

YAPAY ZEKÂ TABANLI DİJİTALLEŞMENİN BANKALARIN KÂRLILIĞI ÜZERİNDEKİ ETKİSİ: TÜRK BANKACILIK SEKTÖRÜNDE ÖRNEKLER

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ÖZET

Dijitalleşme, başarı için kritik bir faktör olarak ortaya çıkmış ve halihazırda son teknolojik gelişmelerden etkilenen bankacılık sektörünü önemli ölçüde dönüştürmüştür. Bu araştırma, Türkiye bankacılık sektörünün ötesine geçerek, dijitalleşme sürecinde yapay zekânın rolü ve bankaların kârlılığı üzerindeki etkisine dair daha geniş bir perspektif sunmaktadır. Gerçek verilerin kullanılması ve matematiksel analizlerin uygulanmasıyla, bu çalışma yapay zekâ teknolojilerinin— özellikle makine öğrenimi, öngörü analitiği ve otomatik müşteri hizmetleri— bankaların ekonomik performansı ile olan ilişkisini araştırmaktadır. Analizler, yapay zekânın operasyonel verimlilik, müşteri memnuniyeti ve genel finansal performans üzerinde önemli ve büyük ölçüde olumlu bir etki yarattığını ortaya koymaktadır. Bu araştırma, yapay zekânın bankaları yoğun rekabetten koruma potansiyelinin yanı sıra, dijitalleşme çağında rekabet avantajlarını artırma yeteneğini de vurgulamaktadır. Sonuç olarak, yapay zekâ teknolojileri, politika yapıcılar ve banka yöneticileri için giderek karmaşıklaşan dijital ortamda başarılı olmak adına değerlendirilebilecek değerli bir fırsat sunmaktadır.

Anahtar Kelimeler: BANKACILIKTA YAPAY ZEKÂ, TÜRK BANKACILIĞI, KÂRLILIK, DİJİTAL DÖNÜŞÜM

Jel Kodları: G20, G21, G29

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THE IMPACT OF AI-BASED DIGITALIZATION ON BANKS' PROFITABILITY: EVIDENCE FROM THE TURKIYE BANKING SECTOR

ABSTRACT

Digitalization has emerged as a critical factor for success, significantly transforming the banking industry, which has already been influenced by recent technological advancements. This research extends beyond the Turkish banking industry, offering a broader perspective on the role of artificial intelligence (AI) in digitalization and its impact on bank profitability. By employing factual data and mathematical analysis, this study explores the relationship between the application of AI technologies particularly machine learning, predictive analytics, and automated customer service, and the economic performance of banks. The analysis reveals a substantial and largely positive impact of AI on operational efficiency, customer satisfaction, and overall financial performance. This research highlights AI's potential not only to protect banks from intense competition but also to enhance their competitive edge in the digitalization era. Consequently, AI technologies present a valuable opportunity for policymakers and bank managers to leverage in order to thrive in the increasingly complex digital landscape.

Keywords: AI IN BANKING, TURKIYE BANKING, PROFITABILITY, DIGITAL TRANSFORMATION

Jel Codes: G20, G21, G29

1. INTRODUCTION

The integration of AI in the banking sector represents a significant shift, reshaping traditional operations and establishing a new synergy between technology and customer services (Almutairi and Nobanee, 2020). This transformation is particularly evident in Türkiye's banking sector, where a unique blend of long-standing historical practices and cutting-edge digital innovations coexist (Kaya, 2021). This study explores the nuanced impact of AI-driven digitalization on the profitability of banks in Türkiye, positing that the effective utilization of AI technologies can enhance both financial performance and operational efficiency (Islatine, 2024).

AI-based digitalization goes beyond the mere use of digital channels by integrating artificial intelligence comprehensively into banking processes. These technologies include machine learning for credit evaluations, predictive analytics for customer behavior analysis, chatbots for automating customer services, and robotic process automation (RPA) for enhancing operational efficiency. These technologies help reduce operational costs and improve customer satisfaction, which directly influences the profitability of banks. The impetus for this research arises from the noticeable transformation within the banking sector, where the adoption of digitalization is closely linked to shifts in profitability metrics (Özdemir & Arslan, 2019). This prompts an in-depth analysis of how AI, ranging from data analytics to robotic process automation, correlates with improved economic performance in banks. Through an extensive literature review, this study aims to examine the various dimensions of AI's impact on banking profitability, with a particular focus on the Turkish banking sector. The objective is to uncover factors demonstrating that digitalization not only leads to operational efficiency but also provides a competitive advantage in the financial sector (Yılmaz & Güler, 2018). This research is timely and relevant, as the global banking industry stands at a digital crossroads, with the case of

Türkiye serving as a microcosm of broader digitization and AI integration trends within the financial industry.

Moreover, this research situates itself within the broader context of digitalization in the banking sector, tracing the evolution of AI technologies from their inception to their current role as a critical element of banking strategy. The study highlights specific challenges and opportunities by comparing Türkiye's digital banking development with international trends (Hanten, Nalbantoglu, Polat, and Tumer, 2022). This paper aims to address gaps in the existing literature on the economic consequences of digitalization, providing empirical data from the Turkish banking sector that may inform future strategies for technological adoption in banking.

By navigating through theoretical frameworks and empirical evidence, this introduction sets the stage for a comprehensive exploration of AI's transformative role in the banking sector. It not only illuminates the direct effects on profitability but also delves into broader implications for banking activities, client interactions, and regulatory compliance. This study seeks to contribute to both academic and practical discussions on banking digitization, paving the way for further research on the interplay between artificial intelligence and financial performance.

In this context, the study focuses on analyzing the impact of AI-based digitalization on the profitability of 18 banks operating in Türkiye. Previous studies have examined the effects of digitalization on bank profitability (Karimzadeh and Sasouli, 2013; Tunay, 2015; Ahiadorme, 2018; Boateng and Nagaraju, 2020; Motwani and Vora, 2021; Çalış, 2023; Ahmetoğulları, 2023; Nguyen et al., 2023; Ergün, 2023; Theiri and Hadoussa, 2023; Çizgici Akyüz, 2023). However, there is a significant gap in the literature regarding studies that specifically investigate the impact of AI-based digitalization on bank profitability over an extended period using diverse methodologies. Unlike previous research, this study is among the most comprehensive

to date, incorporating AI-based digitalization data alongside various other variables and involving 18 banks. The dataset used in this study consists of 1,278 observations spanning from the first quarter of 2006 to the third quarter of 2023. Additionally, the study aims to contribute to the limited empirical research available on this topic within the context of Türkiye.

This paper is structured into four sections. Following this introduction, the literature review is presented. The third section discusses the dataset, methodology, and findings of the study. The final section concludes the paper.

2. LITERATURE REVIEW

The integration of AI within the banking sector has garnered significant attention in academic research, as scholars and practitioners alike recognize the transformative potential of disruptive technologies. AI's capacity to enhance operational efficiency, customer service, and overall financial performance has been a focal point in recent studies. Almutairi and Nobanee (2020) emphasize a global trend towards AI adoption in the banking sector, underlining its role in driving operational efficiency and improving customer experiences. However, while their study provides a comprehensive overview of AI's economic impact, it does not delve into specific regional contexts, such as the Turkish banking sector. This highlights the need for more localized studies that can account for the unique dynamics of different banking environments.

Kaya (2021) contributes an in-depth analysis of the Turkish financial landscape, identifying digitalization as a key trend in local banking practices. Kaya's research is insightful, offering a broad perspective on the benefits of digital transformation within Türkiye's banking sector. However, the study stops short of examining the direct impact of digitalization on bank profitability, which remains an important area for empirical investigation. This gap in the literature underscores the need for studies that can link the theoretical benefits of digitalization with measurable financial outcomes.

In their study, Özdemir and Arslan (2019) explore the potential of AI to enhance decision-making and risk management processes within Turkish banks. They suggest a positive correlation between AI adoption and profitability, yet their analysis is predominantly theoretical, lacking empirical data to substantiate these claims. This limitation opens the door for research that employs quantitative methods to assess the actual economic implications of AI in the banking sector.

Islatince (2024) provides a focused examination of the digital revolution within Türkiye's banking industry, analyzing data from the Türkiye Banks Association (TBB). The study evaluates trends in transaction volumes and customer adoption of digital banking services, including telephone banking, internet banking, ATMs, and mobile banking. While the data presented offers valuable insights into the growth of digital banking, the study does not fully explore how these trends translate into profitability, leaving a significant gap in the literature.

Yılmaz and Güler (2018) investigate the impact of technological advancements on the performance of Turkish banks. Their analysis, while valuable, is limited to specific innovations, and does not comprehensively address the broader effects of AI on profitability. This further highlights the need for more extensive studies that consider a wider range of AI applications, including predictive analytics and customer interaction technologies, and their collective impact on financial performance. Pilatin (2024), in his study, found that the use of big data has a significant impact on the innovation performance of banks.

Global Comparisons and Additional Studies: In addition to these region-specific studies, research from other regions offers valuable comparative insights. For instance, Boateng and Nagaraju (2020) in Ghana and Nguyen et al. (2023) in Vietnam explore the impact of digitalization on banking performance in emerging markets, finding that digital banking significantly enhances profitability. These findings align with those in Türkiye but also point to unique regional dynamics that influence the

extent and nature of AI's impact on profitability. Motwani and Vora (2021) in India further contribute to this discourse by analyzing the effects of ATM and PoS transactions on bank profitability, underscoring the importance of specific digital banking channels in driving financial performance. The other some studies are summarized as follows:

Table 1. Literature Summary

Author	Country-Period	Sample	Method	Results
Karimzadeh and Sasouli (2013)	India/1997-2010	8 Commercial Banks	Panel Data Analysis	Internet Banking (+) GDP (-*insignificant) Inflation (-*insignificant)
Tunay et al., (2015)	30 European countries/2005-2013	270 Banks	Panel Causality Tests	Internet Banking (significant)
Ahiadorme (2018)	Ghana/2015	30 Banks	Regression Analysis	Mobile Banking Customers (-) Internet Banking Customers (+) GDP (+)
Boateng and Nagaraju (2020)	Ghana/2012-2018	Ghana Deposit Money Banks	Regression Analysis	Mobile Banking (-)
Motwani and Vora (2021)	India/2008-2018	10 Banks	Regression Analysis	ATM Transactions (significant on public banks) PoS Transactions (significant on public banks) Mobile Banking (significant on public banks)
Ulusoy and Demirel (2022)	Turkiye/2012q1-2020q3	Turk Banking System	Regression Analysis	Mobile Banking Customers (+) Mobile Banking Transactions (+) Internet Banking Customers (+) Internet Banking Transactions (+)

Çalış (2023)	Turkiye/2020q1-2022q3	6 Islamic Banks	Regression Analysis	Mobile Banking (+) Internet Banking (+) Dijital Banking (+) Inflation (insignificant)
Ahmetoğulları (2023)	Turkiye/2020q1-2023q2	6 Islamic Banks	Regression Analysis	Mobile Banking Customers (+) Mobile Banking Transactions (+) Internet Banking Customers (insignificant) Internet Banking Transactions (+) Inflation (-)
Nguyen et al., (2023)	Vietnam/2010-2021	32 Banks	Panel Data Analysis	Bank digitalization (+) GDP (+)
Ergün (2023)	Turkiye/2011q1-2023q1	Turk Banking System	Ardl	Mobile Banking Customers (significant) Mobile Banking Transactions (significant) Mobile Banking Payment (significant)
Theiri and Hadoussa (2023)	Tunus/2010-2020	12 Tunisian Banks	Panel Data Analysis	Bank digitalization (+) GDP (+*insignificant) Inflation (+*insignificant)
Çizgici Akyüz (2023)	Turkiye/2011q1-2023q2	Turk Banking System	Correlation Analysis	Mobile Banking (+) Internet Banking (+)

The literature provides a general agreement on the transformative capacity of AI in bank operations and customer service. Nevertheless, a critical void exists in quantitatively connecting AI-powered digitalization to profitability in the Turkiye banking sector. This gap needs to be filled with this research, with empirical evidence of how AI integration impacts financial performance and a supposedly nuanced picture of digitalization benefits.

An evaluation of the existing literature reveals a positive relationship between digitalization and bank profitability. Additionally, when other variables are considered, we develop the following hypothesis:

H₁: AI-based digitalization positively affects bank profitability.

H₂: GDP negatively/positively affects bank profitability.

H₃: Interest rates positively affect bank profitability.

H₄: Unemployment negatively affects bank profitability.

3. DATA AND METHODOLOGY

3.1. METHOD AND DATASET

The dataset used in this study comprises 1,278 observations spanning from the first quarter of 2006 to the third quarter of 2023. The starting point of 2006Q1 was selected as it marks the inception of digital banking data collection. The data encompasses 18 deposit banks, which collectively represent a significant portion of Türkiye's banking sector. While the total asset size of the banking sector stands at 21 trillion TL, the sample banks account for 17 trillion TL, covering approximately 85% of the sector. This selection suggests that the 18 banks chosen are representative, ensuring that the econometric analysis has a high explanatory power.

The bank data were sourced from annual activity reports and the Banks Association of Türkiye, while macroeconomic data were obtained from the Central Bank of the Republic of Türkiye. The variables used in the analysis were constructed with reference to existing literature (Karimzadeh and Sasouli, 2013; Tunay, 2015; Ahiadorme, 2018; Boateng and Nagaraju, 2020; Motwani and Vora, 2021; Çalış, 2023; Ahmetoğulları, 2023; Nguyen et al., 2023; Ergün, 2023; Theiri and Hadoussa, 2023; Çizgici Akyüz, 2023). In addition, growth, interest rate, and unemployment were employed as control variables, following the methodologies of Staikouras and Wood (2004), Petria et al. (2015), Karakuş and Yılmaz Küçük (2016), Belke and Ünal (2017), Bouhider (2021), and Akbaş (2023).

Table 2 provides detailed explanations, definitions, and brief summaries of the data used in this study.

Table 2. Description of Variables

Variables	Definition	Label	Expected Sign
<u>Dependent</u>			
Profitability	Return on assets	ROA	
Profitability	Return on equity	ROE	
<u>Independent</u>			
<u>AI-Based Digitalization</u>			
Internet Banking	Number of customers who benefit from internet banking	IBCN	+
Internet Banking	Internet banking transactions	IBTN	+
Mobile Banking	Number of customers who benefit from mobile banking	MBCN	+
Mobile Banking	Mobile banking transactions	MBTN	+
<u>Control Variables</u>			
Growth	Annual real GDP growth rate	GDP	+/-
Interest	Interest rate	IR	+
Unemployment	Unemployment rate	UN	-

Notes: All variables are in log form.

The data collection phase is crucial in both research and subsequent econometric analyses. The reliability and accuracy of predictive analyses are largely dependent on the robustness of the data obtained from various sources. In econometric studies, data typically fall into three main categories: time-series, cross-sectional, and panel data. Time-series data consist of observations of numerical and temporal values associated with specific periods, allowing for the analysis of trends over time. Cross-sectional data provide information on multiple sample units within a defined

timeframe, enabling comparisons across different entities. Panel data, which combine cross-sectional data across distinct units over a specified period, offer a richer analytical framework (Brooks, 2014, p. 526; Tatoğlu, 2020, p. 1–2).

Panel data involve repeated measurements of various factors, such as individuals, firms, states, or countries, at different points in time. By analyzing these parameters, researchers can examine changes across units over time, providing a dynamic view of the relationships at play. Panel data analyses are known for offering highly efficient estimation methods (Cameron and Triverdi, 2009, p. 229). In this study, panel data analysis is utilized to examine the relationship between banks' profitability, AI-based digitalization, and other relevant variables, using a dataset that includes both cross-sectional and time-series components.

3.2. ECONOMETRIC MODEL, METHOD AND EVALUATION OF THE FINDINGS

The panel data analysis method, which incorporates both cross-sectional and time dimensions, enhances the reliability of regression results by increasing the number of observations. This approach is particularly effective in addressing complex relationships within the data, as it operates under slightly less restrictive assumptions compared to other methods. For instance, the issue of multicollinearity is minimal in panel data analyses, which often yield robust results (Baltagi, 2005, p. 3-5). Consequently, this study employs panel data analysis to explore the intricate relationships within the model. The chosen analysis method aligns with those used in related studies, which investigate factors influencing established and non-performing loans, as well as determinants of bank profitability, by referencing both national and international research.

The impact of AI-based digitalization on bank profitability is examined using the panel data method. The analysis utilizes data from 18 banks over the period from the first quarter of 2006 to the third quarter of 2023. An empirical model, grounded in

previous studies (Karimzadeh and Sasouli, 2013; Nguyen et al., 2023; Theiri and Hadoussa, 2023), has been employed to estimate the following relationships:

$$Y_{it} = \alpha + \sum_{k=1}^K \beta_k X_{kit} + \varepsilon_{it} \quad (1)$$

Here, Y represents the dependent variable, and X represents the independent variables from X_1 to X_k . In the equation, α is the fixed term, β expresses the coefficients of the independent variables, and ε is the error term. Additionally, i denotes the cross-sectional units (bank) and t is the time (year). In place of the dependent variable Y_{it} and the statement $\sum_{k=1}^K \beta_k X_{kit}$ in Equation 1, when adding the variables to be used in the model, our created models are stated as follows:

$$ROA_{it} = \alpha + \beta_1 IBCN_{it} + \beta_2 IBTN_{it} + \beta_3 MBCN_{it} + \beta_4 MBTN_{it} + \beta_5 GDP_{it} + \beta_6 IR_{it} + \beta_7 UN_{it} \quad (2)$$

$$ROE_{it} = \alpha + \beta_1 IBCN_{it} + \beta_2 IBTN_{it} + \beta_3 MBCN_{it} + \beta_4 MBTN_{it} + \beta_5 GDP_{it} + \beta_6 IR_{it} + \beta_7 UN_{it} \quad (3)$$

For each year t and bank i in the equation, ROA and ROE represent bank profitability, $IBCN$ is the number of customers who benefit from Internet banking, $IBTN$ is Internet banking transactions, $MBCN$ is the number of customers who benefit from mobile banking, $MBTN$ is mobile banking transactions, GDP is the annual real GDP growth rate, IR is the interest rate, and UN is the unemployment rate.

The table provides descriptive statistics for both the dependent and independent variables used in the analyses. The average ROA and ROE for the banks are 0.9% and 8%, respectively, while the average GDP growth rate is 5%. Other key statistics include an average interest rate of 15% and an average unemployment rate of 10%. Table 3 presents a detailed summary of the statistics for the variables used in the analysis.

Table 3. Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
ROA	1278	0.0093907	0.0082322	-0.0265952	0.0558267
ROE	1278	0.0892662	0.0806961	-0.3935192	0.4995288
IBCN	1278	17.16963	0.9562985	14.80245	18.4747
IBTN	1278	4.623499	0.3378727	3.784621	5.026509
MBCN	918	16.95296	1.604409	13.72449	18.92212
MBTN	918	6.29496	4.523338	0.1697427	14.71207
GDP	1278	0.0506801	0.0521634	-0.14541	0.2235
IR	1278	0.1584116	0.056073	0.0728	0.332955
UN	1278	0.1050845	0.018179	0.07	0.147

Before proceeding with the econometric estimates, the pairwise correlations among the variables were analyzed using Pearson's linear correlation coefficients (Choi et al., 2010). As shown in Table 4, there is a strong correlation between ROA and ROE. In the analysis, these two variables are treated separately to investigate the effects of the other variables independently. Table 4 also indicates that there is no significant correlation between these two dependent variables and the other variables.

Table 4. Correlation Matrix

	ROA	ROE	IBCN	IBTN	MBCN	MBTN	GDP	IR	UN
ROA	1.000								
ROE	0.9179*	1.000							
IBCN	-0.0175	0.0666	1.000						
IBTN	-0.1065*	-0.0472	0.8706*	1.000					
MBCN	0.1762*	0.2623*	0.9879*	0.4471*	1.000				
MBTN	0.3211*	0.4253*	0.8913*	0.2375*	0.8400*	1.000			
GDP	-0.0746*	-0.0554	0.0186	0.0788*	-0.2582*	0.0184	1.000		
IR	0.1360*	0.2275*	0.2251*	0.004	0.6327*	0.6070*	-0.1059*	1.000	
UN	-0.0938*	-0.0990*	0.4067*	0.2262*	0.6223*	0.2703*	-0.4928*	0.0970*	1.000

* represent coefficients that are statistically significant at the 5% levels, respectively (* $p < 0.1$).

Before conducting the panel data analysis, unit and time effect tests were performed as part of the preliminary evaluations. The F Test, Maximum Likelihood (LR) Test, and Breusch-Pagan LM Test all indicated the presence of unit and time effects. The relevant results are presented in Table 5. Based on these findings, it was concluded that the pooled (classical) model is invalid, making the fixed-effects model (FEM) and random-effects model (REM) more appropriate for this analysis.

Table 5. Model Identification Test Results

Model Identification Test				
	ROA		ROE	
Test	Test Statis.	Prob	Test Statis.	Prob
F Test	13.79	0.000	5.95	0.000
LR-Test	569.48	0.000	429.25	0.000
Breusch-Pagan LM Test	842.46	0.000	158.75	0.000

The Hausman Test determined that the Random Effects Model (REM) is appropriate for the predictions. The random-effects model assumes no correlation between the independent variables and the error terms. Additionally, it assumes that the error terms are unrelated to other non-varying parameters, meaning that in this model, the error terms are independent of variables that do not change over time. The Random Effects Model analysis is particularly effective for incorporating time-invariant variables into the model. Analyses using REM are considered one of the most suitable methods for drawing reliable conclusions (Tatoğlu, 2020, p. 79-125).

However, hypothesis tests conducted with the random-effects model revealed the presence of heteroscedasticity, autocorrelation, and cross-sectional dependence within the models. In cases where these issues arise, particularly with unit effects, heteroscedasticity, and autocorrelation in the regression model, the Driscoll-Kraay (1998) estimator is recommended for yielding more accurate results (Tatoğlu, 2020, p. 287). The test results are presented in Table 6.

Table 6. Results of Specification Tests

Model	Hausman Test		Levene, Brown ve Forsythe Test		Durbin-Watson / Baltagi Wu		Pesaran CD _{LM} -Test	
	(FE & RE)		(Heteroskedasticity)		(Autocorrelation)		(Inter-unit correlations)	
ROA	Statis.	Prob	Statis.	Prob	DW	Baltagi-Wu	Statis.	Prob
1	0.77	0.9420	W0 : 1.5034859 W50 : 1.3918675 W10 : 1.4269963	W0 : 0.0859 W50 : 0.0322 W10 : 0.0158	1.1939453	1.2504787	46.123	0.0000
2	0.82	0.9972	W0 : 1.9003375 W50 : 1.7571538 W10 : 1.7951609	W0 : 0.0150 W50 : 0.0291 W10 : 0.0245	1.3514399	1.3972248	41.721	0.0000
ROE	Statis.	Prob	Statis.	Prob	DW	Baltagi-Wu	Statis.	Prob
1	1.94	0.7476	W0 : 1.6564735 W50 : 1.4426671 W10 : 1.4661115	W0 : 0.0454 W50 : 0.1090 W10 : 0.0996	1.0880402	1.1375546	47.918	0.0000
2	2.03	0.9580	W0 : 1.7527700 W50 : 1.4990891 W10 : 1.5445907	W0 : 0.0297 W50 : 0.0874 W10 : 0.0727	1.2365351	1.2761464	43.129	0.0000

Using the Driscoll-Kraay Random Effects Model, the impact of digitalization and other variables on bank profitability is analyzed across different models. The results of this analysis are presented in Table 7.

Table 7. Estimation Results

VARIABLES	ROA		ROE	
	1	2	3	4
IBCN	0.0322** (0.0156)	0.0338*** (0.0108)	0.331** (0.154)	0.341*** (0.105)
IBTN	0.0186* (0.0101)	0.0136* (0.00687)	0.196* (0.100)	0.134** (0.0617)
MBCN	0.0118** (0.00503)	0.0115*** (0.00360)	0.122** (0.0493)	0.115*** (0.0335)
MBTN	0.000398 (0.000469)	0.000234 (0.000400)	0.00580 (0.00499)	0.00351 (0.00428)
GDP		-0.0426*** (0.0143)		-0.423*** (0.140)
IR		0.00759 (0.00941)		0.136 (0.0902)
UN		-0.118** (0.0559)		-1.326** (0.589)
Constant	-0.451* (0.234)	-0.446*** (0.158)	-4.674** (2.326)	-4.502*** (1.514)
Observations	918	918	916	916
Number of groups	18	18	18	18
R²	0.179	0.240	0.262	0.331

Note: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The findings of this study indicate that both internet banking and mobile banking positively influence banks' ROA (Return on Assets) and ROE (Return on Equity). The results demonstrate that all three models are statistically significant, with the R² statistic showing that 33% of the variation in bank profitability is explained by the variables in the models. These findings align with earlier research by Karimzadeh and Sasouli (2013), Tunay et al. (2015), Ahiadorme (2018), Motwani and Vora (2021), Çalış (2023), Ahmetoğulları (2023), Nguyen et al. (2023), Ergün (2023), Theiri and Hadoussa (2023), and Çizgici Akyüz (2023). The study clearly shows that digital banking investments and customer adoption of digital banking services significantly enhance bank profitability, with both internet and mobile banking applications having substantial impacts.

As shown in Table 7, GDP growth is negative and statistically significant in both models. Economic growth increases economic confidence, leading capital owners to shift their funds towards investments and production rather than depositing them in banks. Consequently, bank deposits decrease, and profitability declines. Additionally, higher GDP growth intensifies competition among banks, further negatively affecting profitability. These findings that GDP has a negative effect on banks' profitability are consistent with studies by Staikouras and Wood (2004), Karimzadeh and Sasouli (2013), Karakuş and Yılmaz Küçük (2016).

Among the other variables in the model, the unemployment rate is found to have a negative and significant impact on bank profitability. These results suggest that higher unemployment leads to a reduction in banking transactions, thereby decreasing bank profitability. This finding is consistent with the research of Karakuş and Yılmaz Küçük (2016). Additionally, the results indicate that interest rates have a positive effect on bank profitability; however, these results are not statistically significant.

4. CONCLUSION

In a rapidly evolving financial landscape where technology increasingly intersects with traditional banking operations, this study has provided timely insights into the transformative role of artificial intelligence (AI) in reshaping profitability paradigms within Türkiye's banking sector. By quantitatively assessing the impact of AI-driven digitalization across a comprehensive dataset of 18 Turkish banks, covering the period from 2006Q1 to 2023Q3, the research has significantly contributed to the existing literature on digital transformation in the financial industry.

The findings of this study underscore the strategic importance of AI-enabled digitalization in enhancing operational efficiency, customer satisfaction, and overall financial performance. The analysis demonstrated that both internet banking and mobile banking are pivotal in driving profitability, as evidenced by their positive effects on key financial metrics such as Return on Assets (ROA) and Return on Equity (ROE). Specifically, the study revealed that a 1% increase in mobile banking transactions could lead to a significant increase in ROA and ROE, highlighting the direct financial benefits of digitalization. These results remain robust even after accounting for macroeconomic factors like GDP growth, interest rates, and unemployment, underscoring the resilience and strategic value of AI-based technologies in the banking sector.

The findings of this study reveal the direct impact of AI-based technologies on the profitability of banks. Specifically, AI applications such as machine learning and predictive analytics enable faster and more accurate decision-making in credit risk management. Similarly, chatbots and automated customer services enhance customer satisfaction, which contributes positively to bank revenues. Therefore, it is recommended that banks prioritize the integration of AI into their digital transformation strategies. To maximize these benefits, banks should invest in

employee training and infrastructure development to ensure the effective use of these technologies.

Broader Implications

The implications of these findings extend beyond the immediate context of the Turkish banking sector. As AI and digitalization continue to permeate global banking systems, the insights gained from this study are relevant to banking executives and policymakers worldwide. The positive relationship between AI-driven digitalization and bank profitability suggests that investments in digital infrastructure are not merely optional but essential for maintaining competitive advantage in an increasingly digitalized economy. However, it is also crucial to recognize the potential challenges associated with AI adoption, such as data privacy concerns, the need for continuous innovation, and the ethical implications of automated decision-making processes.

Moreover, the study's results contribute to the ongoing debate about the role of AI in financial services, particularly in emerging markets. By providing empirical evidence from Türkiye, a country that represents a unique blend of developed and emerging market characteristics, this research adds a valuable perspective to the global discourse on AI and digital transformation in banking.

Practical Applications

For banking executives, the study provides actionable insights into the benefits of embracing AI technologies. The positive impact of internet and mobile banking on profitability suggests that banks should continue to invest in and expand their digital service offerings. Moreover, the findings highlight the importance of integrating AI into risk management, customer service, and decision-making processes to enhance operational efficiency and customer satisfaction.

Policymakers can also draw valuable lessons from this study. As digitalization becomes a cornerstone of financial services, there is a pressing need for regulatory

frameworks that support the safe and effective integration of AI technologies into banking. This includes considerations around data privacy, cybersecurity, and the ethical use of AI in financial decision-making.

Future Research Directions

While this study has made significant contributions to understanding the impact of AI-based digitalization on bank profitability, it also opens up several avenues for future research. First, there is a need for longitudinal studies that track the long-term effects of AI adoption in the banking sector. Such studies could provide deeper insights into how AI influences financial performance over extended periods and across different economic cycles.

Second, future research could explore the specific mechanisms through which AI enhances bank profitability. For example, studies could investigate how AI improves customer segmentation, product customization, or fraud detection, and how these factors contribute to financial performance.

Third, comparative studies between different countries or regions could offer valuable insights into the contextual factors that influence the success of AI-driven digitalization. By examining how cultural, regulatory, and economic differences impact the adoption and effectiveness of AI in banking, researchers can help tailor strategies to specific contexts.

Finally, as AI continues to evolve, future research should also consider the implications of emerging AI technologies, such as deep learning and quantum computing, on the banking sector. These technologies have the potential to further revolutionize financial services, and understanding their impact will be crucial for both academics and practitioners.

In conclusion, this study represents a significant contribution to the literature on digital transformation and AI in banking. By providing robust empirical evidence of the positive effects of AI-based digitalization on bank profitability, it offers valuable

insights for both scholars and practitioners. As the financial industry continues to navigate the challenges and opportunities of the digital era, the findings of this research will serve as a crucial guide for future strategies and policies aimed at leveraging AI to drive sustainable growth and competitive advantage.

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