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The Impact of Investment in Technological Infrastructure on Economic Growth in Iraq for the Period 2005–2025

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Abstract

This research explores the interdependence between technological infrastructure investment and the non-oil economic growth in the state of Iraq from 2005 to 2025. Using an Autoregressive Distributed Lag (ARDL) bounds testing approach, annual time-series data is taken from official Iraqi and international data sources to differentiate between short-run adjustments and long-run equilibrium effects. The results show that from a short run point of view, technological investment has a positive and statistically significant effect on non-oil growth ($\beta = 0.00028$, $p < 0.001$), while in the long run, the relationship is only marginally significant ($p = 0.055$) and structural constraints appear to moderate the long-run impacts. All diagnostic tests are consistent with model validity, and there is no evidence of serial correlation, heteroskedasticity or residual non-normality. Additional bivariate analysis confirms strong positive relationships between technology investment and digital efficiency, volume of electronic payments, financial inclusion and government automation, which align with the hypothesized channels. The results show that although digital capital deployment has been a trigger for diversification in the short-term, the process needs complementary institutional reform, human capital development, and regulatory modernization for a sustainable growth. This study adds much needed empirical research to the policy body of knowledge for

hydrocarbon economies seeking to pursue development paths that are non-oil-dependent, inclusive and resilient.

Keywords: Technological investment; Non-oil growth; ARDL model; Digital transformation; Financial inclusion; Iraq

Introduction

Information and communication technology (ICT) is one of the most fundamental factors affecting the economic growth and sustainable development in the modern economies. In the last 20 years, ICT has moved beyond its role as a tool to assist in communication and administrative tasks to become a strategic productive infrastructure that has the potential to change economic systems and enhance national competitiveness. Technological infrastructure is now an integral part of productivity improvements, innovation, transaction costs reduction, market efficiency and rapid information and service exchange. The countries with higher investments in digital technologies and ICT infrastructure have tended to have higher economic growth rates, higher institutional efficiency and stronger global economic integration.

Technological infrastructure is especially relevant in developing economies, where it can help address structural constraints to development, like geographical isolation, institutional capacity, and access to markets and financial services. Digital transformation can help to enhance governance, boost financial inclusion, support for SMEs and integration in regional and international markets. Furthermore, the use of E-payment systems and digital financial services can help shrink the informal sector, improve the transparency of monetary and financial transactions, and improve the effectiveness of monetary and fiscal policy.

Meanwhile, the Iraqi economy is suffering serious structural and developmental problems which impede its achievement of stable and diversified economic growth. Oil continues to be the main source of revenue for the government and foreign currency in Iraq. Overshadowing the economy with oil subject the economy to external economic shocks and fluctuations in global oil prices, impacting government expenditure, investments and macroeconomic stability. With significant natural and financial resources, the contribution of non-oil sectors in gross domestic product (GDP) is relatively low. Agriculture, manufacturing, tourism, and digital services are sectors which still need to reach the level of development required to ensure sustainable economic diversification.

The study is based on the main hypothesis, "There is a statistically significant relationship between investment in technological infrastructure and economic growth in Iraq during the period 2005-2025" which is based on the research problem and the related research questions. From this main hypothesis, several sub-hypotheses are emerged, such as the assumption that technological infrastructure investment has a statistically significant relationship with the development of EPS in Iraq, enhancement of financial inclusion, and the efficiency of the government's automation and digital transformation. Moreover, the study assumes that investments on technological infrastructure plays a significant role in the growth rate of non-oil gross domestic product (GDP) in Iraq. Collectively these hypotheses attempt to investigate the role played by technological infrastructure investments in supporting the economic and digital development of several sectors in the Iraqi economy.

This study aims to investigate the effect of technological infrastructure investment on the non-oil economic growth of Iraq in the years 2005-2025 through the ARDL bounds test approach. One of the reasons why the study is important is that it offers empirical facts and figures on the role of digital and technological investments in economic diversification in hydrocarbon dependent economies. The research findings show that institutional changes, regulatory modernization and human capital development are key to maintain the growth momentum of non-oil. The findings provide helpful policy lessons for supporting inclusive, resilient, and technology-driven economic development in countries with economies like Iraq.

Literature review

Previous studies provide an important basis for situating the present study in the literature which explores the link between information and communication technology, digital economy and economic growth. As this research is of a relevant nature, the most relevant studies are reviewed as follows.

Al-Husayny (2024) studied the effect of applying information and communication technology on the gross domestic product for five years from 2010 to 2022 in Iraq, and the results showed that the information and communication technology application has positive effects compared to the non-application period. Some indicators of ICT use were seen to have significant impacts on GDP in the study including mobile phone subscriptions and intensity of internet use. This confirms the presence of technology's correlation with economic development in Iraq.

Abdullrada and Wahaib (2023) emphasized the importance of the digital economy in the development of the Iraqi economy for the period 2010-2022. The study found that the use of technology in GSPs can help to boost GDP, as long as the right digital infrastructure and digital transformation policies are in place.

Abed et al., 2020, studied the role of information technology (measured by the number of mobile phone users) in the economic growth of Iraq from 2006 to 2018 using the ARDL model. The results showed that there existed a long-run equilibrium relationship between the use of mobile phones and economic growth.

In terms of institutional performance, Al-lamy et al. (2020) demonstrated that the performance of SMEs in Iraq can be positively influenced by IT infrastructure components such as digital connectivity, IT systems integration, and technological HR. Likewise, Jabbouri et al. (2016) discovered that there is a positive link between the elements of information technology infrastructure and innovative performance in private universities in Iraq.

This study aimed to investigate the importance of the digital economy in the process of economic development in Iraq for the period 2003-2022, which was undertaken by Ahmed (2025) by applying the ARDL model. The study identified a positive relationship between certain digital economy indicators and economic growth, but also identified institutional and structural problems that need to be addressed to increase the long run impact.

On the Arab comparative level, Alnesh and Jarallah (2024) examined the effects of indicators of ICTs on the gross domestic product of the selected Arab countries from 2007 to 2021 especially for Iraq country. The findings revealed that the effect of the technology indicators varies across countries depending on the extent of digital infrastructure development and institutions.

In terms of the state of digital infrastructure in Iraq, Alsabah et al. (2021) noted that the Internet sector in Iraq is still suffering from a number of technical and regulatory issues that impact the quality of services and its penetration. Even though ICT plays an important role in education, health, industry, and trade, Hussein et al. (2020) also revealed that weak technological diffusion in Iraq is related to institutional, security, and administrative factors.

Research Gap

To date, there have been a number of studies that have investigated the connection between technology and economic growth in Iraq, but most of these studies have adopted a narrow lens on technology, specifically considering either internet usage or mobile telecommunications or the digital economy in general. Relatively little attention has been paid to the greater part of the investment in technological infrastructure and its transmitting systems in the promotion of economic growth. Further, there is little research that combines electronic payments, financial inclusion, government automation, and efficiency of digital transformation as intermediate factors that affect economic performance. The second important gap is that there are no recent empirical studies for the period 2005–2025 using the ARDL approach in the study of short and long-run dynamics. Hence, this study investigates the above gaps in search of a comprehensive empirical analysis in the role of investment in technological infrastructure to foster economic growth and economic diversification in Iraq.

Theoretical and Conceptual Framework

Technological Infrastructure and Economic Growth

The information and communication technology infrastructure is regarded as the backbone of the digital economy, the backbone being the system for the production, processing, exchange and use of information in economic and administrative processes. It is not just the hardware and equipment; it also involves software, networks, databases, human resources and regulatory systems that facilitate the effective utilization of technology (Freitas et al., 2018; Solomon & van Klyton, 2020).

This infrastructure comprises the hardware elements of digital systems such as computers and servers, along with communication devices. It encompasses software to facilitate the functioning of devices and the management of data and different applications etc., and communication networks that provide connectivity and communication via the Internet and broadband. These networks are services and electronic payments (Yao, 2025; CMC Iraq, 2024).

Databases are also crucial for organizing data and assisting in making decisions, and skilled human resources are a necessity for the efficient functioning and development of the system (Anthun et al., 2024; Atique et al., 2024).

The investments in technological infrastructure are defined by their capacity to improve productivity, lower transaction costs and boost market and digital services access. It also depends on knowledge and innovation as significant factors of growth and increasing returns (Ahmed, 2025). This investment is particularly significant in Iraq for promoting economic diversification by expanding the ICT, broadband, digital services and electronic payments sectors, which can help to increase financial inclusion, boost business sectors and strengthen the efficiency of government performance (CMC Iraq, 2024; Hao et al., 2026).

Technological infrastructure is of significance not only in a technical sense; it is also a possible instrument for addressing the imbalances of an economy based on rents in the Iraqi context. Technologies such as telecommunications networks, broadband, digital services and electronic payment systems can help to boost the activity of non-oil sectors, improve financial inclusion, foster the business environment, and improve the efficiency of government services.

Economic Growth in Economic Theory

Economic growth is a fundamental concept in economics. It is the successive rise in real output or real output per capita over a certain period of time. Growth can be measured in terms of a monetary rise in the level of output, but it is also the ability of the economy to produce more goods and services, which in turn translates to better living standards and economic welfare (Hickel & Sullivan, 2024).

The main factors shaping economic growth are technological advancement, capital and labor. Human labor is productive capacity, knowledge and skills, while the capital is an investment in machines, buildings and infrastructure, which increases productive capacity. Technological progress is regarded as the most important contributor to productivity growth, since it is the ability to produce more output and better quality products and services with the same factors of production or with fewer factors of production (Zhang et al., 2021; Atique et al., 2024).

Growth theories have shifted from a view of capital accumulation and labour as the key drivers of growth, to a more pronounced value on technology and knowledge as key factors in achieving sustainable growth. Some of the traditional models have assumed technological progress as an exogenous variable while endogenous growth theory has asserted that technological progress, human resources, and investments in knowledge are endogenous to the economy and are responsible for rising returns in the long-run (Tay et al., 2022; Sankaran et al., 2020).

In this sense, information and communication technology becomes a key element for the dissemination of knowledge, productivity enhancement and the creation of services. The use of the internet, databases, and digital networks has not only increased the speed of disseminating information but has also enhanced the quality of the economic decision-making process, lowered transaction costs and enabled new activities in the productive and service sectors. This explains the linkage between technological infrastructure investment and economic growth, especially in economies that want to diversify their growth sources and lessen the reliance on rentier sectors (Choi & Yi, 2009; Ahmed, 2025).

In Iraq the meaning of economic growth is particularly important because of the fact that the oil sector accounts for the bulk of output and public revenues of the economy and thus overall growth is sensitive to fluctuations in oil prices. Two important points should be noted when trying to understand the effect of technological investment: the first is that it must be assessed through the channels that can provide growth outside the oil sector, which are mainly the digital service, telecommunications, electronic payments, and government automation sectors; and second, that the assessment should be done in collaboration with a competent data source.

The mechanisms by which technology affects economic activity.

There are two main ways that ICT has an impact on economic activity. The first is direct channel, which is affected by the contribution of the technology sector to gross domestic product and employment. The second is indirect channel, by enhancing the efficiency of other sectors by improving the productivity, reducing transaction costs and the diffusion of innovation (Al-Husayny, 2024).

The direct channel is represented by the value added by the Information and Communication Technology industry in telecommunications, Internet, software and digital services. This sector helps to boost GDP from the revenues of digital companies, mobile phone services and internet services, and generates new employment opportunities like network engineering, data management, cyber security, and digital infrastructure maintenance (Andrianaivo & Kpodar, 2011; Obed et al., 2025).

The indirect channel is seen in the impact of technology on various economic areas. Automation, databases and digital networks improve overall factor productivity, the allocation of resources and work costs. E-government, e-commerce and digital payments also contribute to the reduction of transaction costs, speeding up business processes and minimising administrative complexity (Haque & Tausif, 2026; CMC Iraq, 2024).

Technology also has a significant part to play in the dissemination of knowledge and innovation. With the expansion of the internet and digital networks, ideas and expertise can be shared among individuals and institutions faster, thus enhancing the development of new products and services and thus improving the quality of existing products and services (Choi & Yi, 2009). This channel is particularly relevant in developing economies such as Iraq, where it helps in using technology for developing traditional sectors, financial inclusion and strengthening the business environment, thereby stimulating economic growth and diversifying its sources (World Bank, 2020; Abdullrada & Wahaib, 2023).

Such mechanisms play a special role in the case of Iraq. The direct effect of technological investment is the growth of the telecommunications, internet and digital services industries, and the indirect effect is the electronic payment system, financial inclusion, electronic government applications and better transaction efficiency. This represents the channels through which this study's empirical analysis relies to measure the effect of investing technological infrastructure on the economic growth of Iraq for the period 2005-2025.

From the above, it is clear that technological infrastructure is one of the big pathways to support the economic growth either by itself on the telecom and digital services industry or through the indirect effects on productivity, transaction costs reduction, financial inclusion and government automation. Technological investments assume greater value because of the specific characteristics of the Iraqi economy and its heavy reliance on oil, which makes it an important pillar for fostering economic diversification. Thus, the empirical in this study moves to test the effect of investment in technological infrastructure on economic growth in Iraq in the period (2005, 2025) with the use of suitable econometric tools.

Methodology

Research design and analytical framework

This study follows a quantitative econometric approach to explore the relationship between investment in technological infrastructure and non-oil economic growth in Iraq, and testing sub-hypotheses of digital transformation, electronic payments, and financial inclusion. Since the study is concerned with sectors that are most directly affected by technological diffusion, economic growth is measured as the annual growth rate of non-oil gross domestic product (NON_OIL_GROWTH) in percentage terms. This specification distinguishes between technology driven diversification and the revenue from hydrocarbons, which fluctuates.

Data Sources and Sample Period

The analysis is based on annual time-series data for 21 observations (2005-2025). The data were gathered from official institutional sources such as Iraqi Central Statistical Organization, the Central Bank of Iraq, the World Bank Development Indicators and International Telecommunication Union. All price variables are listed in constant prices and all monetary variables in deflated prices with the appropriate price indices to make the prices comparable with each other over time.

Variable Measurement

Annual technological investment (TECH_INVEST) in million USD, which includes public and private investments in telecommunications infrastructure, digital platforms and information technology systems, is the main explanatory variable in Table 1. Four intermediary variables are included in order to analyse the transmission channels: (1) DIGITAL_EFFICIENCY (a composite index, 0-1 scale); (2) E_PAYMENTS (the value of electronic payments, billion USD); (3) FINANCIAL_INCLUSION (the proportion of adults with access to formal financial services); and (4) GOV_AUTOMATION (the share of government procedures made available digitally, percent). There are also a few control variables such as the number of point-of-sale terminals (POS_TERMINALS) and the level of non-oil GDP (NON_OIL_GDP) for supplementary analysis.

Table 1. Definition and Measurement of Study Variables

Variable	Symbol	Measurement	Unit	Expected Relationship
Non-oil economic growth	NON_OIL_GROWTH	Annual growth rate of non-oil GDP	%	Dependent variable
Technological investment	TECH_INVEST	Investment in technological infrastructure	Million USD	Positive
Digital efficiency	DIGITAL_EFFICIENCY	Composite digital efficiency index	0-1 Index	Positive
Electronic payments	E_PAYMENTS	Value of electronic payments	Billion USD	Positive
Financial inclusion	FINANCIAL_INCLUSION	Adults with access to formal financial services	%	Positive
Government automation	GOV_AUTOMATION	Digitized government	%	Positive

		procedures		
POS terminals	POS_TERMINALS	Number of point-of-sale terminals	Number	Positive
Non-oil GDP	NON_OIL_GDP	Size of non-oil GDP	Billion IQD	Control variable

Econometric Procedures

The data were analyzed in EViews 13. The empirical method adopted was a sequential analytical approach that consisted of four stages to analyze the correlation of technological infrastructure investment and non-oil economic development in Iraq systematically. Descriptive statistical analysis was done in the first phase to describe the variables of the study. The economic and digital transformation indicators were assessed for their distributional properties, variability and trends over the study period by calculating mean, median, maximum, minimum and standard deviation. Further, preliminary information on possible relationships among the variables was obtained through correlation analysis before formal econometric estimation could be performed.

In the second stage, a series of stationarity tests were performed on the variables of the time-series to determine the order of integration of each variable. This procedure should be followed in order to prevent spurious regression and to get the correct specification of the econometric models. Variables having less than 0.05 probability value were regarded as stationary at level and those variables having probability value higher than 0.05 were considered as non-stationary variables and treated in a dynamic modeling. The results showed mixed integration order of the variables which justifies the use of the methodologies that can be used for both I(0) and I(1) series.

The third step was to estimate a baseline multiple linear regression model using Ordinary Least Squares (OLS) approach. The model was designed so as to investigate the contemporaneous relationship between non-oil economic growth (NON_OIL_GROWTH) and the two key explanatory variables: technological investment (TECH_INVEST) and number of point-of-sale terminals (POS_TERMINALS). The classical regression assumptions were then tested using the Breusch–Godfrey serial correlation test, White's heteroskedasticity test and Jarque–Bera normality test.

The last stage used the Autoregressive Distributed Lag (ARDL) bounds testing method to reflect the short-run dynamic effects and the long-run equilibrium relationships between technological investment and non-oil economic growth. The ARDL technique was chosen because of its goodness for small-sample time-series analysis and its flexibility to include variables with mixed integrability orders, except the variables that have order of integrability as I (2). The optimal lag structure was determined automatically by the Akaike Information Criterion (AIC) and maximum lag length was set at two years, which is adopted to maintain the degrees of freedom as the relatively small sample size (N = 21). The ARDL framework also allowed for the estimation of cointegrating relationships, and the examination of dynamic adjustment processes using the cointegrating error correction representation.

The baseline ARDL specification is expressed as:

$$\Delta NON\_OIL\_GROWTH_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta NON\_OIL\_GROWTH_{t-i} + \sum_{j=0}^{q} \gamma_j \Delta TECH\_INVEST_{t-j} + \lambda_1 NON\_OIL\_GROWTH_{t-1} + \lambda_2 TECH\_INVEST_{t-1} + \varepsilon_t$$

In the model, Δ denotes the first-difference operator, while p and q represent the optimal lag lengths of the dependent and independent variables, respectively. The term εt represents the white-noise error term.

The short-run effects are captured through the coefficients of the differenced explanatory variables, represented by γj. The long-run relationship is obtained from the error-correction representation, where the long-run multiplier is calculated as:

$$\lambda_2 / \lambda_1$$

The bounds testing method by M. Hashem Pesaran, Yongcheol Shin and Richard J. Smith (2001) is applied to test cointegration between the variables.

Diagnostic Validation

Standard diagnostic tests are used to provide estimator reliability. The Breusch-Godfrey Lagrange Multiplier test looks at residual serial correlation and White's test tests for heteroskedasticity. The Jarque-Bera test is used to test for normality in the residuals. Due to the small sample size, inference is drawn from asymptotic critical values using conservative significance level ($\alpha = 0.05$) and the marginal results ($0.05 < \alpha < 0.10$) are interpreted with caution.

Sub-Hypothesis Testing

To explore intermediary mechanisms, results from four sub-hypotheses are tested with bivariate ordinary least squares regression analysis between TECH_INVEST and proxy variables (E_PAYMENTS, GOV_AUTOMATION, FINANCIAL_INCLUSION, DIGITAL_EFFICIENCY). The results are presented as proof of statistical association instead of causation as the specifications are exploratory in nature and the use of proxy variables gives theoretical basis to the transmission channels included in the primary ARDL model.

Results

Descriptive statistics of the variables

The non-oil gross domestic product (NON_OIL_GDP) in billion Iraqi Dinars (IQD) has a median value of 60,808 and a mean value of 58,237.48, showing a fairly even distribution. The range of series is between a minimum of 35,420 billion IQD and maximum is 76,125 billion IQD with a standard deviation of 12,427.15, which indicates moderate volatility for Iraq's non-oil economic output during the sample period in Table 2. In a corresponding way, the non-oil growth rate (NON_OIL_GROWTH) has an average annual value of 4.38%, varying between a contraction of - 8.1% and an expansion of 12.4%, with a standard deviation of 5.01 percentage points, which represents the cyclicality of Iraq's economic performance outside the hydrocarbon sector.

Table 2. Descriptive Statistics of the Study Variables, 2005–2025

Variable	Mean	Median	Maximum	Minimum	Standard

					Deviation
NON_OIL_GDP, billion IQD	58,237.48	60,808	76,125	35,420	12,427.15
NON_OIL_GROWTH, %	0.0438	0.0520	0.124	-0.081	0.0501
POS_TERMINALS, number	11,252.38	900	110,000	0	26,580.89
TECH_INVEST, million USD	530	420	1,450	120	346.79
DIGITAL_EFFICIENCY, index	0.5671	0.5000	0.81	0.20	0.1605
E_PAYMENTS, billion USD	4.94	0.30	42.0	0.01	10.72
FINANCIAL_INCLUSION, %	0.1696	0.105	0.54	0.03	0.1512
GOV_AUTOMATION, %	0.0643	0.006	0.52	0.0005	0.1330

Source: Author’s calculations based on EViews outputs.

In terms of technological and digital infrastructure indicators, there is noticeable skewness in the number of point of sale terminals (POS_TERMINALS), the mean is 11,252, the median is 900, the minimum is 0, and the maximum is 110,000. This pattern, and a very high standard deviation (26,580.89), indicates that the rollout of electronic payment infrastructure was slow in the early years of the sample but much faster in later years. In the same way, technological investment (TECH_INVEST), in million USD, has a mean of 530 and a median of 420, ranging from 120 to 1,450 million USD with a standard deviation of SD = 346.79, which reveals a moderate but uneven increase in capital investment in digital projects.

The digital efficiency index (DIGITAL_EFFICIENCY) has a median of 0.50, a maximum of 0.81, a minimum of 0.20, and a mean of 0.5671 on a scale of 0-1, indicating a moderate but improving institutional and technical capacity for digital service delivery. The mean of 4.94 is heavily influenced by the largest observations, and is therefore highly right skewed, with a median of 0.30 and a maximum of 42.0 billion USD (SD = 10.72) for the electronic payment volume (E_PAYMENTS), in billion USD. Gap in access to formal financial services is persistent, but slowly closing, with the average level of financial inclusion (proportion of adult population with access to formal financial services) at 16.96% with median 10.5% (SD =

15.12% range 3 - 54%). Last but not least, the level of government automation (GOV_AUTOMATION) has a low average value (6.43%, median = 0.6%) with a high standard deviation (SD = 13.30%) and shows the least developed level of the digital variables, reflecting the incremental nature and often delayed nature of public-sector digital transformation projects.

The descriptive statistics indicate that the digital and technological variables had a strong growth in the last years of the sample period, with a significant gap between the values of the means and the median values for POS_TERMINALS, E_PAYMENTS and GOV_AUTOMATION. The descriptive results, however, do not themselves establish that there is a causal connection between these and economic growth. Hence, the next econometric analysis is conducted using the unit root tests (ADF) and the autoregressive distributed lag (ARDL) model in addition to the error correction mechanism (ECM) estimation and the standard diagnostic tests to rigorously analyze the short run and long run impact of technological infrastructure investment on non-oil economic growth in Iraq.

Unit Root Tests: Stationarity Analysis

The ADF unit root test results show that the main dependent variable, NON_OIL_GROWTH, is stationary at level, I(0) in Table 3. The value of the ADF statistic is -3.0799 and the probability value is 0.0445, which is less than the 5% significance level shown in Figure 1. This suggests rejection of the unit root null hypothesis for this variable. Thus, the non-oil sector growth rate can be added to the regression models without taking first differences. This also maintains the direct interpretation of the estimated coefficients in percentages.

Table 3. ADF Unit Root Test Results at Level

Variable	**ADF Statistic**	**Prob.**	**Significance Level**	**Status**
NON_OIL_GROWTH	-3.0799	0.0445	5%	Stationary, I(0)
DIGITAL_EFFICIENCY	-2.0558	0.2628	Not significant	Non-stationary

E_PAYMENTS	9.5566	1.0000	Not significant	Non-stationary
TECH_INVEST	0.9783	0.9944	Not significant	Non-stationary
POS_TERMINALS	4.1607	0.9999	Not significant	Non-stationary
NON_OIL_GDP	-1.2494	0.6314	Not significant	Non-stationary

Source: Author's calculations based on EViews outputs.

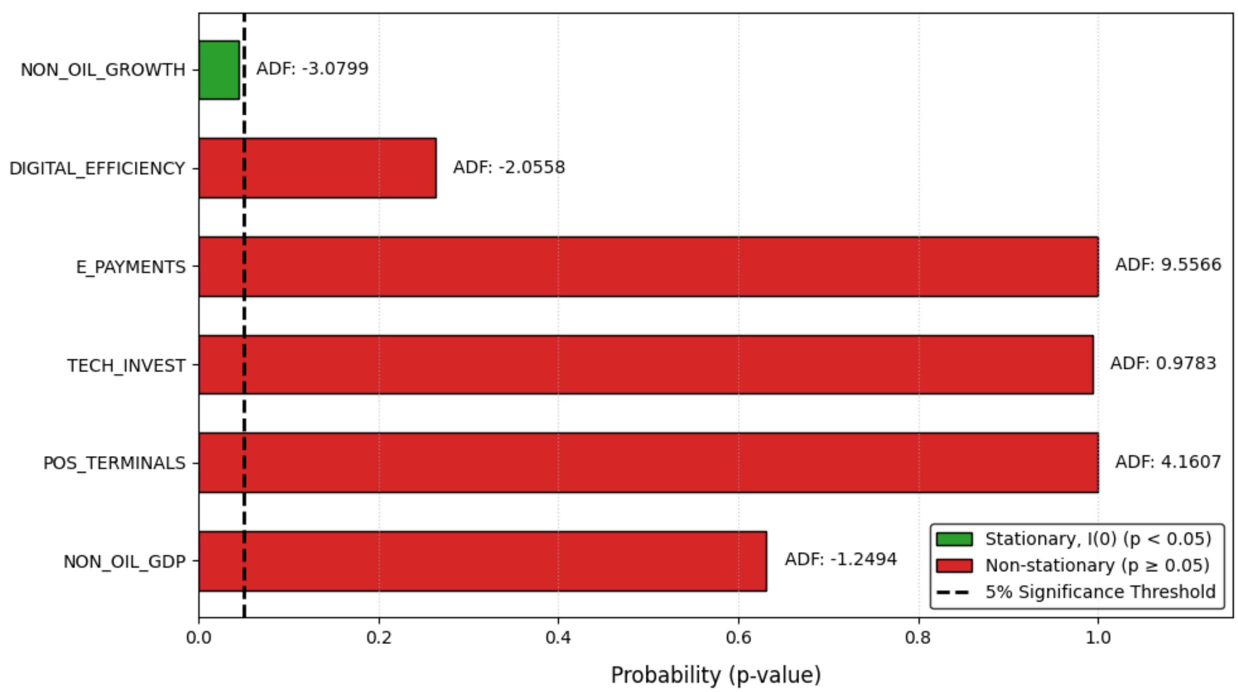


Figure 1. ADF unit root test results at level

The other variables associated with technological and financial development (DIGITAL_EFFICIENCY, E_PAYMENTS, TECH_INVEST, POS_TERMINALS and NON_OIL_GDP) have non-stationary level trends. They are all greater than 0.05 which implies that the null hypothesis of a unit root cannot be rejected. These variables show signs of stochastic trend, which means that they might need differencing or a dynamic modelling approach.

The mixed order of integration (stationary dependent variable and non-stationary explanatory variables) justifies the application of ARDL approach. The ARDL model can be used when the variables are integrated of order I(0), I(1) or some combination of the two but not integrated of order I(2). Thus, the study continues with the estimation of ARDL-type models to take account of the short-run and long-run dynamics.

Testing the Main Hypothesis: Multiple Linear Regression Model

The results of an Ordinary Least Squares (OLS) regression estimating the contemporaneous relationship between non-oil economic growth and two key technological infrastructure variables, technological investment (TECH_INVEST) and the number of point-of-sale terminals (POS_TERMINALS) in Table 4. The constant is positive but statistically insignificant ($\beta = 0.0256$, SE = 0.0282, $t = 0.907$, $p = 0.376$), suggesting that if the explanatory variables were not changing, there would be no difference between the non-oil growth rate and zero at conventional levels of significance.

Table 4. OLS Estimation Results for the Relationship between Non-Oil Growth, Technological Investment, and POS Terminals

Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**Prob.**
C	0.0256	0.0282	0.9070	0.3764
TECH_INVEST	5.41E-05	6.30E-05	0.8591	0.4016
POS_TERMINALS	-9.31E-07	8.22E-07	-1.1330	0.2721

Source: Author's calculations based on EViews outputs.

The coefficient on technological investment is positive but fails to attain statistical significance ($\beta = 5.41 \times 10^{-5}$, SE = 6.30×10^{-5}, $t = 0.859$, $p = 0.402$). That is, for a given year's technological investment increase of 1 million USD, an increase of 0.0054 percentage point is estimated, but the range of confidence is wide, making it impossible to make any definite conclusions regarding the direction and size of the actual effect. Likewise, the coefficient on the POS terminals is negative but not statistically significant ($\beta = -9.31 \times 10^{-7}$, SE = 8.22×10^{-7}, $t = -1.133$, $p = 0.272$), meaning that, at least in isolation and without taking account of time dynamics, there is no strong linear relationship between the mere growth of electronic payment infrastructure and contemporaneous GDP growth in non-oil industry.

The OLS model does not offer a strong statistical support for the existence of a direct contemporaneous relationship between technological investment, POS terminals, and non-oil economic growth. But the lack of good explanatory power, potential residual autocorrelation, and the non-stationarity of some of the explanatory variables, as described in the unit root tests, indicate that the simple OLS specification is not sufficient to capture the complex temporal linkages that lie within this relationship. Hence, the study moves to using Autoregressive Distributed Lag (ARDL) model, which is more appropriate to consider the lagged effects, consider the short run level relationship from long run relationship and to obtain consistent estimates in the presence of mixed order integration between the variables.

Three principal diagnosis tests were performed to test the validity of the linear regression estimates and to evaluate if the model meets the classical regression assumptions: the Breusch-Godfrey serial correlation LM test, the White's heteroskedasticity test and the Jarque-Bera normality test in Table 5.

Table 5. Diagnostic Test Results for the Linear Regression Model

Test	**Statistic**	**Probability**	**Null Hypothesis**	**Decision**
Breusch-Godfrey F-statistic	1.728	0.2092	No serial correlation	Do not reject H0
Breusch-Godfrey Obs*R-squared	3.730	0.1549	No serial correlation	Do not reject H0
White F-statistic	1.2096	0.3517	Homoskedasticity	Do not reject H0

White Obs*R-squared	6.034	0.3029	Homoskedasticity	Do not reject H0

Source: Author’s calculations based on EViews outputs.

The first test was Breusch-Godfrey test for examining the presence of serial correlation up to the second lag. The null hypothesis is that there is no significant serial correlation in the residuals. The results indicate that the F-statistic value is 1.728 and the probability value is 0.2092. Likewise, the Obs*R-squared is about 3.73 and the probability value for Chi-square is 0.1549. As these values are both above the 5% significance level, the null hypothesis is not rejected. This suggests that the lag structure examined does not provide any statistically significant evidence of serial correlation.

Second, White's test was performed to determine if there was equal error variance. This test is used to test the null hypothesis that the residuals are homoskedastic. The F-statistic is 1.2096 with a probability value of 0.3517 and the Obs*R-squared is 6.034 with a Chi-square probability value being 0.3029. The probability values obtained are higher than the 0.05 value so that the null hypothesis cannot be rejected. The model is therefore said to be free of the heteroskedasticity problem and the variance of the residuals is assumed to be constant.

Third, the normality of the residuals of linear regression model was checked by plotting the residual histogram and applying the Jarque-Bera test. The results of normality test are shown in Figure 2.

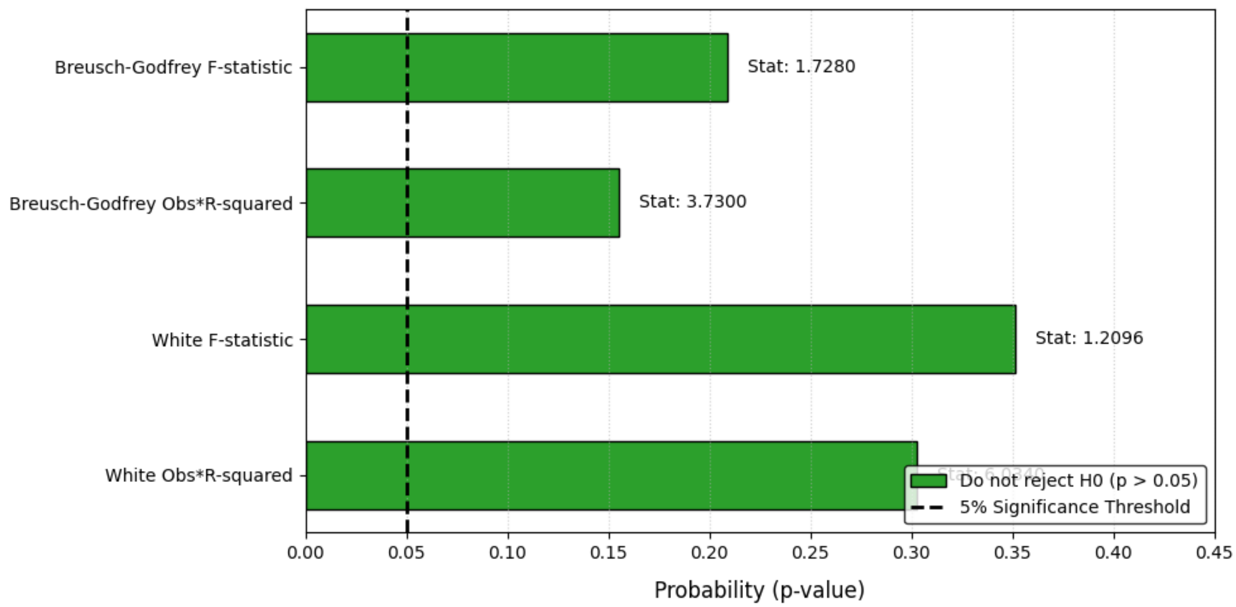


Figure 2. Diagnostic Test Results for Serial Correlation and Heteroskedasticity

The histogram and summary statistics of the OLS regression residuals for the sample period 2005-2025 (N = 21) are shown in Figure 3. Graphically, the residuals are fairly evenly distributed around zero, and have a median value of 0.0022 and a mean value of 1.65×10^{-18}. The distribution is moderately skew (- 0.691) and kurtotic (3.439), which are near the theoretical values of zero and three respectively. The Jarque–Bera test is applied to a series of formal assessments resulting in a value of 1.838 and a probability value of 0.399. This p-value is greater than the set level of significance (5%), so the null hypothesis (normally distributed residuals) cannot be rejected. Hence, OLS assumptions are met.

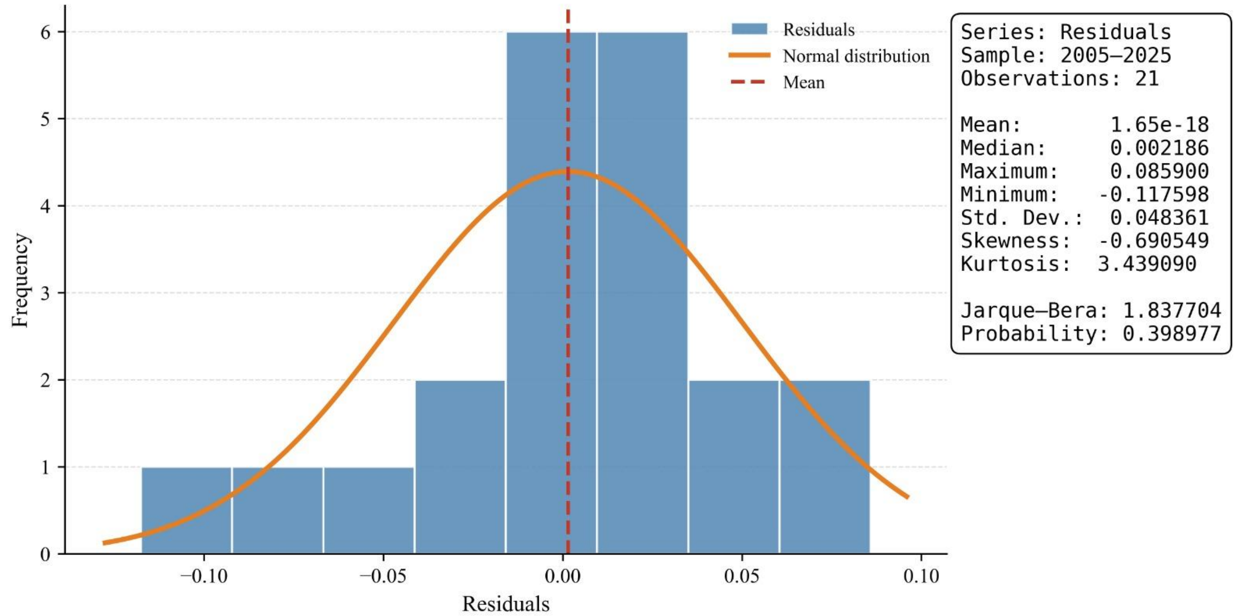


Figure 3. Histogram and Jarque-Bera Normality Test of OLS Residuals

The classical regression assumptions are also not violated as confirmed by supplementary diagnostic procedures. The Breusch-Godfrey LM test for serial correlation and White's test for heteroskedasticity do not reject their null hypotheses at the 5% level, suggesting that the residuals are not significantly serially correlated and are not heteroskedastic. In total, all these results provide a measure of internal consistency and lack of serious econometric misspecification in the OLS specification. But, satisfying the diagnostic assumptions is no justification for the poor explanatory power of the model. The contemporaneous estimates of the coefficients for technological investment and POS terminals are still not statistically significant, as is the overall fit, which does not explain anything substantial in terms of non-oil economic growth. Moreover the time series character of the data makes it difficult to ignore the possibility of non-stationarity that a constant form of OLS can not easily accommodate.

The diagnostic tests indicate that the OLS model meets the assumptions of no serial correlation, homoskedasticity, and approximate normality for the residuals, as indicated by the Jarque–Bera test. However, the explanatory variables were not statistically significant and the ability of the static specification to explain the economic relationship is limited. Considering the possible existence of a dynamic adjustment, lagged effects and mixed integration orders for the variables, the study moves forward to the Autoregressive Distributed Lag (ARDL) approach.

This approach is meant for non-stationary time series that are able to decompose short run variations from long run equilibrium dynamics and that offer more trustworthy inference on the effect of technological infrastructure on the development of non-oil Iraqi economy.

The result of the ARDL analysis in Figure 4 indicates that the contemporaneous coefficient of TECH_INVEST is positive and statistically significant at 1% level. The coefficient is 0.0002818, with a probability value of 0.0000518. This means that, according to Table 6, in the short run, an increase in technological investment has a positive impact on non-oil economic growth in the same year. Specifically, a USD1 million increase in technology investment leads to an average increase of about 0.00028 percentage points in the growth of the non-oil sector, while controlling for other factors.

Table 6. ARDL(2,2) Estimation Results for NON_OIL_GROWTH and TECH_INVEST

Variable	**Coefficient**	**Standard Error**	**t-Statistic**	**Prob.**
NON_OIL_GROWTH(-1)	0.5841	0.2605	2.2423	0.0430
NON_OIL_GROWTH(-2)	0.0425	0.1867	0.2277	0.8234
TECH_INVEST	0.0002818	4.77E-05	5.9062	0.0000518
TECH_INVEST(-1)	-0.0003011	0.0001160	-2.5956	0.0222
TECH_INVEST(-2)	-8.42E-05	0.0001023	-0.8235	0.4251
C	0.04123	0.01482	2.7814	0.0156

Model statistics: R-squared = 0.8310; Adjusted R-squared = 0.7660; F-statistic = 12.78; Prob. F-statistic = 0.000122; Durbin-Watson = 2.298. **Source:** Author’s calculations based on EViews outputs.

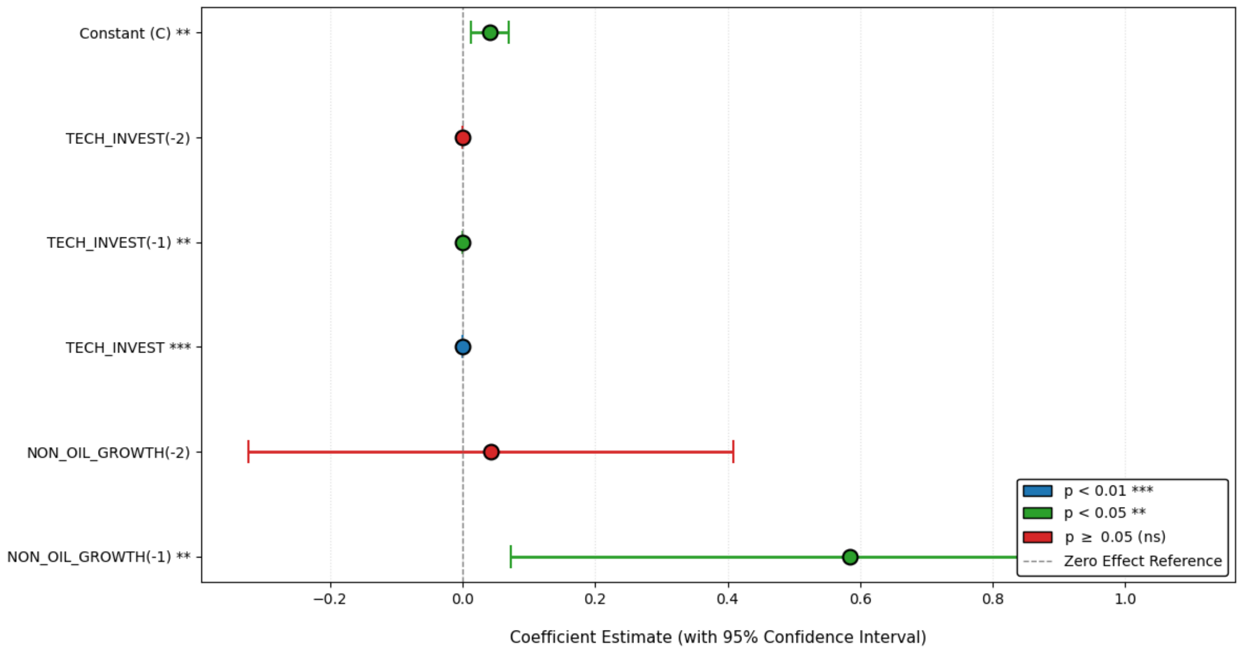


Figure 4. ARDL estimation, coefficient plot of the dependent variable

The coefficient of TECH_INVEST(-1) is also negative and statistically significant with a value of -0.0003011, and a probability value of 0.0222. This indicates a decrease in the short run adjustment effect in the next year. That is, technological investment can have an immediate positive impact, but some of this impact can be a negative impact or adjustment in the next period. This can be due to implementation time lag, adjustment costs, institutional factors, or investment in technology to achieve productive capacity.

The second lag of technological investment (TECH_INVEST(-2)) is negative but statistically insignificant with a probability value of 0.4251. Thus, after two years this specification has no convincing statistics of direct technological investment effect on non-oil growth.

Non-oil growth (-1) is positive and significant at the 5% level, suggesting persistence in non-oil growth. This implies that the growth in the past at least partially affects the growth in the present. However, the NON_OIL_GROWTH(-2) is not statistically significant.

Overall, the model is very good in explaining non-oil growth with an R-squared of 0.831, representing about 83.1% of the variation in non-oil growth. The adjusted R-squared value is also 0.766, which is a relatively good fit, with the number of regressors taken into account. The F-statistic is statistically significant at the 1% level with a probability value of 0.000122, which means that the model is jointly significant. Furthermore, the Durbin-Watson statistic of 2.298 indicates that there is no serious positive serial correlation in the model.

In respect of long-run relationship, the cointegrating equation's coefficient obtained is -0.000277 while the p value is 0.0551. This is a result that is just statistically significant at the 10% level, but not the 5% level. Hence, there is limited evidence of any long run effects. The implication of this is that the influence of technological investment is more distinct and significant in the short-run than in the long-run on non-oil sectors economic growth. One way to explain the small long-term effect is that the institutional, regulatory and structural characteristics limit the capacity of technological investment to provide long-term economic benefits.

The findings of the study support the main hypothesis in the short term. A short-run relationship between technological investment and non-oil economic growth is positively and statistically significant. The long run relationship is, however, weaker, and is of only weak significance. Hence, the primary hypothesis is confirmed in the ARDL model and the qualification is that the relationship is mainly short-term and dynamic.

The behaviour of the cointegrating series extracted from ARDL (2,2) model is shown in figure 5. This series is short-run deviations from the long-run equilibrium relationship between technological investment and non-oil economic growth. The series doesn't show any trend of a steady increase or decrease over time, and the mean is close to zero, suggesting a long-run stable relationship between the variables. In particular, the series shows a tendency to return to the equilibrium line after important economic events, especially after the oil price collapse of 2014 and the COVID-19 pandemic of 2020. This is a mean reverting behavior, indicating that changes in the extremes of the long run equilibrium are only temporary and the system reverts to that equilibrium over time.

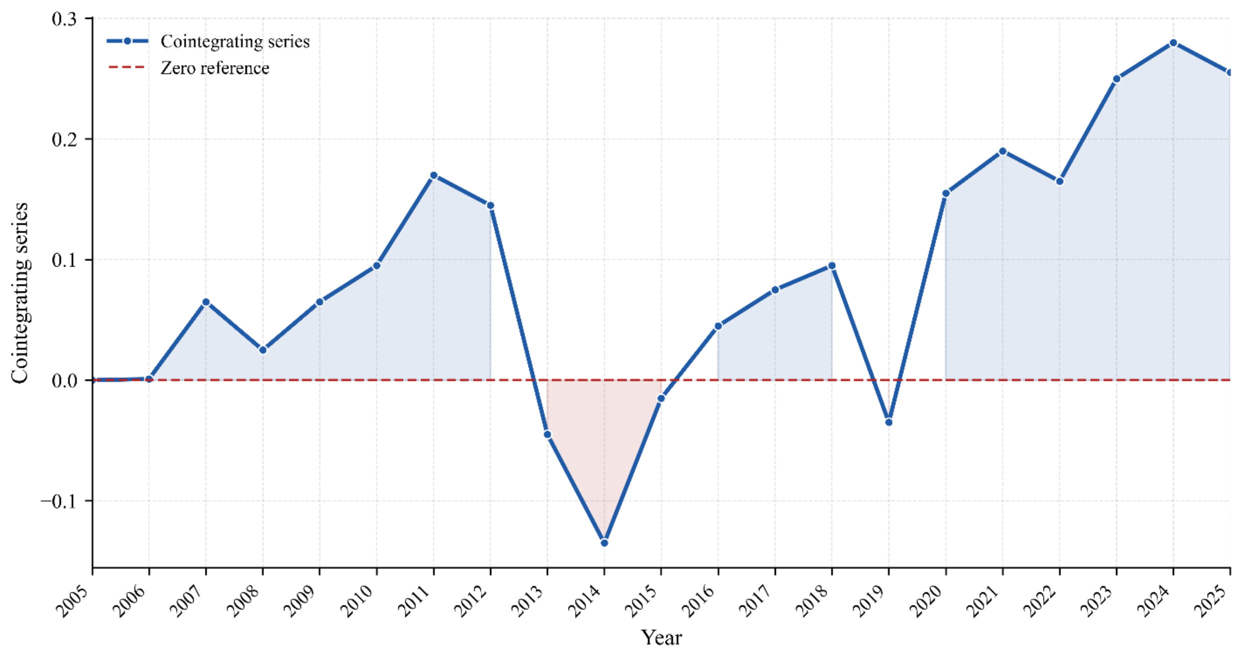


Figure 5. Cointegrating Series from the ARDL (2,2) Model.

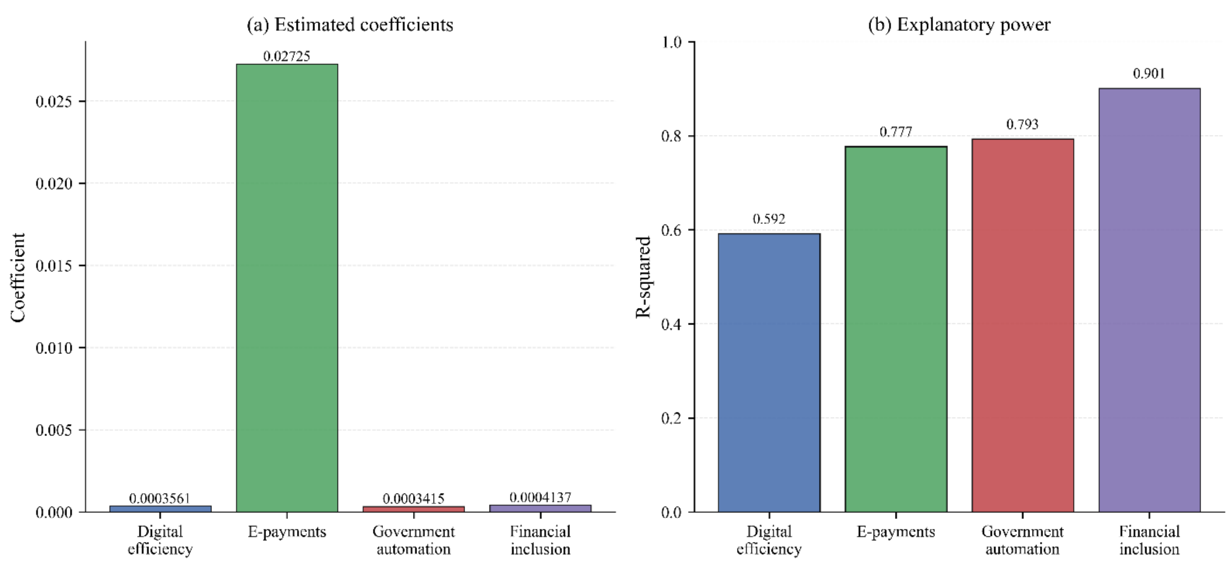
The results of the visual stability test also support the error correction representation in the ARDL model and the reliability of the estimated dynamics relationship. This is only graphical evidence though, and should be used alongside the formal statistical conclusions. Technological investment seems cointegrated but the LR coefficient is not highly significant at the 10% level. Thus, while the cointegrating series does confirm the presence of a dynamic equilibrium relationship, the magnitude and degree of precision of the long run impact of technological investment on non-oil growth must be interpreted with care. Overall, the results indicate that technological infrastructure plays a role in the economic diversification of Iraq, but that the effects of this infrastructure in the long-term may be affected by institutional, structural or external conditions which need to be explored further.

The result of simple linear regressions on the bivariate association between technological investment (TECH_INVEST) and four key indicators of digital and financial development are displayed in Table 7. Technological investment is positively related to all four explanatory variables at the 1% level. Digital efficiency (DIGITAL_EFFICIENCY) has a positive coefficient ($\beta = 0.00036$, $p < 0.001$) and R^2 of 0.592, suggesting that there is a moderate association between institutional and technical digital capacity and digital technology spending in Figure 6. However, electronic payment volume (E_PAYMENTS) has a much higher coefficient value (β = 0.0273, $p < 0.001$; $R^2 = 0.777$) and government automation (GOV_AUTOMATION) has a similar coefficient value (β = 0.00034, $p < 0.001$; $R^2 = 0.793$). The financial inclusion indicator (FINANCIAL_INCLUSION) shows the highest level of statistical significance with a highly significant positive coefficient (β = 0.00041, $p < 0.001$) and an R^2 of 0.901, indicating that the inclusion of financial services in the formal sector is very closely co-varying with technological investment over the sample period.

Table 7. Regression Results of TECH_INVEST with Digital Transformation and Financial Inclusion Variables

Equation, Dependent Variable ~ TECH_INVEST	Coefficient	Prob.	R-squared	Statistical Significance
DIGITAL_EFFICIENCY	0.0003561	0.0000458	0.5917	Significant
E_PAYMENTS	0.02725	1.307E-07	0.7769	Significant
GOV_AUTOMATION	0.0003415	6.326E-08	0.7931	Significant
FINANCIAL_INCLUSION	0.0004137	5.556E-11	0.9008	Significant

Source: Author's calculations based on EViews outputs.



Notes: All reported coefficients are statistically significant at the 1% level. Source: Author's calculations based on EViews outputs.

Figure 6: Effects of digital transformation and financial inclusion indicators on technology investment.

The outcomes of these sub-hypothesis regressions reveal that technological investment is positively associated with the following selected digital transformation indicators, showing strong relationships. The results confirm that technological investment promotes the improvement of electronic payments, financial inclusion, and government automation. The models are simple linear regression; however, the results are not to be interpreted as proof of cause and effect. The results, however, are useful to substantiate the theoretical arguments for focusing on intermediary variables in the more robust ARDL framework used in the main analysis and for investigating the possible channels through which technological infrastructure investment could impact on non-oil economic growth.

Discussion

In this regard, this study gives new empirical evidence to the dynamic relationship between technological infrastructure investment and non-oil economic growth in a hydrocarbon economy in Iraq, which is at the early stages of digital transformation. Beyond the static contemporaneous specifications, we propose an Autoregressive Distributed Lag (ARDL) model, which shows a strong short run growth dividend effect due to the technological investment and a nearly significant long run equilibrium relationship. The results highlight the need for the temporal dimension, institutional environment, and complementary reforms for the successful shift from digital capital to economic diversification.

The positive and significant contemporaneous coefficient of technological investment is consistent with the endogenous growth theory that assumes that the accumulation of capital in knowledge-based industries leads to immediate productivity spillovers that are achieved in the form of increased efficiency in transactions, decreased information asymmetries, and better service delivery. The firstlag coefficient is, however, negative and statistically significant, indicating a short-run adjustment period that may be due to implementation bottlenecks, worker skill mismatch, or costs of temporary reallocation of resources. The lack of a large second-lag effect, plus the large lag-1 effect on the non-oil growth variable, suggests that technological investment is more productive in the short run, but takes time to spread out across sectors. This is consistent with recent literature on investments in the emerging economies; digital investments have been known to deliver short-term profits, but they can also stagnate when absorptive capacity is limited, regulatory fragmentation is present or supporting complementary infrastructure is insufficient (Daruwala et al., 2025).

In the long run, the coefficient from the cointegrating equation is negative and barely significant at 10% level, indicating that the growth enhancing impact of technological investment is not fully sustainable in the long run without institutional and structural support. This is a different attenuation than has been found in advanced economies, where the long-run productivity elasticities of ICT capital are durable, albeit comparable to results from resource dependent and post transition economies. There are structural rigidities in Iraq—such as bureaucratic inefficiencies, low private sector involvement in the digital economy, oil price sensitivity, and unequal human capital development—that may be why the impact of the weak long run. The marginal significance does not mean the irrelevance but it indicates that technology investments are not enough for the sustainable growth (Chen et al., 2024).

The strong positive links between technological investment and digital efficiency, electronic payment volume, government automation and financial inclusion confirm the hypothesized channels of transmission. These intermediary variables are likely to facilitate the initial impulse to grow and reduce transaction costs, formalise informal economic activity, enhance public service delivery and increase access to credit. This extremely high R^2 of financial inclusion (0.901) indicates that technological investment and formal financial access are closely interconnected, possibly driven by policy coordination or common policy drivers, such as central bank digital initiatives or telecom sector liberalization. It is recommended that the intermediaries be added as endogenous transmission variables into future structural modelling to provide an estimation of the intermediary variables' marginal roles on growth elasticity (Boutfssi et al., 2026).

Although the sample period contains some key transition years, it is relatively short for time-series econometrics, which could impact the accuracy of longer-run estimates of coefficients and the ability of structural break tests. The use of the aggregate proxies (such as TECH_INVEST, POS_TERMINALS) might mask sectoral variations, qualitative aspects of digital adoption, and spatial variations among governorates. Furthermore, ARDL model is suitable for mixed order integration but it does not fully address the possible problem of endogeneity due to reverse causality and the omission of institutional variables. Disaggregated firm- or sector-level data should be used in future research, since it allows for additional detail, and there is a need for non-linear adjustment phases which can be accounted for using threshold regression or Markov-switching models, and for qualitative measures of regulatory quality and human capital alignment. Research in this policy field could be further enriched by exploring spatial spillovers, cross-border digital trade linkages and by examining the interactions between technological investments and climate resilient infrastructure.

Conclusion

The findings of this study show that technological infrastructure investment has positive effects on the non-oil economic growth of Iraq, especially in the short term, but the effects are less stable in the long term, and need supportive institutional frameworks. Its impact is immediate, but also via key intermediate mechanisms: digital efficiency, electronic payments, government automation and financial inclusion; all of which have been significantly boosted through technological spending. The digital transformation of Iraq is characterized by a nonlinear pathway and delayed effect, showing a significant acceleration following 2019, and highlighting the importance of using flexible econometric methods such as ARDL, which are able to detect lagged effects and structural breaks. Technology-led diversification is a desperate course towards sustainable growth in Iraq's non-oil sector, which is facing high volatility in the wake of external oil shocks and internal instability. Importantly, these relationships were not captured in the static linear models, emphasizing the need for methods that are aligned with the properties of time-series data.

Accordingly, policy priorities should entail: (1) continuing investment in broadband and digital infrastructure, particularly in areas that lack it; (2) concerted effort to develop transmission channels to boost e-payments, digital wallets, and automated public services; (3) implementing a 10-year national digital strategy with dedicated funding, skills development, and data-protection legislation; (4) complementing technological investment with structural reforms to stabilize the investment climate and facilitate the development of technology-based SMEs; and (5) using regional partnerships and international technical assistance for the acceleration of

Iraq's digital integration. All of these measures can contribute to the transition from short-term technological progress towards sustainable and sustainable economic diversification.

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