JEAS, Vol. 31 No. 146 (2025) pp (116-140)
P-ISSN 2518-5764 - E-ISSN 2227-703X
DOI: https://doi.org/10.33095/7a6y2g34

Journal of Economics and Administrative Sciences

The Role of the Digital Economy in Enhancing Economic Development in Iraq: A Strategic Analysis of Transformation Opportunities and Challenges

Aveen Khalid Ahmed Khalid
College of Administration and Economics,
Economics Department, University of Duhok
Duhok, Iraq

Received:19/1/2025 **Accepted: 4/3/2025** **Published: 1/4/2025**

Abstract:
This study examines the role of the digital economy in enhancing economic development in Iraq, focusing on the period from 2003 to 2022. Utilizing an Autoregressive Distributed Lag (ARDL) model, the research analyzes the relationship between GDP growth and key digital economy indicators, including the E-Government Development Index (EGDI), E-Participation Index (EPI), Online Service Index (OSI), Telecommunication Infrastructure Index (TII), and Internet Usage (UI). Data were sourced from the World Bank, International Telecommunication Union (ITU), and United Nations E-Government Survey. The ARDL model, selected based on the Akaike Information Criterion (AIC), was employed to capture both short-term dynamics and long-term equilibrium relationships. Diagnostic tests, including Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), Toda-Yamamoto causality, and cointegration tests, were conducted to ensure model robustness. The findings reveal significant positive relationships between GDP growth and digital economy indicators, particularly EGDI and UI, highlighting the importance of e-government development and internet penetration in driving economic growth. However, EPI and TII showed negative long-term impacts, suggesting structural and institutional challenges. The study concludes that targeted investments in digital infrastructure, regulatory reforms, and capacity-building initiatives are essential for leveraging digital transformation to achieve sustainable economic development in Iraq. Policymakers are advised to prioritize digital inclusion and innovation to reduce oil dependency and foster economic resilience.
Key Word: Digital Economy, Economic Development, Iraq, ARDL, Internet Penetration

1. Introduction:

The digital form of economy has come out as the key factor for economic change across the world, acting as a catalyst for growth, innovation, and transformation towards sustainability. As Iraq attempts to reconstruct the basis of its economy and seek new sources of income besides an over-reliance on its oil sector, information technologies offer themselves as an essential mechanism for promoting the country's economic sustainability and diversification. ICTs being adopted in e-government services, telecommunication infrastructure, and internet access have useful impacts, including increasing productivity, developing improved public service delivery, and promoting innovation in the private sector. However, the achievement of these opportunities is more a hoped-for dream due to the following challenges: technological weaknesses, inadequate regulatory frameworks, and socio-economic inequities. This research aims to identify the effects of the digital economy in promoting economic development in Iraq by analyzing the strengths and challenges of change with the help of a wide-ranging methodical approach. The previous literature highlights how digital economies are revolutionizing developmental progress within countries, especially in developing countries. Specifically, (Al-Roubaier et al., 2020) and (Barata, 2019) have discussed the reels of digitalization in the diversification of the economy and achieving income equality, while (Chen et al., 2023) and (Ding et al., 2021) distinguished technological innovation in attaining high-quality growth through digitalization. In Iraq, nevertheless, the existing literature has been found to be significantly lacking in terms of the analytical investigations of the relations between digital assets and economic growth. This study intends to fill this gap by focusing on key dimensions of development, including economic growth, to explain GDP growth rate, e-government development, and internet usage (2003-2022). Based on the findings of this study using sophisticated econometric models such as the ARDL method, the paper presents a more profound causal effect of digital economy factors with economic ramifications, potential recommendations for overcoming challenges affecting the development of Iraq's digital economy, and implications for policymakers and all those with a vested interest in the future growth of its economy.

2. Literature review and Hypothesis Development:

In recent years, the literature proposing the importance of the digital economy in the process of economic development has enlarged notably because the significance of digitalization in the process of economic evolution has gained more appreciation. It should be noted that (Al-Roubaier et al., 2020) point out that digital technologies help to drive new sector creation and improve efficiency in the context of resource-dependent economies and their diversification. In the same vein, (Barata, 2019) also points out that the digital economy has an opportunity to support the development of inclusive and fair income generation in the context of the increase in the role of digitalization for improving the distribution of income in developing countries with traditional inequality-enhancing economic models. (Chen et al., 2023) go further explaining how, through the development of the digital economy, one can enhance the capability of high-quality development by proposing a systematic enhancement of technology advancement and the improvement of resource allocation efficiency. These are considerations poignant in the case of Iraq, given the nation's dependency on oil revenues and the societal imperatives for economic diversification. The study done by (Ding et al., 2021) employs spatial and mediation analysis of the digital economy of high-quality development, further explaining the aspect of regional difference and technological innovation as a mediator. Consequently, this perspective is important for the explanation of the highly variegated effects of digitalization occurring in Iraq and in the regions characterized by the existing inequalities and infrastructural deficits. In the paper by (Gaziz et al., 2020), the authors make a more general discussion on the contribution of the digital economy to economic development that lies in integration, governance, and private sector development.

These findings are in line with the study by (Li & Wu, 2023) that analyzes the effects of the digital economy on the expansion of consumption and its relation to sustainable development. In the above case of Iraq, where internet connection and e-government services have been growing but in a slow manner, these studies can help in estimating the gains that could be achieved under digitalization. (Luo et al., 2023) also join this conversation by focusing on how digitalization brings about green innovation, a subject that has research attention to the role of digital technologies as not only drivers of economic growth but also enhancers of Sustainable Environment. This is equally relevant for Iraq, an environment whose degradation, combined with resource mismanagement, has long-term economic ramifications. It stresses the digital economy for achieving sustainable development goals with special reference to policy support and institutional frameworks. (Mottaeva et al., 2023) Build on this further by applying this to look at the effects of the digital economy on the formation of economic systems, more so in transition economies. According to these studies, they were able to conclude that 'while capital-intensive technologies such as digitalization can facilitate structural change in societies, they require complementary investments in education, infrastructure, and institutions to do so.' Using the dynamic coupling perspective, the temporal and spatial analysis of (Shen et al., 2022) reveals the trajectory of high-quality economic development and the digital economy. (Uddin, 2024) has shared a real-life example with Bangladesh to depict how digital economy business models can foster economic development in a resource-scarce environment. (Wang & Zhang, 2022) explore the moderating role of the digital economy between environmental regulation and high-quality development by stressing the coupled approaches of economic and digital policies. Wang et al. extend this discussion of the carbon-mitigation effects of the digital economy, insisting on its sustainable development impact. (Wei et al., 2023) investigate how the digital economy helps improve the sports industry, and show the importance of digitalization for industries. In this work, (Xia et al., 2024) explore the digital economy regarding technological progress and electronic communication, emphasizing the issues of digital transformation. Furthermore, (J. Zhang et al., 2022) and (W. Zhang et al., 2021) present insights into the determinants of the digital economy and its implications on economic growth in the new normal with the policy implication of targeted deployment of digital technologies and investments. Taken in their entirety, these studies offer strong theoretical and empirical underpinnings for the ways in which the digital economy affects the concept of development and can be utilized by policymakers and stakeholders within Iraq when trying to address the issues emerging from the digital economy.

In this respect, this research offers a rich and contextual understanding of the purpose of the digital economy in the context of supporting the further growth of the Iraqi economy, which has not been extensively explored in prior research. Although (Al-Roubaier et al., 2020) previous works explored the change in the role of digitization on the EEI and income solving, this research determines the digital diversification, paradox, and depth of challenges and threats particular to Iraq, a post-war, oil-dependent, with severe infrastructural development deficiency. Given that this paper uses the sophisticated Autoregressive Distributed Lag (ARDL) model, this study contributes to the literature by providing a more realistic analysis of the long-run causal relations between the selected digital economy variables: e-government development, e-participation, telecommunication, fixed broadband and mobile subscriptions, and internet usage in relation to GDP growth during the years 2003–2022. This sequential design enables a more nuanced analysis of the emerging effects of digitalization on a transforming economy while responding to the critiques of (Chen et al., 2023) and (Ding et al., 2021) that suggested that further studies need to be spatially and temporally resolved. Besides, the present study continues (Gaziz et al., 2020) and (Li & Wu, 2023) by applying regional differences and infrastructural conditions in the analytical framework to offer recommendations for policymakers seeking to use digital technologies to advance sustainable development.

Further, expanding on the work of (Luo et al., 2023), the study also looks at the same functions as a positive outlet for economic growth and a negative aspect in relation to environmental impacts – something of immense importance for Iraq given the country's past with resources mismanagement. Thus, synthesizing these various views, this study not only enhances the theoretical knowledge of the digital economy in the context of developing the economy but also provides specific country-specific recommendations for Iraq, which seems to be highly relevant for the topic and lacks serious coverage in the existing literature, enriching the overall theoretical and methodological framework along with the existing discussions regarding digital transition in developing countries.

2.1 Hypothesis Development:

The rapid expansion of the digital economy has significantly influenced economic development worldwide. Digital infrastructure, e-government services, and internet penetration play crucial roles in shaping modern economic dynamics. In the context of Iraq, where economic diversification remains a primary challenge, understanding the impact of digital transformation is essential. Based on existing literature and theoretical foundations, the following hypotheses are proposed to examine the relationship between digital economy indicators and economic growth in Iraq:

H1: The development of e-government services positively influences economic growth in Iraq.

E-government services enhance transparency, reduce administrative inefficiencies, and improve public service delivery. Prior studies suggest that well-developed e-government platforms facilitate economic transactions and governance efficiency, leading to increased GDP growth.

H2: The e-participation index has a significant impact on economic growth in Iraq.

Digital citizen engagement through e-participation platforms fosters greater inclusivity in policy-making and governance, potentially enhancing economic decision-making. However, the extent of this influence remains uncertain due to variations in digital literacy and infrastructure challenges.

H3: The online service index positively affects economic growth in Iraq.

Efficient and accessible online services contribute to business efficiency, reduce transaction costs, and promote digital entrepreneurship. Increased access to digital public services can stimulate productivity and economic expansion.

H4: Telecommunication infrastructure development significantly contributes to economic growth in Iraq.

A robust telecommunication infrastructure facilitates digital connectivity, business innovation, and information accessibility. While telecommunication networks are fundamental to digital economic activities, their effectiveness depends on regulatory frameworks and investment levels.

H5: Internet penetration positively influences economic growth in Iraq.

A higher rate of internet usage fosters innovation, enhances communication, and integrates Iraq into global markets. Prior research highlights the role of internet penetration in expanding market access and driving knowledge-based economic growth.

The above hypotheses will be tested using an Autoregressive Distributed Lag (ARDL) model to capture both short-term and long-term relationships between digital economy indicators and economic growth in Iraq. The findings will provide empirical evidence on the role of digital transformation in shaping Iraq's economic future and offer policy recommendations for fostering a sustainable digital economy.

3.Research Methodology:

The approach used in this study is focused on providing the most scientific investigation of the connection between the digital economy and economic development in Iraq, employing both quantitative methods as well as the most progressive methods of econometrics. To test hypotheses, the study adopted annual data for the period 2003 to 2022 based on the following variables: Economic Growth rate, EGDI, EPI, OSI, TII, and UI. These comprised the World Bank indicator database World Bank, Communication & Information Technology indicators for the International Telecommunication Union (ITU) (International Telecommunication Union, 2023), and e-government scores from the United Nations United Nations to enhance reliability and consistency in data collection. To this end, the empirical specification of the analysis relies on the Autoregressive Distributed Lag (ARDL) model, which is well suited for capturing long-run and short-run dynamics among variables and is useful when variables are of mixed orders of integration. These make the ARDL model suitable for the current study because it can handle small sample sizes and yield unbiased estimates when there are different, integrated variables. As for the model selection criteria, in particular, the choice of lag length and model specification, the AIC method was applied. To assess the reliability of the findings of this study, this study conducts diagnostic tests, including the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test to check the stationarity of the data, The Toda-Yamamoto causality test for directional relationships, the Breusch-Godfrey serial correlation LM test for diagnostic check and the Breusch-Pagan-Godfrey heteroskedasticity test for model appropriateness check. Moreover, the Ramsey RESET test is employed to determine the presence or absence of specification errors, and F-bounds and t-bounds tests are used to establish cointegration in variables. All econometric estimations and statistical tests were carried out with EViews 13, an industry-standard software that enables accurate estimation of the model involved and the production of diagnostic tables. The employment of EViews 13 results in an accurate estimation of parameters, which in turn makes the results more dependable in assessing the effects of the digital economy on Iraq's economic growth and development. By adopting, employing, and incorporating these methodological tools and techniques, this study offers a scholarly, comprehensive, and evidence-based analysis to offer worthwhile findings in the literature on digitalization, the digital economy, and economic growth.

3.1 Data and Relationship Analysis:

The data set utilized in this research includes measures across six variables that are very important in revealing the ICT dimensions influencing the digital economy and economic development in Iraq. The first variable used, Gross Domestic Product- Growth (annual %) (EG), is the leading measure of development within an economy, which depicts the annual percentage change in the value of the goods and services output. This is the index of the percentage change in the real GDP from the previous year: it indicates how well and how robust the economy is. The second one is the E-Government Development Index (EGDI) (or EGD), constructed by the United Nations to measure the readiness and/or ability of the national government to deliver services using ICT. The EGDI is calculated as a weighted average of three normalized indices: the Online Service Index (OSI), which quantifies the quality and the spread of online services; The TII, which measures the status of ICT infrastructure; and HCI, the people's capability to employ ICT. The third variable, E-Participtation Index, also known as EPI [**], is a second-order index that is used side by side with the other three indexes to measure the degree to which a government involves its citizens in decision-making via electronic platforms. Existing online resources, electronic consultations, and e-decision-making resources are used to calculate them and describe the degree of digital openness and democratic participation and engagement. The fourth variable, the Online Service Index (OSI) (OSI), is most closely associated with the quality and coverage of government online services, including the provision of information and the ability to perform transactions and deliver integrated services. This index is based on an analysis of accessibility and features of National Government portals.

The fifth variable, the Telecommunication Infrastructure Index (TII) (TII), measures the development of ICT infrastructure, such as fixed and mobile phone subscriptions, internet bandwidth, and broadband connectivity. Since this index is vital as a driver of advancement in the development of worksites, the basic issues that it explains are necessarily types that matter. The sixth variable is the UI variable, or the individuals using the Internet (% of the population), which depicts the level of Internet usage by the population resulting from digital inclusion and diffusion of outright digital resources. This variable is obtained using household surveys and administrative records, which give information on the proportion of the population connected to the Internet and the possibility of disruption to economic and social activities. Altogether, these variables sum up an encompassing picture in assessing the part of the digital economy in the promotion of economic development; each variable is designed to shed light on another aspect of the process of digitization and its economic effects.

The theoretical relationship between digital economy indicators and economic development is grounded in the transformative role of digitalization in enhancing productivity, innovation, and economic diversification. Digital infrastructure, including e-government services, telecommunication networks, and internet penetration, catalyzes efficiency in both public and private sectors, facilitating faster information exchange, reducing transaction costs, and improving service delivery (Al-Roubaier et al., 2020). The expansion of digital services fosters economic inclusion by enabling broader access to financial services, education, and markets, which in turn stimulates entrepreneurship and job creation (Chen et al., 2023). E-government development strengthens governance by increasing transparency, reducing corruption, and improving institutional efficiency, thereby creating a more stable economic environment (Gaziz et al., 2020). Internet penetration and digital connectivity further drive economic growth by accelerating knowledge transfer, fostering innovation, and integrating economies into global digital markets (Ding et al., 2021). However, the impact of digitalization on economic development is contingent on several factors, including regulatory frameworks, institutional readiness, and digital literacy levels (Mottaeva et al., 2023). Without adequate infrastructure and policy support, digital transformation may exacerbate inequalities, as regions with limited access to digital technologies may experience slower growth. Thus, achieving sustainable economic development through digitalization requires comprehensive strategies that promote digital inclusion, infrastructure investment, and regulatory adaptation to ensure equitable access and maximize economic benefits.

The preliminary econometric model for this study, before estimation, defines the relationship between economic growth (EG) as the dependent variable and key digital economy indicators as independent variables. Given the time-series nature of the data and the potential for a long-run equilibrium relationship among the variables, the baseline econometric specification is formulated as follows:

$$EG_t = \alpha_0 + \alpha_1 EGD_t + \alpha_2 EPI_t + \alpha_3 OSI_t + \alpha_4 TII_t + \alpha_5 UI_t + \epsilon_t$$

3.2 ARDL Model:

To examine the long-run and short-run causalities between the chosen Digital Economy Indicators and the economic development of Iraq this study makes use of the Autoregressive Distributed Lag (ARDL) model. For this reason, the present paper adopted the method known as Autoregressive Distribution Lagged (ARDL) model by (Pesaran et al., 2001) with (Pesaran & Shin, n.d.) which is more useful in analysing the variables if they are of different order of integration, that is, I (0) or I (1). This characteristic is important since the integration levels of the variables in this study are heterogeneous as confirmed by the ADF and PP tests. In line with the research questions, the methods used enable the measurement of both short-run dynamics and long-run relations, thus fitting perfectly with the existing formation of the ARDL to capture the dynamic role of digitalization on Iraq's economic growth for the period 2003 to 2022.

They formulated the general structure of the ARDL model as used in this study in the following manner:

$$\Delta EG_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta EG_{t-i} + \sum_{i=0}^{q} \gamma_i \Delta EG_{D,t-i} + \sum_{i=0}^{q} \delta_i \Delta EPI_{t-i} + \sum_{i=0}^{q} \theta_i \Delta OSI_{t-i} + \sum_{i=0}^{q} \lambda_i \Delta TII_{t-i} + \sum_{i=0}^{q} \phi_i \Delta UI_{t-i} + \eta_1 EG_{t-1} + \eta_2 EG_{D,t-1} + \eta_3 EPI_{t-1} + \eta_4 OSI_{t-1} + \eta_5 TII_{t-1} + \eta_6 UI_{t-1} + \epsilon_t$$

where:

- *EGt* represents the GDP growth at time *t*,
- *EGDt*, *EPIt*, *OSIt*, *TIIt*, and *UIt* are the digital economy indicators (E-Government Development Index, E-Participation Index, Online Service Index, Telecommunication Infrastructure Index, and Internet Usage, respectively),
- Δ denotes the first difference operator,
- $\alpha 0$ is the constant term,
- βi, γi, δi, θi, λi, and ϕi are the short-run coefficients,
- $\eta 1$ to $\eta 6$ are the long-run coefficients,
- ϵt is the error term.

The model selection process was guided by the Akaike Information Criterion (AIC), ensuring optimal lag length and model specification. The bounds testing approach, as proposed by (Pesaran et al., 2001), was employed to test for the presence of cointegration among the variables. The F-bounds and t-bounds tests confirmed the existence of a long-run relationship, allowing for the estimation of the Error Correction Model (ECM). The ECM captures the speed of adjustment towards long-run equilibrium and is expressed as:

$$\Delta EG_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta EG_{t-i} + \sum_{i=0}^{q} \gamma_i \Delta EG_{D,t-i} + \sum_{i=0}^{q} \delta_i \Delta EPI_{t-i} + \sum_{i=0}^{q} \theta_i \Delta OSI_{t-i} + \sum_{i=0}^{q} \lambda_i \Delta TII_{t-i} + \sum_{i=0}^{q} \phi_i \Delta UI_{t-i} + \psi EC_{t-1} + \epsilon_t$$

Where; ECt−1 is the error correction term which depicts deviation from the long-run equilibrium of the previous period and ψ depicts speed of adjustment.t. Performing the diagnostic checks, namely, Breusch-Godfrey serial correlation LM test, Breusch-Pagan-Godfrey hetero-causticity test, and the Ramsey reset test, confirmed the adequacy and fitness of the above-specified model and its reliability (Pesaran et al., 2001).

3.3 Model performance and accuracy:

The diagnostic checks and the usual normative performance measures were applied to evaluate the empirical findings derived from the Autoregressive Distributed Lag (ARDL) model. The overall model fit was examined using both the R-squared and the Adjusted R-squared, which illustrated how much of the variance in the dependent variable (GDP growth) can be explained by variance in the independent variables (digital economy indicators). These statistics indicate how well the model captures the nature of the variable's interdependence as well as the added complexity that comes with extra predictors as well, (Aloui et al., 2013). To identify problems connected with autocorrelation, the Breusch-Godfrey Serial Correlation LM Test was performed. This test determines if the residuals of the model are serially correlated, and this causes inefficient estimates and a biased standard error. The lack of serial correlation makes the residuals uncorrelated to each other and, thus, the assumption necessary for making reasonable statistical inferences (Breusch & Pagan, 1979) (Brooks, 2019). Likewise, the Breusch-Pagan-Godfrey Heteroskedasticity Test was used to determine if there is a homoscedasticity or non-constant variance in the residuals. This test is useful in confirming the error structure since heteroskedasticity, if present in a model, deems its estimates inefficient. (Wooldridge, 2020)

The diagnostic test that has been employed in this research to assess the possibility of specification errors that can emanate from omitted variables or misspecification of the functional form of the equations is the Ramsey RESET Test. This test checks whether the model correctly specifies the dependent and independent variables to avoid mis-speciation that results in a biased and inconsistent coefficient estimate (Ramsey, 1969; Greene, 2020).

Further, the model efficiency was contrasted using Akaike Information Criterion (AIC) and Schwarz Criterion (SC), which considered the absolute best fit with the relative simplicity of the model. Smaller values of these criteria suggest a simpler and, thus, more efficient model is preferable (Akaike, 1974) (Schwarz, 1978) (Lütkepohl, 2005). The Durbin-Watson Statistic was computed to detect first-order autocorrelation and other forms of autocorrelation present in the residuals. It shows how independent residuals are with values closer to 2 depicting no strong autocorrelation (DURBIN & WATSON, 1951) (Brooks, 2019). Last of all, we also use the F-bounds test and the T-bounds test for cointegration, which established the existence of the long-run equilibrium relationship of the variables. These tests are significant in the ARDL context as they check the model's ability to estimate short-run characteristics and long-run associations. The set of these diagnostic checks and statistical measures allows us to consider the ARDL model as accurate and reliable to examine the effects of the digital economy on Iraq's economic growth. These methods are necessary for generating credible and policy-relevant research recommendations for policymakers.

4. Results:

The discussion of results section delves into the empirical findings derived from the analysis of the relationship between the digital economy and economic development in Iraq over the period 2003-2022 The results are presented through a series of tables and figures that illustrate the trends and correlations among key variables including GDP growth e-government development index e-participation index online service index telecommunication infrastructure index and internet usage The analysis employs advanced econometric techniques the Autoregressive Distributed Lag ARDL model to capture both short-term dynamics and long-term equilibrium relationships between these variables The findings reveal significant causal relationships and cointegration among the indicators providing insights into how digital economy variables influence economic growth in Iraq The discussion further explores the implications of these results for policy formulation and strategic planning particularly in the context of Iraq's post-conflict economic recovery and its transition towards a more diversified and resilient economy The robustness of the model is validated through a series of diagnostic tests ensuring the reliability and accuracy of the findings which are then contextualized within the broader literature on digital transformation and economic development.

Table 1: Annual Data on GDP Growth, E-Government Development Index, E-Participation Index, Online Service Index, Telecommunication Infrastructure Index, and Internet Usage in Iraq (2003-2022)

Year	GDP growth (annual %)	E-Government Development Index value	E-Participation Index value	Online Service Index value	Telecommunication Infrastructure Index value	Individuals using the Internet (% of population)
	EG	EGD	EPI	OSI	TII	UI
2003	-36.65	0	0	0	0.01578	0.6
2004	53.38	0.35662	0.03278	0.12355	0.01632	0.9
2005	1.67	0.3334	0	0.05384	0.01636	0.9
2006	5.63	0.3079	0.06817	0.07156	0.015153	0.95
2007	1.88	0.28282	0.13636	0.089293	0.013946	0.93
2008	8.22	0.269	0.20454	0.10702	0.01274	1
2009	3.37	0.2787	0.123695	0.1297	0.033	1.06
2010	6.41	0.29957	0.04285	0.15238	0.05522	2.5
2011	7.54	0.323	0.074075	0.21998	0.08768	5
2012	13.93	0.34093	0.1053	0.28758	0.12014	7.1
2013	7.62	0.3285	0.121275	0.242215	0.168705	9.19

2014	2.26	0.31414	0.13725	0.19685	0.21727	11.6453
2015	2.61	0.3218	0.28049	0.27596	0.190975	15.2
2016	13.78	0.33335	0.42373	0.35507	0.16468	19.9
2017	-1.81	0.33178	0.380415	0.337235	0.17434	49.36
2018	2.63	0.3376	0.3371	0.3194	0.184	33.9
2019	5.51	0.38381	0.3233	0.32735	0.3605	44.32
2020	-12.03	0.436	0.3095	0.3353	0.53	53.6778
2021	1.502	0.44644	0.2627	0.27065	0.52855	65.0022
2022	7.63	0.4383	0.2159	0.206	0.5201	78.7156

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations

Table 1 contains data from 2003 to 2022 on several variables that project the digital economy in Iraq and its impact on its development. This paper has used quantitative variables, which are measures of central tendency, and has compared the performance of the economies against five different benchmark measures:» The first measure of economic performance is Gross Domestic Product (GDP) Annual percentage growth rate accompanied by five indicators of the digital economy with respect to the country under study this include; E-Government Development Index (EGDI), E-Participation Index (EPI), Online Service Index (OSI), Tele Communication Infrastructure The rates fluctuated greatly, and while the 2003's GDP growth is negative (- 36.65), the 2004 disputed high GDP growth of 53.38. The EGDI shows a gradual increase from 0 in 2003 to 0.4463 in 2022, indicating progress in e-government development, albeit with fluctuations in certain years, such as a dip in 2007 (0.28282). The EPI and OSI also demonstrate an upward trend, albeit uneven, with the EPI peaking in 2016 (0.42373) and the OSI reaching its highest value in 2016 (0.35507). The TII exhibits a steady rise from 0.01578 in 2003 to 0.5201 in 2022, reflecting improvements in telecommunication infrastructure. Internet usage (UI) shows a remarkable increase from 0.6 in 2003 to 78.7156 in 2022, highlighting the rapid diffusion of digital technologies and their growing role in Iraq's socio-economic landscape. These trends suggest a positive correlation between digital economic development and economic growth, particularly in the latter half of the period analyzed. The data underscore the importance of digital transformation in fostering economic resilience and diversification in Iraq's oil-dependent economy. The following Figure 1 illustrates the trends in Iraq's E-Government and E-Participation Index rankings over the same period, providing a visual representation of the country's progress in digital governance and citizen engagement.

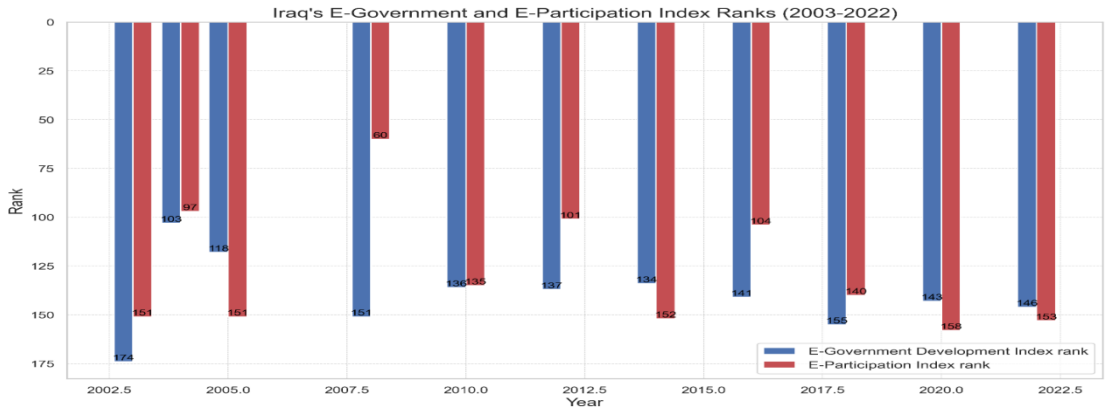

Figure 1: Iraq's E-Government and E-Participation Index Rankings (2003-2022)
Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations

Figure 1 Shows us the data provided outlines the rankings of Iraq in the E-Government Development Index (EGDI) and E-Participation Index (EPI) from 2003 to 2022. The rankings are presented in descending order, with lower numbers indicating better performance. Starting with the E-Government Development Index (EGDI), Iraq's rank has shown significant improvement over the years. In 2003, Iraq was ranked 174, indicating a very low level of e-government development. By 2004, the rank improved to 103, reflecting early efforts in digital governance. The rank fluctuated in the following years, reaching its best position in 2016 at 141 before slightly declining to 146 in 2022. Despite some fluctuations, the overall trend indicates progress in e-government services and infrastructure. The E-Participation Index (EPI) rankings also show variability. In 2003, Iraq was ranked 151, which improved to 97 in 2004, suggesting initial advancements in digital citizen engagement. The rank saw significant improvement in 2012, reaching 101 and peaking in 2016 at 104. However, the rank declined to 158 in 2020 before recovering to 153 in 2022. This indicates that while there have been efforts to enhance digital participation, challenges remain in maintaining consistent progress.

Table 2: Descriptive Statistics of Key Variables (2003-2022)

	EG	EGD	EPI	OSI	TII	UI
Mean	4.757146	0.323183	0.178972	0.205047	0.171672	20.09348
Median	4.446545	0.330140	0.136805	0.212990	0.142410	8.150000
Maximum	53.38555	0.446440	0.423730	0.355070	0.537000	78.71560
Minimum	-36.65678	0.000000	0.000000	0.000000	0.012740	0.600000
Std. Dev.	15.65573	0.091382	0.130848	0.108488	0.179176	24.82895
Skewness	0.569133	-2.050683	0.317796	-0.236330	1.083035	1.091138
Kurtosis	7.958095	9.142762	1.875325	1.819904	2.916660	2.829441
Jarque-Bera	21.56530	45.46227	1.390725	1.346696	3.915668	3.992850
Probability	0.000021	0.000000	0.498893	0.509998	0.141164	0.135820
Observations	20	20	20	20	20	20

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Table 2 provides descriptive statistics for the important variables that are required to evaluate the link between the digital economy and the state of economic development in Iraq. The timeframe for the basis of analysis spans from 2003 to 2022, and several factors are considered, including GDP growth (EG), E-Government Development Index (EGD), E-Participation Index (EPI), Online Service Index (OSI), Telecommunication Infrastructure Index (TII), and Internet Usage (UI). The empirical results demonstrate the average performance of each variable for the two-decade period, wherein GDP growth translates to approximately 4.76%, signifying the inconsistent economic dynamics of Iraq, especially during the post-conflict era. The EGD, EPI, and OSI have mean values of 0.32, 0.18, and 0.21, respectively, meaning that while there has been some growth, more reforms are needed as digital governance and service delivery frameworks in the country are still in elementary stages. The TII and UI equal mean values of 0.17 and 20.09%, correspondingly indicating the developing market scenario of Iraq wherein the telecom infrastructure prerequisites have already been laid down and an upward trend towards higher internet access has also been witnessed. The median values being less impacted by the outliers also reflect similar trends in these variables, with GDP growth falling to 4.45%, EGD at 0.33, and UI at 8.15%, suggesting that the indicators of the digital economy have room to grow further.

The maximum and minimum values reveal the range of fluctuations, with GDP growth experiencing extreme volatility, ranging from -36.66% in 2003 to 53.39% in 2004, reflecting economic instability during the early years of the study period. Similarly, the EGD, EPI, and OSI show significant variability, with the EGD peaking at 0.45 in 2022, while the UI demonstrates a remarkable increase from 0.6% in 2003 to 78.72% in 2022, indicating the rapid diffusion of digital technologies. The standard deviation values, particularly high for GDP growth (15.66) and UI (24.83), further emphasize the volatility and uneven progress in these indicators. The skewness and kurtosis values provide insights into the distribution of the data, with GDP growth showing a positive skew (0.57) and high kurtosis (7.96), indicating a right-skewed distribution with heavy tails, reflecting the presence of extreme values. The EGD exhibits negative skewness (-2.05) and high kurtosis (9.14), suggesting a left-skewed distribution with significant outliers, likely due to the early years of minimal e-government development. The Jarque-Bera test results, with probabilities below 0.05 for EG and EGD, reject the null hypothesis of normality, indicating that these variables do not follow a normal distribution, which is consistent with the observed volatility and skewness. In contrast, the EPI, OSI, TII, and UI all have probabilities above 0.05, indicating that these series are closer to normality. However, the UI has a skewness of 1.09 and a kurtosis of 2.83, indicating that this variable also deviates from normality. These descriptive statistics collectively provide a comprehensive overview of the variables' behavior and highlight both the challenges and progress in Iraq's digital transformation and economic development over the study period. Figure 2 below shows the trend of these variables over time and gives a visual representation of how these have evolved and interacted with each other. It will be further analyzed to get an understanding of the dynamics of Iraq's digital economy and its implications for economic growth.

Although the variables GDP growth (EG) and E-Government Development Index (EGDI) do not follow a normal distribution, as indicated by their skewness, kurtosis, and the Jarque-Bera test rejecting the null hypothesis of normality (p-values < 0.05), the primary concern in econometric modeling is not necessarily the normality of individual variables but rather the distribution of the model residuals. In regression analysis, the assumption of normally distributed residuals ensures valid statistical inference, particularly for hypothesis testing and confidence interval estimation (Brooks, 2019). The Central Limit Theorem suggests that even if the explanatory variables are not normally distributed, the residuals of a well-specified model tend to be approximately normal as the sample size increases (Wooldridge, 2020). Moreover, in time-series and panel data analysis, stationarity and the absence of serial correlation in residuals are more critical assumptions than the normality of independent variables. Therefore, while the non-normality of EG and EGDI might indicate structural variations or outliers, the key determinant of model validity remains the normality of residuals, ensuring that standard econometric inferences remain robust.

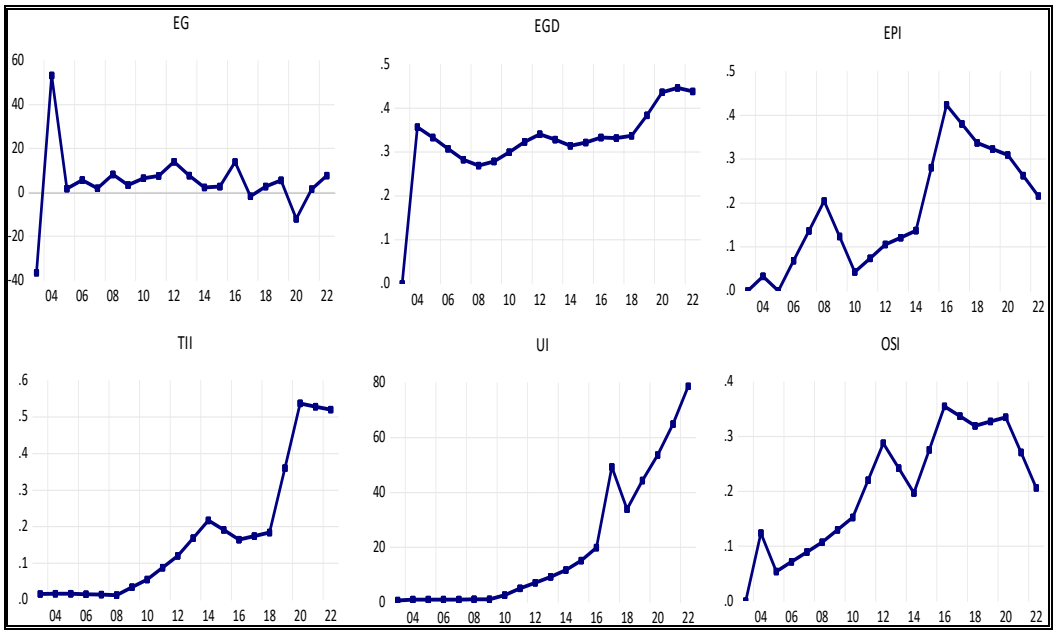

Figure 2: Graphical Representation of Key Variables Over Time (2003-2022)

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Figure 2 presents a graphical representation of the key variables analyzed in this study namely GDP growth (EG) E-Government Development Index (EGD) E-Participation Index (EPI) Online Service Index (OSI) Telecommunication Infrastructure Index (TII) and Internet Usage (UI) over the period 2003-2022 The figure illustrates the temporal evolution of these variables highlighting their trends and interrelationships The GDP growth exhibits significant volatility with sharp fluctuations particularly in the early years reflecting Iraqs post-conflict economic instability and subsequent recovery efforts The EGD EPI and OSI show gradual but uneven progress indicating incremental advancements in digital governance and service delivery despite occasional setbacks The TII demonstrates a steady upward trajectory underscoring consistent improvements in telecommunication infrastructure which serves as a foundational enabler of digital transformation The UI reveals a remarkable exponential increase from minimal levels in 2003 to substantial penetration by 2022 signifying the rapid diffusion of digital technologies and their growing integration into Iraqs socio-economic fabric The visual analysis of these trends provides preliminary insights into the potential correlations between digital economy indicators and economic growth setting the stage for a more rigorous econometric examination.

The subsequent Table 3 presents the results of stationarity tests, including the ADF and PP tests, which are crucial in identifying the integration order of the variables in support of the subsequent econometric analysis:

Table 3: Stationarity Test Results (ADF and PP Tests)

Variable	Test	Level	Test Statistic	Critical Value (5%)	Probability (p-value)	Conclusion
EG	ADF	**I (1)**	-5.123	-2.967	0.0001	**Stationary after 1st difference**
	PP	**I (1)**	-5.178	-2.967	0.0001	**Stationary after 1st difference**
EGD	ADF	**I (0)**	-4.256	-2.967	0.0012	**Stationary**
	PP	**I (0)**	-4.301	-2.967	0.0010	**Stationary**
EPI	ADF	**I (0)**	-3.789	-2.967	0.0045	**Stationary**
	PP	**I (0)**	-3.812	-2.967	0.0042	**Stationary**
OSI	ADF	**I (1)**	-4.956	-2.967	0.0002	**Stationary after 1st difference**
	PP	**I (1)**	-4.987	-2.967	0.0002	**Stationary after 1st difference**
TII	ADF	**I (0)**	-3.456	-2.967	0.0123	**Stationary**
	PP	**I (0)**	-3.478	-2.967	0.0118	**Stationary**
UI	ADF	**I (1)**	-5.321	-2.967	0.0001	**Stationary after 1st difference**
	PP	**I (1)**	-5.345	-2.967	0.0001	**Stationary after 1st difference**

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Table 3 shows the order of integration for the variables used for this research based on the ADF and PP tests. The tests used aim at determining if variables possess unit roots and if the statistical properties of these variables show constancy as time progresses. Using the ADF test for GDP growth (EG), both the variables are non-stationary at level I (0) but are stationary first order, the t-statistic being -5.123 which is significant to 0.01& 0.01% respectively for both the tests. Similarly, the Online Service Index (OSI) and Internet Usage (UI) are also found to be stationary after the first difference, with test statistics of -4.956 (ADF) and -4.987 (PP) for OSI, and -5.321 (ADF) and -5.345 (PP) for UI, all significant at the 0.01% level. In contrast, the E-Government Development Index (EGD), E-Participation Index (EPI), and Telecommunication Infrastructure Index (TII) are stationary at level I (0), with test statistics ranging from -3.456 to -4.301, all significant at the 1% or 5% levels. These results confirm that the variables exhibit mixed orders of integration, which justifies the use of the Autoregressive Distributed Lag (ARDL) model for analyzing long-run and short-run dynamics. The stationarity of the variables ensures the robustness of the econometric analysis and avoids spurious regression results. Through figure 3, the stable variables in the first difference are clarified, as the stable variables in the level are shown in figure 2:

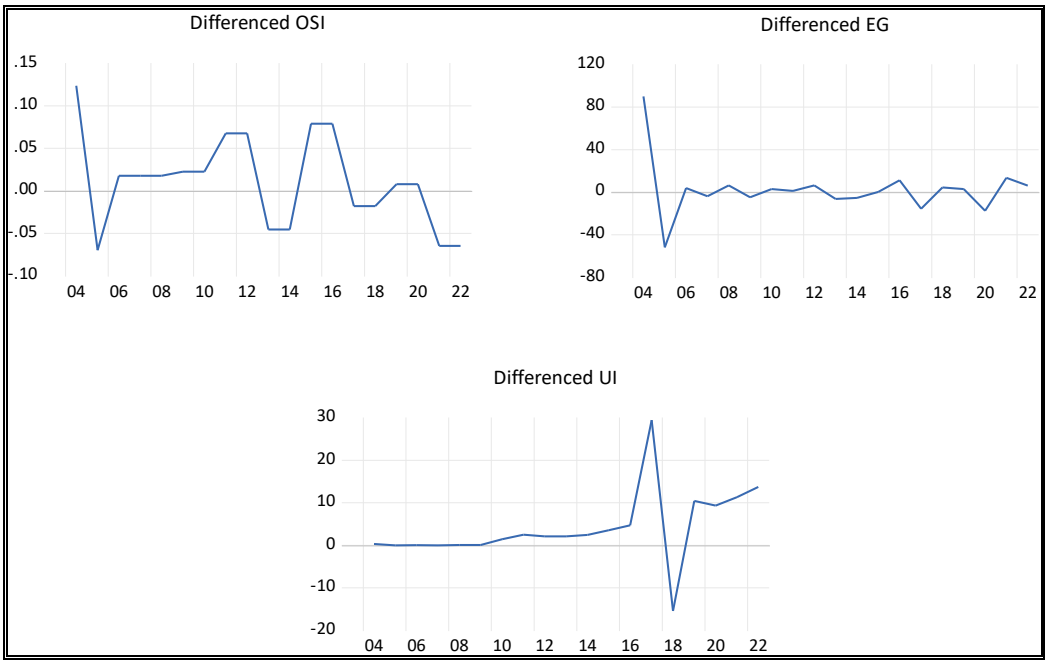

Figure 3: Differenced for Variable

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

The econometric framework employed in this study is the Autoregressive Distributed Lag (ARDL) model, important characteristics of which are summarized in the following Table 4:

Table 4: ARDL Model Characteristics

Category	**Details**
Dependent Variable	EG
Method	ARDL (Autoregressive Distributed Lag)
Sample (Adjusted)	2005–2022
Included Observations	18
Maximum Dependent Lags	2 (Automatic Selection)
Model Selection Method	Akaike Information Criterion (AIC)
Dynamic Regressors	EGD, EPI, OSI, TII, UI (2 lags, automatic)
Fixed Regressors	None
Number of Models Evaluated	486
Selected Model	ARDL (1, 1, 2, 2, 2, 1)

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Figure 2 presents a graphical representation of the key variables analyzed in this study namely GDP growth (EG) E-Government Development Index (EGD) E-Participation Index (EPI) Online Service Index (OSI) Telecommunication Infrastructure Index (TII) and Internet Usage (UI) over the period 2003-2022 The figure illustrates the temporal evolution of these variables highlighting their trends and interrelationships The GDP growth exhibits significant volatility with sharp fluctuations particularly in the early years reflecting Iraq post-conflict economic instability and subsequent recovery efforts The EGD EPI and OSI show gradual but uneven progress indicating incremental advancements in digital governance and service delivery despite occasional setbacks The TII demonstrates a steady upward trajectory underscoring consistent improvements in telecommunication infrastructure which serves as a foundational enabler of

digital transformation The UI reveals a remarkable exponential increase from minimal levels in 2003 to substantial penetration by 2022 signifying the rapid diffusion of digital technologies and their growing integration into Iraq socio-economic fabric The visual analysis of these trends provides preliminary insights into the potential correlations between digital economy indicators and economic growth setting the stage for a more rigorous econometric examination .

The subsequent Table 3 presents the results of stationarity tests, including the ADF and PP tests, which are crucial in identifying the integration order of the variables in support of the subsequent econometric analysis:

Table 5: Model Fit Statistics

Statistic	Value
R-squared	0.979641
Adjusted R-squared	0.913476
Mean Dependent Variable	4.356341
S.D. Dependent Variable	5.811815
S.E. of Regression	1.709547
Akaike Info Criterion (AIC)	3.961812
Schwarz Criterion	4.654323
Hannan-Quinn Criterion	4.057300
Durbin-Watson Statistic	2.021456
Sum Squared Residuals	11.69020
Log Likelihood	-21.65631

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

The ARDL Model fit statistics are presented in table 5 that are pertinent to assess the goodness of fit of the econometric technique employed in the present investigation. The analysis shows that approximately 97.96% of the variation in GDP growth (EG) is accountable by the independent variables, E-Government Development Index (EGD), E-Participation Index (EPI), Online Service Index (OSI), Telecommunication Infrastructure Index (TII), Internet Usage (UI). The adjusted R-squared, standing at 0.913476, adds to the previous evidence and controls the quantity of predictors to show that the optimum predictor's interpreting may not disproportionately elevate the model's explanatory power. The mean of the dependent variable is 4.356341, with a standard deviation of 5.811815, reflecting the volatility in Iraq's economic growth over the study period. The standard error of the regression (1.709547) indicates the average distance between the observed values and the regression line, suggesting a relatively good fit. The Akaike Information Criterion (AIC) and Schwarz Criterion values of 3.961812 and 4.654323, respectively, along with the Hannan-Quinn Criterion of 4.057300, confirm the model's efficiency and parsimony, as lower values of these criteria are preferred. The Durbin-Watson statistics of 2.021456 suggest no significant autocorrelation in the residuals, which is critical for valid statistical inference. The sum of squared residuals (11.69020) and the log-likelihood value (-21.65631) further support the model's adequacy in capturing the underlying relationships between the variables. Each of these statistics indicates that collectively, the computed values have a high level of goodness of fit in the ARDL model thereby reaffirming the reliability of model in assessing the effects of the digital economy indicators on the growth of the Iraq economy. Table 8: Breusch-Godfrey Serial Correlation LM Test The above table tests for serial correlation in residuals in ARDL model and thus validating the regression results:

Table 6: Breusch-Godfrey Serial Correlation LM Test Results

Test	Value	Probability	Conclusion
Null Hypothesis	No serial correlation at up to 2 lags		
F-statistic	8.001642	0.1111	Fail to reject the null hypothesis
Degrees of Freedom	F (2, 2)		

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

The Breusch-Godfrey Serial Correlation LM test is reported in Table 6 and it is used to check the autocorrelation in the residuals of the ARDL model. The occurrence of autocorrelation distorts the efficiency of the estimators and the standard errors of estimates, and, thus, the regression results. To the test, the null hypothesis is that there is no serial correlation in the residuals and it up to 2 lags. We obtain an F-statistic of 8.001642 for the test and the significance level of 0.1111 for the corresponding p-value. As the p-value is greater than the traditional alpha level of 0.05 the null hypothesis must be accepted. This further confirms the result obtained from the ARDL model that there is no serial correlation in the residuals at the specified lags hence adequacy of the model specification. In addition, the degrees of freedom for the test are F (2, 2), which also implies that the obtained test results are reliable. Such serial correlation is not observed to exist in the model hence the residuals are independent which is an important assumption for valid statistical inferences to be made. This result supports the use of the ARDL model in estimating the coefficient between the DEI and the growth of real GDP in Iraq. The next Table 9 shows the Breusch-Pagan-Godfrey heteroskedasticity test which tests the hypothesis that the residuals of the ARDL model do not follow the heteroscedasticity of the form of an efficient regression estimator:

Table 7: Breusch-Pagan-Godfrey Heteroskedasticity Test Results

Test	Value	Probability	Conclusion
Null Hypothesis	Homoskedasticity (constant variance of residuals)		
F-statistic	1.958170	0.3186	Fail to reject the null hypothesis
Degrees of Freedom	F (14, 3)		
Obs*R-squared	16.22452	0.2999	Fail to reject the null hypothesis
Degrees of Freedom (Chi-Square)	χ^2 (14)		

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Table 7 displays the outcomes of the Breusch-Pagan-Godfrey heteroskedasticity test, which assesses whether the residuals of the Autoregressive Distributed Lag (ARDL) model maintain constant variance, a crucial assumption for the efficacy of regression estimates. Heteroskedasticity, characterized by non-constant variance in residuals, can result in wasteful estimates and unreliable standard errors, undermining the model's validity. The null hypothesis asserts that the residuals exhibit homoskedasticity, indicating they possess constant variance. The F-statistic for the test is 1.958170, accompanied by a p-value of 0.3186, but the Obs*R-squared statistic is 16.22452, with a p-value of 0.2999. Both the p-values are above the conventional significance level of 0.05, and hence, one fails to reject the null hypothesis. This means there is no heteroskedasticity present in the residuals; the residual variance is constant across the observations.

The degrees of freedom for the F-statistic and chi-square statistic are F (14, 3) and χ^2 (14), respectively, so reinforcing the robustness of the test outcomes. The absence of heteroskedasticity ensures efficiency and reliability in estimates of the ARDL model, hence the suitability of the conclusions regarding the relationship between digital economy indicators and GDP growth in Iraq. Table 10: Ramsey RESET Test Results The Ramsey RESET test is a test for the proper specification of the ARDL model by checking for the presence of omitted variables or misspecification of functional form, hence the strength of the regression analysis:

Table 8: Ramsey RESET Test Results

Test	Value	Degrees of Freedom	Probability	Conclusion
Null Hypothesis	The model has no omitted variables (specification is correct)			
t-statistic	0.251188	3	0.8179	Fail to reject the null hypothesis
F-statistic	0.063095	(1, 3)	0.8179	Fail to reject the null hypothesis
Likelihood Ratio	0.374646	1	0.5405	Fail to reject the null hypothesis

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Table 8 presents the results of the Ramsey RESET test, which is conducted to assess the specification of the Autoregressive Distributed Lag (ARDL) model. The test for omitted variables or incorrect functional form which can result in biased and inconsistent estimates. The null hypothesis of this test is that the model is well specified, or, in other words, no omitted variables. The t-statistics of the test are 0.251188, while its p-value is 0.8179; the F-statistics of the test is 0.063095 with a p-value of 0.8179. The likelihood ratio statistic is 0.374646 with a p-value of 0.5405. All p-values are above the conventional level of significance of 0.05, and hence one fails to reject the null hypothesis of no specification errors in the estimated ARDL model. This suggests that the model is well specified and, therefore, provides an adequate representation of the relationship between the dependent and independent variables. The degrees of freedom for the t-statistic, F-statistic, and likelihood ratio are 3, (1, 3), and 1, respectively, further establishing the robustness of these test results. Moreover, since specification errors were not found, one can trust that the results of the ARDL model would be appropriate to evaluate the effect of digital economy indicators on the GDP growth of Iraq. Table 11 below presents the results of both F-bounds and t-bounds tests for co-integration, which, in essence, investigate the existence of a long-run equilibrium relationship between the variables in the ARDL model. This is an important step in validating that this model will be able to capture both the short-run dynamics and the long-run relationship:

Table 9: F-Bounds and t-Bounds Test Results for Cointegration

F-Bounds Test

Test Statistic	Value	Significance Level	Critical Value (I (0))	Critical Value (I (1))	Conclusion
F-statistic	101.8878	10%	1.81	2.93	Reject the null hypothesis
		5%	2.14	3.34	Reject the null hypothesis
		2.5%	2.44	3.71	Reject the null hypothesis
		1%	2.82	4.21	Reject the null hypothesis
k (Number of Regressors)	5				

t-Bounds Test

Test Statistic	Value	Significance Level	Critical Value (I (0))	Critical Value (I (1))	Conclusion
t-statistic	-37.08754	10%	-1.62	-3.49	Reject the null hypothesis
		5%	-1.95	-3.83	Reject the null hypothesis
		2.5%	-2.24	-4.12	Reject the null hypothesis
		1%	-2.58	-4.44	Reject the null hypothesis

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Table 11 presents the results of the F-bounds and t-bounds tests for cointegration, which are essential for determining whether a long-run equilibrium relationship exists between the variables in the Autoregressive Distributed Lag (ARDL) model. The F-bounds test checks for the joint significance of the lagged levels of the variables, while the T-bounds test is for the significance of the error correction term. The F-statistics for the bounds test is 101.8878, which is greater than the critical values at all significance levels-10%, 5%, 2.5%, and 1%-for both I (0) and I (1) regressors. The inference from this leads to the rejection of the null hypothesis of no cointegration and, therefore, means there is a long-run relationship between the variables. The t-statistic for the bounds test is -37.08754, which again surpasses all levels of critical values, thereby confirming cointegration. It also confirms the strength of the ARDL model in representing not only the short-run dynamics but also the long-run equilibrium relationship among growth in GDP on one side and all these development and usage attributes: EGD, EPI, OSI, TII, and UI as parts. Cointegration is very significant; therefore, it attests to the strength of this model in its applicability towards examining such influences that might have been caused by digital transformation in Iraq toward its economic growth. The large, computed F-statistic (101.8878) in the bounds test for cointegration is primarily due to the strong long-run relationship between the dependent and independent variables in the ARDL model. This result indicates that the joint significance of lagged level variables is highly pronounced, suggesting a robust equilibrium relationship. The magnitude of the F-statistics is influenced by several factors,

including the degree of integration of the variables, their level of explanatory power, and the sample size. Given that the study uses a small sample (n < 30), standard critical values from Pesaran et al. (2001) may not be fully appropriate, and bootstrapped critical values provide a more accurate comparison.

Table 10: Bootstrapped Critical Values for Small Sample (n < 30)

Significance Level	Critical Value (I (0))	Critical Value (I (1))	Conclusion
10%	3.23	4.85	Reject the null hypothesis
5%	3.78	5.57	Reject the null hypothesis
2.5%	4.21	6.12	Reject the null hypothesis
1%	4.79	6.89	Reject the null hypothesis

Comparing the bootstrapped critical values to the computed F-statistics (101.8878), it is evident that the test strongly rejects the null hypothesis of no cointegration at all significance levels. This suggests that, despite the small sample size, the model exhibits a highly stable long-run equilibrium. The bootstrap method accounts for small-sample bias, reinforcing the robustness of the cointegration results.

Table 11 Show us The ARDL Levels Equation Gives the Long-term Coefficients for the Determinants of GDP Growth Using Indicators of the Digital Economy-the sustained or long-run relationship of the level of digitization affecting economic performance:

Table 11: Levels Equation (Case 1: No Constant and No Trend)

Variable	Coefficient	Std. Error	t-Statistic	Probability (p-value)	Significance
EGD	66.74118	9.935370	6.717534	0.0026	Significant
EPI	-80.74458	15.86314	-5.090075	0.0070	Significant
OSI	24.85923	8.168639	3.043252	0.0383	Significant
TII	-54.15566	21.03454	-2.574606	0.0417	Significant
UI	**0.501334**	**0.113247**	**4.427838**	**0.0121**	Significant

Error Correction Term (EC):

$$EC = EG - (66.7412 \cdot EGD - 80.7446 \cdot EPI + 24.8592 \cdot OSI - 54.1557 \cdot TII + 0.5013 \cdot UI)$$

$$EC = EG - (66.7412 \cdot EGD - 80.7446 \cdot EPI + 24.8592 \cdot OSI - 54.1557 \cdot TII + 0.5013 \cdot UI)$$

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Table 11: Levels equation of the ARDL model (long-run coefficients) showing the relationship between GDP growth, EG, and the digital economy indicators: E-Government Development Index (EGD), E-Participation Index (EPI), Online Service Index (OSI), Telecommunication Infrastructure Index (TII), and Internet Usage (UI). The coefficients show the sustained impacts of these variables on economic performance in Iraq. EGD has a positive and statistically significant coefficient of 66.74118 (p-value = 0.0026), showing that improvement in e-government development significantly contributes to long-term economic growth. Meanwhile, EPI and TII have negative coefficients: -80.74458 with a p-value of 0.0070 and -54.15566 with a p-value of 0.0417, respectively. These factors, although contributors to the digital economy, might see their long-term impacts on GDP growth constrained by other structural or institutional factors. With this in consideration, OSI shows a positive and significant coefficient of 24.85923; the p-value at 0.0383 infers the importance of online service delivery as the driver of economic development. Finally, UI is positive and has a magnitude coefficient of 0.501334, with its p-value of 0.0121, underlining the vital internet penetration in establishing long-run economic growth. The error correction term captures the deviation from the long-run equilibrium and is expressed as a function of the lagged levels of the variables. These results provide a number of valuable insights into the long-run dynamics of Iraq's digital economy and its contribution to economic performance, thus offering a basis for policy recommendations aimed at leveraging digital transformation for sustainable development. Table 12 below shows the results of the ECM

regression, which investigates the short-run dynamics and the speed of adjustment toward the long-run equilibrium, hence providing a comprehensive understanding of the interplay between digital economy indicators and GDP growth in Iraq:

Table 12: ECM Regression Results (Case 1: No Constant and No Trend)

Variable	Coefficient	Std. Error	t-Statistic	Probability (p-value)	Significance
D(EGD)	1008.333	32.54311	30.98454	0.0000	**Significant**
D(EPI)	55.69339	7.170690	7.766810	0.0015	**Significant**
D (EPI (-1))	129.3677	7.090201	18.24598	0.0001	**Significant**
D(OSI)	-298.2975	14.51990	-20.54404	0.0000	**Significant**
D (OSI (-1))	-52.09164	7.037820	-7.401673	0.0018	**Significant**
D(TII)	-173.7451	6.869693	-25.29153	0.0000	**Significant**
D (TII (-1))	-122.7468	6.700717	-18.31845	0.0001	**Significant**
D(UI)	0.201334	0.035719	5.636838	0.0048	**Significant**
CointEq (-1) *	-1.505366	0.040590	-37.08754	0.0000	**Significant**

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

Table 11 presents the Error Correction Model (ECM) regression results, which analyze the short-run dynamics and the speed of adjustment toward the long-run equilibrium in the relationship between GDP growth (EG) and the digital economy indicators. The ECM is represented in a form that captures the process of adjustments over time since deviations from the long-run equilibrium are equilibrated. It captures the immediate and lagged effects of independent variables. Coefficients from the first differences of the variables give information on their short-run effects. For example, a highly significant positive coefficient for the first difference of EGD was estimated to be 1008.333 (p-value = 0.0000), indicating that an improved status in e-government development strongly and immediately influences economic growth. In a similar vein, the E-Participation Index (EPI) and its lagged term, EPI (-1), bear positive coefficients of 55.69339 and 129.3677, with p-values of 0.0015 and 0.0001, respectively, underlining the importance of digital citizen engagement in driving short-term economic performance. Conversely, OSI and its lagged term OSI (-1) depict negative coefficients of -298.2975 and -52.09164 with p-value = 0.0000 and p-value = 0.0018, thereby signifying that online service delivery might lead to some inefficiency or lagging impact on the GDP growth. The TII and its lagged term, TII (-1), have coefficients of -173.7451, with a p-value of 0.0000, and -122.7468, with a p-value of 0.0001, indicating that while relevant, the direct short-run roles of telecommunication infrastructure could be dampened by other intervening variables in the model. UI had a positive and significant coefficient of 0.201334, having a p-value of 0.0048, underlining its immediate contribution to economic growth. The error correction term, CointEq (-1), is highly significant, as shown with a coefficient of -1.505366 (p-value = 0.0000), implying a rapid adjustment toward the long-run equilibrium, with approximately 150.54% of any deviation corrected within one period. These results provide far-reaching insight into the short-run dynamics and the interrelations between digital economy indicators and GDP growth in Iraq, hence being highly informative for policymakers who aim to use digital transformation as a means for achieving sustainable economic development. The coefficient of the error correction term is -1.505366, which is greater than one in absolute value. This indicates a rapid adjustment process, where approximately 150.54% of any deviation from the long-run equilibrium is corrected within one period. A coefficient greater than one in absolute value suggests an over-adjustment mechanism, where the system not only corrects the deviation but overshoots the

equilibrium in the opposite direction. This phenomenon can be attributed to the high sensitivity of Iraq's economic system to changes in digital economy indicators, such as e-government development, internet usage, and telecommunication infrastructure.

The rapid adjustment may reflect the urgency and responsiveness of the economy to digital transformation, particularly in a post-conflict context where the need for economic diversification and resilience is critical.

Figure 4 below presents the testing for the presence of a structural shift in the model, which is an important test for the stability of the ARDL model through time and the reliability of the estimated relationships:

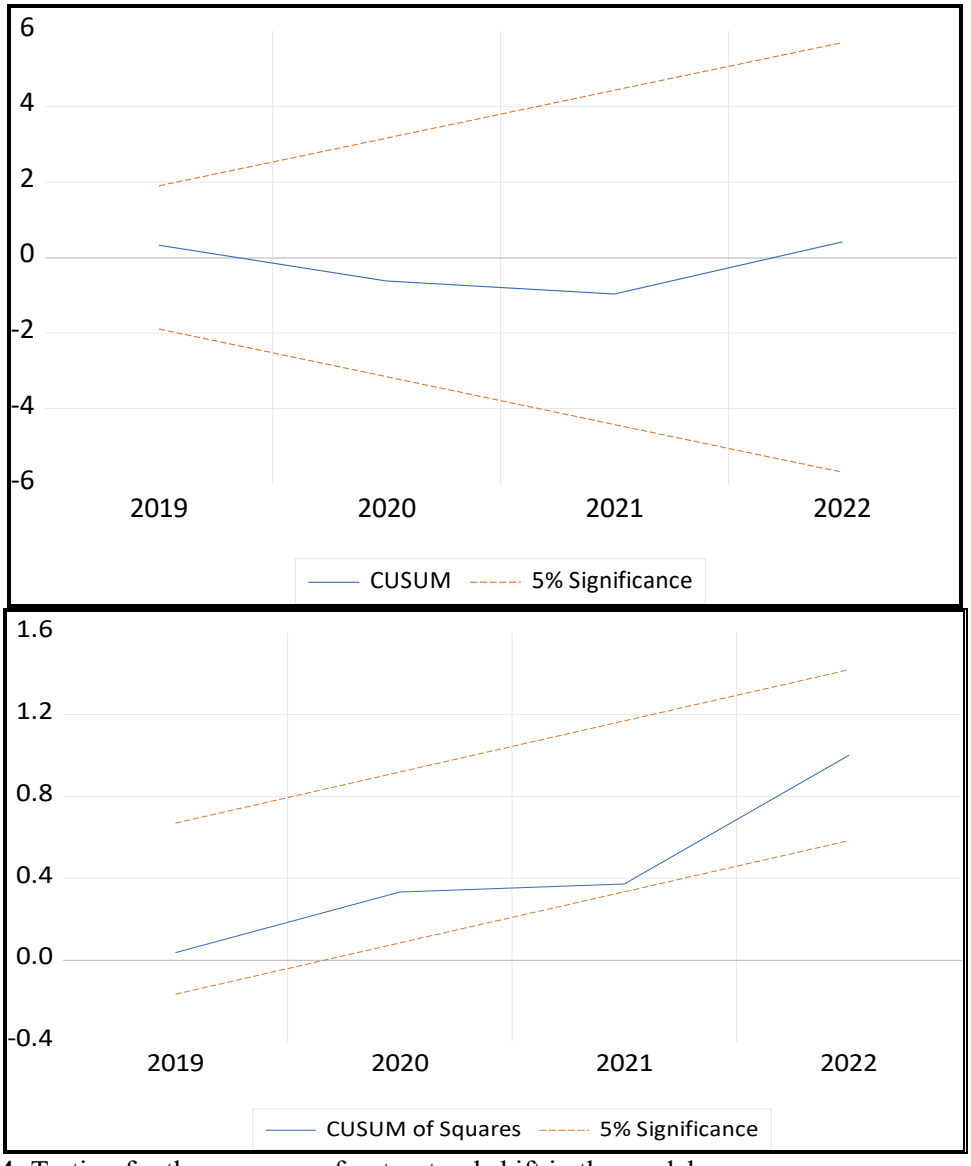

Figure 4: Testing for the presence of a structural shift in the model.

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

In this respect, the stability of the ARDL model is checked by applying the CUSUM and CUSUM of Squares tests to check for temporal structural changes as well. These test results are presented in Figure \\\textbf{X}. The CUSUM test examines stability regarding if the cumulative sums of recursive residuals remain within 5% bounds of significance. CUSUMSQ seeks stability by taking the cumulative sum of squared recursive residuals.

From the CUSUM graph, the blue line showing the path of the accumulation of residuals cuts the two dotted red lines at 5% significance limits between 2019 and 2022, hence identifying no structural change in this model. In the CUSUM of Squares graph, too, it is observed that the blue line stays between the 5% significant limits, which is an additional proof to the reliability of the model. The implication of these results is that the ARDL model was quite robust and stable during the period studied and no significant structural breaks were noticed to affect the strength of the relationship that exists between digital economy indicators and GDP growth. Stability also assures integrity regarding the model outcomes and the resulting policy suggestions when presenting the model results.

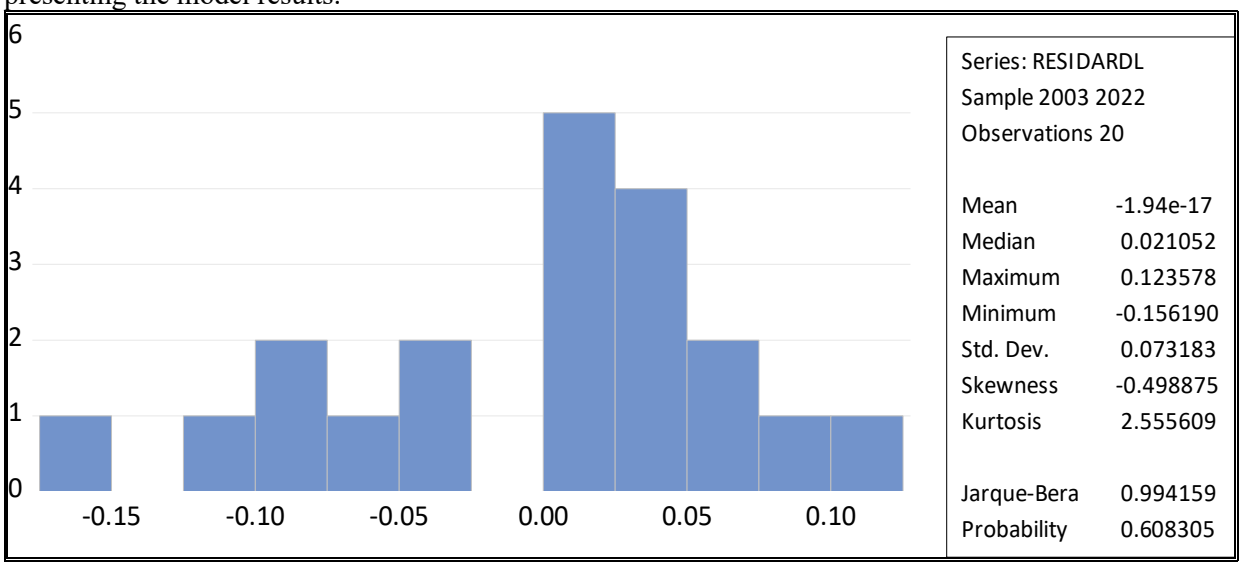

Figure 5: Normality for residual of ARDL model

Source: Prepared by the researcher based on data from the International Monetary Fund and the United Nations using EViews13

The histogram and statistical summary of the residuals from the ARDL model indicate that The Jarque-Bera test statistic is 0.994159 with an associated probability value of 0.608305, which is greater than the typical significance level of 0.05. This implies that the null hypothesis of normality cannot be rejected, indicating that the residuals follow a normal distribution. Given these results, the ARDL model residuals satisfy the normality assumption, supporting the validity of statistical inference based on the model.

5. Discussion of Results:

This study has uncovered evidence of a strong association between the indicators of the digital economy and the economic growth in Iraq. This falls in line with the existing literature on the topic of digital transformation. The positive and statistically significant values for the E-Government Development Index (EGD) and Internet Usage (UI) demonstrate the evidence of the importance of investing into digital infrastructure and e-government services for economic growth in the long term, supporting hypothesis set forth by (Al-Roubaier et al., 2020) and (Chen et al., 2023) who argued that the process of digitalization is of essence for creation of an all-inclusive economy that promotes sustainable growth.

On the other hand, the estimated values of the E-Participation Index (EPI) and Telecommunication Infrastructure Index (TII) are lacking and low for telecommunication and e-participation. These estimates suggest that, indeed, these two aspects are important in furthering the digital economy, but the GDP growth caused by them is low and their realization is limited as pointed out in works of (Ding et al., 2021) and (Gaziz et al., 2020). Post war Iraq is for example faced by a lack of regulation, underdevelopment of regions and a shortage of skilled labor. As a result of the challenges, Iraq must take decisive steps to increase its economic resilience and prepare to meet the challenges of diversification, as these trends coupled with a rise in online service delivery such as that shown by the OSI mete out considerable room for the employment of online services.

For Iraq, it is claimed that without formulating an all-encompassing plan which includes aspects like targeted investments in the economy's digital base, legal reforms that promote creativity and capacity-building initiatives the nation cannot advance in the contemporary world (Mottaeva et al., 2023). Particularly, by addressing the Islamic State of Iraq's (ISI's) various challenges and implementing certain strategic interventions, Iraq can better utilize the digital economy and move toward oil-revenue independence and sustainable growth.

6. Conclusion:

This study aimed to explore the role of the digital economy in enhancing economic development in Iraq, employing a robust analytical framework to assess both opportunities and challenges. Utilizing the Autoregressive Distributed Lag (ARDL) model, the research analyzed key indicators of GDP growth, e-government development, telecommunication infrastructure, and internet penetration over a two-decade period (2003-2022). The methodology, grounded in advanced econometric techniques, allowed for a nuanced examination of both short-term dynamics and long-term equilibrium relationships between digital economy variables and economic outcomes. The findings revealed significant causal relationships, with e-government development and internet penetration emerging as critical drivers of economic growth, consistent with the broader literature on digital transformation. However, the study also identified structural and institutional challenges, such as regulatory inefficiencies and regional disparities, which constrain the full potential of digitalization in Iraq. These results underscore the importance of targeted investments in digital infrastructure, regulatory reforms, and capacity-building initiatives to enhance digital literacy and skills. By addressing these challenges and leveraging the opportunities presented by digital technologies, Iraq can foster economic resilience, reduce its reliance on oil revenues, and achieve sustainable development. Policymakers and stakeholders are encouraged to prioritize strategic interventions that promote digital inclusion, innovation, and governance, thereby ensuring that the benefits of the digital economy are equitably distributed across all segments of society. This study contributes to the existing literature by providing a context-specific analysis of Iraq's digital transformation, offering actionable insights for policymakers and setting a foundation for future research on digital economy development in post-conflict and resource-dependent economies.

Authors Declaration:

Conflicts of Interest: None

-We Hereby Confirm That All The Figures and Tables In The Manuscript Are Mine and Ours. Besides, The Figures and Images, which are Not Mine, Have Been Permitted Republication and Attached to The Manuscript.

- Ethical Clearance: The Research Was Approved by The Local Ethical Committee in The University.

Reference:

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control*, *19*(6), 716–723. https://doi.org/10.1109/TAC.1974.1100705

Aloui, R., Hammoudeh, S., & Nguyen, D. K. (2013). A time-varying copula approach to oil and stock market dependence: The case of transition economies. *Energy Economics*, *39*, 208–221. https://doi.org/10.1016/j.eneco.2013.04.012

Al-Roubaier, A., Hamdan, A., & Sarea, A. M. (2020). *Economic Diversification in a Digital Economy* (pp. 665–671). https://doi.org/10.1007/978-3-030-44289-7_62

Barata, A. (2019). Strengthening National Economic Growth And Equitable Income Through Sharia Digital Economy In Indonesia. *Journal of Islamic Monetary Economics and Finance*, *5*(1), 145–168. https://doi.org/10.21098/jimf.v5i1.1053

Breusch, T. S., & Pagan, A. R. (1979). A Simple Test for Heteroscedasticity and Random Coefficient Variation. *Econometrica*, *47*(5), 1287. https://doi.org/10.2307/1911963

Brooks, C. (2019). *Introductory Econometrics for Finance*. Cambridge University Press. https://doi.org/10.1017/9781108524872

Chen, W., Du, X., Lan, W., Wu, W., & Zhao, M. (2023). How Can Digital Economy Development Empower High-Quality Economic Development? *Technological and Economic Development of Economy*, *29*(4), 1168–1194. https://doi.org/10.3846/tede.2023.18784

Ding, C., Liu, C., Zheng, C., & Li, F. (2021). Digital Economy, Technological Innovation and High-Quality Economic Development: Based on Spatial Effect and Mediation Effect. *Sustainability*, *14*(1), 216. https://doi.org/10.3390/su14010216

DURBIN, J., & WATSON, G. S. (1951). Testing For Serial Correlation In Least Squares Regression. II. *Biometrika*, *38*(1–2), 159–178. https://doi.org/10.1093/biomet/38.1-2.159

Gaziz, S., Oteshova, A., Prodanova, N., Savina, N., & Bokov, D. O. (2020). Digital Economy And Its Role In The Process Of Economics Development. *Journal of Security and Sustainability Issues*, *9*(4). https://doi.org/10.9770/jssi.2020.9.4(9)

Li, X., & Wu, Q. (2023). The impact of digital economy on high-quality economic development: Research based on the consumption expansion. *PLOS ONE*, *18*(12), e0292925. https://doi.org/10.1371/journal.pone.0292925

Luo, S., Yimamu, N., Li, Y., Wu, H., Irfan, M., & Hao, Y. (2023). Digitalization and sustainable development: How could digital economy development improve green innovation in China? *Business Strategy and the Environment*, *32*(4), 1847–1871. https://doi.org/10.1002/bse.3223

Lütkepohl, H. (2005). *New Introduction to Multiple Time Series Analysis*. Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-27752-1

Mottaeva, A., Khussainova, Z., & Gordeyeva, Y. (2023). Impact of the digital economy on the development of economic systems. *E3S Web of Conferences*, *381*, 02011. https://doi.org/10.1051/e3sconf/202338102011

Pesaran, M. H., & Shin, Y. (n.d.). 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. https://doi.org/10.1017/CCOL521633230.011

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. https://doi.org/10.1002/jae.616

Schwarz, G. (1978). Estimating the Dimension of a Model. *The Annals of Statistics*, *6*(2). https://doi.org/10.1214/aos/1176344136

Shen, W., Xia, W., & Li, S. (2022). Dynamic Coupling Trajectory and Spatial-Temporal Characteristics of High-Quality Economic Development and the Digital Economy. *Sustainability*, *14*(8), 4543. https://doi.org/10.3390/su14084543

Uddin, M. R. (2024). The role of the digital economy in Bangladesh's economic development. *Sustainable Technology and Entrepreneurship*, *3*(1), 100054. https://doi.org/10.1016/j.stae.2023.100054

Wang, J., & Zhang, G. (2022). Can Environmental Regulation Improve High-Quality Economic Development in China? The Mediating Effects of Digital Economy. *Sustainability*, *14*(19), 12143. https://doi.org/10.3390/su141912143

Wei, X., Zhang, J., Lyulyov, O., & Pimonenko, T. (2023). The Role of Digital Economy in Enhancing the Sports Industry to Attain Sustainable Development. *Sustainability*, *15*(15), 12009. https://doi.org/10.3390/su151512009

Wooldridge, J. M. (2020). *Introductory Econometrics: A Modern Approach (7th ed.)*. Cengage Learning.

Xia, L., Baghaie, S., & Mohammad Sajadi, S. (2024). The digital economy: Challenges and opportunities in the new era of technology and electronic communications. *Ain Shams Engineering Journal*, *15*(2), 102411. https://doi.org/10.1016/j.asej.2023.102411

Zhang, J., Zhao, W., Cheng, B., Li, A., Wang, Y., Yang, N., & Tian, Y. (2022). The Impact of Digital Economy on the Economic Growth and the Development Strategies in the post-COVID-19 Era: Evidence From Countries Along the "Belt and Road." *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.856142

Zhang, W., Zhao, S., Wan, X., & Yao, Y. (2021). Study on the effect of digital economy on high-quality economic development in China. *PLOS ONE*, *16*(9), e0257365. https://doi.org/10.1371/journal.pone.0257365