocorrelation, as the Durbin-Watson statistic is 2.23, close to 2. The Akaike Information Criterion (AIC) value of -3.44 is used to select the best model from a set of alternative models. Thus, the estimated model shows good explanatory power and statistical efficiency and can be used to estimate the effect of e-government indicators on tax revenue.

3.4 Model Diagnostic Testing

Based on the ARDL(1,0,1,0) model for estimating short-run and long-run effects, the model's performance quality must be verified using the following tests:

3.4.1 Autocorrelation Test (Breusch-Godfrey LM Test)

From the test results shown in Table 4 below, the model shows no autocorrelation. The chi-square statistic is 0.45, which is greater than the critical value of 0.05. Therefore, we accept the null hypothesis that there is no serial correlation in the residuals.

Table 4
Breusch-Godfrey serial correlation LM Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.868740	Prob. F(5,16)	0.5232
Obs*R-squared	4.697345	Prob. Chi-Square(5)	0.4539
Scaled explained SS	3.213946	Prob. Chi-Square(5)	0.6670

Source. Prepared by the researchers based on outputs from EViews 13.

3.4.2 Heteroskedasticity Test (ARCH Test)

The test results in Table 5 show that the Prob. Chi-Square value is 0.30, which is greater than 0.05. Therefore, we accept the null hypothesis that the residuals are homoskedastic and free from heteroskedasticity.

Table 5
Heteroskedasticity test – ARCH

Heteroskedasticity Test: ARCH

F-statistic	1.004282	Prob. F(1,19)	0.3289
Obs*R-squared	1.054271	Prob. Chi-Square(1)	0.3045

Source. Prepared by the researchers based on outputs from EViews 13.

3.4.3. Residual Normality Test (Histogram - Jarque-Bera Test)

The Prob. Jarque-Bera value is 0.58, which is higher than the 0.05 significance level, according to the test results in Figure 2. As a result, the null hypothesis that the residuals are normally distributed is not rejected.

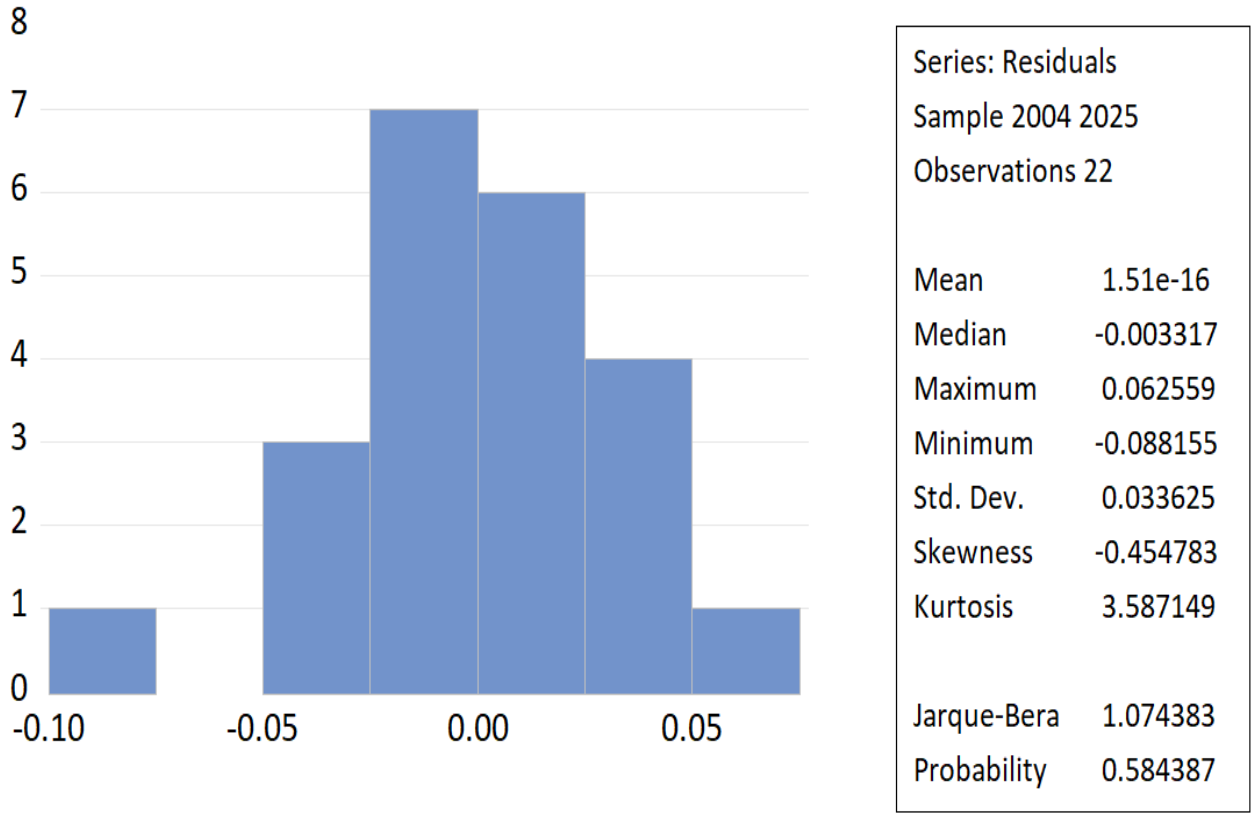


Figure 2
Normality test - histogram jarque-bera

Source. Prepared by the researchers based on outputs from EViews 13.

3.4.4. Stability Test

Structural stability of the forecasted coefficients in the error correction models using the ARDL method can be ascertained if both the CUSUM and CUSUM of Squares plots lie within the critical region at the 5% significance level in order to ensure that there were no structural breaks in the data. CUSUM and CUSUM of Squares tests were used, which were proposed by Brown et al. (1975). This followed standard practice in most studies. The results are depicted in Figure 3:

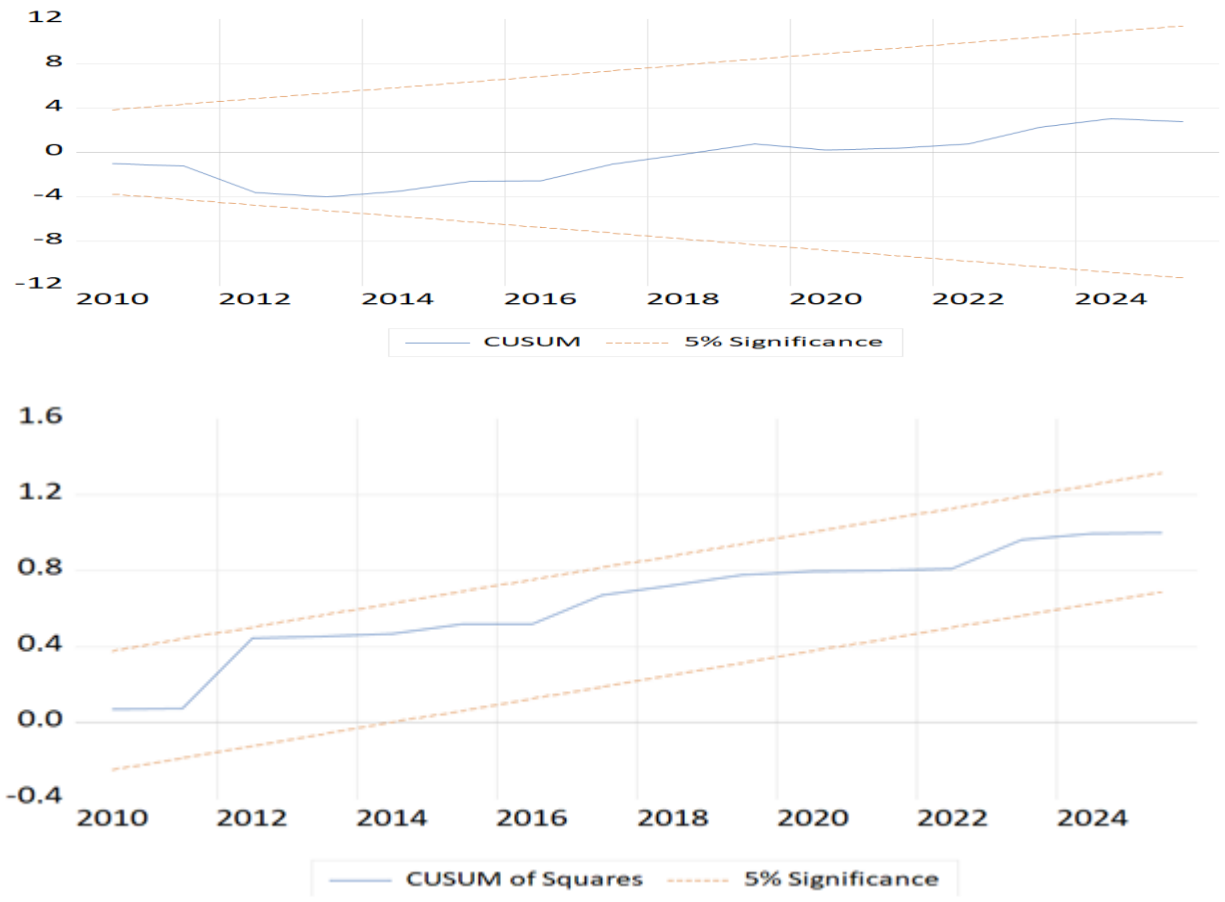


Figure 3

Stability test results (CUSUM and CUSUM of Squares)

Source. Prepared by the researchers based on outputs from EViews 13.

From the figure above, we observe that both the CUSUM and CUSUM of Squares plots remain within the critical bounds at the 5% significance level. Therefore, we accept the model's stability, noting that it remains stable during a certain period toward the end of the study period.

3.4.5. Ramsey RESET Test

A specification test verifies that the econometric model is correctly specified in both functional form and econometric specification. It can help identify issues such as omitted important variables or an incorrect functional form. The null hypothesis states that the model is correctly specified, while the alternative hypothesis states that there is a specification issue. This test helps establish the reliability of the model's results and the soundness of inferences drawn from it (Table 6).

Table 6
Ramsey reset test results

Ramsey RESET Test
Equation: UNTITLED
Omitted Variables: Powers of fitted values from 2 to 4
Specification: TAXREV_GDP TAXREV_GDP(-1) OSI HCI HCI(-1) EGDI C

	Value	df	Probability
F-statistic	2.424688	(3, 13)	0.1124
Likelihood ratio	9.776647	3	0.0206

F-test summary:

	Sum of Sq.	df	Mean Squares
Test SSR	0.008519	3	0.002840
Restricted SSR	0.023744	16	0.001484
Unrestricted SSR	0.015225	13	0.001171

LR test summary:

	Value
Restricted LogL	43.92947
Unrestricted LogL	48.81779

Source. Prepared by the researchers based on outputs from EViews 13.

A specification test confirms that the econometric model is correctly specified in terms of both functional form and econometric specification. It can also help detect problems such as omitted important variables or an incorrect functional form. Null hypothesis: the model is correctly specified. Alternative hypothesis: a specification issue exists. There is no statistical indication that any important variables are missing from the model, and the model has the correct functional form. In this instance, the F statistic is more suitable for small samples, so it is used rather than the Likelihood Ratio test, which produced a p-value of 0.0206. The model is therefore assumed to be correctly specified, and results can be interpreted.

3.4.6. Breusch–Godfrey Serial Correlation LM Test

Serial correlation commonly arises in econometric analysis, especially in time series regression data. If there is serial correlation, OLS estimators may be unbiased but inefficient. A more advanced test can identify the presence of serial correlation. This is the Breusch-Godfrey Lagrange Multiplier (LM) test. It tests for serial correlation of several orders in the residual series from a regression. Unlike other tests, the Breusch-Godfrey LM test can be used in a regression that includes lagged values of the dependent variable. The test uses either the F or Chi-square test to test the significance of the correlation in the residuals. It therefore tests the null hypothesis that there is no serial correlation in the random errors (Table 7).

Table 7
Breusch–Godfrey serial correlation LM test results

Breusch-Godfrey Serial Correlation LM Test: Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	1.250979	Prob. F(2,14)	0.3163
Obs*R-squared	3.335549	Prob. Chi-Square(2)	0.1887

Source. Prepared by the researchers based on outputs from EViews 13.

The probabilities associated with the Obs*R-squared and F statistics from the Breusch-Godfrey Serial Correlation LM Test are 0.1887 and 0.3163, respectively. Because both are above 5%, we cannot reject the null hypothesis that the residuals have no serial correlation. This is desirable because it means the model's error terms have no autocorrelation or time dependence. This increases confidence in the parameter estimates and statistical inferences.

3.5. Estimation of Short-Run and Long-Run Relationships and the Error Correction Model

3.5.1 Short-Run Relationship Estimation and the Error Correction Model

An Error Correction Model (ECM) with the research variables in their first-difference form is used to estimate the short-run association. The rate at which short-run disequilibrium transitions to long-run equilibrium is represented by the one-period lag included in the error correction term. A long-term association is demonstrated by a negative and statistically significant error correction coefficient ($p < 0.05$). The pace of adjustment to equilibrium is indicated by the value of this coefficient. Table 8 displays the outcomes of the short-run relationship and the error correction model:

Table 8
Error correction model estimation for the short-run relationship (ARDL Model)

ARDL Error Correction Regression
Dependent Variable: D(TAXREV_GDP)
Selected Model: ARDL(1, 0, 1, 0)
Case 2: Restricted Constant and No Trend
Date: 06/26/26 Time: 19:52
Sample: 2003 2025
Included observations: 22

ECM Regression
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HCI)	0.400863	0.037282	10.75671	0.0000
CointEq(-1)*	-0.517900	0.145225	-3.566179	0.0026

Source. Prepared by the researchers based on outputs from EViews 13.

The relationship can be explained as follows:

We can observe a long-term equilibrium relationship between the variables under investigation based on the error correction estimates. The error correction coefficient (cointeq(-1) = 0.51) is statistically significant and negative. This indicates that the variables have a short-run equilibrium relationship that adapts to the long-run equilibrium. A reasonable adjustment rate is shown by an error correction coefficient of -0.51, which suggests that roughly 51% of the short-run disequilibrium is rectified in a single session. We can also observe that the research variables are cointegrated, based on the short-run connections mentioned above.

The Human Capital Index coefficient shows a significant, positive relationship with tax revenue (TAXREV_GDP). A 1% rise in HCI results in a 0.40% rise in tax revenue. This is likely because human capital promotes governance and economic efficiency. Better health, skills and education translate into higher productivity, higher employment and income, more taxpayers and ultimately higher revenue.

3.5.2. Interpretation of Long-Run Results

After confirming the existence of a long-run relationship, the long-run coefficients should be obtained.

Table 9
Long-run coefficients estimation results (ARDL Model)

Levels Equation
Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
OSI	0.144129	0.034652	4.160601	0.0006
HCI	0.451507	0.140765	3.207012	0.0049
EGDI	0.154806	0.032297	4.793501	0.0001
C	0.940487	0.595183	1.580166	0.1336

Source. Prepared by the researchers based on outputs from EViews 13.

The long-run findings from Table 9 are as follows:

Tax revenues (TAXREV_GDP) are positively and significantly related to the coefficient for the E-Government Development Index (EGDI). A 1% rise in EGDI is associated with a 0.15% rise in tax revenues. This suggests that increasing the level of e-government can improve tax administration by simplifying services, increasing compliance and improving efficiency, which can result in higher tax revenues.

Tax revenues (TAXREV_GDP) are positively and significantly related to the coefficient for the Online Service Index (OSI). A 1% rise in OSI results in a 0.14% rise in tax revenues. This suggests that by increasing the level and quality of e-government services, taxpayers can more easily interact with tax services (registration, filing and payment), which can in turn reduce the time, effort and costs associated with tax compliance. Digital tax services can improve data accuracy, facilitate inter-agency information sharing and reduce corruption and errors, which can lead to a larger tax base, more efficient tax collection and higher tax revenues. This coefficient also suggests that spending on e-services can strengthen the tax

administration's capacity to raise resources and improve overall government performance during e-government implementation.

The coefficient for the Human Capital Index (HCI) and tax revenues (TAXREV_GDP) is positive and significant. A 1% rise in HCI results in a 0.45% rise in tax revenues. This suggests that building human capital (digital skills, literacy and education) can increase the efficiency of tax administration and facilitate the use of modern technologies in tax administration and tax collection. Increased digital and general skills among taxpayers can also lead to higher compliance, lower costs and errors, higher-quality interactions with e-services, and increased tax revenues. This finding suggests that building human capital is essential for successful e-government implementation and for improving the efficiency of the tax administration.

4. Findings and Hypothesis Testing

- All the variables in the model were found to be integrated of order one, I(1).
- A cointegration relationship exists between e-government indicators and tax revenues, and a long-run equilibrium relationship was found using the Bounds Test.
- The F-statistic value (5.034821) in this study is greater than the upper critical value at the 5% significance level.
- Indeed, the first hypothesis is confirmed, as there exists a cointegration relationship between tax revenues and e-government indicators in Algeria for the period 2003–2025 at a 5 percent significance level ($\alpha \leq 0.05$).
- The ARDL model estimation results show that the model is statistically significant and has good explanatory power. Diagnostic tests also confirm normality of error distributions, stability of parameter estimates and proper model specification. Further, the model shows no heteroskedasticity or autocorrelation.
- The short-run error correction term is negative and statistically significant. This implies that the system adjusts rapidly to the long-run equilibrium and corrects disequilibrium.
- The results in this study also reveal a positive and significant influence of OSI, HCI and EGDI on tax revenue over time. It can therefore be said that investments in human resources, improved digital services and e-government development all play a role in enhancing tax administration, compliance and tax revenue. This highlights the importance of digitalization to Algeria's fiscal health.
- This finding is also in line with hypothesis 2, which posits that "There is a statistically significant impact of e-government indicators on tax revenues in Algeria over the period 2003–2025, at a significance level of $\alpha \leq 0.05$."

5. Conclusion

The findings affirm a significant, positive relationship between e-government indicators and tax collection. This supports the importance of e-government in effective tax administration. Additionally, the study has found that the development of e-government services, e-government infrastructure and the improvement of the capacity of e-government within a government can enhance tax compliance, transparency, the expansion of the tax base, and the effectiveness of tax collection, all leading to increased revenues and, ultimately, government financial health. These findings align with the economic literature, which has found that e-government can enhance the efficiency of fiscal management and resource mobilization.

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