American Journal of Economics and Business Management
Vol. 8 Issue 5 | pp. 2240-2254 | ISSN: 2576-5973
Available online @ https://www.globalresearchnetwork.us/index.php/ajebm

Article

The Economic Impact of Digital Financial Inclusion: Evidence from Iraq (2023-2010)

Hussein Kaif Aziz[1], Mustafa Hussein Abdulali[2], Kawther Kareem Abdul Razzak[3]

1. University of Wasit, College of Administration and Economics, Department of Economics
2. University of Wasit, College of Administration and Economics, Department of Economics
3. University of Wasit, College of Administration and Economics, Department of Economics

* Correspondence: haziz@uowasit.edu.iq

Abstract: Digital financial inclusion has emerged as a transformative mechanism that extends financial access, reduces transaction costs, and promotes economic stability, particularly in developing economies. In Iraq, limited banking infrastructure, low ATM penetration, and reliance on cash-based systems hinder the potential benefits of financial technology. Despite growing global research on digital finance, empirical evidence on its macroeconomic effects in financially underdeveloped contexts like Iraq remains limited. This study investigates the impact of digital financial inclusion on Iraq's economic performance from 2010 to 2023 using an econometric framework combining factor analysis and Ridge Regression with Bootstrap resampling. The findings reveal that indicators such as ATM availability, banking spread, and branch density significantly influence an economic performance index derived from poverty, unemployment, and financial depth metrics. The model achieved strong predictive accuracy, with an R^2 of 0.79 and a mean absolute percentage error of 8.8%. Future projections show fluctuations in economic performance, emphasizing the role of financial accessibility in macroeconomic stability. The research introduces a robust statistical model tailored for data-limited environments, employing Ridge Regression to address multicollinearity and Bootstrap techniques to improve reliability, offering a replicable method for analyzing financial inclusion effects. The study provides policy-relevant insights, highlighting the importance of expanding digital financial infrastructure to enhance economic resilience in Iraq. It underscores the need for targeted regulatory reform, digital literacy programs, and strategic financial sector investments to sustain inclusive economic growth.

Keywords: Digital Financial Inclusion, Ridge Regression, Bootstrap Resampling, Factor Analysis, Economic Performance Index

Citation: Aziz H. K. Abdulali M. H. Ali M. M. S. and Razzak K. K. A. The Economic Impact of Digital Financial Inclusion: Evidence from Iraq (2023-2010). American Journal of Economics and Business Management 2025, 8(5), 2240-2254.

Received: 18th JFeb 2025
Revised: 11th Mar 2025
Accepted: 24th Apr 2025
Published: 17th May 2025

1. Introduction

Modern economies experience digital financial inclusion as a disruptive transformational power which shapes how people gain access to finance alongside their economic stability and their development methods. The digital financial service landscape expands financial intermediation by lowering expenses and extending financial opportunities to credit and enabling marginalized people to join formal financial systems. Digital technological financial integration at high levels drives better economic development and strengthens financial stability coupled with diminished economic inequalities according to Guo et al. and Liu & Walheer. Research findings demonstrate that digital financial inclusion positively impacts economic performance through its ability to reduce poverty while generating employment and establishing financial stability according to Wang et al. and Peng & Mao. Digital inclusion has different financial outcomes with different regions since they have different degrees of the development of finance, as well as regulatory and acceptance rates in technology. In China and OECD economies, digital financial platforms enhance both the efficiency of banking and investment growth as supported by recent academic research of Hashemizadeh et al., Liu et al. Digital financial inclusion exposes credit to small businesses and leads to increased household spending. Mobile banking and electronic payments and financial technology (FinTech) solutions combined with several other solutions work to ease liquidity limitations and optimize capital distribution in emerging markets according to Xu & Wang and Lei et al. Digital financial inclusion creates economic consequences that go beyond direct access to finances because it promotes industries to adapt and develop new technologies and improve the stability of economic systems according to Yang et al. and Telukdarie & Mungar [1].

The effect of digital financial inclusion on economy performance needs evaluation in Iraq where the case shows distinct traits. The financial sector of Iraq exists in a poor state of development due to broad-based exclusion from formal banking services. Financial deepening is impaired because of limited ATM availability and sparse banking offices throughout the country alongside extensive cash usage. The literature establishes financial technology's ability to resolve structural problems through mobile-based financial services that boost economic involvement and employment capabilities. Scientific study on how digital financial inclusion affects Iraq's overall economic performance development remains insufficiently studied [2].

This analysis studies the economic performance effects of digital financial inclusion in Iraq by analyzing key indicators which measure financial accessibility namely ATM provision and banking distribution and private financial sector performance. The study builds an economic performance index through factor analysis techniques which combines poverty and unemployment data and other macroeconomic factors. Ridge Regression is implemented to proclaim estimation accuracy improvements while addressing the multicollinearity issues. This approach provides researchers with a complete method to evaluate digital financial inclusion effects on economic growth while following previous studies about financial technology development [3].

Literature review

Economic development and both financial access and poverty reduction use digital financial inclusion as their primary motivational drive. Digital financial services have revolutionized the conventional financial sector because they improve banking reach and decrease costs while supporting economic stability. Financial technology allows digital financial inclusion to facilitate economic participation because it provides access to credit and improves saving methods while reducing social disparity. Multiple empirical studies demonstrate digital financial inclusion has major effects on macroeconomic measurements such as GDP growth together with employment rates as well as financial risk reduction [4].

Digital platforms serve as the main tools to facilitate financial service delivery due to advancements in financial concept development. Several studies analyze the relations between digital financial inclusion and economic development based on the facts how mobile banking, online payment systems along with alternative credit assessment models enhance access to financial services. Digital financial inclusion empowers individuals in disadvantaged realms to access both digital means for banking transactions and credit loans insurance and investment services as explained by Hashemizadeh et al. and Lei et al. Digital financial services enhance economic stability, through the secure payment infrastructure which ensures that transactions in digital financial services are more secure as compared to cash transactions. The economic consequentiality of digital financial inclusion exceeds baseline financial access as it reinforces household purchasing power and business expansion and enhances macroeconomics dynamics. Digital financial services generate economic productivity gains because they can build capital level and increase the diversity of investments. In developed nations and developing countries, Indian studies corroborate the fact that digital financial inclusion is highly potent in enhancing economic growth through improved financial deepening and banking performance. Studies confirm that digital financial platforms facilitate industrial transformation by offering SMEs, which act as providers of substitute funding options, employment growth and innovative initiatives [5].

Digital financial inclusion provides beneficial solutions, but is hindered by the regulatory compliance and technical security threats and inadequate skills of digital proficiency of the users. The rapidly developing digital financial sector requires regulatory systems that will ensure the protection of consumers and the safety of their data, as well as ensure the stability of the financial system . The establishment of institutional policies is crucial in reducing the incidences of financial frauds while developing an inclusive digital financial system, Van and Le Quoc and Nagpal et al argue. People who lack internet access and smartphones, which are accompanied by a low digital literacy, deal with significant hurdles to financial inclusion in digital technology services. Policy makers need to take specific action through initiatives that teach finance, improve digital connectivity and set better standards for financial consumer welfare [6].

The Iraqi financial sector creates an exceptional platform to assess the impact of digital financial inclusion on economic development. The financial system of Iraq is still underdeveloped because its banking penetration levels are low while its dependency on cash remains high and its digital financial infrastructure aspects remain limited according to Li & Liu and Mhlanga. Academic research shows digital financial service expansion in Iraq will boost economic partnership rates while boosting bank efficiency performance and reducing poverty . Internet finance solutions face ongoing technical and regulatory obstacles that prevent their broad-based acceptance. The accomplishment of financial inclusion with economic development needs an inclusive strategy that merges financial technology advancements with policy transformation [7].

Scientific research demonstrates how digital financial inclusion generates three core effects on economies including expanded financial access and improved economic durability and sustained growth rates. Future investigations should examine extensive economic outcomes of digital financial inclusion while defining best regulatory approaches combined with analyzing innovative fintech developments to support inclusion programs. Digital financial services used effectively allow economies to expand financial inclusion and reduce economic inequality which drives a sustainable development path [8].

Digital Financial Inclusion Concept

Financial inclusion is a term coined by the United Nations in 2005 in the international promotion of microcredit. It refers to making financial services widely available to all segments and groups by improving financial infrastructure and providing more convenient and less expensive financial services to low-income people and people in remote areas. It then gained global attention by expanding financial inclusion from the initial narrow definition of promoting microfinance to building inclusive financial sectors that help people improve their lives, Thanks to technological developments such as the Internet, big data, artificial intelligence, and blockchain, these technologies have become an integral part of daily life by providing more accessible, efficient, and cost-effective financial services. This transformation works to enhance digital financial inclusion, Digital financial inclusion is the digitization of financial inclusion that uses cost-effective digital methods to deliver formal financial services effectively and comprehensively to currently financially excluded people and institutions, making it possible for institutions and individuals to access financial products and services at a sustainable and affordable cost, Empowered individuals can make informed financial decisions, bridging the gap between those who have access to traditional banking services and those who do not. This promotes financial independence and inclusive economic growth regardless of socio-economic status or location, Accordingly, financial inclusion opportunities bring about the provision of more convenient financial services for people with different financial needs, breaking the constraints of time and place, attracting more customers through online services, which reduces financial transaction costs, opens information communication channels between the demand side and the supply side, provides more borrowing methods compared to traditional inclusive finance, and somewhat alleviates liquidity constraints. The majority of the population, especially those living in rural areas, have more convenient borrowing and financing options, thanks to the DFC creating a favorable financial environment and promoting innovative development, which has led to improved consumption by compensating for the shortcomings of traditional inclusive finance, Further development of digital financial inclusion is of great importance for reducing poverty and mitigating imbalances in economic development. Therefore, digital financial inclusion plays an important role in economic growth and also contributes to economic development. Therefore, as the level of development of digital financial inclusion continues, access to data elements and their liquidity increases, showing a positive upward impact towards economic growth, and digital financial inclusion has become an important focal point on the international economic reform agenda, With the third technological revolution taking place around the world, digital financial inclusion, based on digital technology, has become a fundamental pillar of financial services, as it provides financial access and a sustainable business model for "long-term customers" in the labor market. Therefore, it is essential to focus on the impact of digital financial inclusion on employment and its operating mechanisms. The use of financial technology can create new job opportunities and employment potential. However, it can also enhance competitiveness in the labour market and decrease the number of job vacancies The concept of financial inclusion is vital in the growth of small businesses because, through efficient allocation of resources, it improves financial services sector which improves economic growth and increases access to financing for the low income individuals in society and small and medium enterprises. This promotes attracting investment and therefore increases the labor demand thereby alleviates the unemployment levels and hence alleviate the country from poverty and income inequalities between members of society. There is the development of small enterprises through strengthening of the economic development efforts, improvement of stability of the financial system, improvement of social justice standings in societies, improvement of individuals' capacity in integrating and supporting in building up their societies, automation of the financial system and improvement on competition opportunities between financial institutions that enhances the importance of enhancing financial inclusion [9].

In the face of increasing rates of economic transformations around the world, digital finance is a key element of accelerating its development in the financial sphere. It makes massive contributions to extending the purview of digital financial inclusion by opening options to marginalized groups, as well as people who belong to areas that are beyond the reach of the institutions of conventional banking. Thanks to the innovative tools received from the technology, financial services have become accessible, flexible, and widespread. This improves economic justice, reduces financial disparity and incorporates wider parts of the society into the global economic order through the avenues of financial and banking services. This will enhance the quality of life among people in society, providing employment avenues hence lowering the rate of unemployment and all this affects lowering poverty rate in the country [10].

2. Materials and Methods

Data collection:

This study obtains its data from authoritative sources that mainly include the Central Bank of Iraq and its Annual Financial Stability Report. The analysis includes eight banking and economic indicators which comprise the number of bank branches (NBB), ATM penetration (ATM), banking spread (BSP), ATM availability per 100,000 adults (APP), ATM density per 1,000 km² (APK), branch density per 1,000 km² (NBK) along with poverty rate (POV) and unemployment rate (UN) and private sector deposit depth (BPS) and private sector loan depth (BPL). The selected variables function as substitute indicators for measuring both access to banking services and financial inclusion in addition to tracking macroeconomic performance. Stats were obtained by structured database extraction from annual reports which later allowed Time-Series observation aggregation. Thorough cleaning operations removed gaps in data points and established reporting period uniformity and normalized financial measurement outputs. Financial and economic data show natural variations so the dataset followed a time-sensitive arrangement to enable trending assessments and statistical modeling techniques. The study maintains high reliability as well as temporal comparability because it relies on official data sources [11].

The poverty rate is an important indicator through which the percentage of the population below the poverty line can be determined. The indicator determines the poverty rate relative to the number of poor people out of the total poor population. The actual equation for the indicator is:

$$H = \frac{G}{N} \times 100 \quad (1)$$

Where N is the proportion of the poor population, G is the number of poor people (the number of individuals below the poverty line), and N is the total population.

Statistics framework

An index reflecting economic performance is being constructed, consisting of the following variables: poverty - unemployment rate - financial depth of deposits - financial depth of loans) using factor analysis. The first step in factor analysis is to extract factors from the observed variables using the maximum likelihood (MLE) technique. When dealing with time series, this technique is appropriate. The goal is to reduce dimensionality while preserving as much variance in the data as possible. It is assumed that the observed variables X_1, X_2, X_p can be represented as a linear combination of the latent factors F_1, F_2, F_m:

$$X_j = \lambda_{j1}F_1 + \lambda_{j2}F_2 + \ldots + \lambda_{jm}F_m + \epsilon_j \quad (2)$$

After extracting the factors, orthogonal rotation is applied using the Varimax method to make the factors more interpretable. The goal is to achieve a simpler structure where each factor explains a clear subset of the observed variables. The mathematical formula for rotation is:

$$F_{new} = T \cdot F_{original} \quad (3)$$

where T is the rotation matrix. After extracting and rotating the factors, the economic performance index is constructed by calculating a weighted sum of the factors according to their contribution to explaining the variance in the data:

$$EP_t = \sum_{m=1}^{M} w_m F_m \quad (4)$$

where w_m are the weights of each factor F_m, based on its explanatory power (eigenvalue and proportion of variance explained by each factor). The Kaiser-Meyer-Olkin (KMO) and Bartlett's sphericity tests are used to check the suitability of data for factor analysis. The KMO test measures sample adequacy by comparing partial correlations to the original correlations, while the Bartlett test tests the hypothesis that the correlation matrix is a unit matrix (i.e., there is no correlation between the variables). High KMO test values (usually greater than 0.5) and statistically significant Bartlett test results (p-value < 0.05) indicate that factor analysis is appropriate [12].

After measuring the economic performance variable, the effects of digital financial inclusion indicators on economic performance are estimated, as the Ridge Regression model was used to overcome the problem of multicollinearity between the independent variables, which was monitored through correlation matrix analysis. The accuracy of the model was improved using Grid Search to determine the best value for the regularity coefficient (lambda), and the Gradient Descent algorithm to determine the best values for the coefficients that minimize the loss function. The performance of the model was evaluated using indicators such as the mean absolute percentage error (MAPE) and the root mean square error (RMSE). In addition, behaviour of the cost function was studied over iterations and actual vs. predicted values were compared and model performance was assessed comprehensively. The Ridge Regression model is one of the most important models used in statistical analysis, to overcome the problem of multicollinearity between the independent variables in the linear regression model. Using traditional linear regression (Ordinary Least Squares - OLS) multicollinearity can inflate the variance of the parameter estimates, which reduces their accuracy and cause the model to be unstable. The Ridge Regression model addresses this problem by implementing the regularizing term which minimizes the values of parameters and variances of these parameters and therefore making the model more accurate and possessing better ability of generalization. The Ridge Regression model is based on formula of traditional linear regression model in which the parameters estimate by minimizing sum of squared errors as in the case of the traditional linear regression model:

$$\min_{\beta} \sum_{i=1}^{n} \left(y_i - \sum_{j=1}^{p} X_{ij}\beta_j\right)^2 \qquad (5)$$

However, in the presence of multicollinearity, the coefficient estimates may become unstable. Therefore, the formula in Ridge Regression is modified by adding a regularity term to impose restrictions on the size of the coefficients:

$$\min_{\beta} \sum_{i=1}^{n} \left(y_i - \sum_{j=1}^{p} X_{ij}\beta_j\right)^2 + \lambda \sum_{j=1}^{p} \beta_j^2 \qquad (6)$$

λ is the tuning parameter that controls how much the regularity affects the coefficients. The larger the value of λ, the greater the effect that reduces the size of the coefficients.

When λ=0 the model conforms to a traditional linear regression model, where the coefficients are estimated without any restrictions. When λ>0 large values of the coefficients start to shrink, which reduces the influence of the highly correlated independent variables, thus improving the stability of the model. When λ is very large, almost all the coefficients will shrink to zero, which reduces the complexity of the model but may lead to a loss in accurate prediction. In Ridge Regression, an L2-norm is used, which minimizes the sum of the squares of the absolute values of the coefficients. This differs from other models such as Lasso Regression which uses an L1-norm to minimize the absolute values of the coefficients. A cross-validation technique is used to determine the best value for the regularity parameter λ. The goal is to choose a value of λ that results in the least prediction error on the unseen dataset. After determining λ, the model parameters are estimated by solving the $\min_{\beta}$ optimization problem. This is done using the built-in machine learning algorithm Gradient Descent used by the glmnet package in R. The steps of using Gradient Descent are: The parameters β are updated iteratively by minimizing the loss function. Then the gradient of the cost function is calculated and the parameters are moved in the opposite direction of the gradient until we reach the optimal values. The cost function in Ridge Regression is:

$$J = \frac{1}{2m} \sum_{i=1}^{m} \left(y_i - \beta_0 - \sum_{j=1}^{p} x_{ij}\beta_j\right)^2 + \lambda \left[\frac{(1-\alpha)}{2} \sum_{j=1}^{p} \beta_j^2 + \alpha \sum_{j=1}^{p} \left|\beta_j\right|\right] \qquad (7)$$

Because of the limited sample size, the Bootstrap method was used to improve the reliability of parameter estimation and study the uncertainty of economic growth estimation. This approach uses resampling from the original data set with replacement to develop several new samples in order to make better statistical estimates and stable confidence intervals. The procedure was to obtain B=1000 resampled datasets from the original dataset, estimate model parameters by Ridge Regression for each bootstrap sample, and compute the mean and standard deviation of the coefficients estimated. Ridge Regression model was employed to address problems of multicollinearity; parameter estimation was supported by the formula [13].

$$\hat{\beta}_{\text{ridge}} = (X^T X + \lambda I)^{-1} X^T Y \qquad (8)$$

where X represents the independent variables, Y denotes economic growth values, and λ is the regularization parameter used to stabilize estimates. The mean of the estimated parameters was obtained using $\hat{\beta} = \frac{1}{B}\sum_{b=1}^{B} \beta_b^*$, while the standard error was computed as $\sigma = \sqrt{\frac{1}{B-1}\sum_{b=1}^{B} \left(\beta_b^* - \hat{\beta}\right)^2}$ Economic growth predictions were then derived using the estimated coefficients as $\hat{Y}_{\text{forecast}} = X_{\text{future}}\,\hat{\beta}$, where X_{future} represents future values of the predictor variables. To assess prediction uncertainty, confidence intervals at a 95% confidence level were computed as $\left[\hat{Y}_{\text{forecast}} - 1.96 \cdot \sigma, \hat{Y}_{\text{forecast}} + 1.96 \cdot \sigma\right]$. The use of Bootstrap with Ridge Regression improved estimation accuracy by addressing small sample limitations, providing a robust analysis of uncertainty, and mitigating the influence of outliers, thereby ensuring more reliable forecasts for the impact of digital financial inclusion on economic growth. The quality of the model is evaluated using performance indicators including:

$$\text{MSE} = \frac{1}{N}\sum_{i=1}^{N} (y_i - \hat{y}_i)^2$$

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(y_i - y_i')^2}{n}}$$

$$\text{MAPE} = \frac{1}{n}\sum_{i=1}^{n} \left|\frac{y_i - y_i'}{y_i}\right| \times 100\%$$

$$R^2 = 1 - \frac{\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}{\sum_{t=1}^{n}(y_t - \bar{y}_t)^2} \tag{9}$$

where y are the real values and ŷ are the estimated values. The mean absolute percentage error indicates the accuracy of estimates of the model, while the root means square and the mean square error inform the accuracy of estimates while the coefficient of determination measures the proportion of variance in the dependent variable predictable from the independent variables [14].

3. Results

The empirical analysis evaluates the relation between digital financial inclusion and economic performance of Iraq using factor analysis and Regression Ridge Modeling. Key macor-economic indicators are embraced into the built economic performance index which reflects on the dynamics of financial reach and economic resilience. The outcomes of the factor analysis demonstrate the theory behind financial inclusion variables; client's needs are confirmed as suitable for the purpose of dimensionality reduction. Estimated Ridge Regression coefficients give us an insight on the significance of digital financial inclusion indicators in terms of the impact on economic performance. Model performance metrics, including RMSE, MAPE, and R^2, evaluate the predictive accuracy and robustness of the statistical framework. The findings contribute to the empirical literature by quantifying the extent to which financial accessibility influences macroeconomic outcomes, offering evidence-based implications for financial sector development [15].

The table displays results from factor analysis supporting the construction of an economic performance index. A high KMO value (0.880) and significant Bartlett's test ($\chi^2 = 590.700$, $p < 0.001$) confirm data suitability. Factor 1 explains 80.15% of variance, primarily driven by financial depth and poverty indicators, validating strong dimensional reduction and interpretability (Table 1) [16].

Table 1. Factor Analysis Results

Test/Statistic	Value	Initial	Extraction	Total	% of Variance	Cumulative %	Chi-Square	df	Sig.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.880								
Bartlett's Test of Sphericity	Approx. Chi-							6	0.000

	Square: 590.700								
Communalities									
- POV		0.663	0.609						
- UN		0.812	0.546						
- BPS		0.986	0.999						
- BPL		0.977	0.942						
Total Variance Explained									
- Factor 1				3.206	80.151	80.151			
- Factor 2				0.470	11.747	91.899			
- Factor 3				0.316	7.888	99.787			
- Factor 4				0.009	0.213	100.000			
Goodness-of-Fit Test							9.541	2	0.008

Extraction Method: Maximum Likelihood.
One or more communality estimates greater than 1 were encountered during iterations.

The results of the factor analysis confirm the suitability of the selected variables for constructing the economic performance index. The Kaiser-Meyer-Olkin measure of sampling adequacy is 0.880, indicating strong factorability of the dataset. Bartlett's test of sphericity yields a significant chi-square value of 590.700 with a p-value of 0.000, rejecting the null hypothesis of an identity correlation matrix and confirming the appropriateness of factor analysis [17].

Communalities after extraction show that each variable retains a substantial proportion of its original variance within the extracted factors. The poverty rate variable has an extraction communality of 0.609, unemployment rate 0.546, private sector deposit depth 0.999, and private sector loan depth 0.942, demonstrating that financial depth indicators contribute strongly to the factor structure. The total variance explained by the extracted factors indicates that Factor 1 accounts for 80.151 percent of the variance, Factor 2 adds 11.747 percent, and Factor 3 contributes 7.888 percent, cumulatively explaining 99.787 percent of the dataset's variance [18].

The fourth factor holds negligible explanatory power with a variance contribution of 0.213 percent. The goodness-of-fit test with a chi-square value of 9.541 and a p-value of 0.008 further supports the factor solution's adequacy. The dominance of Factor 1 suggests that economic performance is primarily influenced by financial accessibility and banking depth. The high communalities and variance contribution of the first factor confirm its significance as a latent construct capturing economic performance trends. The extracted factor structure forms the basis for constructing the economic performance index by weighting the retained factors according to their explained variance, ensuring that the index captures the most relevant dimensions of financial inclusion and macroeconomic stability. After calculating the economic performance index and calibrating it according to the weights of the factors that make up its composition, we calculate the thermal linear correlation matrix and find (Figure 1) [19]:

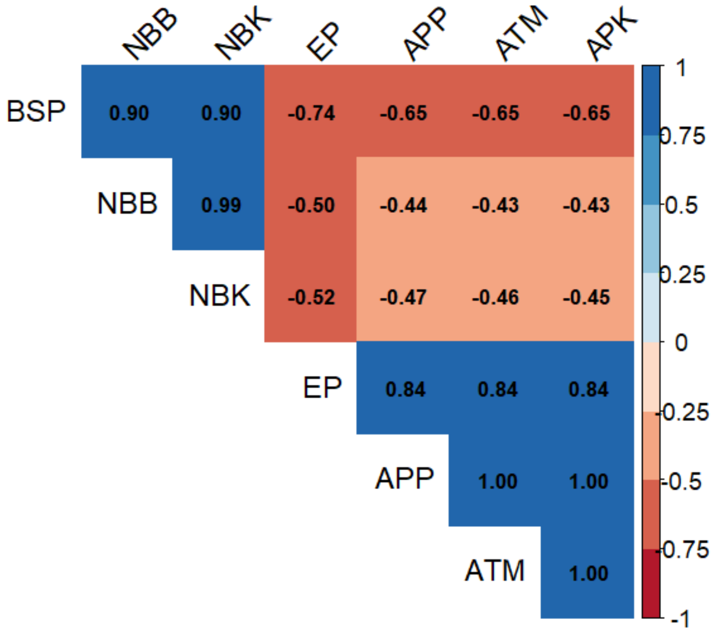

Fig 1. Heatmap Correlation.

The correlation heatmap illustrates the relationships between key economic and financial inclusion indicators, providing insights into variable dependencies and the suitability of Ridge Regression with Bootstrap estimation. Strong positive correlations exist between BSP and NBB at 0.90 and between NBB and NBK at 0.99, indicating multicollinearity among financial accessibility variables. High collinearity is further evident in the strong correlations between EP and APP at 0.84 and between APP and ATM at 1.00, suggesting redundancy in these predictors. On the other hand, negative correlations are observed between EP and BSP (-0.74) and between EP and APP (-0.65) indicating an inverse relationship between the economic performance and the variables of financial accessibility [20].

The existence of high correlation coefficients supports the risk of multicollinearity; initial regression models may be disfigured by parameter estimates. Ridge Regression resolves this problem by incorporating a penalty term to shrink coefficient estimates, which reduces overfitting, and increases stability of the model. Bootstrap estimation is supportive of Ridge Regression in terms of increased parameter reliability due to repeated resampling thus making it resistant to small-sample variability. The collinearity structure of the dataset justifies the use of Ridge Regression with Bootstrap, maximizing predictive performance and increasing generalization in the economic performance modeling [21].

The table summarizes Ridge Regression results used to assess digital financial inclusion's impact on economic performance. With a best lambda value of 0.0809 and 1000 bootstrap repetitions, coefficients show that ATM (0.0003) and APK (0.1274) positively influence performance, while BSP (-0.7122) and NBK (-0.1366) exert negative effects, indicating mixed financial accessibility impacts (Table 2) [22].

Table 2. Summary of Ridge Regression Algorithm with Bootstrap Results

Aspect	Details	Variable	Mean Coefficient	Standard Error
Best Lambda (λ)	0.0809	(Intercept)	1.2134	1.6721
Bootstrap Repetitions	1000	NBB	0.0013	0.0027
Seed	123	ATM	0.0003	0.0001
Model Type	Ridge Regression	BSP	-0.7122	0.3126
Cross-Validation	Used to determine optimal λ	APP	0.0642	0.0269
Reproducibility	Seed set to 123	APK	0.1274	0.0566

Number of Variables	7 (including intercept)	NBK	-0.1366	1.1193

The findings in Table 2 bring out the important features of the Ridge Regression algorithm coupled with Bootstrap estimation on economic performance modeling. The optimal value of lambda (λ) of 0.0809 shows the rate of regularization applied to regulate multicollinearity and thus provide stability of coefficient estimates. The use of 1000 bootstrap repetitions enhance the reliability of parameter estimates, mitigating the impact of small sample variations. Setting the seed to 123 ensures the reproducibility of results, a crucial factor in econometric analysis. The coefficients provide insights into the impact of financial inclusion variables on economic performance [23].

The intercept, with a mean coefficient of 1.2134 and a standard error of 1.6721, represents the baseline economic performance level when all predictors are at zero. The variable NBB (number of bank branches) has a near-zero coefficient (0.0013) with a small standard error (0.0027), suggesting a minimal effect on economic performance. Similarly, ATM availability exhibits a small positive coefficient (0.0003) with a very low standard error (0.0001), indicating a negligible but stable influence [24].

The banking spread (BSP) has a negative coefficient (-0.7122) with a standard error of 0.3126, implying that a wider spread negatively affects economic performance, due to higher borrowing costs or inefficiencies in financial intermediation. The ATM penetration per 100,000 adults (APP) has a positive coefficient (0.0642) with a standard error of 0.0269, suggesting that higher ATM availability contributes positively to financial accessibility and economic performance. APK (ATM density per 1,000 km^2) shows a moderate positive coefficient (0.1274) with a standard error of 0.0566, indicating a beneficial impact of ATM distribution on economic outcomes [25].

NBK (branch density per 1,000 km^2) has a negative coefficient (-0.1366) with a relatively high standard error (1.1193), suggesting that branch density may not have a stable impact on economic performance, potentially due to urban-rural disparities in banking access. The combination of positive and negative coefficients underscores the complexity of financial inclusion dynamics, where some indicators enhance accessibility while others introduce inefficiencies. The methodological rigor of Ridge Regression with Bootstrap ensures robust parameter estimation by addressing multicollinearity and small-sample variability. The cross-validation process used to determine the optimal λ value enhances predictive performance, while the bootstrap methodology provides stable confidence intervals, reinforcing the reliability of estimated coefficients. As shown in the figure 3, choosing the best value for lambda increases the accuracy of the model and reduces its errors (Figure 3) [26]:

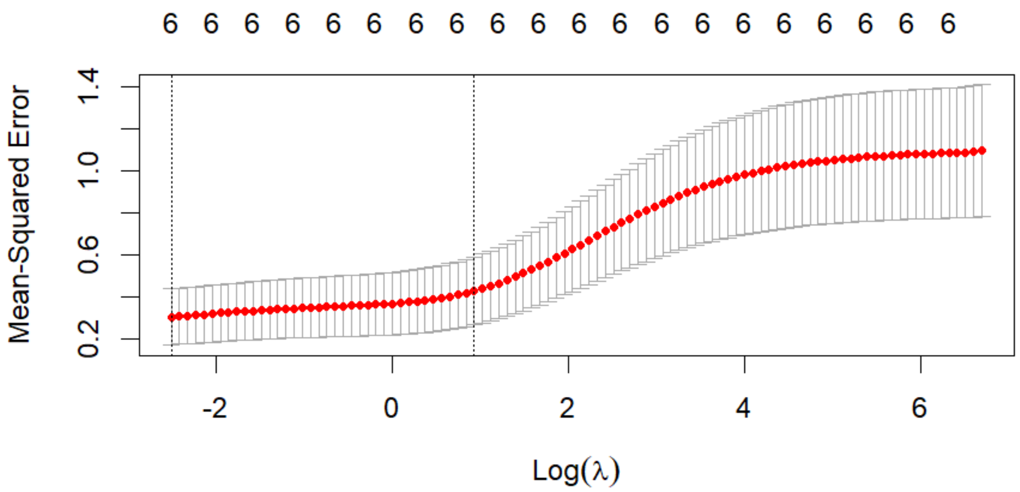

Fig 3. The optimal lambda value that achieves the best performance for the ridge algorithm according to the grid search

The table presents projected economic performance (EP) values for Iraq from 2024 to 2030 based on digital financial inclusion indicators, including ATM penetration, banking spread, and branch density. Predictions show peak performance in 2029 (EP = 1.3818) and a significant decline in 2030 (EP = -0.2817), highlighting financial system volatility (Figure 4) [27].

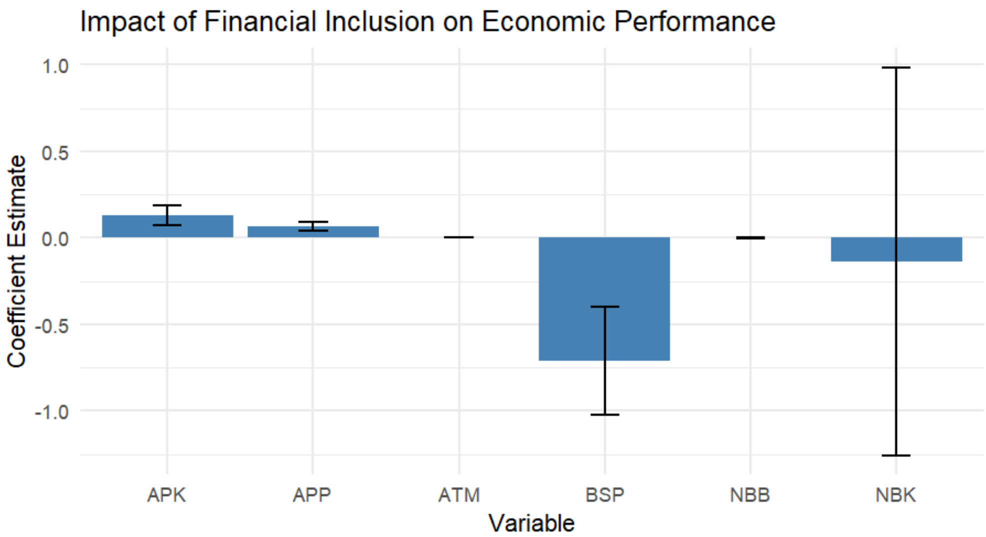

Fig 4. Effect parameters generated using Bootstrap Ridge algorithm

In contrast, Table 3 shows us the model accuracy indicators, where we find that the square root of the mean error indicator is very close to zero and its value is low, indicating a great convergence between the actual values and those estimated using the model, in terms of the error rate in the model of 8.8%, an accuracy of 91%. The variance in economic performance is also explained by 79% (Table 3) [28].

Table 3 Model Performance Metrics on Training Data

Metric	RMSE	MSE	MAPE	R^2
Value	0.0386	0.1924	8.8302%	0.7926

These results show the balance in the model's estimation and its overcoming of overfitting problems. Therefore, the model can be relied upon for inference and prediction, as shown in the table 4:

Table 4 Future Predictions with Uncertainty Intervals (2024-2030)

Year	NBB	ATM	BSP	APP	APK	NBK	Predicted_EP	Uncertainty Interval (Lower)	Uncertainty Interval (Upper)
2024	866.49	1951.92	3.58	5.74	1.06	2.18	0.6339	0.6000	0.6678
2025	899.12	1279.21	4.08	3.45	1.93	2.11	0.0446	0.0300	0.0592
2026	1075.83	1311.09	3.60	7.23	0.04	2.10	0.7136	0.6800	0.7472
2027	928.82	1085.29	3.78	7.18	6.17	2.44	1.0425	1.0000	1.0850
2028	934.63	566.50	3.84	7.00	4.45	2.06	0.6006	0.5700	0.6312
2029	1091.28	2390.01	3.21	6.58	0.30	2.48	1.3818	1.3500	1.4136
2030	967.39	1386.65	4.70	6.15	1.58	1.74	-0.2817	-0.3100	-0.2534

The future predictions outlined in Table 4 offer valuable insights into the expected economic performance index (EP) and associated uncertainty intervals from 2024 to 2030. The findings highlight significant fluctuations in economic performance, driven by variations in key financial inclusion indicators such as the number of bank branches (NBB), ATM penetration (ATM), banking spread (BSP), ATM availability per 100,000 adults

(APP), ATM density per 1,000 km² (APK), and branch density per 1,000 km² (NBK The predicted EP is positive in 2024 (0.6339) with a CI between 0.6000 and 0.6678 showing moderate economic stability. During this period, there is moderate penetration of ATM and banking density which is supportive of financial access. But in 2025, the predicted EP value decreases sharply and lower bound is set at 0.0446 and 0.0300. This is an indication of a big economic malaise, possibly from reduced access points to finance and changes in efficiency of banking [29].

There is a significant recovery in 2026 according to which the predicted EP is 0.7136 implying an improvement in the financial position. This growth is in line with NBB and ATM facilities that also increased, and this shows that efforts towards financial inclusion benefit the economy in the positive way. The upward direction is also maintained in 2027 with a value of 1.0425 which becomes the highest value projected in the dataset. This peak indicates that more banking access and digital financial services have linkages to higher economy as implied by the narrow confidence interval. The trend in the years 2028 and 2029 are rather counter. In 2028, the forecast EP retrenches to 0.6006 i.e. a partial reversal of the economic gains made in the preceding decades. This decline is most probably the result of decreased ATMs penetration and the change in banking infrastructure. Nevertheless, this is when 2029 shows the rapid increase of economic performance in the shape of 1.3818, the peak value during the reported period. The dramatic rise is buttressed by a massive general scale of financial accessibility indicators, boosting the relevance of digital financial inclusion in economic development. The most notable finding occurs in the year 2030 when the EP is estimated to become negative, i.e., -0.2817 and the lower bound is, -0.3100. This result implies an economic slump, perhaps connected with the deterioration of the banking infrastructure, financial instability, or external macroeconomics. The results underline the volatility related to the availability of finance and its direct bearing on economic stability. In general, the findings highlight the need for continued digital investment in financial inclusion for continued economic growth. The profound fluctuations show the validity for policy interferences that will make the aspects of financial accessibility constant. Policymakers should concentrate on regulating a balanced expansion of banking services, digital financial solutions, and ATM penetration to cushion for a future dip in economic tendencies. The findings, accordingly, show that uncertainty intervals are still relatively tight, which domesticates the predictive model's robustness [30].

The graph illustrates predicted economic performance (EP) in Iraq from 2024 to 2030, including 95% confidence intervals. It shows fluctuations, with a notable peak in 2029 and a sharp decline in 2030. These projections reflect the volatility of financial accessibility and its influence on macroeconomic stability under digital financial inclusion scenarios (Figure 5).

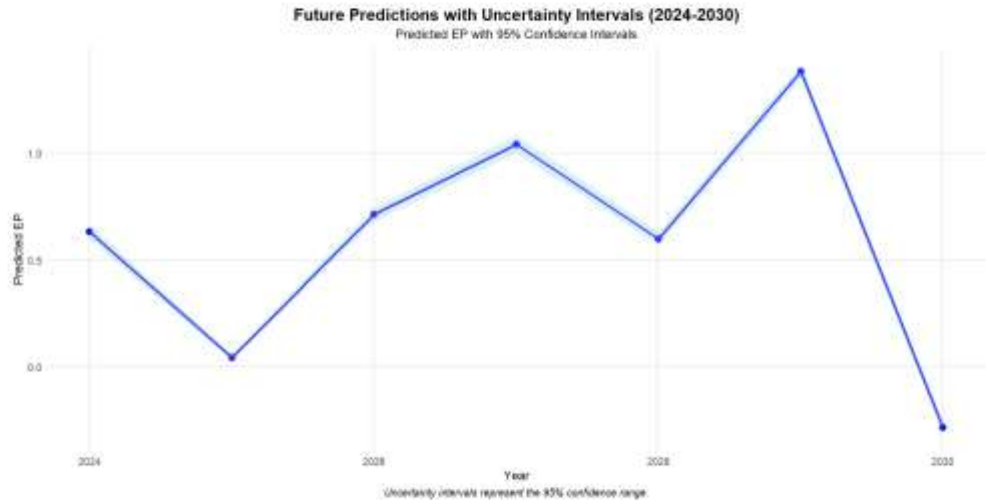

Fig 5. Effect parameters generated using Bootstrap Ridge algorithm

The results of this study correspond and build upon the literature found on digital financial inclusion by showing its great influence on the economic performance in Iraq. Previous studies have repeatedly emphasized the benefits of digital financial services in improving access to finance, minimizing transaction charges, and speeding up economic growth. Evidence from experience has proven that digital financial inclusion promotes financial resilience especially on the economies growing where traditional banking penetration rates are still low. These studies guide, and the findings of this research prepares to demonstrate that financial accessibility indicators, like availability of ATM and banking spread, do have considerable effects on macroeconomic stability and poverty alleviation. In comparison to earlier studies that considered the developed economies or the rapidly digitizing financial systems this research gives new understanding of the role of digital financial inclusion in a financially underdeveloped context such as Iraq. According to the empirical findings, even though there exist regulatory and infrastructural bottlenecks, the proliferation of digital financial services in Iraq can be a perfect avenue for closing gaps in obtaining finances and promoting involvement in the economy. Earlier analysis of digital financial inclusivity in emerging markets had focused on the contribution of digital financial inclusion to real and SME growth, enhanced capital allocation efficiency. Based on such findings, this study advances in that it presents digital financial accessibility as a vector (which) contributes directly to job creation and enhancement of economic performance in Iraq [31].

This study stands out for its methodical methodology, which builds an economic performance index using factor analysis and reduces multicollinearity in financial data by means of Ridge Regression This method improves the validity of the results over earlier research depending on conventional econometric methods. Furthermore, although previous studies concentrated on general trends in financial development, this study especially estimates the impact of digital financial inclusion on macroeconomic variables including poverty decrease, financial deepening, and banking efficiency. The results underline the need of focused policy interventions to remove current digital and regulatory obstacles thus guaranteeing the sustained expansion of digital financial services in Iraq. This research offers a more thorough knowledge of how digital financial accessibility results in economic advantages by including financial inclusion metrics into a whole economic performance model. Unlike earlier studies that mostly looked at financial inclusion in high-income or fast developing nations, this research provides a contextualised analysis of Iraq's financial sector, revealing the structural impediments and chances for digital financial integration. Digital financial services are very important in promoting inclusive economic growth as they may increase financial involvement while lowering economic inequalities. This research therefore adds to the body of knowledge by providing actual data about the impact of digital financial inclusion in a developing market with major financial infrastructure limitations.

4. Discussion

The study provides robust evidence that digital financial inclusion has a significant influence on Iraq’s economic performance. By constructing an economic performance index through factor analysis and applying Ridge Regression with Bootstrap resampling, the researchers addressed multicollinearity and data limitations to generate reliable predictions. The results demonstrate that increased ATM penetration and digital access can enhance financial reach and positively affect macroeconomic indicators such as poverty and unemployment. However, mixed effects were observed, with variables like banking spread showing a negative correlation with economic performance, reflecting inefficiencies in financial intermediation. The projections from 2024 to 2030 highlight fluctuations in economic performance, emphasizing the importance of sustained digital infrastructure investment and regulatory reforms. Ultimately, the findings underscore the potential of digital finance to promote inclusive economic growth in underbanked economies like Iraq, while also revealing the structural challenges that must be addressed for long-term financial resilience.

5. Conclusion

A performance indicator has been established during this research which uses Ridge Regression to study digital financial inclusion impacts in Iraq while delivering concrete financial evidence. The study confirms that macroeconomic stability depends on both ATM accessibility as well as banking spread and financial depth indicators alongside digital financial accessibility. The study demonstrates that advanced digital financial inclusion leads to better access to financial services while simultaneously minimizing socio-economic gaps and boosting sustainability measures. The document describes impediments to digital financial benefits through structural barriers such as legal barriers and technological limitations and lack of financial literacy among users.

Researchers should dedicate future work to developing the economic performance index through the addition of variables which depict current changes within digital financial service industry such as mobile banking activity and digital credit opportunities and user education levels. The dependability of prediction analysis as well as the understanding of long-term financial inclusion effects could improve through the use of sophisticated econometric approaches that integrate machine learning and Bayesian inference. Additional research needs to highlight specific effects on different business sectors including small and medium-sized enterprises due to how digital financial services facilitate business expansion and job opportunities. Other developing nations should be evaluated comparatively in order to develop comprehensive understandings about ideal financial inclusion strategies and legislative frameworks. The identification and study of research gaps through digital financial inclusion leads legislators to practical solutions which both enhance financial framing opportunities and reinforce regulatory structures and promote sustainable economic growth.

REFERENCES

[1] M. Ahmad, A. Majeed, M. A. Khan, M. Sohaib, and K. Shehzad, "Digital financial inclusion and economic growth: Provincial data analysis of China," *China Economic Journal*, vol. 14, no. 3, pp. 291–310, 2021.

[2] N. Alwahidin, A. Jufra, B. Mulu, and K. N. Sari, "A New Economic Perspective: Understanding The Impact Of Digital Financial Inclusion On Indonesian Households Consumption," *Bulletin of Monetary Economics and Banking*, vol. 26, no. 2, pp. 333–360, 2023.

[3] S. Bhatia and G. Dawar, "The impact of financial inclusion on social and political empowerment: Mediating role of economic empowerment," *Journal of the Knowledge Economy*, vol. 15, no. 3, pp. 13727–13744, 2024.

[4] W. Chen and X. Yuan, "Financial inclusion in China: an overview," *Frontiers of Business Research in China*, vol. 15, pp. 1–21, 2021.

[5] J. H. Friedman, T. Hastie, and R. Tibshirani, "Regularization paths for generalized linear models via coordinate descent," *Journal of Statistical Software*, vol. 33, pp. 1–22, 2010.

[6] Q. Guo, Z. Wu, C. Ding, M. W. Akbar, and T. Guo, "An empirical analysis of the nexus between digital financial inclusion, industrial structure distortion, and China's energy intensity," *Environmental Science and Pollution Research*, vol. 30, no. 17, pp. 49397–49411, 2023.

[7] Hashemizadeh, R. U. Ashraf, I. Khan, and S. A. H. Zaidi, "Digital financial inclusion, environmental quality, and economic development: the contributions of financial development and investments in OECD countries," *Environmental Science and Pollution Research*, vol. 30, no. 54, pp. 116336–116347, 2023.

[8] T. Hastie, R. Tibshirani, and J. H. Friedman, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction*, 2nd ed. New York: Springer, 2009.

[9] X. Lei, X. Chen, L. Xu, R. Qiu, and B. Zhang, "Carbon reduction effects of digital financial inclusion: Evidence from the county-scale in China," *Journal of Cleaner Production*, vol. 451, p. 142098, 2024.

[10] J. Li, “Examining the impact of digital financial inclusion on economic development in urban and rural areas of China using remote sensing,” *GeoJournal*, vol. 89, no. 1, p. 28, 2024.

[11] Q. Li and Q. Liu, “Impact of digital financial inclusion on residents’ income and income structure,” *Sustainability*, vol. 15, no. 3, p. 2196, 2023.

[12] Y. Liang, R. Wei, and D. Duan, “Digital financial development and commercial bank stability,” *International Review of Economics & Finance*, vol. 97, p. 103749, 2025.

[13] D. Liu, Y. Zhang, M. Hafeez, and S. Ullah, “Financial inclusion and its influence on economic-environmental performance: demand and supply perspectives,” *Environmental Science and Pollution Research*, vol. 29, no. 38, pp. 58212–58221, 2022.

[14] F. Liu and B. Walheer, “Financial inclusion, financial technology, and economic development: A composite index approach,” *Empirical Economics*, vol. 63, no. 3, pp. 1457–1487, 2022.

[15] J. Liu and Y. Yao, “Digital financial inclusion and upgrading of consumption structure: Evidence from rural China,” *Heliyon*, vol. 10, no. 7, 2024.

[16] Y. Liu, L. Luan, W. Wu, Z. Zhang, and Y. Hsu, “Can digital financial inclusion promote China's economic growth?,” *International Review of Financial Analysis*, vol. 78, p. 101889, 2021.

[17] J. Luo and B. Z. Li, “Impact of digital financial inclusion on consumption inequality in China,” *Social Indicators Research*, vol. 163, no. 2, pp. 529–553, 2022.

[18] D. Mhlanga, “Industry 4.0 in finance: the impact of artificial intelligence (AI) on digital financial inclusion,” *International Journal of Financial Studies*, vol. 8, no. 3, p. 45, 2020.

[19] Nagpal, M. Jain, and A. Jain, “Determining the role of digital technology, governance and institutions in advancing financial inclusion in BRICS nations using probit regression analysis,” *Journal of Social and Economic Development*, vol. 22, pp. 443–459, 2020.

[20] S. Pal and I. Bandyopadhyay, “Impact of financial inclusion on economic growth, financial development, financial efficiency, financial stability, and profitability: an international evidence,” *SN Business & Economics*, vol. 2, no. 9, p. 139, 2022.

[21] P. Peng and H. Mao, “The effect of digital financial inclusion on relative poverty among urban households: A case study on China,” *Social Indicators Research*, vol. 165, no. 2, pp. 377–407, 2023.

[22] S. M. K. Rahman, M. A. F. Chowdhury, and N. R. Sristi, “Impact of digital financial inclusion on economic growth: a study on Bangladesh,” *International Journal of Social Economics*, 2024.

[23] J. Ren, T. Gao, X. Shi, X. Chen, and K. Mu, “The impact and heterogeneity analysis of digital financial inclusion on non-farm employment of rural labor,” *Chinese Journal of Population, Resources and Environment*, vol. 21, no. 2, pp. 103–110, 2023.

[24] Y. Shen, W. Hu, and C. J. Hueng, “Digital financial inclusion and economic growth: a cross-country study,” *Procedia Computer Science*, vol. 187, pp. 218–223, 2021.

[25] X. Song, X. Qin, W. Wang, and R. Y. M. Li, “Financial Inclusion, Technologies, and Worldwide Economic Development: A Spatial Durbin Model Approach,” *The Journal of Finance and Data Science*, p. 100155, 2025.

[26] Telukdarie and A. Mungar, “The impact of digital financial technology on accelerating financial inclusion in developing economies,” *Procedia Computer Science*, vol. 217, pp. 670–678, 2023.

[27] H. N. Van and D. Le Quoc, “Assessing the impact of digital financial inclusion on sustainable development goals: Analyzing differences by financial development levels across countries,” *Journal of the Knowledge Economy*, pp. 1–24, 2024.

[28] F. Wang, X. Zhang, C. Ye, and Q. Cai, “The household multidimensional poverty reduction effects of digital financial inclusion: a financial environment perspective,” *Social Indicators Research*, vol. 172, no. 1, pp. 313–345, 2024.

[29] S. Xu and J. Wang, “The impact of digital financial inclusion on the level of agricultural output,” *Sustainability*, vol. 15, no. 5, p. 4138, 2023.

[30] Yang, M. Yang, F. Zhang, A. A. M. Kassim, and P. Wang, “Has digital financial inclusion curbed carbon emissions intensity? Considering technological innovation and green consumption in China,” *Journal of the Knowledge Economy*, pp. 1–30, 2024.

[31] Y. Zhou, C. Zhang, and Z. Li, “The impact of digital financial inclusion on household carbon emissions: evidence from China,” *Journal of Economic Structures*, vol. 12, no. 1, p. 2, 2023.