"Decoding Digital Transformation in Banking: From Insight to Impact through a Panel Study of Tunisian Banks with PCA and Logistic Regression"

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ABSTRACT

This study explores the factors influencing the adoption of digital technologies in the Tunisian banking sector. Using a structured survey completed by 122 senior banking professionals from ten major banks, the research examines five key areas: external influences, benefits, attitudes, organizational capacity, and technology diffusion. Statistical methods, including Principal Component Analysis and logistic regression, were applied to identify the main drivers of digital adoption. The results show that none of the analyzed factors significantly explain the adoption of digital technologies in Tunisian banks. This contrasts with findings in more digitally advanced countries and highlights specific challenges such as the widespread use of cash, low banking access, limited digital literacy, and trust issues. Although the COVID-19 pandemic has boosted digital finance adoption, Tunisia's banking sector remains in an early stage of digital transformation. The study concludes that banks need to strengthen digital skills, invest in emerging technologies like biometrics and artificial intelligence, and improve cybersecurity to unlock the full potential of digital banking. These insights offer guidance for policymakers and practitioners aiming to accelerate digital innovation in developing economies.

Keywords: Digital Technology, Banking Sector, Fintech, Financial Inclusion, Digital Banking

INTRODUCTION

Digital transformation has become a structural imperative in the banking sector, acting as a catalyst for the redesign of business models, product offerings, and service delivery mechanisms. It not only reshapes the customer experience but also redefines the nature of banking professions and internal organizational dynamics. With increasing digital expectations, banks are progressively investing in dematerialized services, automation, and remote access platforms to enhance operational efficiency and reinforce customer engagement (Herlin, 2015; Denis, 2019; Lundberg et al., 2023).

Recent advancements in artificial intelligence (AI), blockchain, and data analytics are pushing the financial sector toward disruptive innovation. These technologies enable hyper-personalized services and real-time decision-making, transforming traditional banking logic (Kraus et al., 2021). Accordingly, digital transformation is no longer a choice, but a necessity for maintaining competitiveness and meeting evolving regulatory and consumer demands (Arner et al., 2020).

This paper investigates the strategic impact of digital technologies on banking functions and the creation of value-added services. It further explores whether digital innovations reinforce client trust and generate sustainable competitive advantages.

A successful digital transition requires the reconfiguration of business models in alignment with technological shifts (Sathananthan et al., 2017). This raises several critical questions: Are traditional banking models still viable? What theoretical frameworks best support the development of digital-first banking strategies?

To address these questions, this study applies principal component analysis (PCA) and logistic regression to a panel of Tunisian banks, identifying key determinants of digital adoption and strategic readiness within the

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sector.

LITERATURE REVIEW

The literature on digital transformation has grown significantly in the past decade, yet its strategic application in banking contexts particularly in emerging economies remains underexplored. Scholars increasingly recognize that digital transformation is not solely about adopting new technologies but about embedding digital capabilities into the organization's DNA (Bharadwaj et al., 2013; Vial, 2019; Kraus et al., 2021).

In the banking sector, digital transformation touches every aspect of operations: from customer relationship management to back-office processing and risk management (Martins et al., 2020). Emerging digital tools such as Robotic Process Automation (RPA), Open Banking APIs, and predictive analytics allow banks to reconfigure their value chains and develop new, agile business models (Hanelt et al., 2021).

Moreover, the COVID-19 pandemic served as an accelerator of digital adoption, forcing banks worldwide to re-evaluate their strategic priorities and digitize at speed (Gomber et al., 2021). However, digital readiness varies greatly among institutions, influenced by regulatory frameworks, organizational culture, leadership vision, and customer digital maturity (Lundberg et al., 2023).

This study focuses on the Tunisian banking sector, examining how institutions are navigating the pressures of digitalization and how their strategic trajectories are evolving in response. It aims to bridge the gap between theoretical insights and practical applications of digital transformation in a regional context.

APPROACH AND METHODOLOGY

Anchored in the models developed by Pramanik and al. (2019) and Moritz & Mark (2020), this study investigates the extent to which digital technology adoption serves as a core driver of digital transformation strategies in Tunisian banks. A structured questionnaire, adapted from Pramanik and al. (2019), was designed to assess how financial institutions conceptualize and implement digital transformation. The study has two main objectives: to contribute to the conceptual clarification of digital transformation in the banking sector and to evaluate the centrality of technology adoption in this process. The survey (APPENDIX B) covers five key axis:

Axis 1: External Factors Influencing the Adoption of Digital Technology

Axis 2: Benefits of Adopting Digital Technology

Axis 3: Attitudes Toward Digital Technology

Axis 4: Capacity to Harness Digital Technology

Axis 5: Use and Diffusion of Digital Technology

A mixed-method approach was employed, combining descriptive analysis, Principal Component Analysis (PCA), and binary logistic regression based on responses from 122 senior staff members across ten leading Tunisian banks: AMEN BANK, ATTIJARI BANK, BIAT, STB, UIB, UBCI, ABC, BH, BT, and BNA.

Scoring-Based Insights into Variable Assessment

Axis 1: External Factors Influencing the Adoption of Digital Technology

This axis aims to identify the main external determinants through three key variables:

– customer demand,

– technological proliferation,

– opportunity costs associated with not adopting digital solutions.

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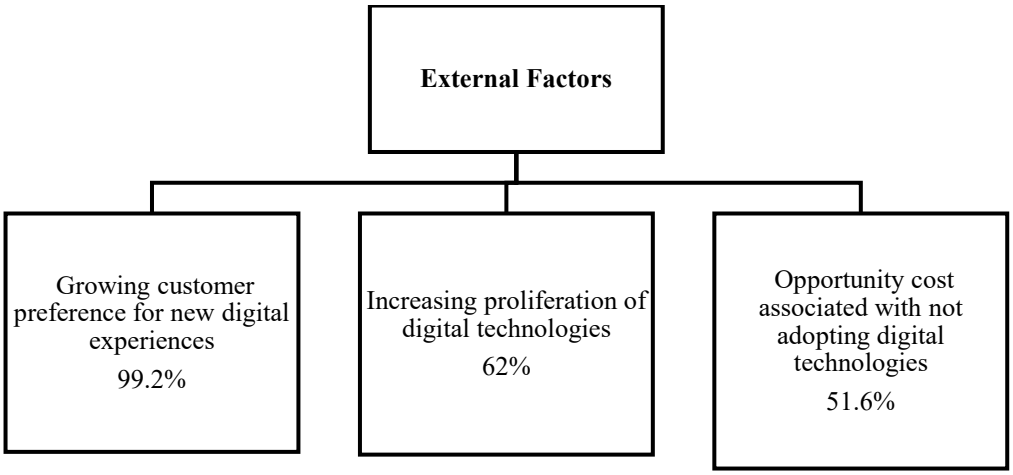
Figure 1. Scoring of External Factors Influencing the Adoption of Digital Technology



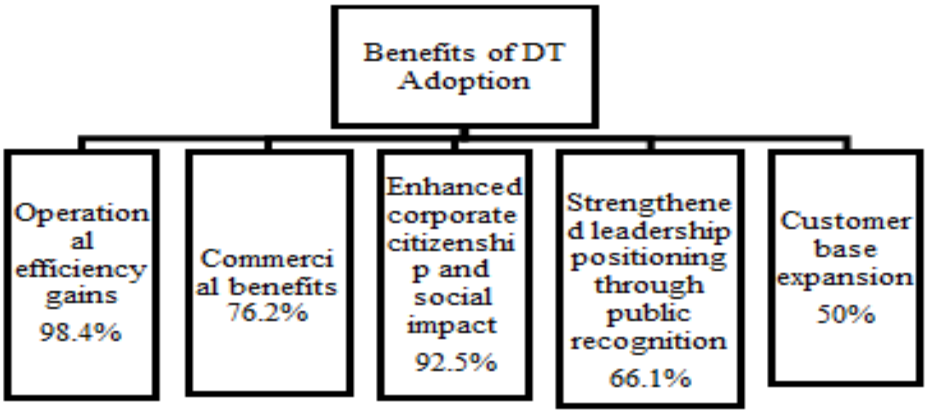
Source: Author's illustration

The average score for external factors influencing the adoption of digital technologies—based on equal weighting of the three items—indicates that 71% of banking professionals in our sample consider external drivers to be highly significant. This finding highlights the pivotal role of external factors in shaping the adoption of digital technology within the Tunisian banking sector.

Axis 2: Benefits of Adopting Digital Technology

This axis examines the key benefits associated with digital technology adoption. These include commercial and operational gains, customer base expansion, public recognition of digital leadership, and enhanced capacity to generate broader social value through digital tools.

Figure 2. Scoring of the Benefits of Digital Technology Adoption



Source: Author's illustration

The average score for the benefits of digital technology adoption—based on equal weighting across five items—reveals that 76.6% of banking professionals place high importance on these advantages. This result highlights that perceived benefits are a strong driver of digital technology adoption within the Tunisian banking sector.

Axis 3: Attitudes Toward Digital Technology

This section analyzes banks' attitudes toward digital technology, based on three variables: a positive stance toward digitalization, the quality of the bank–customer relationship and investment in digital technologies. While all banks surveyed demonstrate a favorable attitude toward digital tools, findings show that digital adoption is primarily aimed at enhancing human interaction through digital channels to strengthen customer relations.

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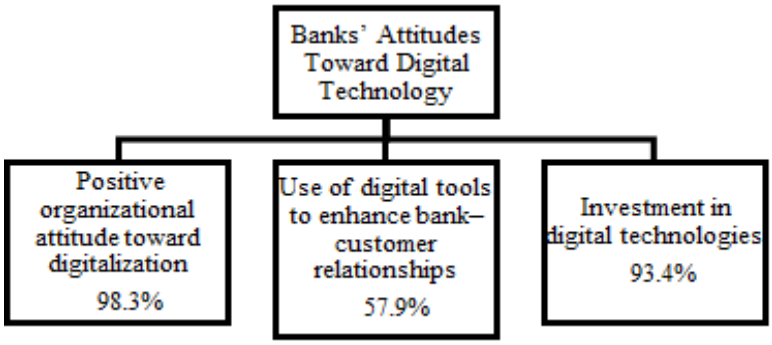
Figure 3. Scoring of Banks' Attitudes Toward Digital Technology



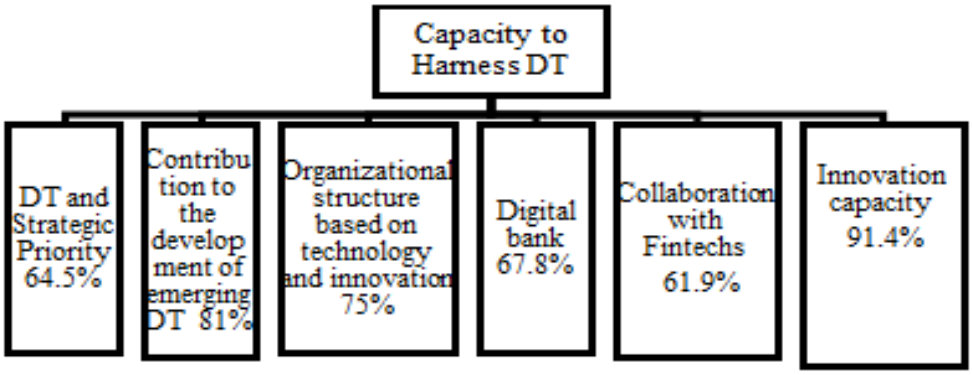
Source: Author's illustration

Assuming equal weighting of the items, the average score shows that 83.2% of banking professionals place high importance on the institution's attitude toward digital technology. This result reflects the broadly positive stance of Tunisian banks toward digital transformation, highlighting their proactive positioning in embracing technological change.

Axis 4: Capacity to Harness Digital Technology

This axis examines the ability of Tunisian banks to leverage digital technologies. A strong organizational alignment between core banking functions and digital units is observed, facilitating institution-wide innovation. Structural changes within banks underscore a strategic focus on adopting new technologies and fostering a culture of innovation. Banks also demonstrate digital capability through partnerships with technology providers, particularly FinTech firms, aiming to reinforce their leadership in digital transformation.

Figure 4. Scoring of the Capacity to Harness Digital Technology



Source: Author's illustration

Using the same weighting, the average score indicates that banking professionals (73.6%) perceive a strong capacity of financial institutions to leverage technological disruption. This finding underscores the awareness among Tunisian banks regarding the challenges associated with adopting digital technologies and demonstrates their active efforts to implement strategies that capitalize on these transformations.

Axis 5: Use and dissemination of digital technology

The final dimension of the survey addresses factors related to the adoption and dissemination of digital technology within the Tunisian banking sector. Banks are increasingly leveraging digital technology to enhance customer experience and accelerate transaction speed. The results reveal that most banks prioritize the development and launch of digital platforms or applications. These platforms provide features such as personalized customer offerings.

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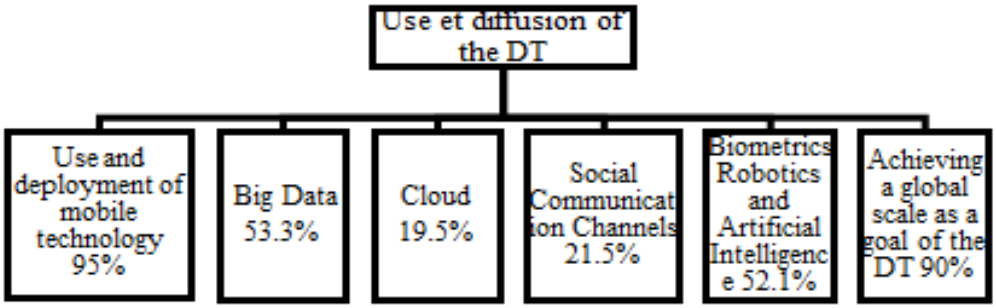
Figure 5 . Scoring of the use and diffusion of the DT



Source: Author's illustration

Assuming equal weighting, the average score regarding the use and diffusion of digital technology indicates that banking professionals (55.2%) place significant importance on its adoption and implementation. Optimal utilization of digital technology is expected to yield long-term benefits for banks. Therefore, banks must prepare adequately, build capacity, and foster innovation to successfully deploy digital technologies.

Descriptive statistics and correlation

We analyzed a dataset comprising 122 individuals, with no missing observations. The variables are well distributed according to their respective measurement scales. Several coding schemes were applied: binary coding for dichotomous responses, as well as both ordered and unordered categorical coding, depending on the nature of the data.

To assess the overall characteristics of the variables, we examined key descriptive statistics including measures of central tendency and dispersion. As shown in Table A1, the arithmetic means are notably low, primarily due to the binary nature of most variables (coded 0 or 1). Consequently, the standard deviations are also small, indicating limited variability. In most cases, observed values range from zero to a maximum of four, and each variable demonstrates strong alignment with its mean, suggesting an adequate linear distribution.

The correlation matrix (Table A2) provides insights into the relationships between variables. As expected, the diagonal values are all equal to one, representing the correlation of each variable with itself. The off-diagonal entries show consistently low correlation coefficients, suggesting weak linear relationships among the variables. Importantly, the low intercorrelations among explanatory variables indicate the absence of multicollinearity, supporting the reliability of subsequent multivariate analyses.

RESULTS AND FINDINGS

Principal component analysis

To structure our questionnaire data, we employed various coding schemes, including binary, ordinal, and nominal formats, depending on the nature of the responses. The initial correlation matrix (Table A2) indicated weak inter-variable correlations, prompting verification of data suitability for Principal Component Analysis (PCA).

Two preliminary tests were conducted: Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy. Bartlett's test rejected the null hypothesis of an identity correlation matrix ($p < 0.01$), confirming significant correlations among variables (Table A3). The KMO statistic, calculated using SPSS, yielded a value of 0.574, exceeding the 0.5 threshold and indicating acceptable sampling adequacy.

Given these results, PCA was applied to reduce dimensionality while retaining the maximum variance. This method is particularly suitable given the high number of variables influencing digital technology (DT) adoption. The analysis was conducted across the five thematic dimensions of the questionnaire to identify the most influential variables driving DT adoption in the Tunisian banking sector.

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Table 1. Principal component analysis: axis 1

Component	Eig.			Extr. SS			Rot. SS		
	T.	Var. (%)	Cum. (%)	T.	Var. (%)	Cum. (%)	T.	Var. (%)	Cum. (%)
growing pref. of DT	1,288	42,945	42,945	1,288	42,945	42,945	1,288	42,942	42,942
Proli.	1,029	34,305	77,25	1,029	34,305	77,25	1,029	34,308	77,25
loss of income	0,682	22,75	100						

Source: author's calculations

Axis 1 comprises three key variables: *growing preference for digital technologies*, *technology proliferation*, and *revenue loss due to non-use of digital technologies*. As shown in Table 1, two principal components explain most of the variance within this axis. The variables *preference for digital technologies* and *technology proliferation* exhibit substantial explanatory power, accounting for 42.9% and 34.3% of the total variance, respectively. These variables thus emerge as significant external drivers of digital technology (DT) adoption. In contrast, the variable *revenue loss due to non-use* accounts for only 22.75% of the variance, suggesting a comparatively limited influence on DT adoption decisions.

Table 2. Principal Component Analysis: Axis 2

Component	Eig.			Extr. SS			Rot. SS		
	T.	Var. (%)	Cum. (%)	T.	Var. (%)	Cum. (%)	T.	Var. (%)	Cum. (%)
business adv.	1,765	35,293	35,293	1,765	35,293	35,293	1,715	34,306	34,306
Op. adv.	1,057	21,14	56,433	1,057	21,14	56,433	1,059	21,18	55,486
nbr of customers	1,008	20,166	76,599	1,008	20,166	76,599	1,056	21,113	76,599
Leader	0,605	12,104	88,703						
citizen bank	0,565	11,297	100						

Source: author's calculations

Axis 2 includes five key variables: *business advantages*, *operational advantages*, *customer base size*, *market leadership*, and *citizen-oriented banking*. As indicated in Table 2, three principal components explain a significant portion of the total inertia within this axis. The variables *business advantages* and *operational advantages* account for 35.2% and 21.1% of the variance, respectively, underscoring their central role in shaping perceived organizational benefits of digital technology adoption. The *number of customers* variable also shows a notable contribution (20.1%), highlighting the perceived customer-related gains from digital integration. In contrast, *market leadership* and *citizen bank* display marginal variance contributions, suggesting a limited influence on perceived benefits in this context.

Table 3. Principal Component Analysis: Axis 3

Component	Eig.			Extr. SS			Rot. SS		
	T.	Var. (%)	Cum. (%)	T.	Var. (%)	Cum. (%)	T.	Var. (%)	Cum. (%)
Attitude	1,2	42,6	42,6	1,2	42,6	42,6	1,2	42,6	42,6

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bank-ctm	1,0	33,5	76,2	1,0	33,5	76,2	1,0	33,5	76,2
digital spdg	0,7	23,7	100						

Source: author's calculations

Axis 3 comprises three variables: *attitude towards technology*, *bank-customer relationship*, and *digital spending*. As shown in Table 3, the first two variables account for the largest share of variance within this axis, at 43% and 34%, respectively. These results highlight the importance of both user mindset and relational dynamics in understanding attitudes toward digital technology. Although the *bank-customer relationship* variable shows a slightly lower individual variance (23.7%), it remains a significant factor in shaping digital adoption attitudes. Overall, *attitude towards technology* and *bank-customer relationship* emerge as key determinants in this dimension.

Table 4. Principal Component Analysis: Axis 4

Component	Eig.			Extr. SS			Rot. SS		
	T	Var. (%)	Cum. (%)	T	Var. (%)	Cum. (%)	T	Var. (%)	Cum. (%)
Priority	2,48	41,40	41,40	2,48	41,40	41,40	2,21	36,96	36,96
Contri ;	1,12	18,72	60,13	1,12	18,72	60,13	1,39	23,16	60,13
Structure	0,79	13,29	73,42						
Digi_bank	0,7	11,65	85,08						
Fintech	0,55	9,15	94,24						
Innov_capa	0,34	5,75	100						

Source: author's calculations

Axis 4 encompasses six variables: *strategic priority*, *bank's contribution to digital technologies*, *organizational structure*, *digital banking*, *Fintech*, and *innovation capacity*. As presented in Table 4, the variables *strategic priority* and *contribution to digital technologies* exhibit the strongest explanatory power within this axis, accounting for 41.4% and 18.7% of the total variance, respectively. These findings suggest that institutional commitment and investment in digital initiatives are critical for enabling effective digital transformation.

In contrast, *organizational structure* and *digital banking* show lower variance contributions (13.2% and 11.6%), while *Fintech* and *innovation capacity* contribute minimally (9.1% and 5.7%). These results imply that while structural and innovative aspects are relevant, they play a more limited role compared to strategic orientation in determining a bank's digital readiness.

Table 5. Principal Component Analysis: Axis 5

Component	Eig.			Extr. SS			Rot. SS		
	T	Var. (%)	Cum. (%)	T	Var. (%)	Cum. (%)	T	Var. (%)	Cum. (%)
Consid	2,48	41,40	41,40	2,48	41,40	41,40	2,21	36,96	36,96
Bigdata	1,12	18,72	60,13	1,12	18,72	60,13	1,39	23,16	60,13

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Cloud	0,79	13,29	73,42						
Social_int	0,7	11,65	85,08						
Adv_tech	0,5	9,15	94,24						
scale	0,34	5,75	100						

Source: author's calculations

Axis 5 includes six variables: *organizational consideration*, *big data*, *cloud computing*, *social interaction*, *advanced technologies*, and *global scalability*. As indicated in Table 5, only two variables *organizational consideration* (41.4%) and *big data* (18.7%) demonstrate substantial variance contributions, positioning them as primary enablers of digital technology usage and diffusion within the Tunisian banking sector.

In contrast, *cloud computing* and *social interaction* account for lower variance shares (13.2% and 11.6%, respectively), while *advanced technologies* and *reaching a global scale* show minimal influence (9.1% and 5.7%). These findings suggest that internal organizational alignment and data capabilities are more critical than technological sophistication or global ambition in driving digital adoption at the sector level.

Regression Analysis: Determinants of Digital Transformation Strategy

To identify the key variables influencing the digital transformation strategy in the Tunisian banking sector, a binary logistic regression was conducted using the variables retained from the Principal Component Analysis. Consistent with Moritz and Mark (2020), logistic regression was chosen due to the binary nature of the dependent variable, which indicates whether a *growing preference for new digital experiences* serves as a significant driver of digital technology adoption.

Binary logistic regression enables the examination of the relationship between a dichotomous outcome and multiple explanatory variables. The aim is to isolate the most statistically significant predictors and provide a robust explanation of digital transformation adoption dynamics in the sector.

Table 6. Regression variables :

Proli	Proliferation of technologies
Business_adv.	Business advantages
Operational_ adv.	Operational advantages
Nbr_customers	Number of customers
Attitude	Attitude towards technology
Bank_customer	Bank-customer relationship
Strategic_priority	The Strategic Priority
Contribution	The Bank's contribution to digital technologies
Digital_Bank	Digital Bank
Bigdata	Bigdata

Source: author's work

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Logistic regression consists of examining the link that could exist between the most relevant variables, retained following the principal component analysis, with the digital transformation strategy in the Tunisian banking sector in order to identify the most significant variables. It is represented by the fol lowing equation:

$$logit(prf_{Croi})_i = \alpha_0 + \beta_1 \text{proli}_i + \beta_2 \text{Bussines\_adv}_i + \beta_3 \text{operational\_adv}_i + \beta_4 \text{nbr\_customers}_i + \\ + \beta_5 \text{attitude}_i + \beta_6 \text{bank\_customer}_i + \beta_7 \text{strategic\_priority}_i + \beta_8 \text{contribution}_i + \beta_9 \text{digital\_bank}_i + \\ \beta_{10} \text{bigdata}_i + \varepsilon_i$$

STEP 1: The null model

The initial step involves estimating a baseline model, commonly referred to as the *null model*, which includes only the intercept and excludes all explanatory variables. This model assesses the likelihood of digital technology adoption without accounting for the predictors identified through the Principal Component Analysis. The primary purpose of the null model is to establish a benchmark, enabling a clearer evaluation of the added explanatory power of the independent variables introduced in subsequent stages.

Table7. Null Model Regression Table

Model	Null
(Constant)	-4,796*** (1,004)

Standard error in parenthesis *** p<0.01, ** p<0.05, * p<0.1

Source: author's calculations

Table 7 shows that the null model is significant with a P value equal to 0 and below the significance threshold of 1%.

Table 8. Variables missing from the equation

Variables	Score	Ddl	Sig.
Bussines_adv.	0,259	1	0,611
Operational_adv.	0,017	1	0,897
Nbr-customers	5,000	1	0,025
Attitude	0,008	1	0,927
bank_ Bank_customer	0,564	1	0,453
Strategic_priority	0,448	1	0,503
contribution	0,247	1	0,619
Digital_Bank	0,034	1	0,853
Bigdata	0,988	1	0,320
General statistics	13,501	9	0,141

Source: author's calculations

Table 8 presents the set of variables excluded from the null model, serving to evaluate their potential contribution if included. This diagnostic step highlights the relative explanatory value of each variable prior to full model

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specification. Among them, *number of clients* emerges as the most promising predictor, with a p-value of 0.025 well below the 5% significance threshold suggesting it would significantly enhance model fit.

Conversely, variables such as *technology proliferation*, *business benefits*, *attitude towards technology*, *bank-customer relationship*, *strategic priority*, *bank's contribution to digital technologies*, *organizational consideration of DT deployment*, and *big data* exhibit p-values above the conventional significance level. This suggests that their inclusion in the model may not provide statistically meaningful improvements in explaining digital technology adoption within the current specification. Subsequently, all variables retained from the Principal Component Analysis were incorporated into the logistic regression to identify those significantly associated with digital technology adoption in the Tunisian banking sector.

Table 9. Composite test

		Chi-square	Ddl	Sig.
Step 1	Step	11,600	9	0,237
	Bloc	11,600	9	0,237
	Model	11,600	9	0,237

Source: author's calculations

Table 9 presents the overall significance test for the logistic regression model. The model's Chi-square statistic (11.6, df = 9) is not significant (p = 0.237), indicating that the variables retained from the PCA do not significantly explain digital technology adoption in the Tunisian banking sector. Consequently, the final model lacks predictive power, as none of the independent variables contribute meaningfully to the outcome. To assess model fit, we used Cox & Snell's (1989) and Nagelkerke's (1991) formulas (Table A 4). Both indicators approximate the variance explained by the model; in this case, values are close to zero, confirming the model's limited explanatory capacity.

Table10. Logistic regression of the model

Model	Sig	(SE)
Bussines_adv.	2,926	11257,742
Operational_adv.	-14,090	27111,482
Nbr_customers	-32,487	3634,673
Attitude	70,721	47389,455
Bank_customer	15,148	10023,716
Strategic_priority	-11,853	3986,374
Contribution	-27,785	12304,941
Digital_Bank	-35,876	21933,141
Bigdata	-8,654	5333,416
Constant	64,646	45726,448

*** p<0.01, ** p<0.05, * p<0.1

Source: calculations of the author

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DISCUSSION

The results reveal a counterintuitive finding: none of the variables in our model significantly explain digital technology adoption in the Tunisian banking sector. This contrasts with empirical studies from Europe and the United States, where digital diffusion is more advanced. The disparity likely reflects contextual differences, as Tunisia remains a developing country with a slower pace of digital adoption.

Cash remains the dominant payment method in Tunisia, especially in rural areas and the informal economy, where cash usage and hoarding prevail. Additionally, low trust in the banking system and practices such as tax evasion hinder the implementation of effective decashing strategies and the broader adoption of digital technologies.

Notably, variables related to *Fintech collaboration* and *bank contributions to emerging digital technologies* (e.g., biometrics, artificial intelligence) have limited explanatory power (9.1% and 18.7%, respectively). Similarly, *advanced technologies* like robotics and AI, as well as *big data* and *cloud computing*, show low contributions (ranging from 9.1% to 18.7%). This suggests limited attention from banking professionals to these technologies, despite their strategic importance in enhancing customer relations, personalized services, and decision-making.

Two main factors may explain these findings. First, the weak correlations between explanatory variables and digital adoption reflect the nascent state of digital transformation in Tunisia. Second, the theoretical frameworks underpinning technology adoption models developed in more advanced economies may not fully apply in Tunisia's fragile and fragmented banking sector. Indeed, banking penetration remains low, with two-thirds of the population unbanked, indicating delayed technology diffusion and limited public acceptance of financial technologies.

Although the COVID-19 pandemic accelerated digital financial service adoption globally, Tunisia's experience remains recent, making it premature for robust evaluations. The overall insignificance of model variables despite banks' investments suggests that Tunisia has yet to reach a critical threshold in digital accumulation and adoption.

Furthermore, the digital and financial literacy necessary to foster fintech adoption is still emerging. Banking professionals perceive substantial risks related to digitalization—including cyber threats and connectivity issues—that remain insufficiently managed or priced into digital products.

The pandemic has underscored the importance of digital financial services and initiated shifts in consumer behavior toward digital finance. Tunisian banking professionals must recognize and adapt to these changes to compete internationally. Embracing forward-looking technologies, such as biometrics and AI, and addressing associated security challenges will be essential. Banks should actively engage in pilot projects for emerging technologies to enhance risk management and fraud detection.

This study constitutes a preliminary effort to identify determinants of digital technology adoption in Tunisia's banking sector. Future research could extend this analysis through comparative studies across countries, deepening understanding of digital transformation strategies in diverse economic contexts.

Limitations and Further Research

This study has limitations even though it offers insightful information about the digital transformation landscape of the banking industry in Tunisia. The statistical power of the regression analysis and the findings' generalizability may be limited by the very small sample size (122 respondents). This limitation highlights the need for larger representative data in future studies and probably contributed to the model's explanatory factors' insignificance.

This study's cross-sectional design only provides a static representation of the use of digital technology at a certain moment in time. This makes it more difficult to document recent advancements, especially in the wake of the COVID-19 epidemic, which has sped up global digital transformation. A longitudinal approach would offer greater understanding of the dynamics and long-term effects of digitalization in the banking industry as digital behaviors and institutional responses continue to change.

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CONCLUSION

This study provides an initial exploration of the determinants influencing digital technology adoption within the Tunisian banking sector. Drawing on responses from senior banking officials and applying robust statistical techniques, five thematic dimensions related to external influences, benefits, attitudes, capacity, and diffusion were identified. Yet, logistic regression analysis demonstrated that these factors do not significantly predict adoption, highlighting Tunisia's unique digitalization challenges.

Key contextual barriers include the widespread use of cash, especially in informal and rural sectors, low banking penetration rates, and pervasive distrust toward financial institutions. Additionally, the limited role of Fintech collaboration, advanced technologies, and data analytics reflects the sector's nascent digital maturity and fragmented structure. The COVID-19 pandemic has catalyzed digital adoption but remains insufficient to drive systemic transformation.

The findings emphasize the critical need to bolster digital and financial literacy, address cybersecurity and connectivity risks, and cultivate a culture of innovation within Tunisian banks. Proactive engagement with emerging technologies such as biometrics and artificial intelligence, supported by pilot initiatives, will be essential to enhancing competitiveness and customer trust.

Overall, this research lays the groundwork for deeper comparative studies across developing economies, providing actionable insights for banking professionals and policymakers aiming to accelerate digital transformation and financial inclusion.

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APPENDIX

Table A1: Summary statistics

Variables	N	Min	Max	Mean	Standard deviation
Growing preference for digital technologies	122	0	1	0,01	0,091
proliferation of technologies	122	1	4	3,57	0,602
Loss of income	122	1	4	3,48	0,606
Business Benefits	122	1	4	3,7	0,585
Operational Benefits	122	0	1	0,02	0,128
Number of customers	122	2	4	3,38	0,621
Leader	122	2	4	3,64	0,515
Citizen Bank	122	0	1	0,07	0,262
Attitude	122	0	1	0,01	0,091
Bank-customer relationship	122	1	4	3,38	0,836
Digital spending	122	0	1	0,07	0,262
Strategic Priority	122	0	4	3,57	0,642
The Bank's contribution to digital technologies	122	0	1	0,2	0,399
Organizational Structure	122	1	3	2,67	0,595
Digital bank	122	2	3	2,69	0,465
Fintech	122	0	1	0,43	0,498
Innovative Capacity	122	0	1	0,78	0,417
consideration	122	0	1	0,03	0,179

Bigdata	122	1	3	1,94	0,956
Cloud	122	1	3	2,26	0,736
Social interactions	122	1	4	3,07	0,67
Advanced technologies	122	0	1	0,42	0,495
Worldscale	122	0	1	0,1	0,299
Valid Number (List)	122				

Source: author's work

Table A2 : Correlation Matrix

	prf_Croi	Proli	Mank	avan_c	avan_o	nbre_clt	leader	citoyenne	Attitude	bank_clt	Dépenses	priorité	contribution	structure	bank_digi	Fintech	capa_innov	considératio	Bigdata	cloud	Intéraction	tech_avancé	E_mond
prf_Croi	1	0,065	-0,072	0,046	-0,012	-,202*	0,064	-0,026	-0,008	0,068	-0,026	0,061	-0,045	0,05	0,061	-0,08	0,048	-0,017	-0,09	-0,156	0,126	0,107	-0,03
Proli	0,065	1	,288**	,203*	-0,016	-0,053	,460**	0,148	0,065	,273**	0,148	,531**	,214*	-0,07	-0,035	0,154	,214*	0,131	-0,086	-0,063	,263**	0,104	0,097
Mank	-0,072	,288**	1	,353**	-,209*	0,113	,421**	-0,066	-,222*	,214*	0,141	,355**	0,123	-0,068	0,09	0,159	0,126	0,008	0,019	,292**	0,157	-0,034	0,105
avan_c	0,046	,203*	,353**	1	-0,045	,332**	,412**	0,143	-0,11	,246**	0,035	,411**	-,210*	0,147	-0,098	0,047	,272**	0,014	-,193*	0,104	0,119	-0,056	0,026
avan_o	-0,012	-0,016	-,209*	-0,045	1	-,183*	-0,035	-0,036	-0,012	0,019	-0,036	-0,116	0,098	0,071	-0,053	0,147	-0,087	-0,024	-0,128	-0,134	-0,111	0,021	0,174
nbre_clt	-,202*	-0,053	0,113	,332**	-,183*	1	-,242**	-0,071	-0,055	,217*	-0,121	,220*	-0,168	0,158	-0,019	-0,16	0,133	-,336**	-,242**	0,089	0,032	-0,141	-,201*
leader	0,064	,460**	,421**	,412**	-0,035	,351**	1	0,015	-0,113	,529**	0,015	,531**	-0,054	0,15	0,114	-0,061	,279**	0,04	-,328**	0,034	,269**	-0,052	-,251**
citoyenne	-0,026	0,148	-0,066	0,143	-0,036	-0,071	0,015	1	-0,026	0,098	0,04	,188*	0,018	-0,003	-,352**	-0,121	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
Attitude	-0,008	0,065	-,222*	-0,11	-0,012	-0,055	-0,113	-0,026	1	0,098	0,04	,188*	0,018	-0,003	-,352**	-0,121	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
bank_clt	0,068	,273**	,214*	0,246**	0,019	,217*	,529**	0,098	0,098	1	0,04	,188*	0,018	-0,003	-,352**	-0,121	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
Dépenses	-0,026	0,148	0,141	0,035	-0,036	-0,121	0,015	0,04	0,04	0,04	1	,188*	0,018	-0,003	-,352**	-0,121	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
priorité	0,061	,531**	,355**	,411**	-0,116	,220*	,531**	,188*	,188*	,188*	,188*	1	0,018	-0,003	-,352**	-0,121	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
contribution	-0,045	,214*	0,123	-,210*	0,098	-0,168	-0,054	0,018	0,018	0,018	0,018	0,018	1	-0,003	-,352**	-0,121	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
structure	0,05	-0,07	-0,068	0,147	0,071	0,158	0,15	-0,003	-0,003	-0,003	-0,003	-0,003	-0,003	1	-,352**	-0,121	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
bank_digi	0,061	-0,035	0,09	-0,098	-0,053	-0,019	0,114	-,352**	-,352**	-,352**	-,352**	-,352**	-,352**	-,352**	1	-0,121	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
Fintech	-0,08	0,154	0,159	0,047	0,147	-0,16	-0,061	-0,121	-0,121	-0,121	-0,121	-0,121	-0,121	-0,121	-0,121	1	-0,001	,300**	-0,016	-,315**	-0,125	,333**	0,117
capa_innov	0,048	,214*	0,126	,272**	-0,087	0,133	,279**	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	-0,001	1	,300**	-0,016	-,315**	-0,125	,333**	0,117
considératio	-0,017	0,131	0,008	0,014	-0,024	-,336**	0,04	,300**	,300**	,300**	,300**	,300**	,300**	,300**	,300**	,300**	,300**	1	-0,016	-,315**	-0,125	,333**	0,117
Bigdata	-0,09	-0,086	0,019	-,193*	-0,128	-,242**	-,328**	-0,016	-0,016	-0,016	-0,016	-0,016	-0,016	-0,016	-0,016	-0,016	-0,016	-0,016	1	-,315**	-0,125	,333**	0,117
cloud	-0,156	-0,063	,292**	0,104	-0,134	0,089	0,034	-,315**	-,315**	-,315**	-,315**	-,315**	-,315**	-,315**	-,315**	-,315**	-,315**	-,315**	-,315**	1	-0,125	,333**	0,117
Intéraction	0,126	,263**	0,157	0,119	-0,111	0,032	,269**	-0,125	-0,125	-0,125	-0,125	-0,125	-0,125	-0,125	-0,125	-0,125	-0,125	-0,125	-0,125	-0,125	1	,333**	0,117
tech_avancé	0,107	0,104	-0,034	-0,056	0,021	-0,141	-0,052	,333**	,333**	,333**	,333**	,333**	,333**	,333**	,333**	,333**	,333**	,333**	,333**	,333**	,333**	1	0,117
E_mond	-0,03	0,097	0,105	0,026	0,174	-,201*	-,251**	0,117	0,117	0,117	0,117	0,117	0,117	0,117	0,117	0,117	0,117	0,117	0,117	0,117	0,117	0,117	1

-0,03	0,016	0,117	-0,124	0,114	-0,003	0,044	0,155	-0,155	0,094	,251**	-,193*
0,107	-,284**	,269**	-,189*	,333**	-,372**	-,542**	,297**	-0,149	,217*	-0,071	-0,122
-0,01	,407**	-,313**	,477**	-,333**	,455**	,233**	-0,072	0,148	-0,089	0,02	0,078
-0,033	-0,001	0,027	0,064	0,02	0,141	,192*	,183*	,218*	-,254**	0,08	1
0,101	-,334**	0,017	-,310**	0,051	-,309**	-0,096	,435**	-0,177	0,011	1	0,08
,494**	0,082	-0,052	-0,021	0,025	-0,131	-0,174	0,024	-,234**	1	0,011	-,254**
-0,171	,241**	0,075	,293**	-0,084	,271**	,196*	-0,051	1	-,234**	-0,177	,218*
0,104	-,198*	,322**	-0,114	,357**	-,436**	-,232*	1	-0,051	0,024	,435**	,183*
-0,135	,368**	-,216*	0,133	-,380**	,494**	1	-,232*	,196*	-0,174	-0,096	,192*
-0,103	,532**	-,426**	,302**	-,596**	1	,494**	-,436**	,271**	-0,131	-,309**	0,141
,184*	-,274**	,491**	-,218*	1	-,596**	-,380**	,357**	-0,084	0,025	0,051	0,02
-,224*	,517**	-,204*	1	-,218*	,302**	0,133	-0,114	,293**	-0,021	-,310**	0,064
-0,026	-,278**	1	-,204*	,491**	-,426**	-,216*	,322**	0,075	-0,052	0,017	0,027
-0,041	1	-,278**	,517**	-,274**	,532**	,368**	-,198*	,241**	0,082	-,334**	-0,001
1	-0,041	-0,026	-,224*	,184*	-0,103	-0,135	0,104	-0,171	,494**	0,101	-0,033
-0,026	0,098	0,04	,188*	0,018	-0,003	-,352**	-0,121	-0,001	,300**	-0,016	-,315**
-0,113	,529**	0,015	,531**	-0,054	0,15	0,114	-0,061	,279**	0,04	-,328**	0,034
-0,055	,217*	-0,121	,220*	-0,168	0,158	-0,019	-0,16	0,133	-,336**	-,242**	0,089
-0,012	0,019	-0,036	-0,116	0,098	0,071	-0,053	0,147	-0,087	-0,024	-0,128	-0,134
-0,11	,246**	0,035	,411**	-,210*	0,147	-0,098	0,047	,272**	0,014	-,193*	0,104
-,222*	,214*	0,141	,355**	0,123	-0,068	0,09	0,159	0,126	0,008	0,019	,292**
0,065	,273**	0,148	,531**	,214*	-0,07	-0,035	0,154	,214*	0,131	-0,086	-0,063
-0,008	0,068	-0,026	0,061	-0,045	0,05	0,061	-0,08	0,048	-0,017	-0,09	-0,156
Attitud	bank_cl	Dépenses	Priorité	Contributi	Structure	bank_dig	Fintech	capa_inn	Considération	Bigdata	Cloud

Intéraction	0,126	,263**	0,157	0,119	-0,111	0,032	,269**	-0,125	-0,01	,407**	-,313**	,477**	-,333**	,455**	,233**	-0,072	0,148	-0,089	0,02	0,078	1	-,268**	-0,037
tech_avancée	0,107	0,104	-0,034	-0,056	0,021	-0,141	-0,052	,333**	0,107	-,284**	,269**	-,189*	,333**	-,372**	-,542**	,297**	-0,149	,217*	-0,071	-0,122	-,268**	1	0,055
E_mond	-0,03	0,097	0,105	0,026	0,174	-,201*	-,251**	0,117	-0,03	0,016	0,117	-0,124	0,114	-0,003	0,044	0,155	-0,155	0,094	,251**	-,193*	-0,037	0,055	1

Source: author's work

Table A3. KMO Index and Bartlett Test

KMO Index and Bartlett Test		
Kaiser-Meyer-Olkin index for measuring sampling quality.		,574
Bartlett sphericity tes	Khi-deux approx.	1088,437
	Ddl	253
	Signification	,000

Table A4. Model fit test

step	-2 Log Likelihood	Cox & Snell R-squared	Nagelkerke R-squared
1	,000[a]	,091	1,000

APPENDIX B. Survey Questionnaire: Digital Transformation in the Tunisian Banking Sector

Bank:

Banker's position:

1. Axis 1: External factors influencing the adoption of digital technology

1.1. Is customers' growing preference for new digital experiences a powerful incentive for your bank to adopt digital technologies?

- No
- Yes

1.2. Does the growing proliferation of new technologies make it imperative for your bank to adopt it?

- No

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- yes Weakly
- yes Moderately
- yes Strongly

1.3. Is the loss of income associated with the non-use of digital technologies a stimulus for the adoption of digital technologies by your bank?

- No
- yes Weakly
- yes Moderately
- yes Strongly

2. Axis 2: Benefits of adopting digital technology

2.1. Does your bank's adoption of digital technology lead to business benefits?

- No
- Yes Weakly
- Yes Moderately
- Yes Strongly

2.2. Are there any operational benefits to your bank's adoption of digital technology? (e.g. faster processes, reduced errors)

- Yes
- No

2.3. Is your bank's adoption of digital channels (mobile app) leading to an increase in the number of customers?

- No
- Yes Weakly
- Yes Moderately
- Yes Strongly

2.4. Does advocating a leadership position in digital technology (public recognitions and distinctions) allow your bank to have more notoriety and a better brand image?

- No
- Yes Weakly
- Yes Moderately
- Yes Strongly

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2.5. Does the adoption of technology allow your bank to strengthen its social practices and be a citizen bank? (in terms of paper saving, financial inclusion)

- Yes
- No

3. Axis 3: Attitude towards digital technology

3.1. Does your bank have a positive attitude towards digital technology?

- Yes
- No

3.2. Is digital technology improving the bank-customer relationship?

- No
- Yes Weakly
- Yes Moderately
- Yes Strongly

3.3. Is spending on digital technology and transforming your bank with technology a strategic priority?

- Yes
- No

4. Axis 4: the ability to exploit digital technology

4.1. Does your bank consider digital technologies to be a strategic priority?

- No
- Yes Weakly
- Yes Moderately
- Yes Strongly

4.2. Is your bank contributing to the development of emerging digital technology (biometrics, artificial intelligence) through pilot projects?

- Yes
- No

4.3. Has your bank designed an organizational structure on technology and innovation? (Online Service Department/ Technology Department/ System and Database Department/ Cybersecurity Division/ Digital Office Director/ Web and Mobile Division)

- No
- Yes, structure under construction

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- Yes, it's done

4.4.Is your bank striving to become a digital bank through technological innovations?

- No
- yes, she is trying to do so
- Yes, it's already a digital bank

4.5.Does your bank work closely with fintechs and specialist technology providers?

- Yes
- No

4.6.What is your bank doing to demonstrate its capacity for innovation? Check the answer(s)

o invests to improve the customer experience	
o Invests in Cyber Security	
o Invests in mobile payment	
o None of the above	

Other (please specify):
.....……
……

5. Axis 5: Use and dissemination of digital technology

5.1.Is the use and deployment of mobile technology a high consideration for your bank?

- Yes
- No

5.2.Does your bank use big data technologies?

- Yes
- No
- In Progress

5.3.Is cloud computing technology deployed within your bank?

- Yes
- No
- In Progress

5.4.Has your bank made social communication channels available to interact with customers? (e.g. Facebook)

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- No
- Yes, with low responsiveness
- Yes, with average responsiveness
- Yes, with a high level of responsiveness

5.5.Is your bank embracing digital technologies such as biometrics, robotics and artificial intelligence?

- Yes
- No

5.6.Is achieving global scale by leveraging digital technologies a primary goal of banking transformation?

- Yes
- No