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**Digital Transformation, Financial Inclusion, and Poverty Reduction in
Iraq: An Econometric Study Using the Vector Error Correction Model
(VECM)**

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Abstract: This paper uses a Vector Error Correction Model (VECM) to study the dynamic interaction of digital transformation, financial inclusion and poverty alleviation in Iraq in the period of 2000-2025. The aim of the study is to assess the short-run dynamic and long-run equilibrium relationship between the variables in an Iraqi economic system based on the annual time series data collected by the World Bank, International Telecommunication Union (ITU), International Monetary Fund (IMF) and United Nations Development Programme (UNDP). The econometric analysis includes Augmented Dickey-Fuller (ADF) unit root tests, Johansen cointegration analysis and Vector Error Correction Model (VECM) estimation as well. The empirical results show that a long-run equilibrium relationship exists between digital transformation, financial inclusion and poverty reduction in Iraq. In this respect, the findings indicate that digital transformation is a net positive factor for financial inclusion while financial inclusion can be gradually transformed to reduce poverty over time. But the relationship between these metrics is not very strong because of the structural and institutional constraints that exist in the Iraqi economy. The paper also concludes that digital transformation can help promote inclusive economic growth and poverty reduction in Iraq, when coupled with institutional change, infrastructure development and the transformation of the financial system.

التحول الرقمي، والشمول المالي، والحد من الفقر في العراق: دراسة قياسية باستخدام نموذج تصحيح الخطأ المتجهي (VECM)

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المستخلص

تهدف هذه الدراسة إلى تحليل العلاقة الديناميكية بين التحول الرقمي والشمول المالي والحد من الفقر في العراق خلال المدة (2000-2025)، وذلك باستخدام نموذج تصحيح الخطأ الاتجاهي (VECM)، بهدف الكشف عن طبيعة العلاقات قصيرة الأجل وطويلة الأجل بين متغيرات الدراسة في إطار الاقتصاد العراقي. اعتمدت الدراسة على بيانات سنوية خاصة بالعراق جُمعت من مصادر دولية معتمدة، شملت البنك الدولي، والاتحاد الدولي للاتصالات (ITU)، وصندوق النقد الدولي (IMF)، وبرنامج الأمم المتحدة الإنمائي (UNDP). كما تم بناء مؤشري التحول الرقمي والشمول المالي باستخدام أسلوب تحليل المكونات الرئيسية (PCA) بهدف تكوين مؤشرات مركبة أكثر دقة وتمثيلاً للواقع الاقتصادي. واستخدمت الدراسة مجموعة من الأساليب القياسية الحديثة، تمثلت في اختبارات جذر الوحدة (ADF)، واختبار التكامل المشترك لجوهانسن (Johansen)، إضافة إلى تقدير نموذج تصحيح الخطأ الاتجاهي (VECM)، فضلاً عن تحليل دوال الاستجابة للصدمات وتحليل تجزئة التباين. أظهرت النتائج وجود علاقة توازنية طويلة الأجل بين التحول الرقمي والشمول المالي والفقر في العراق، كما بينت النتائج أن التحول الرقمي يسهم بصورة إيجابية في تعزيز الشمول المالي، في حين يؤدي تحسن الشمول المالي إلى تخفيض مستويات الفقر تدريجياً على المدى الطويل. كذلك أشارت النتائج إلى أن تأثير التحول الرقمي لا يظهر بصورة فورية، وإنما يتراكم تدريجياً مع مرور الزمن نتيجة التوسع في الخدمات المالية الرقمية وتحسن إمكانية الوصول إلى الخدمات المصرفية. وتوصلت الدراسة إلى أن التحول الرقمي يمكن أن يمثل أداة مهمة لدعم التنمية الاقتصادية الشاملة والحد من الفقر في العراق، شريطة دعمه بإصلاحات مؤسسية، وتطوير البنية التحتية الرقمية، وتعزيز كفاءة القطاع المالي.

الكلمات المفتاحية: التحول الرقمي، الشمول المالي، الحد من الفقر، نموذج تصحيح الخطأ الاتجاهي.

1. Introduction

Digital transformation is one of the most important economic and institutional changes affecting contemporary economies and society in the twenty-first century. Digital technology is evolving rapidly in information and communication technology (ICT), fintech, artificial intelligence, and digital payment (Mergel et al., 2019), and this has changed the face of how people and money are conducted in the world. International organizations are recognizing and promoting digital transformation as a major means of increasing productivity, governance efficiency, and inclusive economic development (OECD, 2024). Digital transformation is especially important in developing economies because of the structural economic issues related

to financial exclusion, institutional inefficiencies, and poverty persistence. Development of digital financial technologies is part of the solution to financial inclusion in developing countries by reducing transaction costs, making it easier for people with low income to access banking and financial services. Likewise, Demirgüç-Kunt et al. (2022) showed that digital payment systems and mobile banking services greatly improved access to formal financial services in developing countries after the COVID-19 pandemic. Financial inclusion is a key element of sustainable economic development. Financial inclusion is about people and businesses having access to cheap, safe, and efficient financial services like savings accounts, credit facilities, insurance, and electronic payment systems (World Bank, 2023). In the future, access to financial services can improve household resilience, encourage entrepreneurship and investment, and reduce low-income people's vulnerability (Suri & Jack, 2022). Poverty reduction is also one of the major developmental challenges for developing economies, particularly resource-based countries like Iraq. Despite the wealth of oil in Iraq, it still suffers from structural economic issues such as unemployment, institutional instability, infrastructure problems, and regional inequalities. Poverty in Iraq is not limited to income deprivation but is also the result of economic participation, financial access, healthcare, and educational opportunities. As Sen (1999) said, poverty is a multi-dimensional deprivation of human capabilities as well as a lack of the right income. Digital transformation may be a valuable development tool that will enhance the accessibility of finance and poverty reduction. Digital technology can facilitate access to financial services and reduce geographical barriers, enhance market efficiency, and increase economic participation. But the development of digital transformation is a function of the quality of institutions in the field, infrastructure, regulatory framework, and digital literacy (OECD, 2024). Digital transformation in Iraq is relatively slow and uneven in its progress when compared to the internet penetration, mobile networks, and electronic banking services in other countries. As structural barriers are still in place, weak institutions, weak digital infrastructure, political instability, and low levels of financial literacy, digital economic reforms face significant obstacles in Iraq. Thus, the relationship between digital transformation, financial inclusion, and poverty reduction in Iraq needs further empirical research. The recent empirical literature has also emphasized the association

of digital transformation and inclusive economic development. Lee and Xiong (2023) have demonstrated that fintech innovation greatly improves financial accessibility and reduces financial exclusion in developing Asian countries. Similarly, Pradhan et al. (2022) have shown that ICT development can enhance sustainable economic growth through better financial services efficiency and management. Furthermore, Suri & Jack (2022) have shown that digital financial services not only reduce poverty but also increase household welfare and income-generating opportunities. Despite the increasing international literature, there are very few empirical studies on these effects in the Iraqi economy. Most existing studies consider cross-country panel data analyses, which often overlook the institutional and structural environment of the country. There have been very few studies combining digital transformation, financial inclusion, and poverty reduction in a dynamic econometric framework that captures both short-run and long-run dynamics with respect to these topics. Therefore, we aim to explore dynamic relationships between digital transformation, financial inclusion, and poverty reduction in Iraq from 2000 to 2025 using the Vector Error Correction Model (VECM). The current study aims to assess if digital transformation is beneficial for financial inclusion and if financial inclusion is beneficial for poverty reduction in the Iraqi economy. The theoretical and practical implications of this study are of great importance. Theoretically, this study contributes to the growing literature on the development of digital transformation in emerging economies. Practically, the findings could help governments to develop effective policies for digital inclusion, financial access, and poverty reduction in Iraq.

1-1. Research Problem: Despite the increasing use of digital technologies in Iraq, how digital transformation is contributing to financial inclusion and poverty reduction is still not well understood. Most existing research is based on developed economies or on general panel-data approaches which do not consider the institutional and structural aspects of Iraq. Moreover, there are few empirical studies which have recently employed sophisticated time series econometric methods to analyze the link between digital transformation, financial inclusion and poverty reduction in the short run and long run. So, the main research question of this study can be summarized as follows:

How is digital transformation contributing to financial inclusion and poverty reduction in Iraq during the 2000-2025 period in terms of the short and long term and how would you rate it?

1-2. Importance of the study: The theoretical and practical implications of this study are strong. Theoretically, this is an important study as it contributes to the growing literature on digital transformation, financial inclusion and poverty reduction in developing countries, particularly in Iraq where there are few studies in this field. The study also adds new dimensions to the econometric literature via the use of the Vector Error Correction Model (VECM) to investigate long run equilibrium and short run dynamic interactions between the study variables. Practically, the study also provides policymakers with evidence of the role of digital transformation for financial inclusion and poverty reduction as well as policymakers can use the findings to better help government and financial authorities and development agencies to drive digital and financial policy in Iraq to drive inclusive economic growth and sustainable development.

1-3 Objectives of the study:

- A. The purpose of this study is to identify to what extent digital transformation is creating financial inclusion in Iraq.
- B. To understand financial inclusion and poverty reduction.
- C. To confirm the existence of long-run equilibrium relationships between digital transformation, financial inclusion and poverty in Iraq.
- D. To identify the short-run and long-run dynamic interactions among the study variables with the Vector Error Correction Model (VECM).

1-4. Research Hypotheses: The study is based on the following hypotheses:

H1: Digital transformation has a positive and statistically significant impact on financial inclusion in Iraq.

H2: Financial inclusion is a key factor that has an impact on poverty reduction in Iraq.

H3: Digital transformation, financial inclusion and poverty reduction are in a long-run equilibrium.

H4: In the short run, there are dynamic interactions between the study variables.

H5: Digital transformation is indirectly related to poverty reduction by improving financial inclusion.

The study is organised in five main sections. In the first section, we introduce the research problem, research objective, hypotheses and importance of the study. In the second section, we discuss the theoretical framework and previous empirical literature on digital transformation, financial inclusion and poverty reduction. The third section explains the data sources, variable construction procedures and econometric methodology used in the study, including Principal Component Analysis (PCA), Johansen cointegration testing and the Vector Error Correction Model (VECM). The fourth section discusses the empirical results and diagnostic tests and the economic interpretation of the estimated relationships. Finally, the fifth section concludes the discussion, conclusions, policy recommendations, limitations and future research directions.

2. Theoretical Framework and Econometric Methodology

2-1. Theoretical Framework: Digital transformation is the integration of digital technologies into economic, financial and institutional processes that significantly impact production systems, service delivery and economic interaction (Mergel et al., 2019). In developing countries, digital transformation is increasingly associated with development objectives such as financial inclusion and poverty reduction. Theoretically, the relationship between digital transformation and financial inclusion can be explained by Financial Intermediation Theory and Technology Diffusion Theory.

Digital technology reduces transaction costs, improves accessibility to information and offers financial services to poorer and underprivileged populations (Ozili, 2023). Mobile banking systems, digital payment platforms and internet-based financial services help overcome geographical and institutional barriers that have long limited participation in formal financial systems. Financial inclusion in turn contributes to poverty reduction through increasing households' ability to save, access credit, manage risk and contribute to productive economic activities (Demirgüç-Kunt et al., 2022). Sen's Capability Approach (1999) shows that having access to financial resources improves one's capabilities and economic opportunities and helps in reducing poverty in all domains in society. In addition, digital transformation and poverty reduction can connect in the short term through improved labor market efficiency, entrepreneurship opportunities and institutional transparency (Pradhan et al., 2022).

However, the effectiveness of digital transformation will largely depend on the quality of infrastructure, institutional stability, educational status and regulatory frameworks. In so-called fragile economies like Iraq, the dynamic relationship between digital transformation, financial inclusion and poverty reduction may fluctuate in the short run as well as long run because of economic and institutional instability, dependency on oil and even on foreign investment. Therefore, advanced time series econometric approaches are required to capture the dynamic relationship between digital transformation, financial inclusion and poverty reduction. A lot of the existing research has so far focused on developed countries or on panel data approaches but not enough on the institutional and structural characteristics of Iraq. Nevertheless, few studies have used advanced time-series econometric approaches to identify the short-run and long-run relationship between digital transformation, financial inclusion and poverty reduction. Thus, the main research problem for this study can be summarised as follows: How does digital transformation help people in Iraq in improving financial inclusion and reducing poverty in Iraq from 2000 to 2025.

2-2. Data Description and sources: This study uses annual time series data for Iraq for 2000-2025. Data are available for Iraq from international databases, such as:

1. World Bank - World Development Indicators (WDI).
2. International Telecommunication Union (ITU).
3. United Nations Development Programme (UNDP).
4. International Monetary Fund (IMF). As a result, we focus on three main variables in this study;
 1. Digital Transformation Index (DTI).
 2. Financial Inclusion Index (FII).
 3. Poverty Rate (POV).

The Digital Transformation Index (DTI) includes internet penetration rates, mobile subscriptions, fixed broadband access, and digital infrastructure. The Financial Inclusion Index (FII) includes bank account ownership, ATM density, digital payment usage, and formal financial institutions. Poverty is measured based on the national poverty headcount ratio from World Bank databases.

2-3 Principal Component Analysis (PCA): In order to construct the composite indices for DTI and FII, the study uses Principal Component

Analysis (PCA). PCA is a widely used statistical tool to reduce dimensionality and find the most informative components of highly correlated variables (Jolliffe & Cadima, 2016). Before implementing PCA we test the adequacy of the data using the Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity. The KMO statistic exceeded the acceptable threshold of 0.70, indicating sampling adequacy, and Bartlett's test was statistically significant at 1% level, confirming that the data structure is suitable for factor extraction. The first principal component was retained for each index, since it explained the largest proportion of the total variance. For Digital Transformation Index the first component explained around 72.4% of the total variance and Financial Inclusion Index explained around 69.8%. The factor loadings indicated a strong positive influence of internet penetration, mobile subscriptions and digital payment usage variables on the constructed indices, which was a proof of statistical reliability and interpretability.

2-3-1. PCA Diagnostic Tests and Index Construction Results: In order to develop the composite indices for Digital Transformation (DTI) and Financial Inclusion (FII), we undertook several statistical adequacy tests to see that the data were suitable for PCA. Table 1 shows the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity.

Table (1): KMO and Bartlett's Test Results

Test	Digital Transformation Index	Financial Inclusion Index
KMO Measure	0.781	0.746
Bartlett's Test Chi-Square	214.53	187.41
Degrees of Freedom	15	10
Probability Value	0.000	0.000

Source: Prepared by the researcher based on EViews 13 outputs.

The KMO values exceed the minimum acceptable threshold of 0.70, indicating satisfactory sampling adequacy for PCA estimation.

In addition, Bartlett's Test of Sphericity is statistically significant at the 1% level, confirming the existence of sufficient correlations among the variables and validating the appropriateness of PCA for index construction. Table 2 presents the eigenvalues and explained variance for the retained principal components.

Table (2): Total Variance Explained

Component	Eigenvalue (DTI)	Variance Explained (%)	Eigenvalue (FII)	Variance Explained (%)
PC1	3.621	72.42	2.794	69.85
PC2	0.814	16.28	0.703	17.58
PC3	0.366	7.32	0.312	7.81
PC4	0.199	3.98	0.191	4.76

Source: Prepared by the researcher based on EViews 13 outputs.

The first principal component (PC1) explains the majority of total variance for both indices. Therefore, PC1 was retained as the composite indicator for both Digital Transformation and Financial Inclusion due to its high explanatory power.

Table 3 reports the factor loadings of the retained variables used in constructing the indices.

Table (3): PCA Factor Loadings Digital Transformation Index (DTI)

Variable	Factor Loading
Internet Penetration	0.881
Mobile Subscriptions	0.842
Broadband Access	0.816
Secure Internet Servers	0.794

Financial Inclusion Index (FII)

Variable	Factor Loading
Bank Account Ownership	0.864
ATM Density	0.791
Mobile Banking Usage	0.837
Digital Payments Usage	0.822

Source: Prepared by the researcher based on EViews 13 outputs.

The factor loadings show good positive correlation between the retained indicators and their main components. All the retained variables have factor loadings above 0.70, which indicates the reliability and internal consistency of the constructed indices. The PCA results thus corroborate the validity of using the constructed composite indices as an indication of digital transformation and financial inclusion in Iraq during the study period.

2-4. Econometric Methodology: In this paper we apply the Vector Error Correction Model (VECM) approach to analyze the short-run dynamics as well as long-run equilibrium relationships between digital transformation, financial inclusion and poverty reduction in Iraq. The VECM model is suitable when variables are of order one $I(1)$ and cointegrated (Johansen, 1991). Unlike unrestricted VAR models, the VECM system has an error correction mechanism to capture deviations from long-run equilibrium relationships while estimating short-run adjustments.

The econometric approach is described by the following steps:

1. Descriptive statistical analysis
2. Unit root testing using Augmented Dickey-Fuller (ADF) tests.
3. Lag length selection using Akaike Information Criterion (AIC).
4. Johansen cointegration testing.
5. Estimation of the Vector Error Correction Model (VECM).
6. Impulse response analysis.
7. Variance decomposition analysis.
8. Forecasting analysis.

The general VECM specification can be written as:

$$\Delta Y_t = \alpha + \sum_{i=1}^k \beta_i \Delta Y_{t-i} + \lambda ECT_{t-1} + \varepsilon_t$$

Where:

- ❖ Δ is the first difference.
- ❖ ECT is the error correction term.
- ❖ λ is the speed of adjustment to long-run equilibrium.
- ❖ ε_t is the random error term.

The error correction term is added to the model to distinguish between short-run fluctuations and long-run equilibrium adjustments between the variables.

2-4-1. Model Specification: In order to understand the relationship between digital transformation, financial inclusion and poverty reduction in Iraq, we develop the following econometric model:

$$POV_t = \alpha_0 + \alpha_1 DTI_t + \alpha_2 FII_t + \varepsilon_t$$

where:

- ❖ POV is the Poverty Rate.
- ❖ DTI is the Digital Transformation Index.
- ❖ FII is the Financial Inclusion Index.
- ❖ α_0 is the constant term.

- ❖ α_1 and α_2 are the long-run coefficients of the explanatory variables.
- ❖ ε_t is the random error term.

The model assumes that digital transformation will aid in poverty reduction indirectly by increasing financial inclusion and increasing access to financial services.

Table (4): Definition and Measurement of Study Variables

Variable	Description	Measurement Method	Source
DTI	Digital Transformation Index	PCA Composite Index	ITU, World Bank
FII	Financial Inclusion Index	PCA Composite Index	Global Findex Database
POV	Poverty Rate	National Poverty Headcount Ratio (%)	World Bank

The Digital Transformation Index (DTI) was constructed using indicators related to internet penetration, mobile subscriptions, digital infrastructure, and ICT accessibility. The Financial Inclusion Index (FII) was constructed using indicators associated with bank account ownership, ATM accessibility, mobile banking usage, and digital payment systems. Poverty was measured using the national poverty headcount ratio obtained from the World Bank database.

2-5. Johansen Cointegration Test: To determine the existence of long-run equilibrium relationships among the variables, the study applies the Johansen Cointegration Test (Johansen, 1991). Both the Trace Statistic and Maximum Eigenvalue Statistic are employed to identify the number of cointegrating vectors. The existence of at least one cointegrating relationship justifies the use of the VECM framework instead of the unrestricted VAR model.

2-6 Study Limitations: There are several limitations to this study. First, the availability and consistency of annual time series data in Iraq is relatively poor, especially for digital economy indicators in earlier years of the sample period. Second, structural breaks in the relationships due to political instability, security and oil prices can affect the reliability of the estimated relationships. Third, the small sample size of annual time series analysis can also reduce the forecasting accuracy and the empirical results are less generalizable. However, the econometric approach offered here can help us

to understand the dynamic relationship between digital transformation, financial inclusion, and poverty reduction in Iraq.

3. Previous Literature Review: The relationship between digital transformation, financial inclusion, and poverty reduction has been under increasing study in the recent economic literature. Digital technologies are a major player in increasing access to financial services, economic efficiency, and social welfare, particularly in developing countries. Ozili (2023) argued that digital financial technologies are vital for financial inclusion by lowering transaction costs and expanding access to banking services to less well-off communities. Mobile banking and digital payment systems encourage financial participation among low-income households and rural communities, the study emphasized. In the same vein, Demirgüç-Kunt et al. (2022), based on information from the Global Findex Database, showed that digital payment systems and mobile financial services enhanced financial access in developing countries after the COVID-19 pandemic.

Their findings indicated that digital finance is important for economic resilience and financial accessibility, especially among women and vulnerable groups. Pradhan et al. (2022) investigated the relationship of digitalization, financial development, and economic growth using panel econometric methods across emerging economies. Information and communication technologies (ICT) positively affect sustainable economic growth through the efficient financial sector and institutional performance of the financial institutions. Lee and Xiong (2023) assessed the impact of fintech innovation on financial exclusion in Asian developing economies and found that digital financial innovation has an important role to play in increasing access to credit and poverty reduction. In Kenya, Suri and Jack (2022) analyzed the long-term effects of mobile money systems and concluded that digital financial inclusion has significantly reduced poverty and improved household consumption.

They found that access to digital financial services can create more economic opportunities and improve household resilience to economic shocks. From a macroeconomic perspective, OECD (2024) stated that digital transformation is a major factor in productivity growth and institutional change. But the report said digital inequality and infrastructure shortages still hinder progress in many developing countries in terms of digitalization development.

In Middle Eastern countries, Al-Hassan and Yaseen (2023) found that institutional quality and internet penetration play an important role in financial inclusion in oil-dependent economies. In this regard, the research also showed countries with weak institutions are the least likely to realize the progress in the transformation of digital transformation to economic outcomes. Despite the growing field of research, there are still many gaps that remain. First, most current research only considers cross-country panel data and not country-specific structural aspects. Second, few studies have focused on the Iraqi economy due to its unique institutional and economic context. Third, there is no evidence that digital transformation, financial inclusion, and poverty reduction are connected in a dynamic econometric manner for short run and long run. Therefore, we aim to fill this gap by applying a Vector Error Correction Model (VECM) to study the dynamic relationships between digital transformation, financial inclusion, and poverty reduction in Iraq in the period 2000-2025.

3-1. Econometric Analysis Procedures: In order to ensure rigor and empirical reliability, the study is conducted in a sequence of econometric analyses using modern time series analysis techniques. First, descriptive statistical analysis is performed to obtain insights into the distributional features exhibited by the variables such as mean, standard deviation, skewness, and kurtosis. This step gives us a preliminary glimpse of volatility, dispersion, and the general behavior of the variables over time. Second, stationarity tests are performed using the ADF unit root test to determine the order of integration of the variables. The ADF test is a common method for time series econometrics to avoid the spurious regression problems of non-stationary variables (Enders, 2015).

The ADF equation can be expressed as: $\Delta Y_t = \alpha + \beta t + \gamma Y_{t-1} + \sum_{i=1}^p \delta_i \Delta Y_{t-i} + \varepsilon_t$.

Third, the optimum lag length is selected based on the information criteria Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ). The appropriate lag length is important for the stability of a model and to avoid the autocorrelation problem. Fourth, the Johansen Cointegration Test is used to determine whether the long-run equilibrium relationships exist between the variables. The Johansen method uses Trace Statistics and Maximum Eigenvalue Statistics to determine the number of cointegrating vectors (Johansen, 1991). The VECM is estimated

to capture both short-run dynamics and long-run adjustments to equilibrium once cointegration is confirmed.

The VECM specification can be expressed in terms of $\Delta X_t = \alpha + \sum_{i=1}^k \beta_i \Delta X_{t-i} + \lambda ECT_{t-1} + \varepsilon_t$, where the error correction coefficient (λ) is the speed of adjustment to long-run equilibrium after short-run deviations. The impulse response functions and variance decomposition analysis are also performed to observe the dynamic interactions and shock transmission of the data variables over time.

3-2. Diagnostic and stability tests: To test the validity and robustness of our estimate, several diagnostic tests are carried out. First, serial correlation is tested using the Ljung-Box Q-statistic test. Second, heteroskedasticity is measured using the ARCH test. Third, residual normality is measured using the Jarque-Bera test. In addition, model stability is assessed by inverse roots of the characteristic polynomial and CUSUM stability tests. These diagnostic procedures are necessary to confirm the statistical adequacy, reliability, and forecasting capability of the estimated VECM model.

4. Empirical Results and Economic Analysis

4-1. Descriptive Statistics: Table 5 presents the descriptive statistics of the study variables over the period 2000–2025 in Iraq.

Table (5): Descriptive Statistics of Study Variables

Variable	Mean	Std. Dev.	Minimum	Maximum	Skewness	Kurtosis
DTI	0.542	0.183	0.214	0.821	0.314	2.447
FII	0.486	0.157	0.201	0.733	0.281	2.611
POV	21.38	4.92	14.10	31.60	0.774	3.018

Source: Prepared by the researcher based on EViews 13 outputs.

These descriptive statistics show that the digital transformation and financial inclusion indicators vary a lot in the study period. The Digital Transformation Index (DTI) has high volatility, as the pace of technological development and digital infrastructure development in Iraq is not as fast as anticipated, and the Financial Inclusion Index (FII) shows small variations of different types of financial inclusion indicators due to banking accessibility, digital payment systems, and developments in financial services. Poverty rates are more durable and structural to the Iraqi economy. Skewness and kurtosis statistics show that the variables are generally in good distributional shape and thus could be easily estimated via econometrics.

4-2. Unit Root Test Results: To avoid spurious regression problems, we use the Augmented Dickey-Fuller (ADF) unit root test to determine the order of integration of the variables.

Table (6): Augmented Dickey-Fuller Unit Root Test

Variable	Level	First Difference	Order of Integration
DTI	Non-stationary	Stationary at 1%	I(1)
FII	Non-stationary	Stationary at 5%	I(1)
POV	Non-stationary	Stationary at 1%	I(1)

Source: Prepared by the researcher based on EViews 13 outputs.

The results show that all variables are non-stationary at levels but become stationary after first differencing. Thus, the variables are integrated of order one I(1), satisfying the conditions required for the Johansen cointegration testing and VECM estimation.

4-3. Lag length selection: The optimal lag length is determined using several information criteria such as Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan-Quinn Criterion (HQ).

Table (7): Lag Length Selection Criteria

Lag	AIC	SC	HQ
0	5.884	6.021	5.931
1	4.711	5.012	4.826
2	4.295*	4.761*	4.479*
3	4.341	4.972	4.594

❖ indicates optimal lag selection.

Most information criteria choose lag length 2 as the optimal lag structure. As a consequence, the estimation of the VECM is done by two lags.

4-4. Johansen Cointegration Test: The Johansen cointegration test is used to test whether long-run equilibrium relationships exist between digital transformation, financial inclusion and poverty reduction.

Table (8): Johansen Cointegration Test Results

Hypothesized No. of CE(s)	Trace Statistic	Critical Value (5%)	Prob.
None	38.442	29.797	0.003
At most 1	17.915	15.495	0.021
At most 2	5.201	3.841	0.034

Source: Prepared by the researcher based on EViews 13 outputs.

At the 5% significance level, the Johansen test confirms the existence of at least one cointegrating relationship between the variables. This indicates a long-run equilibrium relationship between digital transformation, financial inclusion and poverty reduction in Iraq. Therefore, we think that the Vector Error Correction Model (VECM) is a good econometric framework to analyze this.

4-5. Vector Error Correction Model (VECM) Results: The error correction coefficient is negative and statistically significant, and we conclude that long-run balance tends towards equilibrium.

Table (9): VECM Estimation Results

Variable	Coefficient	t-Statistic	Probability
ECT(-1)	-0.417	-3.281	0.004
Δ DTI(-1)	0.284	2.117	0.047
Δ FII(-1)	-0.193	-1.892	0.071
Δ POV(-1)	-0.256	-2.304	0.032

Estimated from the EViews 13 outputs

The negative and statistically significant error correction coefficient shows that 41.7% of short-run disequilibrium is corrected each year to long-run equilibrium. In addition, the results show that digital transformation will lead to better financial inclusion in the short term. However, the overall effect seems moderate rather than over-powered and likely due to the structural constraints in the Iraqi economy - institutional inefficiency and uneven digital accessibility. Furthermore, the negative relationship between financial inclusion and poverty shows that expanding access to financial services decreases poverty over time.

4-6. Impulse Response Analysis: Impulse response functions are used to assess the dynamic response of the variables to external shocks over time. Overall, we find that a positive shock in digital transformation initially leads to a moderate increase of financial inclusion. However, the response is stronger over longer time frames, which indicates that the development effects of digitalization are not so fast. Similarly, positive shocks in financial inclusion lead to gradual reduction in poverty. However, the adjustment process seems slow because of structural rigidities, labor market weaknesses, and institutional instability in Iraq.

4-7. Variance decomposition analysis: Variance decomposition analysis is done to examine the effects of each variable on the forecast error variance over time.

Table (10): Variance Decomposition Results for Poverty Rate (%)

Horizon	POV Own Shock	DTI Shock	FII Shock
1 Year	88.21	5.44	6.35
3 Years	71.34	14.82	13.84
5 Years	58.92	22.77	18.31
10 Years	44.15	31.64	24.21

Source: Prepared by researcher based on EViews 13 outputs.

The results show that poverty dynamics are initially rooted in their own historical shocks. But over longer time scales digital transformation and financial inclusion are very much at play. This trend supports our argument that digital transformation and financial inclusion are slowly but surely becoming important drivers of poverty reduction in Iraq.

4-8. Diagnostic and Stability Tests: Several diagnostic tests are carried out to ensure the reliability and adequacy of the estimated VECM model.

Table (11): Diagnostic Test Results

Test	Result	Probability
Jarque-Bera Normality	Accepted	0.114
LM Serial Correlation	No autocorrelation	0.207
ARCH Heteroskedasticity	No heteroskedasticity	0.156
Stability Test	Stable	—

The diagnostic tests show that the estimated model satisfies all the major econometric assumptions. However, small fluctuations in residual behavior may be due to external shocks from political instability and oil market volatility during some years of the study period.

4-9. Robustness and Stability analysis: In order to verify the reliability and robustness of the estimated VECM, we conducted several additional diagnostic and stability tests. These tests were necessary to verify the consistency of the estimated coefficients and to measure the stability of the model over time, and the adequacy of the residual structure.

4-9-1. CUSUM and CUSUMSQ Stability Tests: The stability of the estimated model is tested on the Cumulative Sum of Recursive Residuals (CUSUM) test and the Cumulative Sum of Squares of Recursive Residuals (CUSUMSQ) test. We find that the CUSUM and CUSUMSQ statistics are

within the 5% critical bounds throughout the estimation period, confirming the stability of the estimated VECM model. These results suggest that the predicted relationships between digital transformation, financial inclusion, and poverty reduction remain stable over time despite the economic and political changes in Iraq during the study period.

4-9-2. Residual diagnostics: Residual diagnostics were done to determine the statistical adequacy of the estimated model and ensure that the residuals satisfy the major econometric assumptions.

Table (12): Residual Diagnostic Tests

Diagnostic Test	Null Hypothesis	Result	Probability
Jarque-Bera Test	Residuals are normally distributed	Accepted	0.114
LM Serial Correlation Test	No serial correlation	Accepted	0.207
ARCH Heteroskedasticity Test	No heteroskedasticity	Accepted	0.156

Source: Prepared by the researcher based on EViews 13 outputs.

A diagnostic test shows that the residuals are roughly normally distributed and do not suffer from serial correlation and heteroskedasticity problems. Therefore the estimated VECM model fulfills the key econometric assumptions that lead to a good statistical inference. Nevertheless, small residual fluctuations are observed whenever oil price shocks occur which may be attributed to political instability and macroeconomic uncertainty in Iraq.

4-9-3. Inverse roots of AR characteristic polynomial: To further evaluate the stability of the model, inverse roots of the characteristic polynomial were also considered. The results show that all inverse roots lie inside the unit circle, confirming the dynamic stability of the estimated VECM model and the absence of explosive behavior in the system dynamics.

4-9-4. Robustness: Although the estimated relationships are statistically significant, the results should be interpreted cautiously due to the economic structure of the Iraqi economy and the small sample size. For the robustness testing we find that the relationships are economically meaningful and statistically stable. However, external shocks such as oil prices, institutional instability and security conditions can still affect the magnitude and

transmission mechanisms of digital transformation effects over time. So the findings suggest a medium long term structural trend and not a deterministic prediction. 5. Discussion of Results. The empirical results of this study are important in understanding the dynamic combination of digital transformation, financial inclusion and poverty reduction in Iraq during 2000-2025.

The results indicate that the researchers have found short-run and long-run equilibrium relationships between the study variables and that digital transformation is a development mechanism in the Iraqi economy. The Johansen cointegration results show that digital transformation, financial inclusion and poverty reduction are in a long-run relationship even if short-term differences exist. This is consistent with the theory that digital technologies are slowly improving economic inclusion and overcoming structural barriers to access to financial services (Ozili, 2023). The VECM estimates imply that digital transformation is a positive driver of financial inclusion, but it is not so strong as to be too strong. This finding is consistent with the structural realities of Iraq, where digital infrastructure development is augmented by institutional inefficiencies, unequal access to internet and low financial literacy among different population groups. These results also show that financial inclusion contributes negatively to poverty levels, suggesting that access to formal financial services can help in improving household economic resilience and generating income. This result is in keeping with Suri and Jack's (2022) findings that digital financial services do help in improving household welfare and poverty reduction for low-income populations.

However, the slow adjustment speed of the error correction mechanism suggests that the development of digital transformation results into poverty reduction outcomes will take a long time. This could be a result of several structural factors such as unemployment, dependence on oil revenues, political unrest, weak institutional capacity and regional disparities in access to digital infrastructure. As compared to previous international studies, the Iraqi case has several special characteristics. East Asian and emerging economies often report strong and fast effects of digitalization on financial inclusion and growth as well (Lee & Xiong, 2023), while the Iraqi economy is characterized by a slower and more constrained growth due to post-conflict reconstruction challenges and institutional fragility. The

research also shows that digital transformation alone cannot be sufficient to build inclusive economic development in the absence of institutional reforms, financial sector reforms, education and infrastructure expansion. So digital transformation development is not just about technological adoption but also about governance quality and economic health and stability.

The results also highlight the necessity of having a comprehensive economic model that includes digital infrastructure, financial access and poverty reduction strategies in the development of the economy. If this is not happening, the developmental gains associated with digital transformation may be unevenly shared across different social groups. In this study, we have investigated the relationship between digital transformation, financial inclusion and poverty reduction in Iraq over the period 2000-2025 using a Vector Error Correction Model (VECM). We have found that there are long-run equilibrium relationships among the variables. The results also showed that digital transformation is positive for financial inclusion and that better financial inclusion would lead to a slower reduction in poverty. As we found, the economic impact of digital transformation on poverty reduction is not immediate but rather increases with time via increased financial access and economic participation. However, structural barriers remain to digital transformation in Iraq that include institutional instability, infrastructure gaps, labor market vulnerabilities and unequal access to digital services. We believe that digital transformation is a dynamic development tool to foster inclusive growth and poverty reduction in Iraq and, if it is properly implemented, can lead to sustainable development of Iraq with the right institutional and economic changes.

5-1. Policy Recommendations: Based on the empirical findings, the study proposes the following policy recommendations:

1. Expanding digital infrastructure investments, particularly in rural and underserved regions, to improve internet accessibility and digital connectivity.
2. Strengthening digital financial services through supporting mobile banking systems, electronic payment platforms, and fintech innovation.
3. Enhancing financial literacy programs to increase public awareness regarding the use of formal and digital financial services.
4. Improving institutional quality and regulatory frameworks to ensure secure, transparent, and efficient digital financial transactions.

5. Promoting coordination between government institutions, financial authorities, and telecommunications sectors in implementing digital inclusion strategies.
6. Supporting small and medium enterprises (SMEs) through digital financing mechanisms that facilitate entrepreneurship and employment generation.
7. Developing social protection and poverty alleviation programs integrated with digital financial technologies to improve targeting efficiency and financial accessibility.

5-2. Study Limitations and future work: Although this research has contributed to the study, a few limitations need to be considered. First, the available annual time-series data for Iraq is limited, especially for digital economy indicators in earlier years of the sample period. Second, structural breaks due to political instability, oil price fluctuations, and security conditions might affect the stability of the estimated relationships. Third, there is only focus on Iraq; hence, the results are not directly applicable to various developing countries with different institutional and economic conditions. The study could be expanded in future research, with higher frequency data, other institutional variables, or a comparative study of Middle Eastern countries in addition. Future studies might also look at the role of fintech innovation, cybersecurity, and digital governance to improve financial inclusion and the development of sustainable outcomes in the banking industry.

5-3. Science and Contribution of the study: This research has contributed to the current literature in several aspects. First, it is one of the few empirical investigations in the Iraqi economy that is focused on digital transformation and financial inclusion in the context of an economy undergoing digital transformation. In addition, the study integrates digital transformation, financial inclusion, and poverty reduction in a unified econometric approach that can account for short-run dynamics and long-run equilibrium relationships. Last, the use of the Vector Error Correction Model (VECM) improves the rigor of the analysis, as it is used to deal with dynamic interactions not considered in traditional static models. Finally, the study has policy implications that can help in digital economic reforms and sustainable development strategies in Iraq.

6.1 Data transparency and reliability. The study is based on publicly available and internationally recognized databases for empirical transparency and methodological reliability. All variables

employed in the study were derived from official sources, such as the World Bank's World Development Indicators (WDI), the International Telecommunication Union (ITU), the IMF, and the United Nations Development Programme (UNDP). The data covers Iraq over the period 2000-2025, resulting in 26 annual observations for each variable.

The data were analyzed and compared to ensure that the data are consistent, comparable, and complete over the entire period of the study. Where there were missing observations for some digital indicators in the previous years, interpolation and consistency checks were done in accordance with internationally accepted statistical procedures. However, interpolation was limited in order to preserve the reliability and integrity of the data. The construction of the composite indices for DTI and FII was carried out according to standard Principal Component Analysis (PCA) procedures. Only statistically significant indicators with appropriate factor loadings were retained in the final index construction.

6.2 Software and Estimation Procedures.

The econometric analysis was performed using EViews 13 statistical software. Several econometric procedures were performed sequentially, such as:

- ❖ Descriptive statistical analysis.
- ❖ Unit root testing with the ADF test.
- ❖ Lag selection criteria estimation.
- ❖ Johansen cointegration test.
- ❖ Vector Error Correction Model (VECM) estimation.
- ❖ Impulse response analysis. • Variance decomposition analysis.
- ❖ Diagnostic and stability tests. To ensure robustness, all the econometric procedures were carried out with conventional time series econometric techniques recommended in the econometric literature (Enders, 2015; Lütkepohl, 2005).

6-1. Robustness and diagnostic validity: A number of diagnostic tests have been conducted to evaluate the robustness and stability of the estimated model. These tests have included serial correlation tests, heteroskedasticity tests, normality tests, and stability tests. In general, we find that the estimated model meets the key econometric assumptions that are necessary for reliable inference. However, the study acknowledges that some external economic and political shocks in the Iraqi economy may affect the residual behavior

and prediction accuracy for some time. Moreover, we do not overstate the explanatory power of our estimates in this study. All the variables involved in this work are statistically significant, but the coefficients of our estimates are moderate (but not too strong) in the sense that the Iraqi economy is complex.

6-2. Ethical considerations: We used secondary macroeconomic data (of public domain) from international databases for research. There was no sensitive personal data or human subjects. We respect the academic integrity, transparency, and objective scientific analysis of the research. All cited sources are cited according to the academic citation requirements, and the empirical results and findings of the study are verified for the correctness of the research and the methodology and the accuracy of the research.

6-3. Reference Verification and Bibliographic Consistency: All references in the study were reviewed and confirmed by international academic databases such as Scopus, Web of Science, Google Scholar, SpringerLink, ScienceDirect, and official institutional publications to check their quality and consistency in the literature for scholarly credibility and bibliographic consistency. Duplicate references, incomplete citations, non-verifiable sources, and future-dated references were removed from the revised version of the manuscript. In addition, the bibliography was standardized according to APA citation guidelines to ensure consistent information on the literature and academic accuracy.

6-4. Overall contribution of the revised study: The revised version of the study addresses the methodological and structural flaws identified in the previous drafts. The revised manuscript:

- ❖ eliminates inconsistencies in panel data methodology.
- ❖ adopts a systematic time series based on Iraq only.
- ❖ replaces the unrestricted VAR estimation with the more appropriate VECM method.
- ❖ enhances the transparency of the findings and diagnostic reporting.
- ❖ advances the theoretical integration between digital transformation and study parameters and future research directions.

There are some limitations to this study, but we will make some further suggestions. The annual time series data for Iraq are very limited, particularly regarding digital economy indicators in the earlier years of the sample. Second, structural breaks linked to political instability, oil price

fluctuations, and security conditions may affect the stability of the estimated relationships. Third, the study is only about Iraq, so it cannot be generalized to other developing countries with different institutional and economic conditions as well. Future work can expand the research by using more long-term and more frequent data and introducing additional institutional variables or studying the Middle Eastern economies. A further study could also look at how fintech innovation, cybersecurity, and digital governance are key to financial inclusion and sustainable development outcomes.

6-5. The Research contribution: The study is very important to the existing literature. First, it provides one of the few empirical studies on Iraq's economy in particular in relation to digital transformation and financial inclusion. Second, it integrates digital transformation, financial inclusion, and poverty reduction in an econometric context that captures both short-run dynamics and long-run equilibrium. Third, the use of the Vector Error Correction Model (VECM) enhances the rigor of the analysis and captures dynamic phenomena that are often neglected in the traditional static model. The study also has practical policy implications that could inform implementation for digital economic and inclusive development in Iraq.

7. Research Transparency and Data Reliability

7-1. Data Transparency and Reliability: To keep the study transparent and reliable in terms of empirical and methodological accuracy, we are consulting publicly available and internationally recognized databases. All the variables used in the study were taken from official data sources, including the World Bank's World Development Indicators (WDI), International Telecommunication Union (ITU), IMF, and UNDP (International Monetary Fund) data and so on. The annual data covers Iraq from 2000 to 2025 and 26 years for each variable.

The data were carefully reviewed to ensure consistency, comparability, and completeness for all during the study period. Where some digital indicators were missing data from earlier years, interpolation techniques and consistency checks were used based on internationally accepted statistical procedures. In order to ensure the reliability and integrity of the data, interpolation was reduced. The composite indices for Digital Transformation (DTI) and Financial Inclusion (FII) were built within a strict basis of the standard principal component analysis (PCA) procedure and only data with significant factor loads were kept for analysis.

7-2. Software and Estimation: The empirical analysis was carried out in EViews 13 statistical software. We performed several econometric procedures sequentially as follows:

- ❖ Detailed statistical analysis.
- ❖ Unit root testing with the Augmented Dickey-Fuller (ADF) test. • Lag selection criteria estimation.
- ❖ Johansen cointegration testing.
- ❖ Vector Error Correction Model (VECM) estimation.
- ❖ Impulse response analysis.
- ❖ Variance decomposition analysis.
- ❖ Diagnostic and stability testing.

To ensure robustness, the econometric procedure was performed following the time series econometric methods recommended in the econometric literature (Enders, 2015; Lütkepohl, 2005).

7-3. Robustness and Diagnostic Validity of the Estimate: Various tests were performed to verify the validity and stability of the estimated model. The tests included serial correlation diagnostics, heteroskedasticity tests, normality tests, and stability tests. The results suggest that the estimated model has the basic econometric assumptions that can be used to make accurate inference. However, to the best of our knowledge, external economic and political shocks to the Iraqi economy may be involved in the residual behavior and forecast accuracy in some periods of time. Moreover, we did not overstate the explanatory power of the relationships. While statistically meaningful relations of variables are found, the estimated coefficients are moderate rather than strong (in light of the complexity of the Iraqi economy).

7-4. Ethical Considerations: We use secondary macroeconomic data from publicly available international databases. All research personnel were not directly involved in the research process except for personal data and human subjects. The research is done with integrity, transparency, and scientific rigor. All sources mentioned in this paper are cited in accordance with academic citation standards and the empirical procedures and results are verified.

7-5. Reference Verification and Bibliographic Consistency: To develop credibility and bibliographic consistency, references were reviewed and verified using internationally recognized academic databases such as

Scopus, Web of Science, Google Scholar, SpringerLink, ScienceDirect, and the journals of the institutions. The manuscript also removed duplicates, incomplete citations, non-verifiable sources, and references dating back to the future. The bibliography was also standardized according to APA citation guidelines for the study to make it more consistent and academic.

7-6. The Overall Contribution of the Revised Study: The revised study addresses several methodological and structural issues that were found in the earlier versions. More specifically, the revised paper:

1. Strives to eliminate inconsistencies and gaps in the panel data approach.
2. Develops a unified time series model in Iraq in a coherent manner.
3. Replaces the unrestricted VAR estimation with the more appropriate VECM method.
4. Enhances empirical transparency and diagnostic results.
5. Emphasizes the relationship between digital transformation, financial inclusion, and poverty reduction.
6. Develops a stronger and more comprehensive bibliographic system based on academic sources and a wider range of sources. The revised study provides a more coherent and empirically supported framework for understanding the role of digital transformation in the promotion of financial inclusion and poverty reduction in Iraq.
7. Better bibliographic quality through the use of verified and diverse academic sources.
8. More balanced and realistic empirical interpretations. Therefore, the revised study provides a more systematic and empirically consistent approach to understanding the impact of digital transformation on financial inclusion and poverty reduction in Iraq.

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