

Digital Transformation, Morocco 2030 Strategy and Economic Growth: An ARDL Bounds Testing Approach

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Abstract. This study examines the short-run and long-run effects of digital transformation on economic growth in Morocco within the framework of the Morocco Digital 2030 Strategy. The analysis employs the Autoregressive Distributed Lag (ARDL) model using data covering the period 1965–2024. Real GDP per capita is used as the dependent variable, while the explanatory variables include the Digital Transformation Index, investment in Information and Communication Technologies (ICT), internet penetration, gross fixed capital formation, foreign direct investment, trade openness, and the inflation rate. Prior to estimation, the time-series properties of the variables are examined using the Augmented Dickey–Fuller (ADF) unit root test. The existence of a long-run relationship among the variables is then verified using the Pesaran Bounds cointegration test. The empirical findings indicate that the Digital Transformation Index has a positive and statistically significant effect on economic growth in the short run. However, its long-run effect, although positive, is not statistically significant, whereas ICT investment emerges as a significant determinant of long-run economic growth. The Error Correction Model (ECM) reveals a rapid adjustment toward the long-run equilibrium following short-run shocks, confirming the stability of the estimated model. Diagnostic tests, including serial correlation, heteroskedasticity, normality, and parameter stability (CUSUM and CUSUMSQ), confirm the robustness of the empirical findings. This study contributes to the digital economy literature by developing a multidimensional Digital Transformation Index that integrates the key dimensions of digital development, applying it to the Moroccan context within the framework of the Morocco Digital 2030 Strategy, and employing an ARDL-ECM approach to jointly examine the short-run and long-run dynamics between digital transformation and economic growth. The findings provide valuable policy insights for accelerating Morocco's digital transition and promoting sustainable and inclusive economic growth.

Keywords: *Digital Transformation; Morocco Digital 2030; Economic Growth; ICT; Digital Economy; ARDL model; Bounds Testing; Cointegration; Error Correction Model.*

1. Introduction

Digital transformation has emerged as a key driver of economic modernization by integrating advanced digital technologies to enhance productivity, innovation, competitiveness, and long-term growth. In developing economies, its economic benefits depend not only on digital adoption but also on the availability of adequate infrastructure, skilled human capital, and effective institutions. Consequently, understanding its macroeconomic implications has become a major priority for policymakers and researchers.

In Morocco, digital transformation represents a strategic pillar of the Morocco Digital 2030 Strategy, which aims to accelerate digitalization, strengthen innovation, modernize public administration, and improve economic competitiveness. Nevertheless, empirical evidence on the contribution of digital transformation to Morocco's economic growth remains limited, as

existing studies mainly focus on isolated digital indicators or cross-country comparisons. This gap highlights the need for a comprehensive country-specific analysis of both the short- and long-run effects of digital transformation on economic performance.

The relationship between digital transformation and economic growth is supported by endogenous growth theory, Schumpeterian innovation theory, and the ICT-led growth hypothesis, which emphasize the role of digital technologies in improving productivity and innovation. However, empirical findings remain inconclusive, suggesting that the growth effects of digitalization are conditioned by institutional quality, regulatory effectiveness, and structural characteristics. These mixed results reinforce the importance of conducting country-specific empirical investigations to better understand the economic impact of digital transformation in Morocco.

This study fills this gap by examining the impact of digital transformation on Morocco's economic growth using the Autoregressive Distributed Lag (ARDL) Bounds Testing approach. The ARDL framework is well suited to capturing both long-run equilibrium relationships and short-run adjustment dynamics, providing a robust evaluation of digital transformation policies over the period 1965–2025. The analysis employs a multidimensional digital transformation index alongside key macroeconomic determinants, including foreign direct investment, trade openness, gross capital formation, inflation, and human capital, to provide a comprehensive assessment of the drivers of economic growth in Morocco.

The main contribution of this study does not lie in the use of the ARDL model, which has become a well-established approach in the empirical literature, but rather in the original combination of three complementary dimensions. First, the study develops and employs a multidimensional digital transformation index that captures several key dimensions of digital development, including digital infrastructure, digital skills, technological innovation, digital governance, and digital inclusion. Second, it applies this framework to the Moroccan context, characterized by the implementation of the Morocco Digital 2030 Strategy, a recent institutional initiative that remains underexplored in the empirical literature. Third, the analysis adopts a dynamic perspective by simultaneously examining the short-run and long-run effects of digital transformation on economic growth. This original combination enriches the digital economy literature by providing novel empirical evidence from an emerging economy undergoing an ambitious digital transformation.

The remainder of this paper is organized as follows. Section 2 reviews the relevant literature on digital transformation, the Morocco Digital 2030 Strategy, and economic growth. Section 3 presents the data, variables, and econometric methodology employed in the analysis. Section 4 discusses the empirical findings. Finally, Section 5 concludes the paper by summarizing the main results, highlighting policy recommendations, and suggesting directions for future research.

2. Literature Review

Digital transformation has become a major driver of structural economic change, extending beyond the adoption of ICT to the widespread integration of advanced digital technologies across production, public administration, finance, education, and governance. Technologies such as artificial intelligence, cloud computing, big data, blockchain, and the Internet of Things enhance productivity, innovation, and organizational efficiency, making digitalization a key determinant of economic development. At the macroeconomic level, digital transformation fosters growth by improving resource allocation, reducing transaction costs, facilitating market integration, accelerating technological diffusion, and strengthening firms' productivity and innovation capacity. It also promotes entrepreneurship by lowering entry barriers and supporting the expansion of digital ecosystems.

The positive relationship between digital transformation and economic growth is primarily explained by Endogenous Growth Theory and Schumpeterian Growth Theory. These frameworks argue that technological innovation, knowledge accumulation, and human capital enhance productivity and sustain long-term economic growth, while digital technologies stimulate innovation through continuous technological upgrading and creative destruction. However, the economic benefits of digitalization depend on complementary factors, including human capital, institutional quality, digital infrastructure, regulatory effectiveness, and innovation capacity. Without these supporting conditions, digital investments may generate limited productivity and growth effects.

Empirical research on the relationship between digitalization and economic growth has grown substantially, extending from developed to emerging economies. Most studies find that internet access, broadband infrastructure, mobile connectivity, and ICT investment positively influence economic growth by enhancing productivity, reducing production costs, improving competitiveness, and facilitating knowledge diffusion and market integration. These effects are particularly relevant in developing countries, where digital technologies help overcome infrastructure constraints. However, empirical evidence remains mixed, as the magnitude of these benefits largely depends on institutional quality, human capital, and supportive public policies. This suggests that digital infrastructure alone is insufficient to ensure sustained economic growth without complementary structural and institutional reforms.

Digital transformation has become a strategic priority for emerging economies seeking to enhance productivity, innovation, and inclusive growth through expanded digital infrastructure, modernized public services, and stronger innovation ecosystems. However, its effectiveness is often constrained by inadequate infrastructure, limited digital skills, weak innovation capacity, and institutional shortcomings. Consequently, the economic impact of digitalization varies across countries according to the quality of governance, human capital, and regulatory frameworks. The literature consistently highlights that sustained growth requires integrated digital strategies combining infrastructure investment with institutional reforms, education, innovation, and support for digital entrepreneurship.

Morocco has made digital transformation a key pillar of its economic modernization through successive initiatives, culminating in the Morocco Digital 2030 Strategy. This strategy aims to expand digital infrastructure, modernize public services, foster digital entrepreneurship, strengthen cybersecurity, promote artificial intelligence, and enhance digital skills to improve productivity and international competitiveness. Despite these ambitious reforms, empirical evidence on the macroeconomic effects of Morocco's digital transformation remains limited. Existing studies mainly examine individual ICT indicators rather than providing a comprehensive assessment of digital transformation within the institutional framework of the Morocco Digital 2030 Strategy.

Despite growing evidence of a positive link between digital transformation and economic growth, important research gaps remain. Most existing studies rely on cross-country analyses or isolated ICT indicators, providing limited insight into country-specific institutional dynamics and the multidimensional nature of digital transformation. In Morocco, empirical evidence remains scarce, particularly regarding the Morocco Digital 2030 Strategy and the joint assessment of its short- and long-run macroeconomic effects. To address these gaps, this study employs the ARDL–ECM approach to examine the relationship between digital transformation and economic growth in Morocco over the period 1965–2025. The findings are expected to provide robust evidence on the effectiveness of Morocco's digital strategy and offer policy recommendations for achieving sustainable and inclusive economic growth.

The relationship between digital transformation and economic growth is grounded in several complementary theoretical frameworks, including Endogenous Growth Theory (Romer, 1986, 1990; Lucas, 1988), Schumpeterian Innovation Theory (Schumpeter, 1934; Aghion & Howitt, 1992), the ICT-led Growth Hypothesis (Jorgenson & Stiroh, 2000; Roller & Waverman, 2001), and the Technology Acceptance Model (Davis, 1989). Among these, Endogenous Growth Theory argues that technological innovation, knowledge accumulation, research and development (R&D), and human capital are the fundamental drivers of sustained economic growth (Romer, 1990; Lucas, 1988). Unlike neoclassical growth models, it treats technological progress as an endogenous outcome of investment in innovation and knowledge creation. Accordingly, investments in digital infrastructure, advanced digital technologies, and human capital improve productivity, stimulate innovation, and strengthen long-term economic performance (Romer, 1990; OECD, 2020). In the Moroccan context, the Morocco Digital 2030 Strategy reflects these theoretical principles by promoting digital infrastructure, innovation ecosystems, digital entrepreneurship, and skills development to enhance productivity, competitiveness, and sustainable economic growth.

Schumpeterian Innovation Theory. Schumpeterian Innovation Theory argues that technological innovation is the fundamental driver of economic development through the process of creative destruction, whereby new technologies continuously replace obsolete production systems, enhancing productivity, efficiency, and competitiveness (Schumpeter, 1934). Building on this framework, Aghion and Howitt (1992) demonstrate that sustained innovation generates long-term economic growth by fostering technological progress and industrial renewal. Digital transformation reinforces this process by promoting automation, digital entrepreneurship, platform-based business models, smart manufacturing, and digital financial services, thereby improving firms' innovation capacity and international competitiveness (Brynjolfsson & McAfee, 2014; OECD, 2020). Consequently, economies that invest in digital innovation are more likely to achieve higher productivity and sustainable economic growth.

The ICT-led Growth Hypothesis posits that investments in information and communication technologies (ICT) stimulate economic growth by generating productivity gains and positive spillover effects across the economy (Jorgenson & Stiroh, 2000; Roller & Waverman, 2001). ICT enhances economic performance by reducing transaction costs, improving communication and information flows, facilitating trade, strengthening public service delivery, and fostering innovation and knowledge diffusion (Vu, 2011). Nevertheless, the growth effects of ICT depend critically on complementary factors, including human capital, institutional quality, regulatory effectiveness, and digital literacy, which determine countries' capacity to fully exploit digital technologies (Nebel, 2018; OECD, 2020).

Recent literature conceptualizes digital transformation as a multidimensional process integrating technological, organizational, institutional, and social changes rather than merely the adoption of ICT (Verhoef et al., 2021; OECD, 2020). Digital transformation enhances economic growth through multiple transmission channels. Digital infrastructure improves production efficiency and technology adoption, digital government increases administrative effectiveness and reduces transaction costs, digital finance promotes financial inclusion and investment, while digital platforms facilitate market integration and international trade (World Bank, 2021). Moreover, emerging technologies such as artificial intelligence and big data strengthen innovation, productivity, and evidence-based decision-making (Brynjolfsson & McAfee, 2014). Consequently, digital transformation contributes to economic growth both directly through productivity gains and indirectly by fostering innovation, entrepreneurship, investment, and institutional modernization.

Drawing on Endogenous Growth Theory (Romer, 1990; Lucas, 1988), Schumpeterian Innovation Theory (Schumpeter, 1934; Aghion & Howitt, 1992), and the ICT-led Growth

Hypothesis (Roller & Waverman, 2001; Vu, 2011), this study proposes that digital transformation promotes economic growth through a series of interconnected transmission mechanisms. Specifically, digital transformation enhances innovation, which increases productivity, stimulates investment, and ultimately fosters long-term economic growth. In parallel, digital transformation strengthens government effectiveness, human capital development, financial inclusion, international competitiveness, and trade openness. These complementary channels reinforce one another, generating productivity gains, institutional improvements, and innovation-led growth that support sustainable and inclusive economic development.

3. Data and Econometric Methodology

a. Data and Variables

This study uses monthly data covering the period from 1965 to 2025, providing a total of 732 observations. The variables were transformed into their natural logarithmic form in order to linearize the time series, reduce heteroskedasticity, and facilitate the interpretation of the estimated coefficients as elasticities. The data were obtained from two main sources: the World Bank and the High Commission for Planning of Morocco.

The selection of the explanatory variables is grounded in economic growth theory and the empirical literature on digital transformation and economic development. The dependent variable, real GDP per capita, is used as a proxy for economic performance. The main variable of interest is the Digital Transformation Index (DIG), which captures the overall level of digital development by integrating several key dimensions, including digital infrastructure, digital skills, technological innovation, digital governance, and digital inclusion. Improvements in this index are expected to enhance productivity, foster innovation, and promote economic growth.

Investment in Information and Communication Technologies (ICT) is included to capture the impact of digital investment on technological capital accumulation and productive efficiency. The number of Internet users (INT) is incorporated as an indicator of the diffusion of digital technologies across the population and reflects the extent to which digital services are adopted by households and businesses.

Gross Fixed Capital Formation (GFCF) is used as a proxy for productive investment, consistent with both neoclassical and endogenous growth theories, which identify physical capital accumulation as a key driver of economic growth. Foreign Direct Investment (FDI) is also included because it facilitates technology transfer, knowledge spillovers, human capital enhancement, and integration into global value chains.

Trade openness (OPEN) is incorporated to measure the degree of Morocco's integration into international markets. Greater openness is generally expected to promote international trade, strengthen competition, improve productivity, and facilitate the diffusion of technological innovations. Finally, the inflation rate (INF) is introduced as a control variable to account for macroeconomic stability. High inflation may discourage investment, increase economic uncertainty, and hinder economic growth.

Taken together, these variables provide a comprehensive framework for assessing the direct impact of digital transformation on economic growth while controlling for the main macroeconomic factors that may influence this relationship in the Moroccan context.

The econometric model is specified as follows, since all variables are transformed into logarithms, the empirical specification becomes :

$$\ln GDP_t = \beta_0 + \beta_1 \ln DIG_t + \beta_2 \ln FDI_t + \beta_3 \ln GFCF_t + \beta_4 \ln ICT_t + \beta_5 \ln INF_t + \beta_6 \ln INT_t + \beta_7 \ln OPEN_t + \varepsilon_t$$

where:

GDP = Real Gross Domestic Product per capita
DIG = Digital Transformation Index
ICT = Information and Communication Technology Investment
INT = Internet Users
GFCF = Gross Fixed Capital Formation
FDI = Foreign Direct Investment
OPEN = Trade Openness
INF = Inflation Rate
 ε_t stochastic error term.

This log-linear specification allows the estimated coefficients to be interpreted as long-run elasticities and helps stabilize the variance of the time-series variables while mitigating potential heteroskedasticity.

b. Econometric Methodology

Table 1. Augmented Dickey–Fuller (ADF) Unit Root Test Results

Variable	Level ADF Statistic	p-value	First Difference ADF Statistic	p-value	Order of Integration
GDP	-5.641700	0.0000***	-6.590082	0.0000***	I(0)
DIG	-1.204968	0.6735	-3.382707	0.0122**	I(1)
ICT	-1.734683	0.4133	-5.008203	0.0000***	I(1)
INT	-1.775586	0.7158	-3.171830	0.0221**	I(1)
GFCF	-3.199315	0.0204**	-4.967284	0.0000***	I(0)
FDI	-2.513018	0.0117**	-5.351822	0.0000***	I(0)
OPEN	-1.287175	0.6372	-5.216228	0.0000***	I(1)
INF	-3.568243	0.0333**	-5.196747	0.0001***	I(0)

*** : significatif à 1 % ; ** : 5 % ; * : 10 %

Source: Authors' calculations using EViews 13

Table 1 reports the results of the Augmented Dickey–Fuller (ADF) unit root test conducted to determine the order of integration of the variables before estimating the ARDL model. The findings indicate that GDP, GFCF, FDI, and INF are stationary at levels, whereas DIG, ICT, INT, and OPEN become stationary after first differencing. Thus, the dataset consists of a combination of I(0) and I(1) variables, with no variable integrated of order two I(2).

Economically, these results suggest that Morocco's macroeconomic indicators exhibit stable long-run behavior, while digital transformation, ICT investment, Internet penetration, and trade openness follow persistent upward trends driven by technological progress and increasing economic integration. This pattern reflects the structural evolution of the Moroccan economy and the gradual expansion of its digital ecosystem.

The absence of I(2) variables satisfies the key requirement of the Pesaran et al. (2001) ARDL Bounds Testing approach, confirming the suitability of the ARDL framework for examining both the long-run equilibrium and short-run dynamics between digital transformation and economic growth.

Accordingly, this study employs an Autoregressive Distributed Lag (ARDL) model to analyze the relationship between digital transformation and economic growth in Morocco over the period 1965–2025. The sample spans the country's major digital policy reforms, including e-

Maroc 2010, Maroc Numeric 2013, the Digital Development Agency (ADD), and the Morocco Digital 2030 Strategy. The ARDL methodology is selected because it accommodates mixed integration orders $I(0)/I(1)$, allows flexible lag selection, performs well with finite samples, and simultaneously estimates long-run relationships and short-run adjustments through the Error Correction Model (ECM), making it a robust framework for macroeconomic time-series analysis.

4. Empirical Results and Discussion

a. Descriptive Statistics

Table 2 presents the descriptive statistics for the study variables based on 397 monthly observations, summarizing their central tendency, dispersion, distribution, and normality. The results indicate moderate average economic growth in Morocco, accompanied by sustained investment in ICT infrastructure and gross fixed capital formation, increasing trade openness, relatively low inflation, and a substantial expansion in Internet penetration. The Digital Transformation Index also exhibits a stable upward trend, reflecting the country's gradual digital development.

Table 2. Descriptive Statistics of the Variables

	GDP	DIG	ICT	GFCF	FDI	OPEN	INF	INT
Mean	3.767240	4.600258	3.576917	3.257172	0.597267	4.169911	0.554576	45.50991
Median	3.926708	4.600911	3.549305	3.267926	0.571411	4.226650	0.410414	51.53748
Maximum	12.37288	4.602166	3.973890	3.442604	1.863170	4.614192	2.077711	91.20000
Minimum	-7.178207	4.596129	3.363463	3.081085	-0.409577	3.821493	-1.192749	0.003710
Std. Dev.	2.465033	0.001915	0.129913	0.090218	0.423609	0.215006	0.726608	34.60462
Skewness	-1.092990	-0.604177	1.052950	-0.094649	-0.132521	0.069570	0.323696	-0.044837
Kurtosis	7.343040	2.002546	3.925885	2.009311	2.506848	1.906305	2.394409	1.495446
Jarque-Bera	391.0533	40.61032	87.53983	16.82781	5.184925	20.10688	12.99938	37.57812
Probability	0.000000	0.000000	0.000000	0.000222	0.074836	0.000043	0.001504	0.000000
Sum	1495.594	1826.303	1420.036	1293.097	237.1149	1655.455	220.1669	18067.43
Sum Sq. Dev.	2406.250	0.001453	6.683407	3.223126	71.06019	18.30615	209.0719	474202.0
Observations	397	397	397	397	397	397	397	397

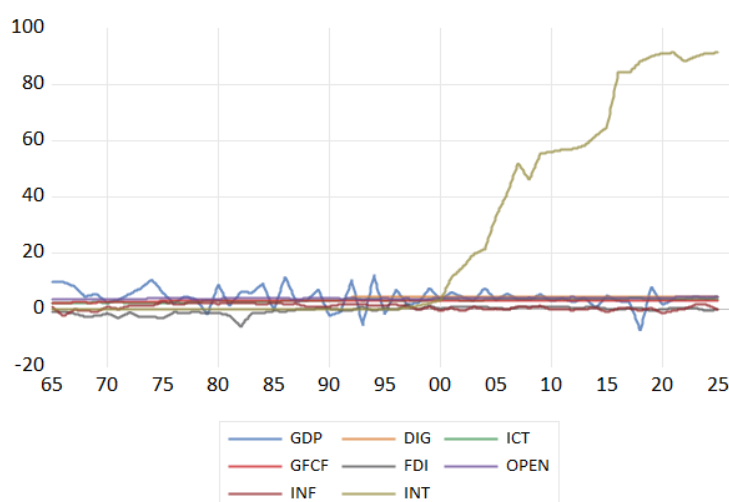
Source: Authors' calculations using EViews 13

The dispersion measures reveal notable heterogeneity across variables. GDP and Internet users display the highest variability, reflecting business cycle fluctuations and the rapid diffusion of digital technologies, whereas the Digital Transformation Index shows limited variation, suggesting a gradual and consistent digitalization process.

The distributional statistics indicate that most variables deviate from normality, as confirmed by the Jarque–Bera test, with the exception of Foreign Direct Investment (FDI). Such departures are common in macroeconomic time-series data due to structural reforms, policy shifts, and external shocks, and do not compromise the reliability of the econometric analysis.

Overall, the descriptive statistics highlight the structural transformation of the Moroccan economy toward greater digitalization and international integration. The diversity of the variables provides a robust empirical foundation for the subsequent ARDL estimation, allowing both the short-run dynamics and long-run relationship between digital transformation and economic growth to be examined.

Figure 1. Evolution of Macroeconomic and Digital Indicators in Morocco



Source: Authors' calculations using EViews 13

Figure 1 illustrates the evolution of the study variables over the 1965–2025 period. The graphical analysis reveals distinct long-run patterns across the macroeconomic and digital indicators. Internet Users (INT) exhibit the strongest upward trend, increasing rapidly after 2000 as a result of expanding digital infrastructure, mobile connectivity, and government-led digitalization initiatives. This persistent growth is consistent with the variable's non-stationary nature identified by the ADF unit root test.

By contrast, GDP displays cyclical fluctuations associated with economic expansions and downturns, including a marked decline during the COVID-19 pandemic followed by a gradual recovery. The remaining variables—DIG, ICT, GFCF, FDI, OPEN, and INF—show relatively stable movements with moderate long-term increases, indicating lower short-run volatility.

From an economic perspective, the figure highlights Morocco's gradual transition toward a more digital and globally integrated economy. The sustained expansion of Internet access and digital technologies reflects continuous investment in digital infrastructure and the implementation of national digital strategies, while the relative stability of the main macroeconomic indicators suggests a resilient economic environment.

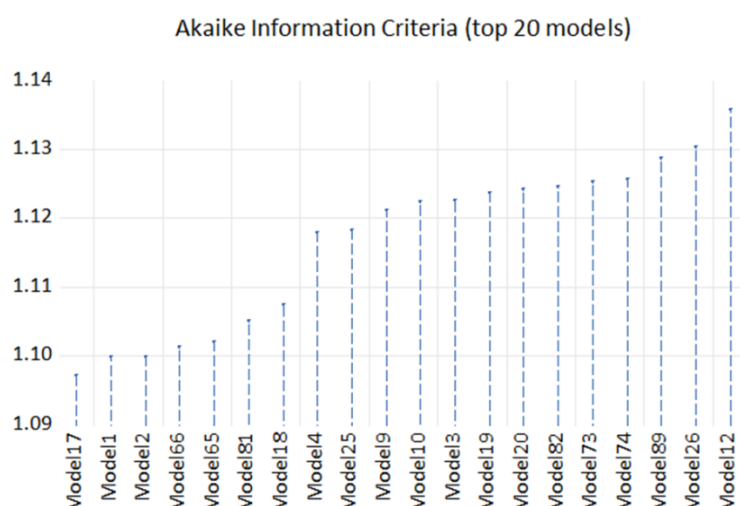
Overall, the graphical evidence is consistent with the descriptive statistics and unit root results, confirming that digital variables exhibit pronounced long-term trends whereas most macroeconomic variables remain relatively stable. These findings further support the suitability of the ARDL Bounds Testing approach for analyzing both the short-run dynamics and long-run relationship between digital transformation and economic growth in Morocco.

b. Results and Discussion

Figure 2 reports the Akaike Information Criterion (AIC) values for the twenty best ARDL model specifications generated by EViews. The AIC selects the optimal model by balancing goodness of fit and model parsimony, with the preferred specification corresponding to the lowest AIC value.

The results indicate that Model 17 achieves the minimum AIC (approximately 1.097), followed closely by Models 1 and 2, making it the most appropriate specification among the competing alternatives. Although the AIC differences across models are relatively small, the selected model provides the best trade-off between explanatory power and parameter efficiency.

Figure 2. Akaike Information Criterion (AIC) for the Top 20 Candidate ARDL Models



Source: Authors' calculations using EViews 13

Economically, the optimal lag structure ensures a reliable estimation of the dynamic relationship between economic growth (GDP) and its determinants—digital transformation (DIG), ICT investment (ICT), gross fixed capital formation (GFCF), foreign direct investment (FDI), trade openness (OPEN), inflation (INF), and Internet users (INT). Consequently, the selected ARDL specification provides a robust framework for estimating both the long-run equilibrium relationship and the short-run adjustment process through the ARDL Bounds Test and the Error Correction Model (ECM).

Table 3. Short-Run Error Correction Model (ECM)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COINTEQ*	-0.018984	0.002961	-6.411076	0.0000
D(DIG)	-769.2081	267.1729	-2.879064	0.0042
D(FDI)	-4.855750	0.342395	-14.18173	0.0000
D(ICT)	6.590103	2.407065	2.737816	0.0065
D(INF)	2.799793	0.286710	9.765253	0.0000
D(INT)	-0.259187	0.053226	-4.869568	0.0000
D(OPEN)	-8.756571	2.750747	-3.183343	0.0016
R-squared	0.453094	Mean dependent var	-0.015133	
Adjusted R-squared	0.444659	S.D. dependent var	0.545923	
S.E. of regression	0.406829	Akaike info criterion	1.056670	
Sum squared resid	64.38323	Schwarz criterion	1.127048	
Log likelihood	-202.2206	Hannan-Quinn criter.	1.084551	
F-statistic	53.71239	Durbin-Watson stat	0.265027	

Source: Authors' calculations using EViews 13

Table 3 presents the short-run estimates of the ARDL(1,1,1,0,1,1,1) model in its Error Correction Model (ECM) form. The model is highly significant ($F = 53.71$, $p < 0.01$) and explains approximately 45.3% of the variation in economic growth ($R^2 = 0.453$), while the low AIC (1.0567) confirms the adequacy of the selected specification.

The error correction term ($ECT = -0.018984$, $p < 0.01$) is negative and statistically significant, confirming the existence of a stable long-run equilibrium among the variables. Its magnitude indicates that nearly 1.9% of short-run disequilibria are corrected each quarter, implying a

gradual convergence of the Moroccan economy toward its long-run equilibrium following temporary shocks.

The short-run coefficients reveal mixed effects across the explanatory variables. ICT investment and inflation exert positive and significant effects on economic growth, suggesting that digital infrastructure investment and a stable macroeconomic environment support short-term economic activity. In contrast, digital transformation, foreign direct investment, Internet users, and trade openness display negative and significant short-run effects, indicating that their economic benefits may be delayed because of adjustment costs, structural reforms, technology adoption processes, and transitional inefficiencies.

Overall, the ECM results suggest that although some digital and macroeconomic factors generate immediate growth effects, the full benefits of digital transformation emerge progressively over time. The significant error correction mechanism confirms the stability of the estimated ARDL model and supports its suitability for analyzing both the short-run dynamics and the long-run relationship between digital transformation and economic growth in Morocco.

Table 4. Long-Run Coefficient Estimates of the Selected ARDL Model

Variable *	Coefficient	Std. Error	t-Statistic	Prob.
DIG(-1)	446.7199	1240.528	0.360105	0.7190
FDI(-1)	-9.518081	5.126361	-1.856693	0.0641
GFCF	-6.963147	18.96953	-0.367070	0.7138
ICT(-1)	-69.89539	35.37142	-1.976042	0.0489
INF(-1)	-2.246135	2.428712	-0.924825	0.3556
INT(-1)	0.401297	0.252738	1.587796	0.1131
OPEN(-1)	-45.03635	33.55570	-1.342137	0.1803
C	-1598.665	5691.437	-0.280889	0.7789

Source: Authors' calculations using EViews 13

Table 4 reports the long-run estimates of the selected ARDL(1,1,1,0,1,1,1) model, which capture the equilibrium relationship between economic growth and its determinants. The results show that ICT investment is the only variable that is statistically significant at the 5% level and exhibits a negative long-run effect on GDP. This finding may reflect the presence of a digital productivity lag, whereby the benefits of ICT investment are delayed because of implementation costs, institutional constraints, and the need for complementary investments in human capital and innovation.

Foreign Direct Investment (FDI) also has a negative coefficient and is marginally significant at the 10% level, suggesting that its long-run contribution to economic growth remains limited, possibly because of weak technological spillovers or sectoral concentration. In contrast, the Digital Transformation Index (DIG), Gross Fixed Capital Formation (GFCF), Inflation (INF), Internet Users (INT), and Trade Openness (OPEN) do not exhibit statistically significant long-run effects, despite some positive estimated coefficients.

From an economic perspective, these findings suggest that Morocco's digital transformation has not yet generated uniformly measurable long-run growth benefits. Digital infrastructure expansion alone appears insufficient to sustain economic growth without complementary improvements in digital skills, institutional quality, innovation capacity, and the productive adoption of digital technologies.

Overall, the long-run results indicate that only ICT investment significantly influences GDP in the estimated model, while FDI shows weak evidence of a long-run effect. The remaining

variables are statistically insignificant, highlighting that the long-term economic returns from digital transformation remain conditional on broader structural and institutional reforms. These findings should be interpreted jointly with the short-run ARDL-ECM results to provide a comprehensive assessment of the relationship between digital transformation and economic growth in Morocco.

Table 5. ARDL Bounds Test for Cointegration

Test Statistic		Value	
F-statistic		4.472957	

	10%		5%		1%	
Sample Size	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Asymptotic	1.920	2.890	2.170	3.210	2.730	3.900

* $I(0)$ and $I(1)$ are respectively the stationary and non-stationary bounds.

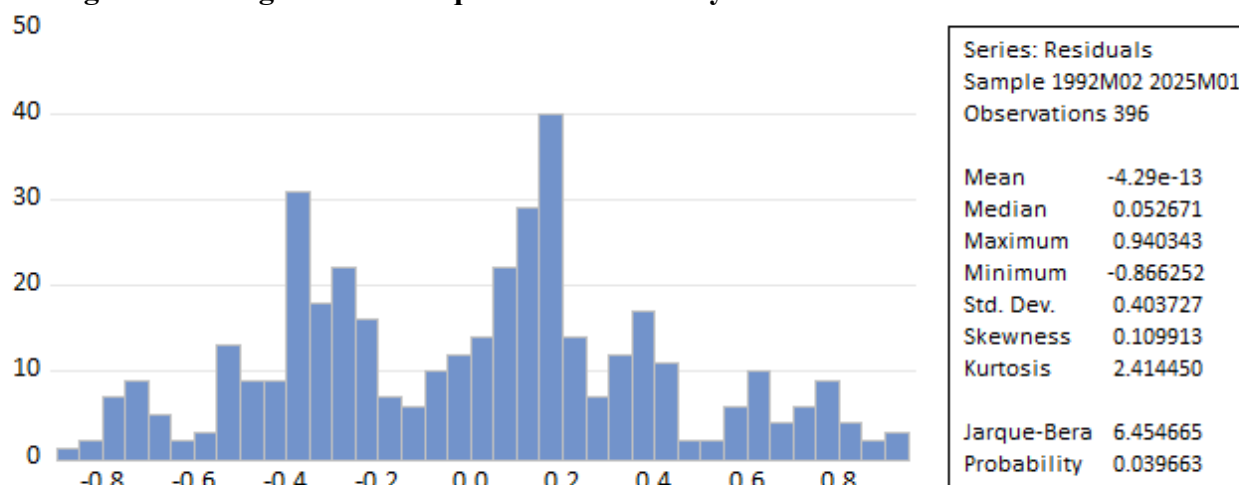
Source: Authors' calculations using EViews 13

Table 5 presents the results of the Pesaran, Shin, and Smith (2001) ARDL Bounds Test used to examine the existence of a long-run relationship among the study variables. The estimated F-statistic (4.472957) exceeds the upper critical bound at the 1% significance level, leading to the rejection of the null hypothesis of no cointegration. This provides strong evidence of a stable long-run equilibrium relationship between economic growth and its explanatory variables.

From an economic perspective, the findings indicate that GDP, digital transformation (DIG), ICT investment (ICT), gross fixed capital formation (GFCF), foreign direct investment (FDI), trade openness (OPEN), inflation (INF), and Internet users (INT) are linked by a common long-run equilibrium despite temporary short-run fluctuations. This suggests that digitalization and key macroeconomic fundamentals jointly influence Morocco's long-term economic performance.

The confirmation of cointegration also validates the estimation of the long-run ARDL coefficients and the Error Correction Model (ECM). Combined with the significant and negative error correction term, the results confirm that short-run disequilibria are gradually corrected toward long-run equilibrium, supporting the suitability of the ARDL framework for analyzing the dynamic relationship between digital transformation and economic growth in Morocco.

Figure 3. Histogram and Jarque–Bera Normality Test of the ARDL Model Residuals



Source: Authors' calculations using EViews 13

Figure 3 presents the histogram of the residuals and the Jarque–Bera normality test for the estimated ARDL model. The residuals are centered around zero, with low skewness and moderate dispersion, indicating that the model does not exhibit systematic prediction errors. Their distribution is approximately symmetric and visually close to normal.

Although the Jarque–Bera test rejects the null hypothesis of perfect normality at the 5% significance level ($p = 0.0397$), the departure from normality is relatively small. Given the large sample size (396 observations), this slight violation is unlikely to affect the consistency or asymptotic validity of the estimated coefficients and statistical inferences.

From an econometric perspective, these results suggest that the residuals satisfy the normality assumption to a reasonable extent and do not undermine the reliability of the ARDL model. Together with the remaining post-estimation diagnostic tests, the residual analysis supports the robustness of the estimated specification.

Economically, the residual behavior indicates that the model captures most of the systematic variation in Morocco's economic growth explained by digital transformation, ICT investment, foreign direct investment, inflation, trade openness, and Internet users. The remaining unexplained variation is likely attributable to temporary external shocks and omitted macroeconomic factors, confirming the suitability of the ARDL framework for analyzing the relationship between digital transformation and economic growth in Morocco.

Table 6. Breusch–Godfrey Serial Correlation LM Test

F-statistic	678.6000	Prob. F(2,379)	0.0000
Obs*R-squared	309.5560	Prob. Chi-Square(2)	0.0000

Source: Authors' calculations using EViews 13

Table 6 reports the results of the Breusch–Godfrey Serial Correlation LM Test, which examines whether the residuals of the estimated ARDL model are serially independent. The results show that both the F-statistic and Obs*R-squared are highly significant ($p < 0.01$), leading to the rejection of the null hypothesis of no serial correlation.

These findings indicate the presence of residual autocorrelation, suggesting that the current ARDL specification does not fully capture the dynamic behavior of the data. As a result, while the estimated coefficients remain informative, the associated standard errors and statistical significance tests may be less reliable because of biased inference.

From an economic perspective, the persistence of serial correlation reflects the dynamic nature of Morocco's macroeconomic variables, where economic growth, digital transformation, investment, trade openness, inflation, and Internet penetration evolve gradually and are influenced by persistent policy measures and external shocks.

Overall, the diagnostic results suggest that the model should be refined before drawing definitive policy conclusions. Possible improvements include selecting an alternative lag structure, incorporating additional dynamic or structural-break variables, or estimating robust standard errors (e.g., HAC/Newey–West) to obtain more reliable statistical inference.

Table 7. ARCH Heteroskedasticity Test

F-statistic	2178.117	Prob. F(1,393)	0.0000
Obs*R-squared	334.6235	Prob. Chi-Square(1)	0.0000

Source: Authors' calculations using EViews 13

Table 7 reports the results of the ARCH Lagrange Multiplier (LM) Test, which examines whether the residual variance is constant over time. The results indicate that both the F-statistic

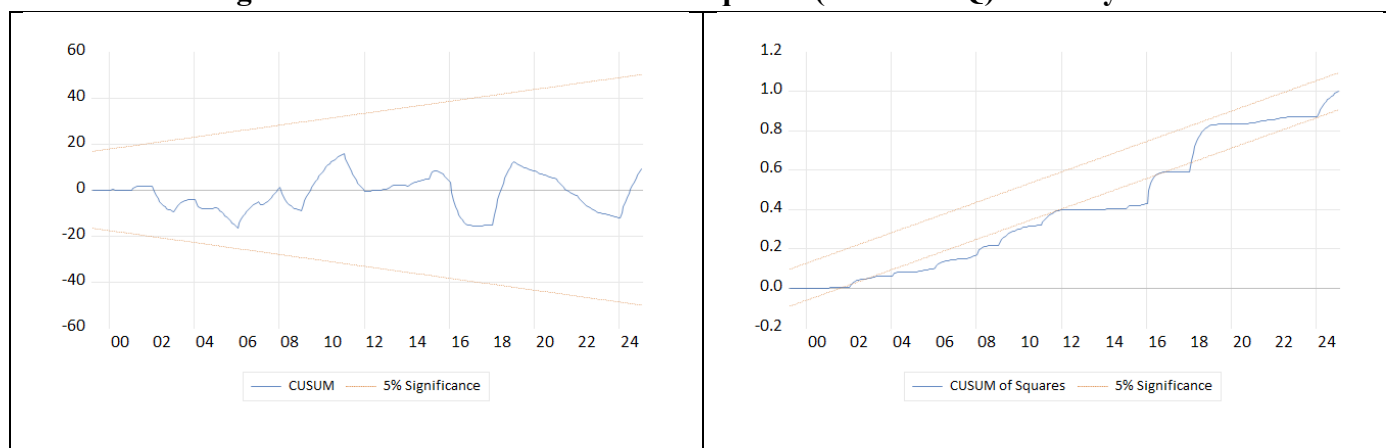
and Obs*R-squared are highly significant ($p < 0.01$), leading to the rejection of the null hypothesis of homoskedasticity. This confirms the presence of ARCH effects, implying that the residual variance changes over time.

From an econometric perspective, conditional heteroskedasticity suggests that, although the ARDL coefficient estimates remain consistent, conventional standard errors and significance tests may be inefficient. Therefore, robust covariance estimators, such as White or HAC (Newey–West) standard errors, should be employed to ensure reliable statistical inference.

Economically, the results indicate that the volatility of Morocco's economic growth has varied over the study period because of persistent macroeconomic and external shocks, including changes in investment, international market conditions, and successive stages of digital transformation. These findings reveal the presence of volatility clustering, a common feature of macroeconomic time-series data.

Overall, while the ARCH-LM test rejects the homoskedasticity assumption, it does not invalidate the estimated long-run ARDL coefficients. Instead, it highlights the importance of using robust inference procedures to obtain reliable conclusions regarding the impact of digital transformation on economic growth in Morocco.

Figures 4. CUSUM and CUSUM of Squares (CUSUMSQ) Stability Tests



Source: Authors' calculations using EViews 13

Figure 4 presents the CUSUM and CUSUM of Squares (CUSUMSQ) tests, which assess the parameter and structural stability of the estimated ARDL model. In both tests, the recursive residuals remain within the 5% critical bounds throughout the sample period, indicating that the null hypothesis of parameter stability cannot be rejected.

The CUSUM results confirm that the estimated coefficients remain stable over time, while the CUSUMSQ test shows no evidence of variance instability or structural breaks, despite major economic events such as financial shocks, the acceleration of digital transformation, and the COVID-19 pandemic. Although the CUSUMSQ curve approaches the upper critical limit toward the end of the sample, it does not exceed it, confirming the robustness of the model.

From an economic perspective, these findings indicate that the long-run relationship between economic growth (GDP) and its determinants—digital transformation (DIG), ICT investment (ICT), gross fixed capital formation (GFCF), foreign direct investment (FDI), inflation (INF), Internet users (INT), and trade openness (OPEN)—remained stable throughout the study period. Consequently, the estimated coefficients can be considered reliable for economic interpretation and policy analysis.

Overall, the CUSUM and CUSUMSQ tests confirm the structural stability of the ARDL(1,1,1,0,1,1,1) model. Combined with the Bounds Test and the Error Correction Model (ECM), these results provide strong evidence of the robustness of the estimated short-run and long-run relationships between digital transformation and economic growth in Morocco.

5. Conclusion

This study employs the Autoregressive Distributed Lag (ARDL) approach to examine the relationship between digital transformation and economic growth in Morocco within the framework of the Morocco Digital 2030 Strategy. The preliminary analysis confirms a mixture of I(0) and I(1) variables, while the ARDL Bounds Test provides strong evidence of a stable long-run equilibrium relationship, validating the use of the ARDL methodology to investigate both short-run and long-run dynamics.

The empirical findings reveal that the Moroccan economy gradually adjusts toward its long-run equilibrium following short-term shocks, as indicated by the significant and negative error correction term. In the short run, ICT investment and inflation positively influence economic growth, whereas digital transformation, foreign direct investment, Internet penetration, and trade openness exert negative effects, suggesting that digitalization involves transitional adjustment costs before its economic benefits are fully realized. In the long run, ICT investment remains the only statistically significant determinant of GDP, while the remaining variables do not exhibit significant long-run effects, indicating that digital infrastructure alone is insufficient to generate sustained economic growth without complementary structural reforms.

From a policy perspective, the results indicate that maximizing the economic benefits of digital transformation requires a comprehensive strategy extending beyond infrastructure expansion. Morocco should strengthen digital skills, innovation capacity, institutional quality, research and development, and the productive adoption of digital technologies while promoting technology-intensive foreign investment capable of generating productivity gains and knowledge spillovers.

This study contributes to the literature by providing one of the few comprehensive ARDL analyses of digital transformation and economic growth in Morocco, integrating digital transformation, ICT investment, Internet penetration, foreign direct investment, gross fixed capital formation, trade openness, and inflation within a unified empirical framework. Future research should incorporate additional dimensions such as institutional quality, digital governance, artificial intelligence, cybersecurity, innovation performance, and human capital, while exploring nonlinear or asymmetric econometric models to provide deeper insights into the long-term growth effects of digital transformation in emerging economies.

6. References

- Aghion, P., Akcigit, U., & Howitt, P. (2015). The Schumpeterian growth paradigm. *Annual Review of Economics*, 7, 557–575.
- Barro, R. J. (1991). Economic growth in a cross section of countries. *Quarterly Journal of Economics*, 106(2), 407–443.
- Calderon-Monge, E., & Ribeiro-Soriano, D. (2024). The role of digitalization in business and management: A systematic literature review. *Review of Managerial Science*, 18, 449–491.
- Chakravorty, S., Chatterjee, D., & Kar, A. K. (2023). Digital transformation research: A systematic review. *Technological Forecasting and Social Change*.
- Chtioui, N., & Boushib, K. (2026). The role of FDI, ICT, and human capital in Morocco's growth trajectory: An empirical ARDL analysis. *African Journal of Business and Economic Research*.

- Czernich, N., Falck, O., Kretschmer, T., & Woessmann, L. (2011). Broadband infrastructure and economic growth. *The Economic Journal*, 121(552), 505–532.
- Dale W. Jorgenson, D. W., & Kevin J. Stiroh, K. J. (2000). Raising the speed limit: U.S. economic growth in the information age. *Brookings Papers on Economic Activity*, 2000(1), 125–235.
- Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, 74(366), 427–431.
- Echaoui, M., Karim, M., Omayma, M., & Touzani, A. (2026). The dynamics of ICT and economic growth in Morocco: A quantitative approach. *International Journal of Economics and Financial Issues*, 16(3), 18–25.
- International Telecommunication Union. (2025). *Measuring Digital Development: Facts and Figures 2025*. ITU.
- Kuznets, S. (1973). Modern economic growth: Findings and reflections. *American Economic Review*, 63(3), 247–258.
- Lars-Hendrik Röller, L.-H., & Leonard Waverman, L. (2001). Telecommunications infrastructure and economic development: A simultaneous approach. *American Economic Review*, 91(4), 909–923.
- Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, 22(1), 3–42.
- Marino-Romero, J. A., & Folgado-Fernández, J. A. (2024). Digital transformation: A literature review in the context of international economies and finance. *South African Journal of Business Management*, 55(1).
- Niebel, T. (2018). ICT and economic growth: Comparing developing, emerging and developed countries. *World Development*, 104, 197–211.
- OECD. (2018). *Digital Government Review of Morocco: Laying the Foundations for the Digital Transformation of the Public Sector in Morocco*. OECD Publishing.
- Organisation for Economic Co-operation and Development (2020). A roadmap toward a common framework for measuring the digital economy. OECD Publishing.
- Pesaran, M. H., & Shin, Y. (1999). An autoregressive distributed lag modelling approach to cointegration analysis. In S. Strom (Ed.), *Econometrics and Economic Theory in the 20th Century* (pp. 371–413). Cambridge University Press.
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289–326.
- Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5), S71–S102.
- Saad, J. A., & Bensaoud, R. (2026). Development of the ICT sector and the digitization of Morocco. In *The Oxford Handbook of the Moroccan Economy*.
- Sagala, G. H., & Öri, D. (2024). Toward SMEs digital transformation success: A systematic literature review. *Information Systems and e-Business Management*.
- Solow, R. M. (1956). A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70(1), 65–94.
- Verhoef, P. C., Broekhuizen, T., Bart, Y., et al. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122, 889–901.
- Vial, G. (2019). Understanding digital transformation: A review and research agenda. *Journal of Strategic Information Systems*, 28(2), 118–144.
- World Bank. (2021). *World Development Report 2021: Data for Better Lives*. Washington, DC: World Bank.

- Zhang, Q., Wu, P., Li, R., & Chen, A. (2024). Digital transformation and economic growth efficiency improvement in the digital media era. *International Review of Economics & Finance*, 92, 667–677.