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The Impact of Digital Transformation in Banks on Economic Growth: A Study of a Sample of Countries from 2012 to 2021

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Abstract:

This study aims to highlight the relationship between digital transformation indicators in the banking sector and economic growth for a sample of countries. Three panel models were employed: the aggregate model, fixed-effects model, and random-effects model. After individually estimating each model, statistical tests were applied in the empirical study.

The study concludes that the random-effects model is the most effective, indicating a direct and positive impact of digital transformation indicators in the banking sector on economic growth.

Keywords: Digital transformation, economic growth, digital services.

1. Introduction:

The world is experiencing significant developments in various sectors, with a notable reliance on modern technology and communication. The banking sector, in particular, has witnessed substantial growth and transformation due to the significant digital shift. This transformation became especially pronounced during the COVID-19 pandemic, where technology and digital innovations played a crucial role in various banking services. The impact of this digital transformation on the economy is substantial, as the banking sector is a key driver of economic development and growth. Despite the positive aspects, challenges such as cybersecurity have emerged.

Research Problem: Given the context, the main research question is: **How does digital transformation in banks affect economic growth?**

Subsidiary questions include:

- How has digital transformation affected banks?
- What challenges does digital transformation pose in the banking sector?
- What are the repercussions of digital transformation on economic growth?

Study Hypotheses: To address the research questions, the following hypotheses are proposed:

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- Digital transformation in banks has contributed to improving banking services for customers.
- Digital transformation in banks has faced several challenges hindering its expansion.
- Digital transformation in banks, through the increase and development of financial transactions, contributes to economic growth.

Study Significance: The importance of this study lies in shedding light on the impact of digital transformation in banks on the economy and its development.

Study Objectives: This study aims to achieve the following:

- Understand digital transformation in banks.
- Highlight the impact of digital transformation in banks on economic growth through a study of a sample of countries.

Research Methodology: This study adopts a descriptive approach with analysis, by collecting data and analysis it using the Stata program to study the subject, its variables, correlations, and draw conclusions.

2. Previous Studies:

- Study of (Nargiza Jiyanova1, Malika Azimjonova Shavkat kizi, Azizakhon Umarova Abdulkhak Makhkambaev, Nargiza Akramova, **Digital transformation of banks as a way to sustainable development of the economy, 2023**): This study aimed to highlight the impact of digital transformation in banks on sustainable economic development. It compared local banks with advanced international banks to discover various challenges hindering digital transformation in the latter. The results emphasized the necessity of developing a clear plan for digital transformation, following a comprehensive study of the material and financial aspects to achieve the intended goal.

- Study of (Shurooq Hadi Abdul Ali, Iradan Hatem Khudair, **Digital Transformation of Banking Operations as a Tool for Developing Strategic Financial Performance: A Case Study of Baghdad Bank, 2020**): This study aimed to understand the nature of digital transformation in banking operations. It analyzed indicators of strategic financial performance using standard analysis to measure the correlation between independent and dependent variables. The practical results indicated no significant correlation or impact between digital transformation of banking operations and strategic financial performance.

- Study of (Estelle Xue Liu, **Stay Competitive in the Digital Age: The Future of Banks, 2021**): This study aimed to emphasize the importance of enhancing competitive capabilities among banks through digital transformation in various services. The results highlighted the significance of good infrastructure and legal and commercial environments in supporting digital progress.

- Study of (Florian Ulrich-Diener, Miroslav Spacek, **Digital Transformation in Banking: A Managerial Perspective on Barriers to Change, 2021**): This study aimed to identify the main obstacles facing digital transformation in the banking sector. Results highlighted elements of interest in the digital transformation process, including strategic management, technology, organization, customers, and employees.

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- Study of (Sanaa Rahab, Halima Shabi, **The Impact of Digital Transformation on the Job Performance of Employees in Commercial Banks: A Case Study of Commercial Banks in El Tarf, 2023**): This study aimed to highlight the dimensions of digital transformation in banks and how they affect the performance of bank employees. The results indicated that digital transformation in banks positively contributed to enhancing the performance of bank employees by facilitating work through digital transformation techniques.

Analysis of Previous Studies: Through the previous studies discussed and in comparison with the current study, there are commonalities, such as the focus on digital transformation in the banking sector. However, the current study seeks to highlight the impact of digital transformation in banks on economic growth, a facet not extensively covered in earlier research. Differences also exist in the objectives of previous studies, with some focusing on the functional performance of banks and others on economic development.

3. Literature Review :

3.1 - Concepts of Digital Transformation in Banks

3.1.1 - Digital Transformation

Digital transformation is defined as "a radical change in the institution with an extraordinary impact on strategies and organizational structure"[1].

It involves integrating new processes into the organization, such as adopting new technologies, tools, and internet-related work methods. Additionally, it requires a new internal organization supported by senior management[2].

It is also defined as "a gradual process undertaken by the institution to adjust its strategies and daily operations, starting from changes in employee roles and business model innovations, attempting to leverage digital phenomena." This includes creating new digital businesses and using big data.

3.1.2 - Digital Transformation in Banks

Digital transformation in banks is defined as "how technology is used within banks to improve financial performance and enhance the quality of services provided to customers." It involves deploying technology to serve the workflow within the bank's various departments, improving services, and facilitating access while ensuring time and effort savings"[3].

3.1.3 - Requirements for Digital Transformation in Banks

[1] Shurooq Hadi Abdul Ali, Iradn Hatem Khudair, Digital Transformation of Banking Operations as a Tool for Enhancing the Strategic Financial Performance of the Bank of Baghdad as a Model, Journal of Management and Economics, Al-Mustansiriya University, Issue 126, December 2020, p. 3.
[2] Sanaa Rahab, Halima Shabi, The Impact of Digital Transformation on the Job Performance of Employees in Commercial Banks - A Case Study of Commercial Banks in El Tarf Province, Journal of Industrial Economics (Khazartak), Volume 13, Issue 01, 2023, p. 692.
[3] Osama Mohammed Al-Taba'i Al-Danoun, The Impact of Digital Transformation on the Financial Performance of Egyptian Banks - A Case Study of Banque Misr, Issue No. 2 - April 2022, p. 553.

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Digital transformation in banks requires several elements[4]:

- **Technologies**: The process necessitates a system of devices, data, and software operating within technical environments that allow the efficient use of all assets without interruption.
- **Data**: Providing accurate data facilitates accurate future predictions, contributing to achieving the banks' goals and expectations.
- **Human Resources**: The effective and qualified human resource is essential for implementing digital transformation in banks, controlling technology, and using and analyzing data for effective decision-making.
- **Operations**: Coordinating and updating various internal and external operations with advanced applications and technologies is necessary for optimal application of digital transformation in banks.

3.1.4 - Techniques of Digital Transformation in Banks

Several techniques contribute to digital transformation in banks[5]:

- **Artificial Intelligence Techniques in Banks**: The banking sector has witnessed several advancements, with customers increasingly executing transactions using electronic applications and smart solutions. Notable uses of artificial intelligence in banks include financial technology, customer interaction, and examples like Santander Bank using robots to deal with customers.
- **Blockchain Technology in Banks**: Blockchain technology enhances scientific efficiency and develops innovative and competitive capabilities in banks. It has been used for its decentralized advantage, facilitating digital payment services and external transfers, reducing time and costs.
- **Digital Marketing Technology in Banks**: Digital marketing is the optimal use of digital technologies, information, and communication technologies to activate the marketing function. It involves using modern technology such as the Internet and mobile phones to achieve marketing goals and customer satisfaction.

3.1.5 - Dimensions of Digital Transformation in Banks

Several dimensions of digital transformation in banks include[6]:

- **Electronic Clearance**: It is a network for financial settlement of electronic bonds between banks at the central bank level. The National Electronic Clearing Union was established in

[4] Sanaa Rahab, Halima Shabi, op.cit, p. 693.
[5] Ben Lwassif Hanane, Boulahia Salim, Investing in the Digital Field: The Choice for the Transformation of Marketing Banking Services in the Arab World, Al-Maayar Journal, Tissemsilt University, Volume 12, Issue 2, December 2021, p. 767.
[6] Shurooq Hadi Abdul Ali, Iradn Hatem Khudair, op.cit, p. 4.

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the United States in 1973, managing a massive volume of financial transactions continuously and daily.

- **Real-Time Gross Settlement System**: This system provides a mechanism for the final processing and settlement of high-value payment orders that customers can continuously exchange. This system began operating in 2006, and the central bank owns it, reducing manual work and avoiding the risks arising from the comprehensive settlement of payments between banks.
- **Electronic Payment**: With the evolution from metallic and paper currency to electronic currencies, the method of payment has become electronic. Electronic payment is the rapid transfer of electronic money from one account to another at low cost.

3.1.6 - Components of Digital Transformation in Banks

The components of digital transformation in banks are divided into three categories[7]:

- **Customer Relationship**: The desired outcome of this digital transformation is to improve customer experience by introducing digital techniques and simplifying external communications.
- **Internal Organization Processes**: Through adopting a digital transformation strategy, new processes emerged due to changes in the infrastructure, with transactions and exchanges becoming digital, reducing paper transactions and increasing the speed of these transactions, and reducing costs.
- **Political Power of Leadership**: Through several reports, the reason for the failure of digital transformation is attributed to the management's fear of change. This transformation results in changes in various management styles and processes, affecting the service provided to customers and its quality, making management resistant to this change. Therefore, the path of digital transformation should be clear and realistic.

3.1.7 - Challenges of Digital Transformation in Banks

The challenges of digital transformation in banks include[8]:

- **Lack of Technical Skills**: A shortage of technical skills among bank employees is crucial and must be addressed in formulating and preparing a digital strategy.
- **Lack of Organizational Culture**: The lack of organizational culture among workers and bank customers hampers the digital transformation process.
- **Lack of Coordination**: Insufficient coordination between different levels and the failure to divide roles, responsibilities, and goals hinder digital transformation.
- **Weak IT Infrastructure**: Inadequate infrastructure related to information technology equipment and technologies hinders digital transformation.
- **Legal and Legislative Deficiencies**: Legal and legislative deficiencies in this field hinder the digital transformation process.

Figure 01 : Challenges of Digital Transformation in Banks

[7] Nargiza Jiyanova and others، Digital transformation of banks as a way to sustainable development of the economy، 2023، TransSiberia ،P05.
[8] Khaira Chaouchi, Zahra Khalouf, Digital Transformation in Algeria, Journal of Accounting, Auditing, and Finance, University of Djilali Bounaama Khemis Miliana, Volume 5, Issue 1, 2023, p. 21.

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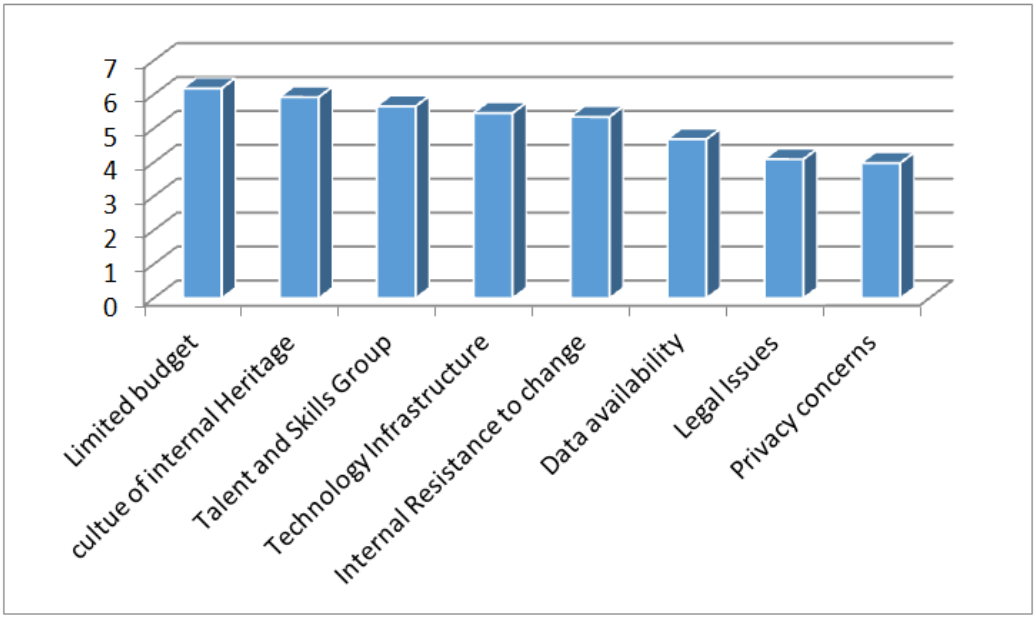

Source : Jim Marous, Digital Banking Report, State of Digital Banking Transformation, DBR Media LLC, USA, 2019, p 56.

In Figure 01, we observe various challenges facing the digital transformation process in banks, evaluated and measured on a scale of 9. It is evident that the challenge of limited budget had the highest score, with 6.18 out of 9. This could be attributed to the significant cost associated with digital transformation, including the purchase of new hardware and modern technologies. This cost may exceed the financial capacity of banks.
Following closely is the challenge of internal heritage culture with a score of 5.92 out of 9. This is related to the cultural mentality of customers, often based on trust. Some customers may not trust automated machines, such as ATMs, to access their funds. Instead, they prefer human interaction in their transactions, hindering the digital transformation process in banks.

3.2 - Economic Growth

3.2.1 - Definition of Economic Growth

Economic growth, as defined by several economists, including **Simon Kuznets**, is "the long-term increase in a state's capacity to provide a wide and diverse range of economic goods increasingly to its population. This growing capacity relies on technological progress and institutional and ideological modifications that are necessary"[9].
It is also defined as "a term that expresses the increase that occurs in the Gross Domestic Product (GDP) in the long term. In the short term, economic growth is defined as expansion or recession in the economic business cycle. Economic growth can also be defined as the change in an individual's share of the real GDP, which can be either positive or negative"[10].

[9] Fadila Mellouah," economic growth determinants in Algeria, a standardized study for the period (1990-2018), published in the Journal of Economics and Applied Statistics, Volume 17, June 2020, page 127.
[10] Shahat Wahiba," economic growth in Algeria, determinants and prospects, a standardized study for the period 1990-2019, a doctoral thesis presented to fulfill the requirements of the third level doctorate, Department of Applied Economics, specializing in Applied Macroeconomics, University of Algiers 3, 2021-2022, page 11.

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3.2.2 – Factors of Economic Growth

- **Innovation**: Innovation and technological advancement are considered reasons for progress. In recent years, significant developments have been observed in various fields due to technological advancements.
- **Environment**: It is an important indicator to determine the speed of economic growth in any country.
- **Investment**: Every increase in investment is accompanied by an increase in economic growth.
- **Institutional Stability**: This involves institutions applying the principles of macroeconomics to achieve stability and, consequently, an increase in economic growth.

3.2.3- Models for Assessing Sources of Growth

Developing appropriate policies to stimulate growth at the practical level requires an assessment of the following ratios:

- The relative contribution ratio of each factor of production to growth individually.
- The total contribution ratio of production factors to growth, compared with the productivity contribution ratio to growth.
- The contribution ratio of technological progress to increased productivity, compared with the contribution ratio of efficiency improvement to increased productivity.

Economists have developed two methods to measure these ratios. The first method focuses on studying the sources of growth in a single country over a specific period, known as the Growth Accounting Method. This method uses time-series data. The second method aims to explain and justify the differences in an individual's share of national income (i.e., income level rather than growth rate) among different countries. It assesses how much of these differences can be attributed to variations in the availability of production factors between countries and how much to differences in the productivity of production factors. This method uses cross-sectional data and is referred to in economic literature as the Development Accounting Method.

3.2.3 - Banking Sector Development on Economic Growth

The banking sector has a fundamental role in supporting and promoting economic growth. This is achieved by using savings, held in the form of non-productive liquid assets, and converting them into productive assets by providing them in the form of loans to investors. This contribution enhances the stability of investment projects, leading to increased production and, consequently, economic growth. Therefore, the development of the banking sector, with all its functions and services, through the introduction of various digital technologies, will contribute to the rapid development of economic growth[11].

[11] Adel Zegrir," discussing the relationship between the development of the banking system and economic growth - both theoretically and practically. Journal of Economic and Financial Studies (University of Ouargla), Issue 08, Volume 01, page 137.

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4- The Study Framework: Measuring the Impact of Digital Transformation Indicators in the Banking Industry on Economic Growth.

4.1- Methodology and Tools

we aim to investigate the impact of digital transformation indicators in banks, expressed by the total number of SWIFT users and the total number of institutions offering digital payment services, on economic growth in a sample of countries represented by (Mexico, Turkey, Argentina, Italy, Germany, France). Based on the above, we can rely on panel models in this study to demonstrate this impact, as follows:

- **Identifying Study Variables:** Based on the empirical results of previous studies, we will use the three panel models (Fixed Effects, Random Effects, and Aggregate) to measure the impact of digital transformation indicators in banks on economic growth. The following table represents the study variables.

Table No. 01: Standard Study Variables

Code	Indicator
Dependent Variable	
y	Economic Growth
Independent Variables	
X 1	Total number of SWIFT users
X 2	Total number of institutions providing digital payment services

Source: Compiled by the researchers.

- Study Data and Tools : Through our review of statistics on the website of the Bank for International Settlements (BIS), data for the study were collected, spanning from 2012 to 2021, covering six countries (Mexico, Turkey, Argentina, Italy, Germany, France). The data was then processed using the (Stata .15 software). Since the aim of the empirical study is to build a standard model that illustrates the nature of the relationship between study variables, we opted to use panel models, also known as cross-sectional time-series data, which combines the characteristics of cross-sectional and time-series data.

4.2 - Results and Discussion

4.2.1 - Comparison Between Panel Models

To compare panel models, we need to extract the results of each model, as illustrated in the following table.

Table No. 02: Results of Panel Models Estimation Outputs.

Interpretive Variables	Aggregate Impact Model	Fixed Effects Model	Random Effects Model

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X 1	0. 2626612 (0.000)	0. 3135278 (0.000)	0. 3514508 (0.000)
X 2	0. 3078969 (0.000)	0. 1223912 (0.001)	0. 1353022 (0.000)
Constant	24.90673 (0.000)	25.71866 (0.000)	25.45251 (0.000)
Number of Observations	60	60	60
R-squared	0.9231	0.9938	-
Adjusted R-squared	0.9204	0.9929	-
Prob (F-Stat)	0.0000	0.0838	0.0000

Source: Compiled by researchers based on the outputs of the (Stata 15) program (see Appendix 01)

To compare the three estimated models in Table 02, we perform the following tests:

- **Breusch and Pagan Test**: This test is used to differentiate between the Aggregate regression model and the random effects model. The hypothesis for this test is formulated as follows:

$$\begin{cases} \mathbf{H_0}: \text{(Aggregate model) has no random effects} \\ \mathbf{H_1}: \quad \text{has a random effects} \end{cases}$$

Table No. 03: Breusch and Pagan Test Results

chibar2(01)	200.31
Prob > chibar2	0.0000

Source: Compiled by researchers based on the outputs of the (Stata 15) program (see Appendix 02)

From the table, we observe that the Prob > Chi2 value is statistically significant, i.e., less than 5%. Therefore, we accept the alternative hypothesis (H1) indicating the presence of random effects. In other words, we choose the random effects model over the Aggregate impact model.

- **The Hausman test :** is employed to differentiate between the fixed effects model and the random effects model, within two hypothesis:

$$\begin{cases} \mathbf{H_0}: \text{Random Effects Model} \\ \mathbf{H_1}: \quad \text{Fixed Effects Model} \end{cases}$$

This test relies on calculating both chi2 (10) and Prob>ch, and the results using Stata 15 are presented in the following table:

Table No.04: Hausman Test Results

chi2(2)	2.96
Prob>chi2	0.2276

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Source: Compiled by researchers based on the outputs of the (Stata 15) program (see Appendix 03)

The Prob > Chi2 value in the above table indicates that the probability for the test is not statistically significant at the 5% level. This leads us to accept the null hypothesis (Ho). Therefore, we find that the random effects model is preferable compared to the fixed effects model.

- Fisher's Restricted Test : serves as a test for differentiation between the aggregate regression model and the fixed effects model, verifying the presence of individual effects within two given hypothesis:

$$\begin{cases} \mathbf{H_0}: \text{(Aggregate model) has no fixed impact} \\ \mathbf{H_1}: \text{has a fixed impact} \end{cases}$$

Table No. 05: Fisher's Restricted Test Results

F(5, 52)	118.09
Prob> F	0.0000

S**ource:** Compiled by researchers based on the outputs of the (Stata 15) program (see Appendix 01)

The results of this test indicate that the F-statistic (5, 52) with a value of 118.09 is statistically significant at a 5% level of significance (since Prob > F = 0.0000 < 0.05). Therefore, we accept the alternative hypothesis (H1), which suggests the presence of fixed effects in the model. Consequently, the preferred model within this test is the fixed effects model.

4.2.2- Estimation of the Optimal Model: Through our examination of the comparative tests, we find that the random effects model is the most suitable for the study. However, before relying on its results, it is crucial to ensure that this model does not suffer from standard problems, such as autocorrelation and heteroscedasticity.

- Wooldridge Test: This test measures the autocorrelation of errors, which is the degree of correlation between the values of the same variable over a specified period, rather than between one or more variables. There are several tests to measure autocorrelation, with one of the most important being the Wooldridge test[12]. The test can be conducted using the command (xtserial) in the Stata 15 program. The results of this test were as follows:

xtserial y x1 x2

Wooldridge test for autocorrelation in panel data

H0: no first-order autocorrelation

F(1, 5) = 1.096

Prob > F = 0.3432

Source: Compiled by researchers based on the outputs of the (xttest3) command in Stata 15.

[12] Jelali Etoumi, Testing the impact of some factors on the capital structure of Algerian private banks - an applied study during the period (2009-2014), New Economy Journal, Volume 19, 2018, p. 239.

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The results of the Wooldridge test for detecting autocorrelation issues indicate that the probability value is greater than 0.05. This allows us to accept the null hypothesis, suggesting the absence of autocorrelation problems. Therefore, based on this test, it appears that autocorrelation is not a significant issue in the chosen model.

- Modified Wald test: This test allows us to know the heterogeneity of the variance. The latter affects the estimates of the variance of the model's estimators. It is used to determine the presence of this problem or not by using the Modified Wald test within the property provided by the command (xttest3) in the program (stata.15). As indicated by the command results below:

xttest3

Modified Wald test for groupwise heteroskedasticity

in fixed effect regression model

H0: sigma(i)^2 = sigma^2 for all i

chi2 (6) = 232.35

Prob>chi2 = 0.0000

Source: Compiled by researchers based on the outputs of the (xttest3) command in Stata 15.

From the results of the Modified Wald test, it is concluded that the random effects model is experiencing an issue of heteroskedasticity. This conclusion is drawn because the statistically significant probability value (Prob > F < 0.05) is less than 5%, leading to the rejection of the null hypothesis and acceptance of the alternative hypothesis.

4.2.3- Analysis of the Estimated Model: Based on the tests revealing the presence of statistical issues, it appears that the model suffers from heteroskedasticity. To address this problem, the method of correcting errors in panel time series data, also known as `xtgls`[13], is employed. This method is resorted to when the cross-sectional dataset has fewer time periods available.

xtgls y x1 x2

Cross-sectional time-series FGLS regression

Coefficients: generalized least squares

Panels: homoskedastic

Correlation: no autocorrelation

Estimated covariances	= 1	Number of obs	= 60
Estimated autocorrelations	= 0	Number of groups	= 6

[13] Danie, H.T, Robust Standards Errors for Panel Regressions with Cross-Sectional Dependence, The Stata Journal (Number3 2007, p 285.

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Estimated coefficients = 3 Time periods = 10

Wald chi2(2) = 720.66

Log likelihood = 21.62075 Prob > chi2 = 0.0000

y	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
x1	.2626612	.0410488	6.40	0.000	.1822071	.3431153
x2	.3078969	.0375904	8.19	0.000	.234221	.3815728
_cons	24.90673	.1177032	211.61	0.000	24.67603	25.13742

Source: Compiled by researchers based on the outputs of the (xttest3) command in Stata 15.

Through the results of this method, the equation of the estimated optimal model can be written as follows:

$$y = 24.90673 + 0.26612x_1 + 0.3078969x_2$$

Through these models, we observe that the more the use of the Swift system (x1) increases by one unit among banks and financial institutions in the study sample, economic growth increases by 0.26 units. This implies that the Swift system accelerates banking activities between banks and financial institutions, facilitates the provision of financial services, and thus enhances economic growth. This aligns with the theory of supply leadership. It is also evident that as the total number of institutions providing digital services (x2) increases by one unit, it leads to an increase in economic growth by 0.307 units. From this, we can conclude that as banks move towards digital transformation, it reinforces the increase in economic growth.

5- Summary:

Digital banking transformation has contributed to the development and increase of economic growth through the introduction of technologies and methods into the banking sector. These innovations have increased the speed of banking services and financial transactions, positively impacting the global economy. The banking sector serves as a fundamental source of funds required for the continuity of various economic sectors. Among the benefits of digital transformation are time efficiency, cost reduction, and addressing the sector's need for financial sustainability. However, digital transformation poses challenges, particularly in terms of security due to the digitization's connection to the internet. The following conclusions were drawn from the discussion:

- Digital transformation in banks has contributed to economic growth by accelerating financial operations, leading to increased investment.
- Digital transformation in banks has helped reduce costs and save time.
- Digital banking services have sped up financial transactions.
- Digital transformation in banks has enhanced the quality of service provided to customers, increasing their satisfaction.

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- The global expansion of digital transformation in banks has been observed through a study of a sample of countries.
- Challenges and obstacles, such as resistance to change from customers and bank employees, as well as cybersecurity concerns, hinder the widespread adoption of digital transformation in banks.

6- References:

- Shurooq Hadi Abdul Ali, Iradn Hatem Khudair, Digital Transformation of Banking Operations as a Tool for Enhancing the Strategic Financial Performance of the Bank of Baghdad as a Model, Journal of Management and Economics, Al-Mustansiriya University, Issue 126, December 2020.
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7- Appendices:

Appendix 1: Estimation of the Three Panel Models:

- Aggregate Impact Model

```
reg y x1 x2
```

```
      Source |       SS           df       MS      Number of obs   =        60
-------------+----------------------------------   F(2, 57)        =    342.31
       Model |  20.5239699         2   10.261985   Prob > F        =    0.0000
    Residual |  1.70877326        57  .029978478   R-squared       =    0.9231
```

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```
-------------+----------------------------------   Adj R-squared   =     0.9204
       Total |  22.2327432        59  .376826156   Root MSE        =     .17314

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .2626612   .0421151     6.24   0.000     .1783271    .3469954
          x2 |   .3078969    .038567     7.98   0.000     .2306679    .3851259
       _cons |   24.90673   .1207609   206.25   0.000     24.66491    25.14855
------------------------------------------------------------------------------
```

– Fixed Effects Model

```
xtreg y x1 x2 , fe

Fixed-effects (within) regression               Number of obs      =         60
Group variable: ind                             Number of groups   =          6

R-sq:                                           Obs per group:
     within  = 0.4415                                         min =         10
     between = 0.9088                                         avg =       10.0
     overall = 0.9031                                         max =         10

                                                F(2,52)            =      20.55
corr(u_i, Xb)  = 0.6049                         Prob > F           =     0.0000

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .3135278   .0736391     4.26   0.000     .1657601    .4612955
          x2 |   .1223912   .0353053     3.47   0.001      .051546    .1932364
       _cons |   25.71866   .3730551    68.94   0.000     24.97007    26.46725
-------------+----------------------------------------------------------------
     sigma_u |   .2521481
     sigma_e |  .05157314
         rho |  .95984524   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0: F(5, 52) = 118.09                     Prob > F = 0.0000


areg y x1 x2 , absorb (country)

Linear regression, absorbing indicators         Number of obs      =         60
                                                F(   2,     52)    =      20.55
                                                Prob > F           =     0.0000
                                                R-squared          =     0.9938
                                                Adj R-squared      =     0.9929
                                                Root MSE           =     0.0516

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .3135278   .0736391     4.26   0.000     .1657601    .4612955
          x2 |   .1223912   .0353053     3.47   0.001      .051546    .1932364
       _cons |   25.71866   .3730551    68.94   0.000     24.97007    26.46725
-------------+----------------------------------------------------------------
     country |          F(5, 52) =    118.089   0.000           (6 categories)
```

- Random Effects Model

```
xtreg y x1 x2 , re

Random-effects GLS regression                   Number of obs      =         60
```

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```
Group variable: ind                             Number of groups   =         6

R-sq:                                           Obs per group:
     within  = 0.4415                                         min =        10
     between = 0.9084                                         avg =      10.0
     overall = 0.9027                                         max =        10

                                                Wald chi2(2)       =     79.12
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

------------------------------------------------------------------------------
           y |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          x1 |   .3514508   .0610242     5.76   0.000     .2318456     .471056
          x2 |   .1353022   .0344887     3.92   0.000     .0677055    .2028988
       _cons |   25.45251   .3068876    82.94   0.000     24.85102     26.054
-------------+----------------------------------------------------------------
     sigma_u |  .22205468
     sigma_e |  .05157314
         rho |  .94881879   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Appendix 2: Comparative Results between the Random Effects Model and the Aggregate Model:

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        y[ind,t] = Xb + u[ind] + e[ind,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                 ---------+-----------------------------
                       y |   .3768262       .6138617
                       e |   .0026598       .0515731
                       u |   .0493083       .2220547
        Test:   Var(u) = 0
                            chibar2(01) =    200.31
                          Prob > chibar2 =    0.0000
```

Appendix 3: Comparative Results between the Random Effects Model and the Fixed Effects Model:

```
hausman fe re

                ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |       fe           re         Difference          S.E.
-------------+----------------------------------------------------------------
          x1 |    .3135278     .3514508       -.037923        .0412161
          x2 |    .1223912     .1353022       -.012911        .0075491
------------------------------------------------------------------------------
                          b = consistent under Ho and Ha; obtained from xtreg
           B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        2.96
                Prob>chi2 =      0.2276
```