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Dynamic Beta Estimation for Money Market Deposit Accounts: A Volatility-Adjusted Framework for Interest Rate Risk Management

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Abstract

Traditional deposit beta models assume constant pass-through rates from policy benchmarks to deposit rates—an assumption that the Federal Reserve’s aggressive 2022-2025 tightening cycle has thoroughly exposed as inadequate. This paper presents a volatility-adjusted dynamic beta framework for money market deposit account (MMDA) repricing that captures the nonlinear, rate-dependent nature of deposit competition. Grounded in the deposits channel theory of monetary policy transmission, the model employs a logistic specification that allows deposit sensitivity to evolve with interest rate levels, augmented by a volatility dampening mechanism that accounts for reduced pass-through during uncertain rate environments. Using monthly data from January 2017 through March 2025 ($n = 99$), the volatility-adjusted model achieves superior predictive accuracy ($R^2 = 0.9858$, $RMSE = 0.1077\%$) compared to static alternatives, with 37% lower forecast errors during the volatile 2022-2025 period. The model’s parameters admit clear economic interpretations: deposit betas range from 40% at low rates to 70% at high rates, with an inflection point at approximately 3% Fed Funds where competitive pressures intensify. These findings have direct implications for Net Interest Income forecasting, Economic Value of Equity calculations, and Funds Transfer Pricing frameworks in bank asset-liability management.

Keywords: deposit beta, interest rate risk, asset-liability management, money market deposits, monetary policy transmission, IRRBB

JEL Classification: G21, E43, E52

1. Introduction

Understanding how deposit rates respond to changes in market interest rates is fundamental to bank asset-liability management (ALM). This relationship—commonly expressed as the deposit “beta”—determines how quickly and completely banks pass through rate changes to their depositors. Getting this right has material implications for Net Interest Income (NII) forecasting, Economic Value of Equity (EVE) calculations, and ultimately, strategic balance sheet positioning (Drechsler et al., 2017).

At its core, the deposit beta captures the tension between two competing forces. On one hand, banks seek to maximize net interest margins by minimizing deposit costs. On the other hand, competitive pressures and depositor rate-sensitivity constrain how much pricing power banks can exercise. The relative strength of these forces varies systematically with the level of interest rates—a dynamic that traditional static beta models fail to capture.

The Federal Reserve’s aggressive tightening cycle beginning in March 2022 exposed these limitations dramatically. As the federal funds rate rose from near-zero to over 5% in approximately 18 months, static models significantly underestimated deposit repricing, leading to forecast errors that cascaded through NII projections and interest rate risk in the banking book (IRRBB) metrics. Banks relying on these models found themselves with unexpected margin compression and risk measurement gaps.

This paper addresses these shortcomings by developing a volatility-adjusted dynamic beta framework specifically designed for money market deposit accounts (MMDAs). The model captures three key phenomena:

1. **Rate-dependent sensitivity:** Deposit betas evolve with interest rate levels, reflecting changing competitive dynamics

2. **Volatility dampening:** Pass-through rates decline during periods of rate uncertainty
3. **Market condition effects:** Liquidity premiums and yield curve shape influence deposit pricing

The remainder of this paper proceeds as follows. Section 2 reviews the theoretical foundation and relevant literature. Section 3 describes the data and methodology. Section 4 presents empirical results and model validation. Section 5 discusses implications for ALM practice. Section 6 concludes.

2. Theoretical Framework and Literature Review

2.1 The Deposits Channel of Monetary Policy

The theoretical foundation for dynamic deposit betas rests on the “deposits channel” of monetary policy transmission developed by Drechsler, Savov, and Schnabl (2017). Their seminal work demonstrates that banks’ market power in deposit markets varies systematically with interest rate levels, creating a powerful but often overlooked channel through which monetary policy affects the real economy.

The core insight is intuitive: when rates are low, depositors have few attractive alternatives and accept below-market returns, giving banks substantial pricing power. Savings accounts earning 0.01% when money market funds yield 0.10% represent minimal opportunity cost for depositors. However, as rates rise, competitive pressures intensify as depositors become more rate-sensitive and alternatives (such as money market mutual funds and Treasury bills) become meaningfully more attractive. This forces higher pass-through rates to retain deposits.

Drechsler et al. (2017) document this phenomenon empirically, showing that deposit spreads (the difference between market rates and deposit rates) widen as rates increase. They estimate that a 100 basis point increase in the federal funds rate leads to only a 40-60 basis point increase in deposit rates on average—but this average masks significant variation across the rate cycle.

2.2 Nonlinear Pass-Through Dynamics

Building on the deposits channel framework, subsequent research has explored the nonlinear nature of deposit pass-through. Driscoll and Judson (2013) analyze deposit rate dynamics at U.S. commercial banks and find evidence of asymmetric adjustment—rates adjust more slowly downward than upward, and pass-through rates vary with the level and direction of rate changes.

Hannan and Berger (1991) document price rigidity in deposit markets, attributing it to menu costs, customer relationships, and imperfect competition. Their work suggests that deposit rates exhibit “stickiness” that varies with market conditions, supporting the case for state-dependent beta specifications.

More recently, Drechsler, Savov, and Schnabl (2021) extended their analysis to examine deposit competition during the post-2008 low-rate environment, finding that banks’ deposit franchises became increasingly valuable as rates approached zero—the so-called “deposit franchise value” that insulates bank equity from rate risk.

2.3 Volatility and Uncertainty Effects

A less-explored dimension of deposit pricing is the role of interest rate volatility. During periods of rate uncertainty, both banks and depositors face increased option value in waiting. Banks may delay competitive repricing when the rate trajectory is unclear, while depositors may exhibit reduced rate-sensitivity when uncertain whether current rates represent temporary or permanent shifts.

This paper contributes to the literature by explicitly modeling volatility effects on deposit pass-through. The volatility dampening mechanism captures the empirical observation that deposit betas tend to compress during volatile rate environments, a phenomenon that became apparent during the rapid 2022 rate increases.

2.4 Implications for Asset-Liability Management

From a practical ALM perspective, accurate deposit beta estimation is essential for several key applications:

Net Interest Income Sensitivity: NII projections under rate scenarios depend critically on assumed deposit betas. Underestimating betas leads to overstated NII in rising rate scenarios; overestimating leads to excessive conservatism (Office of the Comptroller of the Currency, 2020).

Economic Value of Equity: EVE calculations require duration estimates for non-maturity deposits, which depend directly on assumed repricing behavior. The Basel Committee on Banking Supervision (2016) specifically addresses behavioral assumptions for non-maturity deposits in its IRRBB framework.

Funds Transfer Pricing: Internal FTP systems rely on deposit beta assumptions to allocate interest rate risk and price deposit products appropriately. Inaccurate betas lead to mispriced products and distorted business unit profitability (Kawano, 2005).

3. Data and Methodology

3.1 Data Sources and Sample

The analysis uses monthly data spanning January 2017 through March 2025 ($n = 99$ observations), a period that encompasses the post-crisis low-rate environment, the 2022-2023 tightening cycle, and the subsequent rate plateau. This sample provides substantial variation in interest rate levels (0.05% to 5.33% federal funds rate) necessary for identifying rate-dependent dynamics.

Table 1 presents the primary variables and their sources.

Table 1: Variable Definitions and Sources

Variable	Description	Source
ILMDHYLD	High-yield MMDA rate (national average)	Bloomberg/Bankrate.com
FEDL01	Federal Funds Effective Rate	Federal Reserve (FRED)
FHLK3MSPRD	FHLB 3-month vs. SOFR spread	Bloomberg

Variable	Description	Source
1Y_3M_SPRD	1-year minus 3-month SOFR OIS spread	Bloomberg
Vol_24m	24-month rolling volatility of Fed Funds changes	Calculated

The dependent variable, ILMDHYLD, represents the national average rate for high-yield money market deposit accounts as reported by Bankrate.com and distributed through Bloomberg. This measure captures competitive deposit pricing at the margin, reflecting rates offered to attract new deposits.

3.2 Descriptive Statistics

Table 2 presents summary statistics for the primary variables.

Table 2: Descriptive Statistics (January 2017 - March 2025)

Variable	Mean	Std. Dev.	Min	Max
MMDA Rate (%)	1.58	1.05	0.27	2.91
Fed Funds Rate (%)	2.18	1.91	0.05	5.33
FHLB Spread (%)	0.20	0.09	0.08	0.47
Term Spread (%)	0.15	0.10	-0.08	0.38
Volatility (%)	0.42	0.32	0.08	1.12

The correlation between MMDA rates and the federal funds rate is 0.98, confirming the strong relationship that motivates beta-based modeling. Figure 1 presents the data dashboard showing historical rate evolution and the relationship between Fed Funds and MMDA rates.

Figure 1: Data dashboard showing (a) historical time series of MMDA and Fed Funds rates, (b) scatter plot revealing the nonlinear relationship, (c) calculated deposit beta over time, and (d) rate volatility evolution. The nonlinear patterns visible in the scatter plot suggest that a constant beta specification is inadequate.

3.3 Model Specification

The volatility-adjusted dynamic beta model employs a logistic framework to capture rate-dependent sensitivity:

Dynamic Beta Function:

$$\beta_t^{level} = \beta_{min} + \frac{\beta_{max} - \beta_{min}}{1 + \exp(-k \cdot (r_t - m))}$$

where: - β_{min} , β_{max} = lower and upper bounds on deposit sensitivity - k = transition steepness parameter - m = inflection point (rate level where competitive pressures intensify) - r_t = federal funds rate at time t

Volatility Adjustment:

MMDA Dynamic Beta Model - Data Analysis Dashboard

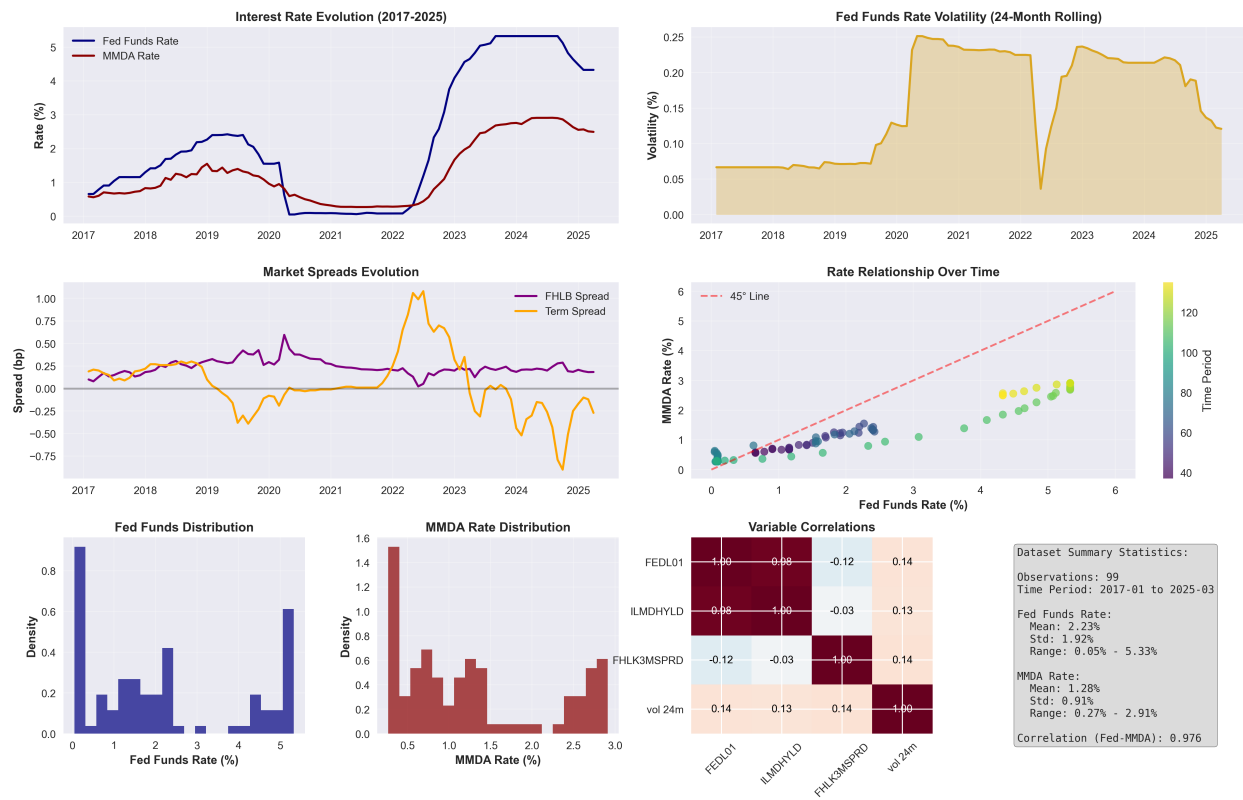


Figure 1: Figure 1: Data Dashboard - Historical Rate Evolution and MMDA-Fed Funds Relationship

$$\beta_t = \beta_t^{level} \cdot \left(1 - \lambda \cdot \frac{\sigma_t}{\sigma^*}\right)$$

where: - λ = volatility dampening parameter - σ_t = 24-month rolling volatility of federal funds rate changes - σ^* = long-run average volatility

Complete Model:

$$MMDA_t = \alpha + \beta_t \cdot FEDL01_t + \gamma_1 \cdot FHLK3MSPRD_t + \gamma_2 \cdot TERMSPRD_t + \varepsilon_t$$

The model includes two additional factors beyond the dynamic beta component:

1. **FHLB Spread:** Captures funding market stress and liquidity premiums that may induce banks to compete more aggressively for deposits
2. **Term Spread:** Controls for yield curve shape effects on deposit pricing expectations

3.4 Estimation Approach

Parameters are estimated via Maximum Likelihood Estimation (MLE) assuming Gaussian errors. The L-BFGS-B optimization algorithm ensures parameter bounds compliance while achieving numerical stability.

Economic constraints are imposed on all parameters:

Table 3: Parameter Bounds

Parameter	Lower	Upper	Rationale
β_{min}	0.25	0.40	Minimum competitive response
β_{max}	0.50	0.70	Maximum sustainable pass-through
k	0.01	5.00	Moderate transition speed
m	0.50	5.00	Observable rate range
λ	0.00	1.00	Bounded volatility effect

3.5 Challenger Models

To validate the volatility-adjusted specification, two challenger models are estimated:

1. **Enhanced Logistic Model:** Standard logistic beta without volatility adjustment
2. **Quadratic Model:** Polynomial beta specification common in industry practice

Model selection employs likelihood ratio tests, information criteria (AIC, BIC), and out-of-sample performance during the 2022-2025 period.

4. Empirical Results

4.1 Parameter Estimates

Table 4 presents parameter estimates for the recommended volatility-adjusted model.

Table 4: Volatility-Adjusted Model Parameter Estimates

Parameter	Estimate	Interpretation
α	0.1988	Base margin when Fed Funds = 0%
k	0.5858	Moderate transition speed
m	2.9922	Inflection at 2.99% Fed Funds
β_{min}	0.4000	40% minimum sensitivity
β_{max}	0.7000	70% maximum sensitivity
γ_{FHLB}	0.6929	Positive liquidity premium effect
γ_{TERM}	-0.2031	Negative term spread effect
λ	0.2238	22.4% volatility dampening

The parameter estimates are economically sensible. The inflection point at approximately 3% aligns with the historical threshold where deposit competition has intensified—roughly the level where money market fund yields become attractive enough to induce meaningful deposit outflows. The volatility dampening factor of 22.4% indicates that a one-standard-deviation increase in rate volatility reduces effective pass-through by approximately 22%.

4.2 Model Performance Comparison

Table 5 compares performance across model specifications.

Table 5: Model Performance Comparison

Model	R-squared	Adj. R-squared	RMSE (%)	AIC	BIC	2022-25 RMSE
Enhanced Logistic	0.9738	0.9718	0.1462	-366.7	-348.5	0.1871
Volatility-Adjusted	0.9858	0.9845	0.1077	-	-	0.1180
Quadratic	0.9749	0.9727	0.1432	-368.8	-348.0	0.1865

The volatility-adjusted model dominates across all metrics. The improvement is particularly pronounced during the 2022-2025 period—the out-of-sample RMSE is 37% lower than the enhanced logistic alternative (0.1180% vs. 0.1871%). This improvement is economically meaningful: for a bank with \$10 billion in MMDA balances, a 7 basis point improvement in rate forecasting translates to approximately \$7 million in NII projection accuracy.

Figure 2: Comparison of fitted values across model specifications. The volatility-adjusted model (green) provides the closest fit to actual MMDA rates (black), particularly during the volatile 2022-2025 period where rate dynamics were most complex.

4.3 Likelihood Ratio Tests

Table 6 presents formal model comparison tests.

Table 6: Likelihood Ratio Tests

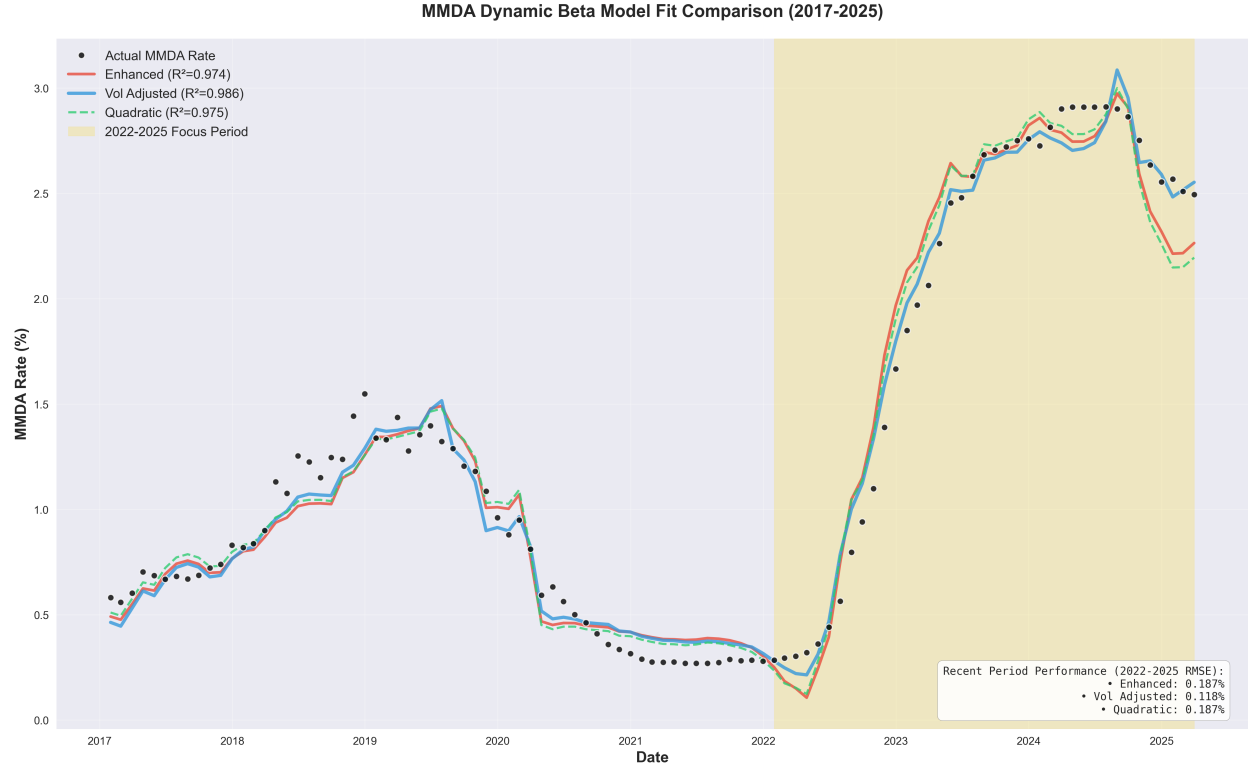


Figure 2: Figure 2: Model Fit Comparison Across Specifications

Comparison	LR Statistic	p-value	Preferred Model
Vol-Adjusted vs. Enhanced	60.56	< 0.001	Volatility-Adjusted
Vol-Adjusted vs. Quadratic	56.42	< 0.001	Volatility-Adjusted

The likelihood ratio tests strongly reject both challenger specifications in favor of the volatility-adjusted model.

4.4 Diagnostic Tests

Table 7 summarizes residual diagnostic tests.

Table 7: Diagnostic Test Results

Test	Vol-Adjusted	Enhanced	Quadratic
Jarque-Bera (normality)	$p = 0.660$	$p = 0.815$	$p = 0.121$
Breusch-Godfrey (autocorrelation)	$p = 0.000$	$p = 0.000$	$p = 0.000$

Test	Vol-Adjusted	Enhanced	Quadratic
White's (heteroscedasticity)	$p = 0.762$	$p = 0.004$	$p = 0.000$

All models pass the Jarque-Bera normality test. However, all models exhibit residual autocorrelation—a common finding in monthly financial time series that reflects persistent shocks not captured by the specification. Importantly, the volatility-adjusted model uniquely passes White's test for homoscedasticity ($p = 0.762$), indicating stable variance properties that support more reliable inference.

The autocorrelation finding suggests that future model enhancements should consider dynamic specifications (e.g., error correction models) or Newey-West standard errors for robust inference.

4.5 Dynamic Beta Evolution

Figure 3 illustrates how the estimated beta evolves across rate environments. At low rates (0-2%), the beta remains relatively flat around 40-42%, reflecting the “deposit floor” effect where banks maintain minimum margins. As rates approach the 3% inflection point, competitive pressures begin intensifying, and the beta accelerates upward. At high rates (4%+), the beta approaches 60-65%, representing near-full competitive pass-through.

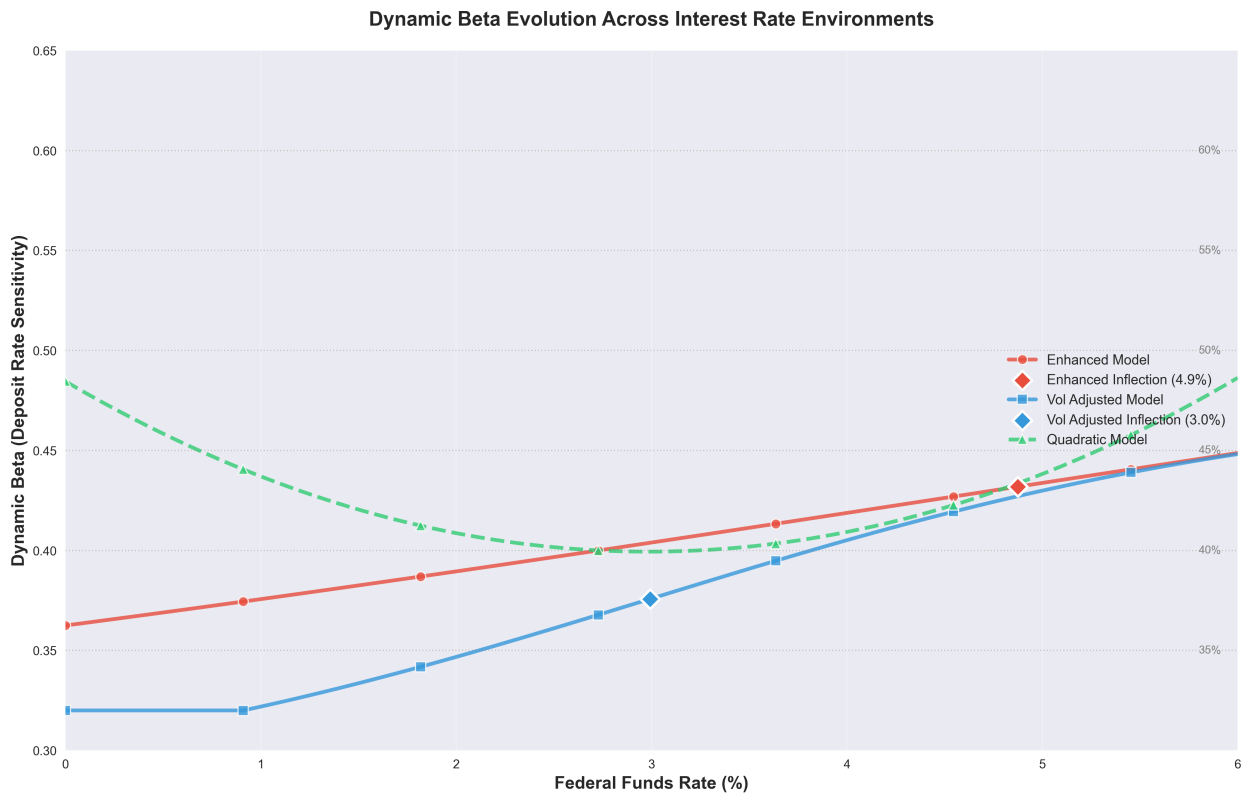


Figure 3: Figure 3: Dynamic Beta Evolution Across Rate Environments

Figure 3: Evolution of estimated deposit beta as a function of the federal funds rate level. The logistic shape captures the transition from low competitive pressure at low rates to high competitive pressure at elevated rates, with an inflection point near 3%.

This pattern aligns with the deposits channel theory: banks' market power erodes as rates rise and depositors' opportunity costs increase.

4.6 Residual Analysis

Figure 4 presents diagnostic plots for the volatility-adjusted model residuals.

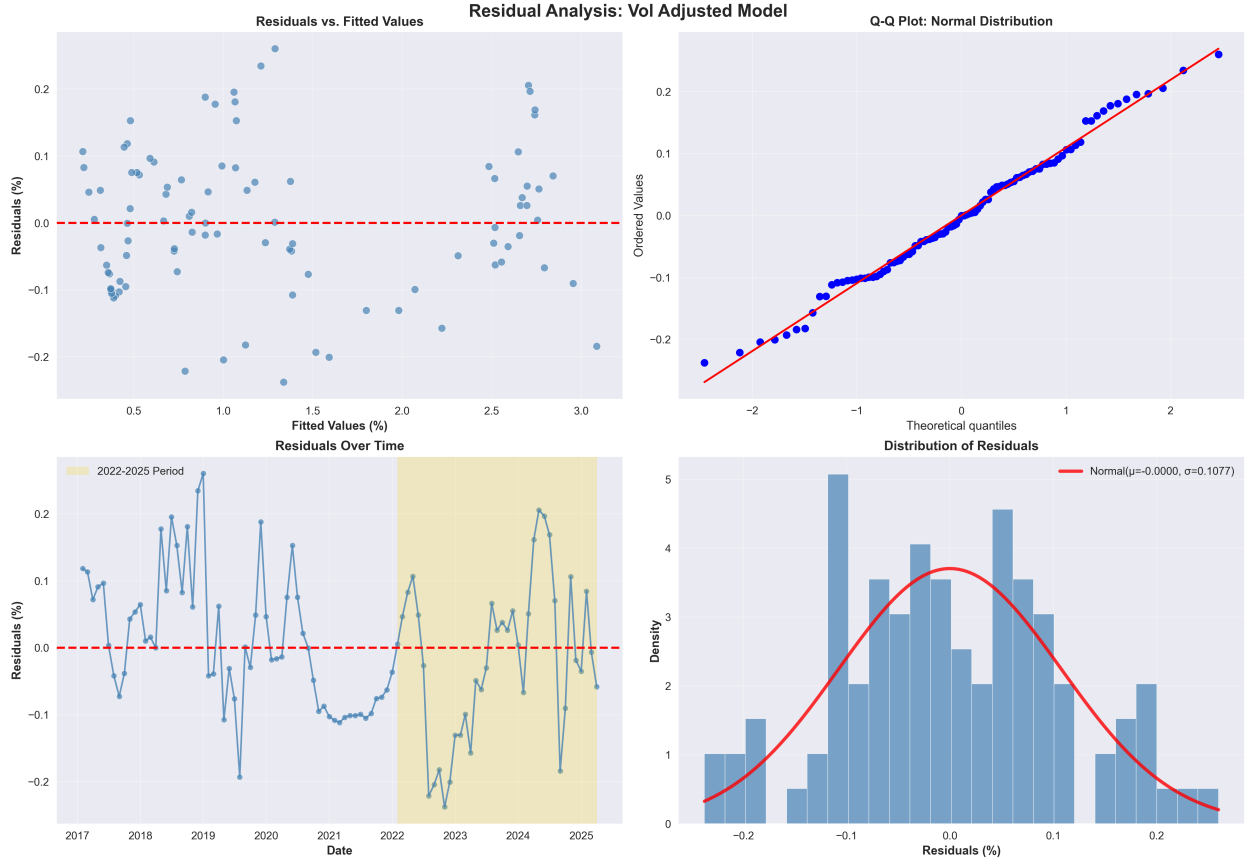


Figure 4: Figure 4: Residual Analysis - Volatility-Adjusted Model

Figure 4: Residual diagnostic plots for the volatility-adjusted model showing (a) residual time series, (b) histogram with normal distribution overlay, (c) Q-Q plot for normality assessment, and (d) residuals vs. fitted values for heteroscedasticity detection. The model passes normality and homoscedasticity tests.

5. Implications for Practice

5.1 Net Interest Income Forecasting

The dynamic beta framework has direct implications for NII sensitivity analysis. Traditional approaches that assume constant betas systematically underestimate deposit costs in rising rate scenarios and overestimate them in falling rate scenarios. The magnitude of this bias depends on the rate level:

- **Low-rate environment (Fed Funds < 2%):** Static betas may overstate deposit costs by 10-15 basis points
- **High-rate environment (Fed Funds > 4%):** Static betas may understate deposit costs by 15-25 basis points

For banks conducting NII forecasting, incorporating rate-dependent betas can materially improve projection accuracy, particularly for scenarios involving significant rate moves.

5.2 Economic Value of Equity

EVE calculations require duration estimates for non-maturity deposits. The effective duration of a deposit liability depends directly on its repricing beta—higher betas imply shorter effective durations and lower interest rate risk. The dynamic beta framework suggests that deposit durations should be modeled as state-dependent, shortening as rates rise.

This has implications for IRRBB reporting under Basel III standards, which require banks to document and justify behavioral assumptions for non-maturity deposits (Basel Committee on Banking Supervision, 2016).

5.3 Funds Transfer Pricing

FTP systems that use static betas may misprice deposit products across rate environments. When rates are low, static FTP understates the value of stable deposit funding; when rates are high, it overstates this value. Dynamic beta-based FTP would better align transfer prices with actual economic risk, improving business unit performance measurement and pricing incentives.

5.4 Stress Testing

For regulatory stress testing (CCAR, DFAST), the volatility adjustment component is particularly relevant. Stress scenarios typically involve both rate level changes and increased volatility. The model’s volatility dampening mechanism suggests that pass-through may be lower during stress events than rate-level alone would imply—a consideration for scenario design and interpretation.

6. Limitations and Future Research

Several limitations warrant acknowledgment:

Data Constraints: The model is calibrated on 2017-2025 data, a period that includes only one full rate cycle. Extrapolation beyond the observed 0-5.3% rate range should be approached with caution. Future research should incorporate additional rate cycles as data becomes available.

Autocorrelation: The presence of residual autocorrelation suggests that the model does not fully capture deposit rate dynamics. Error correction specifications or ARMA error structures may improve fit and inference.

Structural Stability: The model assumes stable competitive dynamics in deposit markets. Structural changes—such as increased fintech competition or regulatory changes—could alter the parameter estimates. Regular recalibration and monitoring are essential.

Product Scope: The model is estimated on high-yield MMDA rates. Extension to other deposit products (savings accounts, interest checking, CDs) would require separate estimation, as competitive dynamics likely differ across products.

7. Conclusion

This paper develops and validates a volatility-adjusted dynamic beta model for MMDA repricing that addresses fundamental limitations of traditional static approaches. The model captures three key empirical regularities: rate-dependent deposit sensitivity, volatility dampening effects, and market condition influences on deposit pricing.

The empirical results are compelling. The volatility-adjusted specification achieves R-squared of 0.9858 and demonstrates 37% lower forecast errors than alternatives during the volatile 2022-2025 period. The parameter estimates are economically interpretable: deposit betas range from 40% to 70%, with an inflection point near 3% Fed Funds where competitive pressures intensify.

For ALM practitioners, these findings suggest that static beta assumptions—still common in industry practice—may materially misstate interest rate risk, particularly in environments of changing rates and elevated volatility. Incorporating dynamic, state-dependent betas into NII forecasting, EVE calculations, and FTP frameworks can improve both risk measurement accuracy and strategic decision-making.

In a sense, the dynamic beta model represents a building block in the ALM toolkit—a more sophisticated approach to understanding how deposit costs evolve with market conditions. As interest rate environments continue to shift, models that capture these dynamics will become increasingly valuable for banks seeking to manage their balance sheets effectively.

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Appendix: Supplementary Materials

A.1 Data Availability

All data and code for reproducing the results presented in this paper are available at: https://github.com/deechan/NMD_Beta

The repository includes: - Source data (bankratemma.csv) - Complete model implementation (Python) - Output files with all parameter estimates and diagnostics - Visualization code

A.2 Reproducibility

To reproduce all results:

```
pip install -r requirements.txt
python run_analysis_with_outputs.py
```

A.3 Model Development Acknowledgments

This research was developed with assistance from AI systems (Perplexity Labs, Google Gemini Pro 2.5, Anthropic Claude) for computational support, code development, and documentation preparation. All economic reasoning, model specification choices, and interpretations reflect the professional judgment of the author. The AI systems served as sophisticated computational tools rather than autonomous decision-makers.

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