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Research Article

Derivatives use, bank risk and profitability: Panel evidence from Turkish commercial banks (2011-2024)

Türev ürün kullanımı, banka riski ve kârlılığı: Türk ticari bankaları üzerine panel veri analizi (2011-2024)

Zekeriya Gül[1]

[1] Asst. Prof. Dr, Gaziantep University, Faculty of Economics and Administrative Sciences, Department of Business Administration, Gaziantep, Türkiye, zekeriyagul@gantep.edu.tr

ORCID: 0000-0002-4241-117X

Abstract

This study examines the relationship between financial derivatives use, bank risk, and profitability by employing random-effects and cluster-robust random-effects models on panel data for 11 commercial banks operating in Türkiye over the 2011–2024 period. The findings from the bank risk model indicate that derivatives use does not have a statistically significant effect on bank risk. By contrast, the change in the loans-to-total-assets ratio is negatively associated with banks' Z-scores, implying that increases in lending intensity are associated with higher bank risk. In addition, bank size is positively related to banks' Z-scores, suggesting that larger banks tend to exhibit lower risk. In the profitability model, derivatives use is negatively associated with return on assets, although this effect weakens after the use of cluster-robust standard errors. The results also show that the cost-to-income ratio is negatively associated with profitability, whereas gross domestic product is positively associated with return on assets across model specifications. Overall, the findings suggest that derivatives do not play a decisive role in shaping bank risk and profitability in Turkish commercial banks, while bank-specific and macroeconomic factors appear to be more influential.

Keywords: Financial Derivatives, Bank Risk, Bank Profitability

JEL Codes: G21, G32, C23

Öz

Bu çalışma, 2011–2024 döneminde Türkiye'de faaliyet gösteren 11 ticari bankaya ait panel veriyi kullanarak finansal türev ürün kullanımı, banka riski ve kârlılık arasındaki ilişkiyi rassal etkiler modeli ve kümelenmiş dirençli standart hatalara sahip rassal etkiler modeli aracılığıyla incelemektedir. Banka riski modelinden elde edilen bulgular, türev ürün kullanımının banka riski üzerinde istatistiksel olarak anlamlı bir etkisinin bulunmadığını göstermektedir. Buna karşılık, kredilerin toplam aktiflere oranındaki değişim Z-skoru ile negatif ilişkilidir; bu durum, kredi yoğunluğundaki artışın banka riskini artırdığına işaret etmektedir. Ayrıca, banka büyüklüğü bankaların Z-skorları ile pozitif ilişkilidir; bu da daha büyük bankaların daha düşük risk düzeyine sahip olma eğiliminde olduğunu göstermektedir. Kârlılık modelinde ise, türev ürün kullanımı aktif kârlılığı ile negatif ilişkilidir; ancak bu ilişkinin kümelenmiş dirençli standart hatalar kullanıldığında zayıfladığı görülmektedir. Sonuçlar ayrıca, maliyet-gelir oranının kârlılık ile negatif, gayri safi yurt içi hasılanın ise aktif kârlılığı ile pozitif ilişkili olduğunu göstermektedir. Genel olarak bulgular, türev ürünlerin Türk ticari bankalarının risk ve kârlılık yapısını belirlemede belirleyici bir rol oynamadığını; buna karşılık banka özgü ve makroekonomik faktörlerin daha etkili olduğunu ortaya koymaktadır.

Anahtar Kelimeler: Finansal Türevler, Banka Riski, Banka Kârlılığı

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Introduction

Financial derivatives have become an integral component of modern banking operations and have substantially changed the way banks manage market-related risks. These instruments are financial contracts whose values are derived from underlying assets, indices, or financial variables such as interest rates, exchange rates, and commodity prices. The expansion of financial derivatives has enabled banks to separate, transfer, and manage specific types of risk independently of the underlying assets, thereby providing a degree of financial flexibility that was previously difficult to achieve. As a result, banks have moved beyond their traditional role as financial intermediaries and increasingly function as sophisticated risk-management institutions (Hull, 2022, pp. 23–28).

Financial derivatives can be classified into several categories according to their contractual structures and purposes. The main categories include forward and futures contracts, which obligate the parties to buy or sell an asset at an agreed price on a specified future date. Option contracts give the buyer the right, but not the obligation, to buy or sell the underlying asset at a specified price within a specified period. Swap contracts involve agreements under which two parties exchange cash flows, usually in the form of interest-rate or foreign-currency payments, and are used by banks to manage exposure to interest-rate and currency risks. Banks also use credit derivatives and other complex financial products to hedge risks or generate revenue (Hull, 2022, pp. 1–28).

The importance of derivatives in banking lies in their dual function as risk-management tools and potential sources of income. From a risk-management perspective, derivative instruments allow banks to hedge exposures to adverse fluctuations in interest rates, exchange rates, and other market variables. This can help stabilize cash flows, reduce earnings volatility, and protect interest-rate-sensitive positions. From a profitability perspective, banks may generate fee-based income by offering derivative products and related financial services to corporate clients. Such non-interest income can become particularly important when pressure on traditional lending margins constrains profitability (Saunders & Cornett, 2023, pp. 496–501). Nevertheless, the growing use of these instruments also requires advanced risk-management practices because the complexity and leverage inherent in derivative contracts may increase exposure to counterparty risk and abrupt market movements when they are not managed prudently (Jukonis, 2022, pp. 3–5).

The impact of financial derivatives on bank risk is therefore dual in nature. Although derivatives are commonly used to reduce a bank's financial risk through hedging strategies, their use may also create additional market, credit, and operational risks if adequate controls are not maintained. Because many derivatives are leveraged instruments, relatively small movements in the prices of underlying assets can produce substantial changes in the value of derivative positions. Consequently, the use of derivatives remains an important issue for both bank management and financial regulators (Resti & Sironi, 2007, pp. 473–537).

The volume of financial derivative transactions has expanded globally over time, and Turkish commercial banks have increased their use of these instruments in response to a volatile financial environment. As the Turkish financial system became increasingly integrated with international financial markets, banks' derivative portfolios grew in both size and complexity, ranging from relatively simple instruments such as interest-rate swaps to more complex products such as foreign-exchange options. This expansion reflects Turkish commercial banks' efforts to strengthen their resilience to financial-market volatility and maintain competitiveness within the sector (Central Bank of the Republic of Türkiye, 2023).

Within the Turkish banking sector, the integration of derivatives has affected the way commercial banks manage volatility arising from domestic and international financial conditions. As bank balance sheets have expanded, financial derivatives have gained importance as mechanisms for managing currency and maturity mismatches between financial assets and liabilities. The growth of derivatives use has also been driven by the need to offer clients solutions for managing risks associated with fluctuations in the Turkish lira. Derivatives have therefore become important tools for balance-sheet management in the Turkish banking system (Pala & Hepşen, 2024, pp. 1519–1520).

This study examines the relationship between financial derivatives use, bank risk, and profitability through a review of the relevant literature and an empirical panel-data analysis. Following the literature review, the study presents the data and econometric methodology, reports descriptive statistics and diagnostic tests, and evaluates the estimated relationships between derivatives use, bank risk, and profitability. The final section summarizes the main findings, discusses their implications, and outlines directions for future research.

Literature review

The literature on financial derivatives use in banking reports mixed and sometimes contradictory findings. One strand suggests that derivatives can improve bank performance and support risk-management objectives. Ghosh (2017), using data on 5,491 U.S. commercial banks, found that derivative use reduced insolvency risk and improved risk-adjusted returns in important specifications. Similarly, Bendob et al. (2015) examined 19 commercial banks in Gulf Cooperation Council (GCC) countries over 2000–2013 and reported that derivatives use improved financial performance and reduced non-systematic risk, particularly during crisis periods. These findings suggest that derivatives can strengthen financial resilience when they are used appropriately to manage banking risks.

In contrast, another strand of the literature suggests that derivatives can increase financial fragility. Li and Marinč (2014) analysed listed U.S. bank holding companies over 1997–2012 and found that derivatives use increased systematic risk. Huan and Parbonetti (2019), using panel data for 555 banks in 18 developed markets over 2006–2015, likewise found that derivatives use increased bank risk. Miloș and Miloș (2022) analysed 120 listed financial institutions in the European Union over 2008–2021 and found that greater derivatives exposure was associated with lower market valuation. More recently, Wang et al. (2025), using 493 listed banks in 28 countries, found that derivatives holdings significantly increased systemic risk, particularly during economic downturns and among highly leveraged or less liquid banks. Taken together, these studies indicate that derivatives may heighten financial vulnerability when they are used for purposes other than effective hedging or when associated risks are not adequately controlled.

A third group of studies indicates that the effects of derivatives depend on institutional settings, regulatory frameworks, bank characteristics, and macroeconomic conditions. Titova et al. (2020) found that European banks using hedging derivatives exhibited lower risk and higher value, although these benefits weakened or reversed in the post-crisis period. Chang et al. (2018) reported that European banks using derivatives tended to be more profitable but also riskier. Bazih and Vanwalleghem (2021), studying emerging-market banks, found that derivatives use was associated with lower bank value, had no significant effect on total risk, and improved bank stability; they also documented effects on systematic risk. Overall, this evidence suggests that the consequences of derivatives use vary with the type and purpose of the instruments as well as the prevailing institutional and economic environment.

Evidence from the Turkish banking sector is similarly inconclusive. Tanrıöven and Yenice (2014), using quarterly data from December 2002 to March 2014, found that derivatives use increased both bank profitability and bank risk, with the effect on risk being more pronounced. Taşkın and Sarıyer (2020), employing panel regression and factorial ANOVA for 2007–2017, reported that derivatives use reduced profitability while increasing bank risk. Bayri (2023), analysing Turkish deposit banks over 2008–2019, also found a negative relationship between derivatives use and profitability. By contrast, Turan and Ersoy (2024) found no statistically significant relationship between derivatives use and either profitability or risk for Turkish banks over 2012–2023.

Another important line of research focuses on the determinants of derivatives use. Infante et al. (2018) used quarterly data for Italian banks over 2003–2017 and identified bank size and group membership among the principal determinants of derivative activity, while also discussing derivatives as substitutes for capital and liquidity in risk management. Pala and Hepşen (2024) found that derivatives activity in Turkish banks was significantly associated with factors such as foreign-exchange positions, bank size, capital, credit-risk pressure, inflation, and foreign ownership. Their findings further indicated that over-the-counter derivatives were used primarily for hedging, whereas derivatives traded in organized markets were more frequently associated with speculative purposes, especially among larger banks.

Despite the growing body of research on financial derivatives in banking, an important gap remains. Existing studies provide mixed evidence on whether derivatives enhance profitability, strengthen risk management, or increase financial fragility, and this ambiguity is particularly relevant for emerging-market banking systems. Moreover, much of the prior literature examines profitability and risk separately, limiting an integrated assessment of the broader implications of derivatives use for bank performance and stability. The present study addresses this gap by evaluating derivatives use, bank risk, and profitability within a common analytical framework and by providing updated evidence from the Turkish banking sector.

The study therefore contributes to the Turkish banking literature by jointly examining the association of financial derivatives use with both bank risk and profitability. This joint assessment helps clarify the mixed findings in previous Turkish studies and provides a more integrated view of the role of derivatives in commercial banking.

Data and methodology

This section presents the study sample, variable definitions and data sources, the econometric framework, and the statistical procedures used in the empirical analysis. Because the study relies exclusively on publicly available secondary financial and macroeconomic data and does not involve human or animal participants, ethics committee approval was not required.

The sample of the study

The study sample consists of 11 commercial banks operating in Türkiye. The banks were selected on the basis of data availability and sectoral coverage and together accounted for approximately 85.21% of total commercial-banking-sector assets as of December 31, 2024. This high asset share provides broad coverage of the sector, although the results should still be interpreted as evidence for the sampled banks. Table 1 reports the banks' rankings by asset size, their total assets, and the corresponding total for the Turkish commercial banking sector.

Table 1: Ranking of Commercial Banks Included in the Study by Asset Size (USD Million)

Rank	Bank Name	Total Asset Size
1	T.C. Ziraat Bankası A.Ş.	152,631
2	Türkiye Vakıflar Bankası T.A.O.	113,987
3	Türkiye İş Bankası A.Ş.	94,211
4	Türkiye Halk Bankası A.Ş.	85,267
5	Türkiye Garanti Bankası A.Ş.	73,913
6	Akbank T.A.Ş.	71,303
7	Yapı ve Kredi Bankası A.Ş.	67,476
9	DenizBank A.Ş.	38,849
11	Türk Ekonomi Bankası A.Ş.	17,330
15	HSBC Bank A.Ş.	5,402
19	Şekerbank T.A.Ş.	3,319
	Total assets of sampled banks	723,688
	Total assets of the commercial banking sector	849,295
	Share of sampled banks in total sector assets	85.21%

Source: The Banks Association of Türkiye (2025)

The definition of the variables

Table 2 presents the definitions, codes, measurement procedures, and data sources for the variables used in the analysis. Bank-specific financial ratios were calculated from the banks' publicly available balance sheets and income statements, while the macroeconomic variable was obtained from an official national source.

Table 2: Variables Used in the Analysis

Variables	Code	Definitions, Measurements and Previous Studies	Data Source
Dependent Variables			
Bank Stability / Inverse Risk Proxy	(ZSCORE)	An inverse proxy for insolvency risk and financial stability, calculated as (ROA + Equity/Assets) / σ(ROA), where σ(ROA) denotes the standard deviation of return on assets for each bank over the sample period. Lower values indicate higher insolvency risk, whereas higher values indicate greater financial stability. Previous studies include Bazih and Vanwalleghem (2021) and Ghosh (2017).	Banks' financial statements; author's calculations
Return on Assets	(ROA)	A profitability indicator calculated as net profit divided by total assets. Previous studies include Li and Yu (2010) and Ghosh (2017).	Banks' financial statements; author's calculations
Independent Variables			
Gross Derivatives	(GRDERIV)	The total derivative position of a bank measured on a gross basis before netting, calculated as (Derivative Assets + Derivative Liabilities) / Total Assets. The ratio captures the intensity of derivatives activity relative to bank size. Previous studies include Infante et al. (2018) and Miloş and Miloş (2022).	Banks' financial statements; author's calculations
Bank Size	(BS)	The natural logarithm of total assets, included to control for differences in bank scale, market power, and diversification. Previous studies include Ghosh (2017) and Turan and Ersoy (2024).	Banks' financial statements; author's calculations
Loans to Total Assets	(LTA)	The proportion of total assets allocated to lending, calculated as loans and receivables divided by total assets. The variable captures lending intensity, asset structure, and potential liquidity and credit-risk exposure.	Banks' financial statements; author's calculations
Deposits to Total Assets	(DTA)	The share of total assets funded by deposits, used as a proxy for liability structure and reliance on deposit-based funding. Previous studies include Ghosh (2017) and Taşkın and Sarıyer (2020).	Banks' financial statements; author's calculations
Non-Performing Loan	(NPL)	The ratio of non-performing loans to total loans, used as an indicator of asset quality and credit risk. Previous studies include Pala and Hepşen (2024).	Banks' financial statements; author's calculations
Cost to Income	(CIR)	Operating expenses divided by operating income, used as a proxy for operating efficiency; higher values indicate lower efficiency. Previous studies include Bendob et al. (2015).	Banks' financial statements; author's calculations
Gross Domestic Product	(GDP)	A macroeconomic control representing the overall level of economic activity. GDP enters the empirical models in natural-logarithm form. Previous studies such as Bendob et al. (2015) have used GDP as a macroeconomic control.	Central Bank of the Republic of Türkiye

Econometric model

Panel-data methods form the basis of the empirical analysis because they combine cross-sectional and time-series variation and allow researchers to account for unobserved heterogeneity across banks. Compared with purely cross-sectional or time-series approaches, panel data generally provide more observations, greater variability, more degrees of freedom, and potentially more efficient estimation. At the same time, panel-data models may be affected by cross-sectional dependence, heteroskedasticity, serial correlation, measurement error, and endogeneity. Appropriate specification and diagnostic tests were therefore employed to assess these issues and guide the choice of estimator (Baltagi, 2008, pp. 4–7). The empirical analysis was conducted using Stata 13. Models (1) and (2) were estimated to examine the following hypotheses:

H_1: The use of financial derivatives is associated with bank risk.

H_2: The use of financial derivatives is associated with bank profitability.

$$ZSCORE_{it} = \alpha + \beta_1 GRDERIV_{it} + \beta_2 BS_{it} + \beta_3 \Delta LTA_{it} + \beta_4 DTA_{it} + \beta_5 NPL_{it} + \beta_6 CIR_{it} + \beta_7 GDP_{it} + \mu_i + \varepsilon_{it} \quad \textbf{(1)}$$

$$ROA_{it} = \alpha + \beta_1 GRDERIV_{it} + \beta_2 BS_{it} + \beta_3 \Delta LTA_{it} + \beta_4 DTA_{it} + \beta_5 NPL_{it} + \beta_6 CIR_{it} + \beta_7 GDP_{it} + \mu_i + \varepsilon_{it} \quad \textbf{(2)}$$

where i denotes the individual bank in the sample (i = 1, 2, …, 11), and t denotes the year (t = 2011, 2012, …, 2024). The parameter α is the common intercept, $\beta_1, \beta_2, \ldots, \beta_7$ are the slope coefficients, μ_i represents the unobserved bank-specific effect, and ε_{it} denotes the idiosyncratic error term.

In the models, ZSCORE and ROA are the dependent variables. ZSCORE is an inverse proxy for bank risk, with higher values indicating greater stability and lower insolvency risk, while ROA measures bank profitability. GRDERIV is the main explanatory variable. BS, ΔLTA, DTA, NPL, and CIR are included as bank-specific controls, whereas GDP is included as a macroeconomic control variable.

Empirical results

Descriptive statistics

According to the descriptive statistics in Table 3, the sampled Turkish commercial banks have an average ROA of approximately 0.016 and an average Z-score of approximately 20.7. The mean loans-to-total-assets ratio (LTA) is 0.619 and the mean deposits-to-total-assets ratio (DTA) is 0.576, indicating that lending and deposit funding constitute substantial components of bank balance sheets. The mean gross-derivatives ratio is 0.011, while the average non-performing-loan ratio (NPL) is 0.032 and the average cost-to-income ratio (CIR) is 0.367. The dispersion reported in Table 3 indicates meaningful cross-bank and time variation in these measures.

Table 3: Descriptive Statistics

	Z-Score	ROA	GRDERIV	BS	LTA	DTA	NPL	CIR	GDP
Mean	20.7	0.016	0.011	18.467	0.619	0.576	0.032	0.367	21.257
Std. Dev.	10.1	0.008	0.006	1.528	0.067	0.051	0.013	0.162	0.1994
Min.	5.1	-0.022	0.001	14.957	0.394	0.442	0.011	0.110	20.922
Max.	38.3	0.047	0.024	21.861	0.733	0.699	0.068	0.830	21.572
Obs	154	154	154	154	154	154	154	154	154

Correlation matrix and variance inflation factor diagnostic

Correlation analysis was used to examine the direction and strength of pairwise relationships among the variables. Variance inflation factors (VIFs) were also calculated as an additional diagnostic for multicollinearity before regression estimation.

Table 4: Correlation Matrix and Variance Inflation Factor

Variables	ZSCORE	ROA	GRDERIV	BS	Δ LTA	DTA	NPL	CIR	GDP
ZSCORE	**1.000**								
ROA	0.207	**1.000**							
GRDERIV	0.030	-0.222	**1.000**						
BS	0.088	0.231	0.041	**1.000**					
ΔLTA	-0.138	-0.361	0.184	-0.363	**1.000**				
DTA	0.164	0.140	-0.108	-0.241	-0.044	**1.000**			
NPL	-0.160	-0.194	0.132	-0.428	0.301	0.071	**1.000**		
CIR	-0.196	-0.067	-0.048	-0.567	0.208	-0.051	0.121	**1.000**	
GDP	-0.028	0.306	0.051	0.610	-0.351	0.093	-0.075	-0.590	**1.000**
Variance Inflation Factor									
	GRDERIV	BS	Δ LTA	DTA	NPL	CIR	GDP	**Mean VIF**	
	1.08	2.83	1.31	1.24	1.43	1.77	2.20	1.69	

The results in Table 4 indicate that the pairwise correlations are generally low to moderate. Although some coefficients are larger than others, none suggests severe multicollinearity. The VIF results provide the same conclusion: all individual VIF values are well below the conventional threshold of 10, and the mean VIF is 1.69. Multicollinearity therefore does not appear to be a major concern in the estimated models.

Breusch–Pagan LM and Pesaran CD tests (cross-sectional dependence)

Before conducting panel unit-root tests, cross-sectional dependence was examined using the Breusch–Pagan LM and Pesaran CD tests because the appropriate generation of panel unit-root tests depends on whether dependence across panel units is present. Cross-sectional dependence refers to contemporaneous correlation across the errors of different panel units. If ignored when present, it can distort standard errors and statistical inference.

Table 5 reports the cross-sectional-dependence tests. The null hypothesis of cross-sectional independence cannot be rejected for either model. For the ZSCORE model, the Breusch–Pagan LM and Pesaran CD statistics have p-values of 0.1473 and 0.4105, respectively; for the ROA model, the corresponding p-values are 0.1163 and 0.9328. These results provide no evidence of cross-sectional dependence, supporting the use of first-generation panel unit-root tests in the subsequent analysis.

Table 5: Cross-Sectional Dependence Test Result

	ZSCORE Model		ROA Model	
	Statistic	Prob.	Statistic	Prob.
Breusch and Pagan LM test	65.992	0.1473	67.73	0.1163
Pesaran CD test	0.808	0.4105	0.084	0.9328

Panel unit-root tests

Testing the stationarity of the variables is important in panel-data analysis because non-stationary series can produce misleading statistical relationships. Given the absence of evidence of cross-sectional dependence, first-generation panel unit-root tests were employed. Specifically, the Levin, Lin, and Chu (2002) test was used under a common unit-root-process assumption, while the Im, Pesaran, and Shin (2003) test was used to allow heterogeneity across panel units.

Table 6: Unit Root Test Results

Variables	LLC Test (Level)				IPS Test (Level)			
	Intercept		Intercept + Trend		Intercept		Intercept + Trend	
	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.	Stat.	Prob.
ZSCORE	-3.680	0.000***	-3.299	0.000***	-3.208	0.000***	-3.669	0.000***
ROA	1.997	0.977	-1.508	0.065*	-0.667	0.252	-1.920	0.027**
GRDERIV	-1.904	0.028**	-0.494	0.310	-3.111	0.000***	-3.210	0.000***
BS	5.371	1.000	-1.761	0.039**	5.392	1.000	-1.696	0.044**
LTA	4.155	1.000	-1.034	0.150	3.687	0.999	3.462	0.999
Δ LTA	-1.739	0.041**	-3.678	0.00***	-3.923	0.00***	-2.180	0.014**
DTA	-6.749	0.00***	-5.850	0.00***	-2.724	0.003***	-1.136	0.127
NPL	-1.504	0.066*	-2.003	0.022**	-1.289	0.098*	-2.405	0.008***
CIR	-2.081	0.018**	-0.371	0.355	-0.731	0.232	-1.463	0.0716*
GDP	-2.4063	0.0081	-7.446	0.000***	3.1189	0.999	-3.5999	0.0002***
*** p < 0.01, ** p < 0.05, * p < 0.10.								

The results in Table 6 indicate that most variables are stationary in at least one of the reported level specifications. The loans-to-total-assets ratio (LTA) is non-stationary in levels across the reported tests; therefore, its first difference (ΔLTA) is used in the regression analysis.

Panel-data model selection tests

Breusch–Pagan Lagrange multiplier test

The Breusch–Pagan Lagrange multiplier (LM) test compares the pooled OLS and random-effects specifications. Its null hypothesis is that the variance of the panel-level effect is zero, in which case pooled OLS is adequate. The LM test is statistically significant for both the ZSCORE model ($p < 0.001$) and the ROA model ($p = 0.0286$), indicating that a panel estimator is preferable to pooled OLS and, specifically, that random effects should be considered.

Table 7: Breusch and Pagan Lagrangian Multiplier Test Result

	ZSCORE Model		ROA Model	
	LM Statistic	Prob.	LM Statistic	Prob.
Breusch and Pagan	636.00	0.0000	3.62	0.0286

F-test

The F-test compares pooled OLS with the fixed-effects specification. A statistically significant result rejects the null hypothesis that the unit-specific effects are jointly zero. The F-test is significant for both the ZSCORE model ($p < 0.001$) and the ROA model ($p = 0.0176$), indicating that fixed effects are preferable to pooled OLS.

Table 8: F-Test Result

	ZSCORE Model		ROA Model	
	F Statistic	Prob.	F Statistic	Prob.
F- Test	205.59	0.0000	2.27	0.0176

Hausman test

The Hausman test was then used to choose between the fixed-effects and random-effects estimators by testing whether the regressors are systematically correlated with the unobserved unit-specific effects.

Table 9: Hausman Test Results

	ZSCORE Model		ROA Model	
	Chi-Sq. Statistic	Prob.	Chi-Sq. Statistic	Prob.
Hausman Test	2.59	0.8579	3.18	0.8680

The Hausman test p-values reported in Table 9 are greater than 0.05 for both models. The null hypothesis therefore cannot be rejected, indicating that the random-effects estimator is preferred to the fixed-effects estimator for both specifications (Hausman, 1978, p. 1263).

Panel-data diagnostic tests

Wooldridge test for autocorrelation (serial correlation)

The Wooldridge test was used to assess first-order serial correlation in the panel models. The null hypothesis is that the idiosyncratic errors are not first-order serially correlated; rejection therefore indicates evidence of serial correlation.

Baltagi–Wu LBI test (serial correlation)

The Baltagi–Wu locally best invariant (LBI) statistic provides an additional diagnostic for serial correlation in panel models. Values near 2 are generally consistent with little first-order serial correlation, whereas substantially lower values may indicate positive serial correlation.

Likelihood-ratio test for panel-level heteroskedasticity

A likelihood-ratio (LR) test was used to assess whether the variance of the disturbance term is constant across panel units. A significant result indicates panel-level heteroskedasticity and suggests that conventional standard errors may be unreliable. The diagnostic was therefore considered together with robust inference in the final random-effects specifications.

Table 10: Diagnostic Tests Results

Test Name	ZSCORE Model		ROA Model	
	Statistic	Prob.	Statistic	Prob.
Wooldridge Serial Correlation	1.150	0.3087	14.238	0.0036
Baltagi-Wu LBI test	1.5084		1.5018	
Breusch–Pagan LM	65.992	0.1473	67.73	0.1163
Pesaran CD Test (Cross-Sectional Dependence)	0.808	0.4105	0.084	0.9328
LRTest for Panel-Level Heteroskedasticity	84.07	0.0000	54.75	0.0000

The Wooldridge results in Table 10 provide no evidence of first-order serial correlation in the ZSCORE model ($p = 0.3087$), but they indicate serial correlation in the ROA model ($p = 0.0036$). The Baltagi–Wu LBI statistics are 1.5084 for ZSCORE and 1.5018 for ROA, values below 2 that are also consistent with possible positive serial correlation. The Breusch–Pagan LM and Pesaran CD tests provide no evidence of cross-sectional dependence in either model. By contrast, the LR test indicates panel-level heteroskedasticity for both ZSCORE (LR $\chi^2 = 84.07$, $p < 0.01$) and ROA (LR $\chi^2 = 54.75$, $p < 0.01$). In view of these diagnostics, the random-effects models were re-estimated with standard errors clustered at the bank level to obtain inference that is more robust to within-bank heteroskedasticity and serial correlation.

Analysis and findings

Bank risk model

The results in Table 11 show that the estimated coefficients remain broadly similar when bank-clustered standard errors are used. The coefficient on derivatives use (GRDERIV) is positive but statistically insignificant in both specifications, so the analysis provides no evidence of a statistically detectable association between GRDERIV and the Z-score. Hypothesis H1 is therefore not supported. Bank size

(BS), by contrast, has a positive and statistically significant coefficient in both the conventional random-effects model (p = 0.005) and the cluster-robust specification (p = 0.024). The coefficient of 0.84770 indicates that, holding the other variables constant, a one-unit increase in log bank assets is associated with an increase of approximately 0.85 units in the Z-score. Because higher Z-scores indicate greater stability, the result points to a positive association between bank size and financial stability in the sample.

GDP also has a positive coefficient in both specifications, but statistical significance in the conventional random-effects model (p = 0.049) disappears when bank-clustered standard errors are used (p = 0.117). The positive association between GDP and the Z-score is therefore not robust to the alternative inference procedure.

Table 11: Regression Model Results

Dependent Variable: ZSCORE								
Variables	**Random Effects Model**				**Random-Effects Model with Cluster-Robust Standard Errors**			
	Coef	**S. Err**	**z-stat**	**P**	**Coef**	**S. Err**	**z-stat**	**P**
GRDERIV	0.15976	0.42371	0.38	0.706	0.15976	0.53319	0.30	0.764
BS	0.84770	0.30134	2.81	0.005	0.84770	0.37506	2.26	0.024
Δ LTA	-1.37904	0.55236	-2.50	0.013	-1.37904	0.32701	-4.22	0.000
DTA	0.16443	0.61228	0.27	0.788	0.16443	0.98043	0.17	0.867
NPL	-1.59815	1.87271	−0.85	0.393	-1.59815	2.34623	-0.68	0.494
CIR	-0.12496	2.02461	-0.06	0.951	-0.12496	3.27351	-0.04	0.970
GDP	4.42045	2.24969	1.96	0.049	4.42045	2.82190	1.57	0.117
Cons	0.97956	0.44376	2.21	0.027	0.97956	0.53793	1.82	0.069
R^2	0.11				0.11			
Model p-value	0.00				0.00			

The change in the loans-to-total-assets ratio (ΔLTA) has a negative and statistically significant coefficient in both specifications. It is significant at the 5% level in the conventional random-effects model (p = 0.013) and at the 1% level with bank-clustered standard errors (p < 0.001). The estimated coefficient of −1.38 indicates that increases in lending intensity are associated with lower Z-scores and, therefore, higher bank risk. Overall, bank size and ΔLTA are the most consistent correlates of bank stability in the model, whereas the GDP association is not robust across inference procedures. The reported R^2 is approximately 0.11.

Return on assets model

Table 12 shows that the coefficient on gross derivatives (GRDERIV) is negative in both profitability specifications. It is statistically significant in the conventional random-effects model (p = 0.015) and marginally significant at the 10% level when bank-clustered standard errors are used (p = 0.059). Thus, greater derivatives use is associated with lower ROA, but the strength of the statistical evidence weakens under cluster-robust inference. The results therefore provide only qualified support for hypothesis H2.

Bank size (BS) has a positive coefficient, but it is only marginally significant in the conventional random-effects model (p = 0.074) and is not statistically significant with bank-clustered standard errors (p = 0.113). GDP displays a more robust positive association with ROA, with p-values of 0.003 and 0.008 in the two specifications, respectively. This result is consistent with higher bank profitability during periods of stronger aggregate economic activity, although the coefficient should be interpreted as an association rather than a causal effect.

Table 12: Regression Model Results

Dependent Variable: ROA								
Variables	Random Effects Model				Random-Effects Model with Cluster-Robust Standard Errors			
	Coef	S. Err	z-stat	P	Coef	S. Err	z-stat	P
GRDERIV	-0.27986	0.11509	-2.43	0.015	-0.27986	0.14819	-1.89	0.059
BS	0.00141	0.00079	1.78	0.074	0.00141	0.00089	1.58	0.113
Δ LTA	0.01393	0.01713	0.81	0.416	0.01393	0.01401	0.99	0.320
DTA	0.02212	0.01631	1.36	0.175	0.02212	0.01942	1.14	0.255
NPL	-0.06657	0.05698	-1.17	0.243	-0.06657	0.05122	-1.30	0.194
CIR	-0.01454	0.00581	-2.50	0.012	-0.01454	0.00602	-2.41	0.016
GDP	0.01762	0.00600	2.94	0.003	0.01762	0.00664	2.66	0.008
Cons	-0.39725	0.11869	-3.35	0.001	-0.39725	0.13157	-3.02	0.003
R^2	0.24				0.24			
Model p-value	0.00				0.00			

The cost-to-income ratio (CIR) has a negative and statistically significant association with ROA in both the conventional random-effects model ($p = 0.012$) and the cluster-robust specification ($p = 0.016$). Higher operating costs relative to operating income are therefore associated with lower bank profitability. The model is jointly significant in both specifications ($p < 0.001$), and the reported R^2 is approximately 0.24.

Robustness check

As a robustness check, the baseline random-effects models with bank-clustered standard errors were re-estimated using one-period lags of the bank-specific explanatory variables. This timing structure is intended to reduce contemporaneous simultaneity and reverse-causality concerns and is consistent with approaches used in prior banking studies (Melecky & Podpiera, 2013; Köhler, 2018; Andrieș et al., 2022; Xu et al., 2019). The alternative specification assesses whether the baseline relationships between derivatives use, bank risk, and profitability are sensitive to timing-related feedback effects.

In the bank-risk specification, the coefficient on lagged derivatives use remains statistically insignificant ($p = 0.860$). This result is consistent with the baseline finding that derivatives use is not significantly associated with the Z-score. The negative coefficient on lagged ΔLTA also remains statistically significant ($p = 0.040$), providing additional support for the association between increases in lending intensity and lower bank stability.

Table 13: Robustness Check Regression Model Results

Variables	Zscore Model				ROA Model			
	Coef	S. Err	z-stat	P	Coef	S. Err	z-stat	P
L.GRDERIV	0.08280	0.46995	0.18	0.860	-0.00124	0.00074	-1.67	0.095
L.BS	0.58320	0.33436	1.74	0.081	0.00033	0.00122	0.27	0.790
L. ΔLTA	-0.72254	0.35205	-2.05	0.040	0.01348	0.01968	0.68	0.493
L.DTA	0.74650	0.77104	0.97	0.333	0.02723	0.02675	1.02	0.309
L.NPL	-0.64735	2.22029	-0.03	0.977	-0.15463	0.10986	-1.41	0.159
L.CIR	-0.30699	2.46255	-0.12	0.901	-0.00832	0.00588	-1.41	0.157
GDP	3.93457	3.36397	1.17	0.242	0.02485	0.00804	3.09	0.002
Cons	0.89442	0.68662	1.30	0.193	-0.53137	0.15170	-3.50	0.000
R^2	0.13				0.27			
Model p-value	0.00				0.00			

In the profitability model, the coefficient on lagged derivatives use remains negative and is marginally significant at the 10% level ($p = 0.095$). The direction of the association with ROA is therefore unchanged, although the statistical evidence is weaker when the bank-specific explanatory variables are lagged.

Overall, the robustness analysis supports the baseline result for bank risk because derivatives use remains statistically insignificant in the lagged specification. For profitability, the results continue to indicate a negative association between derivatives use and ROA, but the evidence is only marginally significant under the lagged specification.

Conclusion

Financial derivatives are important tools that banks use to manage financial exposures, particularly in periods of economic and financial volatility. This study examined the association of derivatives use with bank risk and profitability for 11 Turkish commercial banks over 2011–2024. The period encompasses substantial macroeconomic volatility, including high inflation, sharp interest-rate movements, and persistent exchange-rate pressures. The bank-risk results show no statistically significant association between derivatives use and the Z-score in either the conventional random-effects model or the specification with bank-clustered standard errors. In the profitability model, derivatives use is negatively associated with ROA; the coefficient is significant in the conventional specification and only marginally significant after clustering standard errors at the bank level.

Across the specifications, bank-specific and macroeconomic variables show more consistent relationships with risk and profitability than derivatives use itself. Bank size and changes in lending intensity are the most robust correlates of the Z-score, while operating efficiency and GDP are important correlates of ROA. These results suggest that derivatives should be viewed as complementary instruments within a broader risk-management framework rather than as tools that automatically improve profitability or reduce bank risk.

The bank-risk findings are consistent with Turan and Ersoy (2024), who reported no statistically significant relationship between derivatives use and bank risk in Turkish banks, and with Bazih and Vanwalleghem (2021), who found no significant effect on total bank risk. They differ, however, from Ghosh (2017) and Bendob et al. (2015), who reported risk-reducing effects of derivatives. The profitability findings are consistent with Bayri (2023) and Taşkın and Sarıyer (2020), both of whom reported negative relationships between derivatives activity and bank profitability in Türkiye. They differ from Ghosh (2017), Bendob et al. (2015), and Tanrıöven and Yenice (2014), which reported positive profitability effects in at least some specifications. Overall, the evidence indicates that the consequences of derivatives use are not uniform and depend on the purpose of use, bank characteristics, market conditions, and econometric specification.

Bank managers should align derivative positions with identifiable exposures arising from interest-rate, exchange-rate, liquidity, and maturity mismatches. Derivatives should not be evaluated solely in terms of short-term profitability; their role in reducing earnings volatility and balance-sheet vulnerability should also be considered. Strong internal controls are essential, including position limits, regular stress testing, and effective board-level oversight of derivative activities.

For regulatory authorities, the findings underline the importance of monitoring both the scale of derivative positions and the quality of banks' risk-management practices. Regular stress tests can be used to assess the sensitivity of derivative portfolios to exchange-rate movements, interest-rate shocks, and liquidity shortages. Supervisors should also evaluate whether derivative activities are consistent with banks' stated risk tolerance, capital positions, and underlying market exposures. Such monitoring can help identify potentially destabilizing positions before they become systemically important.

This study has several limitations. The analysis is based on a selected set of bank-specific and macroeconomic variables, so institutional, managerial, regulatory, and market-related factors that may also affect bank risk and profitability are not fully captured. In addition, the sample is limited to 11 commercial banks in Türkiye, which constrains the generalizability of the results to other banking systems and institutional settings.

Future research could address these limitations by incorporating additional institutional, managerial, regulatory, and market variables and by extending the analysis to larger cross-country samples. Comparisons between Turkish banks and banks in other emerging and developed economies would help determine whether the relationships documented here are specific to the Turkish banking system or also arise under different regulatory and macroeconomic conditions.

Overall, the results indicate that the relationship between financial derivatives use, bank risk, and profitability is context dependent. Derivatives appear to function as complementary tools within banks' broader risk-management systems, and their effectiveness is likely to depend on the purpose for which they are used, banks' internal risk-management frameworks, and the regulatory environment.

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