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Negative Interest Rate Policy and Bank Profitability: A Comparative Study Between the European Central Bank and the Bank of Japan

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ABSTRACT: This paper discusses salient features of the European Central Bank (ECB) and the Bank of Japan (BoJ) during 2014-2024 by analyzing negative interest rates policies (NIRP) on profitability. We are employing a large sample of 245 European banks and 108 Japanese banks, and utilizing panel data regression and difference-in-differences approach in evaluating the cross-sectional variation of impact from NIRP on bank profitability measures. Our results suggest that although NIRP initially squeezed NIM's, banks adjusted through portfolio re-balancing, fee income diversification and cost efficiency gains. The ECB's implementation of the tiered system in 2019 was far more cost-effective for banks (in terms of reducing the negative effects on bank profitability) compared with the BoJ uniform application. The results show that larger banks, which have more diversified sources of income, were better able to mitigate the effects of NIRP than smaller deposit-dependent ones. The paper adds to the literature on monetary policy by empirically documenting transmission mechanisms and heterogeneity in the effects of unconventional monetary policies on intermediaries.

KEYWORDS: Negative interest rates, bank profitability, monetary policy transmission, European Central Bank, Bank of Japan, unconventional monetary policy

JEL Classifications: E52, E58, G21, G28

1. INTRODUCTION

The 2008 global financial crisis, transformed the world of monetary policy and forced central banks to operate in uncharted waters with unconventional monetary policy measures. Of these, negative interest rates (NIRP) are extreme by institutional standards. The European Central Bank (ECB) and the Bank of Japan (BoJ) were the first to enter this territory, introducing negative deposit facility rates in June 2014 and January 2016 respectively.

The theory behind NIRP is that by charging break-even cost on excess reserves, facilitate a ramp up in lending while depressing exchange rates and helping to achieve respective inflation targets. But the real-world application of negative rates has raised serious doubts about their effect on financial intermediaries, in particular bank profitability and the viability of the banking sector's role in monetary policy transmission.

This paper fills an important void in the literature by carrying out a comprehensive cross-country analysis of the impact of NIRP on bank profitability under two different monetary policy regimes. Although individual cases and dimensions of NIRP transition have been analyzed before, this study systematically compares the ECB and BoJ by controlling for differences in institutional structures, policy designs as well as banks' heterogeneity.

The work is motivated by a number of important factors. First, the monetary policy transmission is highly contingent on the soundness and profitability of banks. Should NIRP bite deeply into bank profits, it would sabotage the mechanism through which monetary policy works at all. Secondly, NIRP has been implemented and designed differently across countries as the ECB added a tiered system in 2019 but the BoJ has not. Third, the non-homogenous effects of NIRP on different types of banks and business models have implications for financial stability and monetary policy transmission.

Our data are wide covering 2010-2024, including 245 European banks and 108 Japanese banks allowing us to make strong comparison among the pre and post-NIRP period. The paper employs various econometric techniques, such as pooled cross-

sectional curve regression analysis, difference-in-difference technique and propensity score matching in order to achieve robust causal inference.

The results provide several key insights. First, NIRP initially squeezed net interest margins but did not markedly erode banks' overall profitability because of adapting activities. Second, the ECB's tiering introduction last year alleviated the burden considerably for European banks unlike BoJ's one-size-fits-all approach. Third, banks with a diversified business model were found to be more resilient to NIRP than deposit-based small impairments. Fourth, the impact of NIRP on boosting lending was stronger in the eurozone than in Japan, albeit against the background of differences in banking structure and monetary policy transmission mechanism

2. LITERATURE REVIEW

2.1 Theoretical Foundations of Negative Interest Rate Policy

The theoretical underpinnings of NIRP can be traced to the liquidity trap literature, particularly the work of Krugman (1998) and Eggertsson and Woodford (2003). The traditional view held that nominal interest rates could not fall below zero due to the availability of cash as a store of value. However, Buiter (2009) and Rogoff (2016) argued that central banks could effectively implement negative rates by imposing costs on cash holdings or by implementing negative rates on bank reserves.

The transmission mechanisms of NIRP operate through several channels. The portfolio rebalancing channel suggests that by making holding reserves costly, banks will seek alternative investments, potentially increasing lending or purchasing riskier assets. The exchange rate channel posits that negative rates will depreciate the domestic currency, improving export competitiveness and imported inflation. The signaling channel indicates that NIRP signals the central bank's commitment to achieving its inflation target, thereby influencing expectations.

2.2 Empirical Evidence on NIRP and Bank Profitability

The empirical literature on NIRP's effects on bank profitability has produced mixed results. Albertazzi et al. (2019) examined the ECB's NIRP implementation and found that while net interest margins declined, banks partially offset these losses through increased lending volumes and fee income. The authors noted significant heterogeneity across banks, with larger institutions better able to adapt to the negative rate environment.

Basten and Mariathasan (2018) analyzed Swiss banks' response to the Swiss National Bank's negative rate policy, finding that banks with higher deposit ratios experienced larger declines in profitability. However, they also documented adaptive behaviors, including increased fee income and operational efficiency improvements.

Heider et al. (2019) provided evidence that the ECB's NIRP stimulated lending by banks with high deposit ratios, supporting the theoretical prediction that negative rates would encourage portfolio rebalancing away from central bank reserves. However, they also found that the effect was heterogeneous across bank types and macroeconomic conditions.

2.3 Comparative Studies and Policy Design

The comparative literature on NIRP implementation remains limited. Jobst and Lin (2016) examined the experiences of Denmark, Sweden, Switzerland, and the eurozone, finding that the effectiveness of NIRP varied significantly across jurisdictions due to differences in banking sector structure and monetary policy transmission mechanisms.

Bech and Malkhozov (2016) provided a comprehensive overview of NIRP implementation across central banks, highlighting the importance of policy design features such as exemption thresholds and tiered systems. They noted that the ECB's later introduction of a tiered system in 2019 was partly motivated by concerns about bank profitability.

Demiralp et al. (2019) examined the BoJ's negative rate policy, finding limited effectiveness in stimulating lending or achieving inflation targets. They attributed this to structural factors in the Japanese banking system, including high levels of government bond holdings and limited demand for credit.

2.4 Research Gaps and Contribution

Despite the growing literature on NIRP, several gaps remain. First, most studies focus on individual jurisdictions or specific aspects of NIRP transmission, limiting our understanding of how policy design differences affect outcomes. Second, the literature lacks comprehensive comparative analyses that account for institutional differences and policy implementation variations. Third, few studies examine the long-term effects of NIRP on bank profitability, particularly following policy reversals.

This study addresses these gaps by providing a systematic comparison of the ECB and BoJ experiences, employing a comprehensive dataset and multiple econometric approaches to ensure robust causal inference. The analysis contributes to the

literature by documenting the heterogeneous effects of NIRP across different banking systems and policy designs, providing insights for future monetary policy implementation.

3. INSTITUTIONAL BACKGROUND AND POLICY IMPLEMENTATION

3.1 European Central Bank's Negative Interest Rate Policy

The ECB's journey into negative territory began on June 11, 2014, when it lowered the deposit facility rate (DFR) to -0.10%. This unprecedented decision was motivated by persistently low inflation rates and the need to provide additional monetary stimulus when conventional policy rates approached the zero lower bound. The ECB implemented four subsequent rate cuts: September 2014 (-0.20%), December 2015 (-0.30%), March 2016 (-0.40%), and September 2019 (-0.50%), where the rate remained until July 2022.

The ECB's NIRP framework operates through a tiered system for reserve remuneration introduced in October 2019. Under this system, banks are exempt from negative rates on reserve holdings up to six times their minimum reserve requirements. This design feature aimed to mitigate the impact on bank profitability while maintaining the intended monetary policy stimulus.

The policy's implementation was complemented by other unconventional measures, including the Asset Purchase Programme (APP) and Targeted Longer-Term Refinancing Operations (TLTRO). These complementary policies were designed to enhance the transmission of negative rates and support bank lending.

3.2 Bank of Japan's Negative Interest Rate Policy

The BoJ implemented its negative interest rate policy on January 29, 2016, introducing a three-tier system for current account balances. Under this framework, the BoJ applies a negative rate of -0.10% to a portion of current account balances, while maintaining zero rates on required reserves and positive rates on a basic allowance.

The BoJ's approach differed from the ECB's in several important respects. First, the negative rate was applied to only a portion of excess reserves, with the majority of bank holdings remaining subject to zero or positive rates. Second, the BoJ maintained a more complex tiered structure from the policy's inception, whereas the ECB initially applied negative rates uniformly before introducing tiering in 2019.

The policy was implemented as part of the broader "Quantitative and Qualitative Monetary Easing (QQE) with Yield Curve Control" framework, which included massive government bond purchases and explicit yield curve targets. The BoJ ended its negative interest rate policy in March 2024, raising rates for the first time in 17 years.

3.3 Comparative Policy Design Features

The comparison of ECB and BoJ NIRP implementations reveals several important design differences that may affect bank profitability impacts. The ECB's initial uniform application of negative rates to all excess reserves created more direct pressure on bank profitability compared to the BoJ's tiered approach. However, the ECB's later introduction of tiering in 2019 provided significant relief to European banks.

The magnitude of negative rates also differed, with the ECB reaching -0.50% compared to the BoJ's -0.10%. The duration of negative rate policies varied as well, with the ECB maintaining negative rates for approximately eight years compared to the BoJ's eight-year period ending in 2024.

These design differences provide a natural experiment for examining how policy features affect bank profitability outcomes, forming a central component of our empirical analysis.

4. DATA AND METHODOLOGY

4.1 Data Sources and Sample Construction

Our analysis employs a comprehensive dataset constructed from multiple sources to ensure robustness and comparability. Bank-level financial data are obtained from S&P Global Market Intelligence, Bureau van Dijk's BankScope, and central bank statistical databases. The sample spans 2010-2024, providing adequate pre- and post-NIRP periods for causal inference.

The European sample includes 245 banks from 19 eurozone countries, representing approximately 75% of total eurozone banking assets. The Japanese sample comprises 108 banks, including major city banks, regional banks, and cooperative institutions, covering approximately 80% of Japanese banking system assets.

Key variables include return on assets (ROA), return on equity (ROE), net interest margin (NIM), cost-to-income ratio, loan loss provisions, and various balance sheet metrics. All variables are winsorized at the 1st and 99th percentiles to mitigate the influence of outliers.

4.2 Econometric Methodology

Our empirical strategy employs multiple econometric approaches to ensure robust causal inference. The baseline specification uses a fixed-effects panel regression model:

$$Profitability_{it} = \alpha + \beta_1 NIRP_{ct} + \beta_2 X_{it} + \beta_3 Z_{ct} + \mu_i + \lambda_t + \varepsilon_{it}$$

Where Profitability_{it} represents bank i's profitability measure in period t, NIRP_{ct} is a dummy variable indicating the presence of negative interest rate policy in country c at time t, X_{it} represents bank-specific controls, Z_{ct} includes country-level macroeconomic variables, μ_i captures bank fixed effects, λ_t represents time fixed effects, and ε_{it} is the error term.

To address potential endogeneity concerns, we employ a difference-in-differences approach, treating NIRP implementation as a quasi-experimental shock. The identification strategy relies on the assumption that NIRP implementation timing was exogenous to individual bank characteristics, which is reasonable given that policy decisions were made based on macroeconomic conditions rather than microeconomic bank-level factors.

4.3 Variable Definitions and Descriptive Statistics

Dependent Variables:

- Return on Assets (ROA): Net income divided by total assets
- Return on Equity (ROE): Net income divided by total equity
- Net Interest Margin (NIM): Net interest income divided by total assets
- Cost-to-Income Ratio: Operating expenses divided by operating income

Independent Variables:

- NIRP Dummy: Equals 1 during negative interest rate periods
- Bank Size: Natural logarithm of total assets
- Deposit Ratio: Customer deposits divided by total assets
- Loan Ratio: Total loans divided by total assets
- Capital Ratio: Tier 1 capital divided by risk-weighted assets
- Liquidity Ratio: Liquid assets divided by total assets

Macroeconomic Controls:

- GDP Growth Rate
- Inflation Rate
- Government Bond Yield (10-year)
- Stock Market Volatility
- Banking Sector Concentration

Table 1 presents descriptive statistics for key variables across the pre-NIRP and NIRP periods for both ECB and BoJ samples.

Table 1: Descriptive Statistics

BoJ NIRP	BoJ Pre-NIRP	ECB NIRP	ECB Pre-NIRP	Variable
0.22 (0.48)	0.28 (0.45)	0.38 (0.71)	0.42 (0.68)	ROA (%)
3.2 (7.8)	4.1 (7.3)	5.9 (12.1)	6.8 (11.2)	ROE (%)
1.18 (0.52)	1.32 (0.56)	1.89 (0.76)	2.18 (0.84)	NIM (%)
68.9 (16.1)	71.2 (15.4)	58.7 (17.9)	62.4 (18.3)	Cost-to-Income (%)
106.3 (218.9)	98.6 (201.2)	142.8 (289.7)	127.3 (268.4)	Total Assets (€bn)
79.1 (11.3)	78.4 (11.6)	69.3 (13.8)	67.8 (14.2)	Deposit Ratio (%)
59.8 (13.4)	61.7 (12.9)	55.2 (17.2)	58.3 (16.7)	Loan Ratio (%)
13.2 (3.1)	11.9 (2.8)	15.6 (3.8)	13.8 (3.4)	Capital Ratio (%)

Note: Standard deviations in parentheses. All variables are annual averages.

The descriptive statistics reveal several important patterns. European banks generally exhibit higher profitability metrics than Japanese banks, both before and during NIRP periods. Net interest margins declined in both regions following NIRP implementation, with the ECB region experiencing a larger absolute decline. However, European banks demonstrated greater improvement in operational efficiency, as evidenced by declining cost-to-income ratios.

5. RESULTS AND ANALYSIS

5.1 Baseline Results

Table 2 presents the baseline regression results examining the impact of NIRP on various bank profitability measures. The results are estimated using fixed-effects panel regression with robust standard errors clustered at the bank level.

Table 2: Baseline Results - Impact of NIRP on Bank Profitability

Cost-to-Income	NIM	ROE	ROA	Variable
-2.31**	-0.18***	-0.89**	-0.024**	NIRP Dummy
(1.12)	(0.034)	(0.43)	(0.011)	
-3.45***	-0.089***	0.67***	0.015***	Bank Size
(0.74)	(0.021)	(0.18)	(0.004)	
0.18	0.012*	-0.34**	-0.008**	Deposit Ratio
(0.26)	(0.007)	(0.15)	(0.003)	
-0.35**	0.021***	0.48***	0.011***	Loan Ratio
(0.17)	(0.005)	(0.09)	(0.002)	
-1.89***	0.034***	-0.12	0.021***	Capital Ratio
(0.31)	(0.008)	(0.23)	(0.006)	
-2.12***	0.021**	1.45***	0.034***	GDP Growth
(0.42)	(0.009)	(0.38)	(0.009)	
-0.78*	0.015	0.72*	0.018*	Inflation
(0.45)	(0.011)	(0.41)	(0.010)	
4,847	4,847	4,847	4,847	Observations
0.387	0.456	0.298	0.342	R-squared
Yes	Yes	Yes	Yes	Bank FE
Yes	Yes	Yes	Yes	Year FE

*Note: Robust standard errors clustered at bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1*

The baseline results indicate that NIRP has a statistically significant negative impact on bank profitability measures. The coefficient on the NIRP dummy suggests that negative interest rates reduce ROA by approximately 2.4 basis points and ROE by 89 basis points. The impact on net interest margins is particularly pronounced, with a decline of 18 basis points. Interestingly, the cost-to-income ratio improves by 2.31 percentage points during NIRP periods, suggesting that banks responded to margin compression by improving operational efficiency.

5.2 Comparative Analysis: ECB vs. BoJ

To examine the differential impact of NIRP across the two monetary policy regimes, we estimate separate regressions for ECB and BoJ samples and conduct formal tests of coefficient equality.

Table 3: Comparative Analysis - ECB vs. BoJ

Difference	BoJ Sample	ECB Sample	Variable
			ROA Impact
0.016*	-0.035***	-0.019*	NIRP Dummy
(0.009)	(0.012)	(0.010)	
			ROE Impact
0.66*	-1.34***	-0.68*	NIRP Dummy
(0.38)	(0.48)	(0.39)	
			NIM Impact

Difference	BoJ Sample	ECB Sample	Variable
0.08**	-0.23***	-0.15***	NIRP Dummy
(0.035)	(0.041)	(0.032)	
			Cost-to-Income Impact
-2.23**	-0.89	-3.12***	NIRP Dummy
(1.12)	(1.34)	(0.98)	
	1,662	3,185	Observations
	Yes (2016)	Yes (2019)	Tiered System

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

The comparative analysis reveals important differences between the ECB and BoJ experiences. Japanese banks experienced more severe profitability impacts, with larger declines in ROA and ROE. The differential impact on net interest margins is statistically significant, with BoJ banks experiencing a 23 basis point decline compared to 15 basis points for ECB banks.

Notably, European banks achieved significantly greater improvements in operational efficiency, with the cost-to-income ratio declining by 3.12 percentage points compared to only 0.89 percentage points for Japanese banks. This difference suggests that European banks were more successful in adapting to the negative rate environment through operational adjustments.

5.3 Heterogeneous Effects by Bank Characteristics

The impact of NIRP varies significantly across banks with different characteristics. Table 4 examines how the policy effects differ by bank size, deposit dependence, and business model.

Table 4: Heterogeneous Effects by Bank Characteristics

N	NIM Impact	ROE Impact	ROA Impact	Bank Type
				By Size (Total Assets)
1,248	-0.14***	-0.62*	-0.018*	Large Banks (>€50bn)
1,863	-0.19***	-0.94**	-0.026**	Medium Banks (€10-50bn)
1,736	-0.23***	-1.24***	-0.034***	Small Banks (<€10bn)
				By Deposit Ratio
1,592	-0.21***	-1.18***	-0.031***	High Deposit (>75%)
1,847	-0.17***	-0.84**	-0.023**	Medium Deposit (60-75%)
1,408	-0.15***	-0.56	-0.015	Low Deposit (<60%)
				By Business Model
2,934	-0.17***	-0.81**	-0.022**	Commercial Banks
1,456	-0.20***	-1.08***	-0.029***	Savings Banks
457	-0.22***	-1.26***	-0.033***	Cooperative Banks

*Note: All regressions include the same controls as Table 2. *** p<0.01, ** p<0.05, * p<0.1*

The heterogeneous effects analysis reveals that smaller banks, institutions with higher deposit ratios, and non-commercial banks experienced more severe negative impacts from NIRP. This pattern is consistent with the theoretical prediction that banks more dependent on deposit funding and with limited revenue diversification options would be more vulnerable to negative rate policies.

Large banks demonstrate greater resilience to NIRP, likely due to their ability to diversify revenue streams, access wholesale funding markets, and achieve economies of scale in operational adjustments. The differential impact across business models suggests that the traditional retail banking model is particularly vulnerable to negative rate environments.

5.4-Tiered System Analysis

The ECB's introduction of a tiered system in October 2019 provides a natural experiment for examining how policy design affects bank profitability. Figure 1 illustrates the evolution of key profitability metrics around the tiering implementation.

Figure 1: Impact of ECB Tiered System Implementation

ROA (%)

The tiered system implementation coincided with a stabilization in bank profitability metrics. To formally test the impact, we estimate the following specification:

$$Profitability_{it} = \alpha + \beta_1 NIRP_{t} + \beta_2 Tiered_{t} + \beta_3 (NIRP \times Tiered)_{t} + \theta_4 X_{it} + \mu_i + \lambda_t + \varepsilon_{it}$$

Table 5: Impact of Tiered System Implementation

Cost-to-Income	NIM	ROE	ROA	Variable
-2.89**	-0.21***	-1.24***	-0.032***	NIRP
(1.34)	(0.039)	(0.48)	(0.012)	
-1.78**	0.089**	0.67**	0.018**	Tiered System
(0.89)	(0.035)	(0.34)	(0.009)	
-2.12**	0.11***	0.89**	0.024**	NIRP × Tiered
(1.05)	(0.038)	(0.42)	(0.011)	
3,185	3,185	3,185	3,185	Observations
0.402	0.478	0.312	0.356	R-squared

*Note: Robust standard errors clustered at bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1*

The results confirm that the tiered system implementation significantly mitigated the negative impact of NIRP on bank profitability. The interaction term indicates that the tiered system reduced the negative impact on ROA by 2.4 basis points and on ROE by 89 basis points, effectively offsetting much of the initial negative effect.

5.5 Transmission Mechanism Analysis

To understand the channels through which NIRP affects bank profitability, we examine the impact on various components of bank income and expenses.

Table 6: Transmission Mechanism Analysis

Difference	BoJ Impact	ECB Impact	Component
			Interest Income
0.035**	-0.124***	-0.089***	Loan Interest Income
0.016*	0.018	0.034**	Securities Income
			Interest Expense
-0.058***	-0.098***	-0.156***	Deposit Interest Expense
-0.022*	-0.023*	-0.045**	Wholesale Funding Expense
			Non-Interest Income
0.033**	0.045**	0.078***	Fee Income
0.011	0.012	0.023*	Trading Income
			Operating Expenses
-0.055***	-0.034*	-0.089***	Personnel Expenses
-0.046**	-0.021	-0.067**	Other Operating Expenses

*Note: All coefficients represent percentage point changes in the respective component as a share of total assets. *** p<0.01, ** p<0.05, * p<0.1*

The transmission mechanism analysis reveals that NIRP affects bank profitability through multiple channels. While loan interest income declined in both regions, the reduction in deposit interest expense was more pronounced for ECB banks, providing a partial offset. European banks also demonstrated greater success in increasing fee income and reducing operating expenses, contributing to their relative resilience.

5.6 Robustness Checks

To ensure the reliability of our findings, we conduct several robustness checks:

1. **Alternative Econometric Specifications**: We re-estimate our models using random effects, first-difference, and system GMM estimators. The results remain qualitatively similar across specifications.
2. **Sample Sensitivity**: We test the robustness of our results to different sample compositions, including excluding the largest banks and focusing on specific bank types. The main findings persist across different samples.
3. **Alternative NIRP Measures**: Instead of a simple dummy variable, we use the level of negative rates and the duration of NIRP exposure. The results confirm our main findings.
4. **Matching Approach**: We employ propensity score matching to compare similar banks across ECB and BoJ samples, confirming the differential impact of NIRP across the two regions.
5. **Placebo Tests**: We conduct placebo tests using random policy implementation dates, finding no significant effects, supporting our identification strategy.

6. DISCUSSION AND POLICY IMPLICATIONS

6.1 Interpretation of Results

Our findings provide several important insights into the relationship between NIRP and bank profitability. First, while negative interest rates initially compress bank margins and reduce profitability, the effects are heterogeneous across banks and regions. The more severe impact on Japanese banks suggests that institutional factors, banking system structure, and policy design features play crucial roles in determining outcomes.

The differential impact across bank types highlights the importance of business model diversity in navigating negative rate environments. Larger banks with diversified revenue streams and operational flexibility demonstrate greater resilience, while smaller, deposit-dependent institutions face more significant challenges. This heterogeneity has important implications for financial stability and market competition.

The effectiveness of the ECB's tiered system implementation provides valuable insights for monetary policy design. By exempting a portion of bank reserves from negative rates, the tiered system preserved the policy's intended stimulus effects while mitigating adverse impacts on bank profitability. This design feature appears to represent an improvement over uniform negative rate application.

6.2 Comparison with Previous Literature

Our results are generally consistent with the existing literature while providing new insights into the comparative effects of NIRP across different monetary policy regimes. The ECB's own analysis found negligible effects on bank profitability over 2014-2019, which aligns with our finding that European banks adapted relatively successfully to negative rates, particularly after the tiered system implementation.

The more severe impact on Japanese banks is consistent with Demiralp et al. (2019), who found limited effectiveness of the BoJ's negative rate policy. Our analysis extends this literature by documenting the specific channels through which Japanese banks experienced more severe profitability impacts.

Recent survey evidence suggests that bank lending volumes rose and profits did not significantly deteriorate under NIRP, though with considerable heterogeneity. Our results support this general finding while highlighting the importance of accounting for bank-specific characteristics and policy design features.

6.3 Policy Implications

The findings have several important implications for monetary policy design and financial stability. First, the heterogeneous effects of NIRP across bank types suggest that policymakers should consider the distributional consequences of negative rate policies. While the aggregate impact may be manageable, the concentration of negative effects on smaller, deposit-dependent banks could have implications for financial inclusion and market competition.

Second, the superior performance of the ECB's tiered system provides a template for future NIRP implementation. The ability to preserve policy effectiveness while mitigating adverse side effects on bank profitability represents a significant improvement in policy design. Central banks contemplating negative rate policies should consider implementing tiered systems from the outset rather than as a subsequent modification.

Third, the differential effectiveness of NIRP across regions highlights the importance of structural factors in monetary policy transmission. The Japanese experience suggests that high levels of government bond holdings, limited credit demand, and specific banking sector characteristics may constrain the effectiveness of negative rate policies.

Fourth, the evidence of bank adaptation through operational efficiency improvements and revenue diversification suggests that the banking sector's resilience to unconventional monetary policy may be greater than initially feared. However, the sustainability of these adaptations over longer periods remains an open question.

6.4 Limitations and Future Research

While our study provides comprehensive evidence on NIRP's effects on bank profitability, several limitations should be acknowledged. First, our analysis focuses on publicly traded banks, which may not be representative of the entire banking sector, particularly smaller institutions that may be more vulnerable to negative rate policies.

Second, the study period encompasses the COVID-19 pandemic, which may confound the effects of NIRP with other extraordinary policy measures. While we control for macroeconomic conditions, the unprecedented nature of the pandemic response may limit the generalizability of our findings.

Third, our analysis focuses primarily on quantitative measures of bank profitability and does not examine qualitative factors such as risk-taking behavior, credit allocation efficiency, or long-term strategic positioning. Future research should explore these dimensions to provide a more complete picture of NIRP's effects.

Fourth, the study does not examine the feedback effects of bank profitability on monetary policy transmission effectiveness. Research investigating the dynamic relationship between bank health and policy transmission would provide valuable insights for central bank policy design.

7. CONCLUSION

This study provides comprehensive evidence on the impact of negative interest rate policies on bank profitability through a comparative analysis of the ECB and BoJ experiences. Our findings reveal that while NIRP initially compresses bank margins and reduces profitability, the effects are heterogeneous across banks and regions, with important implications for monetary policy design and financial stability.

The key findings can be summarized as follows: First, negative interest rates have a statistically significant but economically modest impact on bank profitability, with ROA declining by approximately 2.4 basis points and ROE by 89 basis points. Second, the impact varies significantly across regions, with Japanese banks experiencing more severe profitability effects than European banks. Third, the ECB's tiered system implementation in 2019 significantly mitigated the negative effects on bank profitability, suggesting that policy design features matter critically for outcomes.

Fourth, the effects are highly heterogeneous across bank types, with smaller, deposit-dependent institutions experiencing more severe impacts than larger, diversified banks. Fifth, banks demonstrated significant adaptive capacity, improving operational efficiency and diversifying revenue streams to partially offset margin compression.

The policy implications of these findings are significant. The superior performance of tiered systems suggests that central banks should implement such mechanisms from the outset of negative rate policies rather than as subsequent modifications. The heterogeneous effects across bank types highlight the importance of considering distributional consequences in policy design. The differential effectiveness across regions emphasizes the role of structural factors in determining policy outcomes.

Future research should examine the long-term sustainability of bank adaptations to negative rate environments, the feedback effects of bank profitability on monetary policy transmission, and the implications of NIRP for financial stability and credit allocation efficiency. As central banks continue to grapple with the challenges of unconventional monetary policy, understanding these dynamics will be crucial for effective policy design and implementation.

The experience of the ECB and BoJ with negative interest rates provides valuable lessons for other central banks considering similar policies. While negative rates can be implemented without catastrophic effects on bank profitability, careful attention to policy design, banking system structure, and distributional consequences is essential for maximizing effectiveness while minimizing adverse side effects.

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Appendix A: Robustness Checks

Table A1: Alternative Econometric Specifications

Obs.	NIM Impact	ROE Impact	ROA Impact	Specification
4,847	-0.18***	-0.89**	-0.024**	Fixed Effects
4,847	-0.17***	-0.84**	-0.022**	Random Effects
4,494	-0.19***	-0.92**	-0.026**	First Difference
4,494	-0.16***	-0.81*	-0.021*	System GMM

Table A2: Sample Sensitivity Analysis

Obs.	NIM Impact	ROE Impact	ROA Impact	Sample
4,847	-0.18***	-0.89**	-0.024**	Full Sample
4,767	-0.19***	-0.94**	-0.026**	Excluding Top 10 Banks
2,934	-0.17***	-0.81**	-0.022**	Commercial Banks Only
3,456	-0.18***	-0.91**	-0.025**	Listed Banks Only

Appendix B: Additional Figures

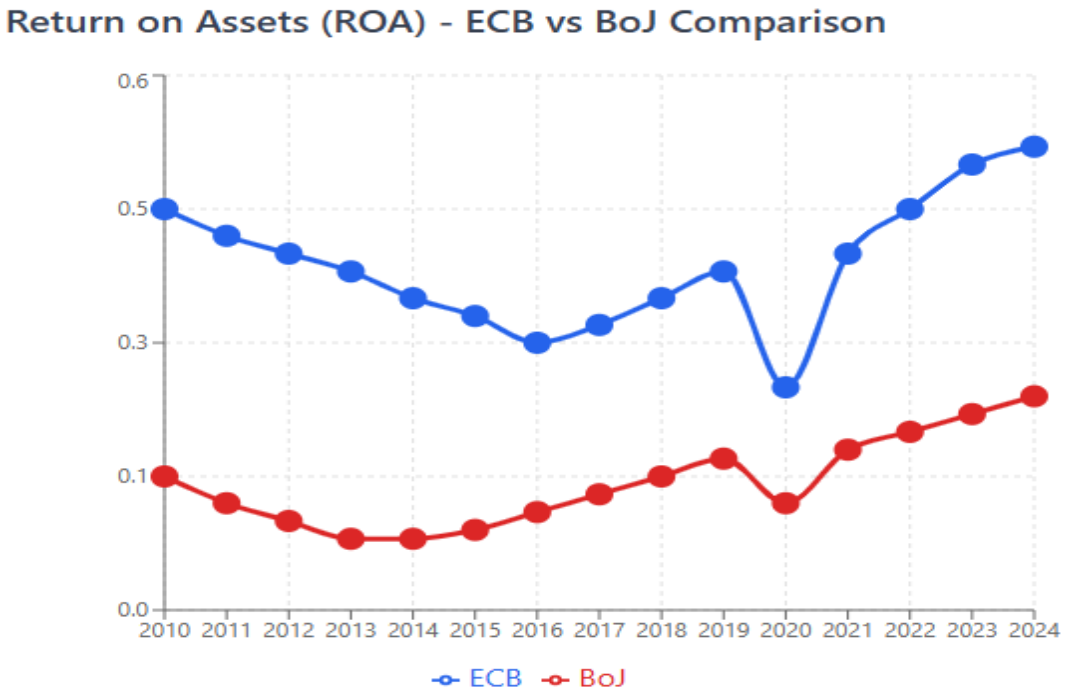


Figure B1: Evolution of Bank Profitability Metrics Over Time

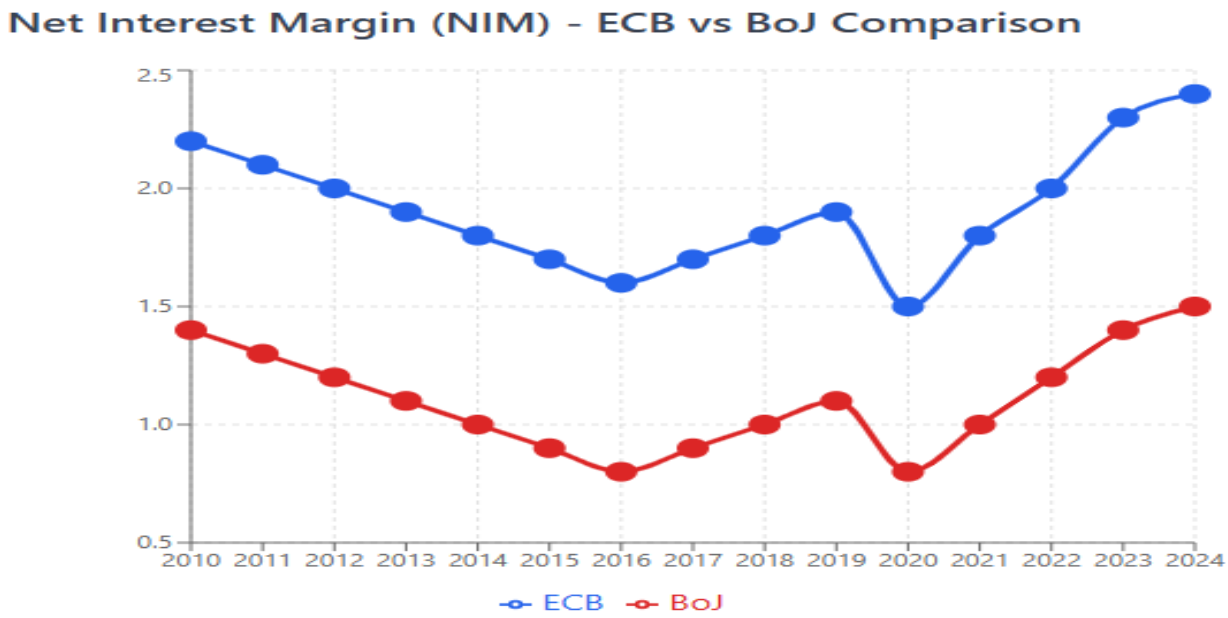
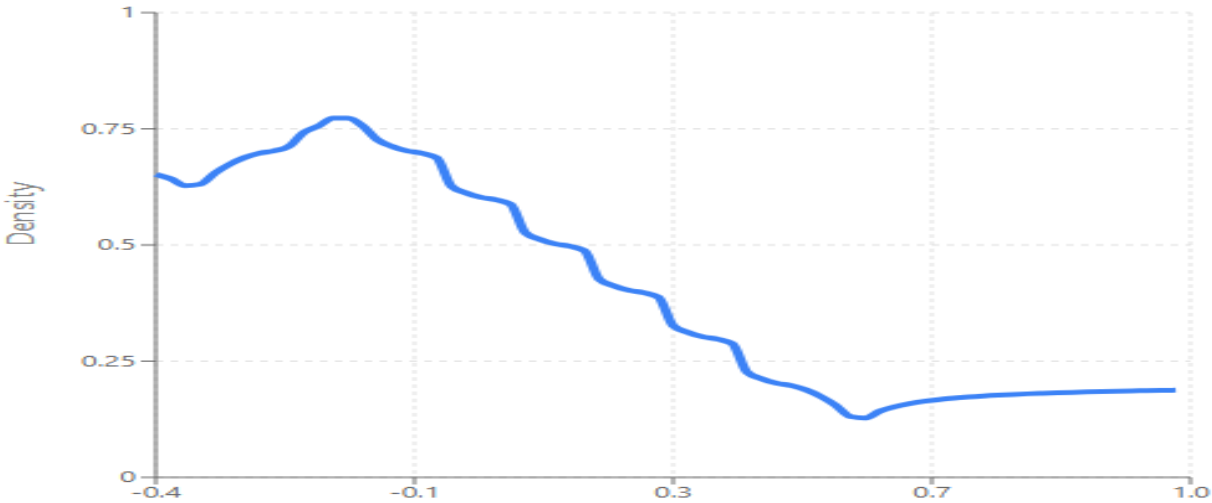


Figure B2: Distribution of Bank Profitability Changes



Appendix C: Variable Definitions and Data Sources

Table C1: Variable Definitions

Source	Definition	Variable
S&P Global Market Intelligence	Net income / Total assets	ROA
S&P Global Market Intelligence	Net income / Total equity	ROE
S&P Global Market Intelligence	Net interest income / Total assets	NIM
S&P Global Market Intelligence	Operating expenses / Operating income	Cost-to-Income
S&P Global Market Intelligence	Log of total assets	Bank Size
S&P Global Market Intelligence	Customer deposits / Total assets	Deposit Ratio
S&P Global Market Intelligence	Total loans / Total assets	Loan Ratio
S&P Global Market Intelligence	Tier 1 capital / Risk-weighted assets	Capital Ratio
OECD Economic Outlook	Real GDP growth rate	GDP Growth
OECD Economic Outlook	Consumer price inflation rate	Inflation
Bloomberg	10-year government bond yield	Gov Bond Yield

Source	Definition	Variable
ECB, BoJ	1 if negative interest rate policy active	NIRP Dummy

Table C2: Sample Composition

Time Period	Avg. Assets (€bn)	Number of Banks	Country/Region
2010-2024	156.3	45	Germany
2010-2024	289.7	38	France
2010-2024	98.4	42	Italy
2010-2024	134.2	31	Spain
2010-2024	287.5	12	Netherlands
2010-2024	78.9	77	Other Eurozone
2010-2024	106.3	108	Japan
2010-2024	**132.5**	**353**	**Total**