Duration Gap Risk Management in Commercial Banks -- A Case Study of First Republic Bank

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Abstract. Traditional duration gap models can only capture the sensitivity of net worth to interest rate changes but struggle to reflect the dynamic impact of client behavior and liquidity constraints in crisis scenarios. To address the model's deficiency in characterizing liquidity risk, this study introduces a client-run factor (λ) and a liquidity coverage factor (θ), constructing an extended duration gap measurement framework incorporating these factors. It further proposes a "Dynamic Duration Gap" model to capture the evolution of risk over short-term time horizons (t). Based on the case of the typical failed bank, First Republic Bank (FRB), this paper analyzed its financial statements and regulatory disclosure data before collapse, calculating its dynamic risk exposures under the new model, revealing the resonance mechanism between market interest rate shocks and client panic behavior. The research results indicate that the intensification of client run behavior, and the continuous depletion of high-quality liquid assets (HQLA) significantly amplified the actual interest rate risk exposure of both banks and accelerated the onset of its liquidity crisis. This model not only addresses the shortcomings of traditional duration analysis in crisis response but also provides an operable quantitative tool for commercial banks to conduct internal stress testing and for regulators to refine micro prudential assessment frameworks.

Keywords: Duration Mismatch Risk Management, Liquidity, Client Behavior, Bank Run, First Republic Bank.

1 Introduction

In the post-epidemic era, while bidding farewell to the ultra-low interest rate environment, the global economy has also ushered in the continued challenge of high inflation. In response to this thorny situation, the world's major central banks, led by the Federal Reserve, resolutely changed the direction of monetary policy and started a radical tightening cycle. This shift not only announced the end of the long-term era of quantitative easing but also fundamentally reshaped the pricing cornerstone and risk structure of the financial market. For commercial banks that are highly dependent on the interest rate environment, their traditional risk management framework and profit logic are facing unprecedented severe tests. The duration gap risk that was concealed or underestimated in the stable low-interest rate environment in the past has rapidly evolved into clearly

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visible interest rate risk and liquidity risk under the new normal, and they are intertwined and amplified.

From 2022 to 2023, to combat nearly out-of-control inflation, the Federal Reserve carried out the most rapid round of interest rate hikes in nearly a decade, raising the federal funds rate from 0.25%, close to zero, to 5% [1]. This brought a huge test to the global financial market. The dramatic change in the interest rate environment caused a sharp drop in the value of long-term bonds and MBS held by banks. For commercial banks that rely heavily on such assets, their balance sheets are under unprecedented pressure. At the same time, depositors began to look for places with higher interest rates, resulting in a rapid outflow of bank deposits. This double squeeze on the asset side and the liability side highlighted the risks of banks' traditional "borrowing short and lending long" and "short-term debt and long-term investment", which ultimately led to the collapse of First Republic Bank (FRB).

The collapse of this bank quickly became the focus of academia and financial market regulators. A large number of existing documents and reports, such as the FDIC's investigation report, have analyzed the reasons for its failure in detail from multiple angles. As for FRB, academic analysis focuses on the fact that its assets account for too high a proportion of long-term fixed-rate mortgages, and its deposits mainly come from a small number of high-net-worth customers, which is not stable enough. Many analyses also mentioned that the current accounting standards allow banks to report the value of certain assets at non-market prices, that is, allowing banks to measure held to maturity assets at amortized cost largely masks the actual huge losses, which are only fully exposed when banks are forced to sell assets [2,3].

2 Literature Review

Within the theoretical framework of interest rate risk management for commercial banks, the duration gap model has long played a cornerstone role. As early as the 1980s, Ho and Saunders proposed the "Duration Gap Model" [4]. Its core logic lies in quantifying the sensitivity of a bank's net worth to interest rate changes by measuring the difference between the duration of bank assets and liabilities (i.e., the duration gap), combined with the bank's leverage ratio. Due to its simplicity and intuitiveness, this model has been widely adopted by regulators and banks to assess the effectiveness of asset-liability management and the bank's interest rate risk exposure [5].

However, as financial market volatility increases and the operating environment and asset structure of banks become increasingly complex, scholars and practitioners deeply involved in risk management practice have gradually recognized three fundamental limitations of the traditional duration gap model, which render it inadequate for managing modern financial risks. First is the model's static nature: The traditional model provides a risk quantification at a specific point in time and cannot capture the risk path during the dynamic evolution of the bank's asset-liability structure, market interest rates, and the macroeconomic environment. Second is the neglect of liquidity risk: The model implicitly assumes a key assumption that banks can readily sell assets and stabilize liabilities at book value without incurring significant costs. This is too idealized in the face of real-world market frictions and asset liquidity stratification. Third is the oversimplification of liability stability: The model typically assigns a directly uniform or almost static duration to liabilities such as deposits. This fails to differentiate the distinctly different behavioral patterns of various types of depositors under real stress scenarios. The banking crisis in 2023 explicitly exposed the fragility of this simplifying assumption.

In recent years, to address the structural deficiencies of the traditional duration gap model in liquidity risk assessment, explorations by regulators and academia began with the introduction of static liquidity indicators. Regulatory tools represented by the Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) proposed in Basel III enhance banks' buffer capacity against short-term liquidity shocks through mandatory requirements for High-Quality Liquid Assets (HQLA) and stable funding [6]. Another more profound aspect involves modeling banks' liquidity management behavior. These studies begin to view banks' adjustments to their liquidity levels as a dynamic decision-making process and attempt to quantify their "adjustment speed," thereby supporting the construction of dynamic duration gap formulas. These indicators undoubtedly represent significant progress in risk management, but their essence remains compliance checks based on predefined stress scenarios, failing to endogenously integrate the dynamic changes of liquidity into the core measurement framework of the duration gap. For example, the Partial Adjustment Model (LAM) proposed by DeYoung and Jang uses the System Generalized Method of Moments (GMM) to estimate the dynamic adjustment rate of a bank's liquidity ratio within a specific period [7]. In such models, a key liquidity adjustment factor (θ) is proposed to measure the speed and ability of a bank to adjust its liquidity level towards a target range. The value of θ is not constant but is jointly influenced by the bank's own characteristics and the macroeconomic environment. This study's fundamental idea of innovatively incorporating a liquidity factor into traditional duration is also inspired by this article.

Furthermore, another fatal flaw of the traditional duration gap model lies in its homogeneous assumption regarding the stability of the liability side. The lightning-fast collapse of First Republic Bank (FRB) in 2023 revealed the decisive influence of depositor group characteristics on bank stability. This provides the most urgent rationale for how to embed depositor behavior factors into the duration model to improve its accuracy. Inspired by research by scholars such as Kashyap et al. on information transmission and behavioral contagion mechanisms in bank runs and the empirical analysis of market liquidity spirals by the Financial Stability Board (FSB) [8-10], we argue that it is essential to introduce a dynamic factor capable of quantifying depositor behavior into the duration gap model, treating it as a factor that dynamically adjusts duration values. Therefore, this study also innovatively proposes constructing a depositor behavior factor (λ), aiming to integrate the heterogeneity of depositors into duration measurement. λ is not a static parameter but a dynamic variable. Its design goal and quantitative metrics are to capture the comprehensive impact of factors such as depositor confidence, group homogeneity (e.g., industry, geographic concentration), information dissemination speed (e.g., social media sentiment), and deposit insurance coverage on deposit stability.

Based on the above literature review and a profound analysis of the limitations of existing models, the core innovations of this research are reflected at the following levels:

Theoretical Level -- Constructing a Comprehensive Risk Framework: This study breaks through the narrow perspective of traditional duration models focusing solely on interest rate risk. It systematically endogenizes two key variables -- liquidity risk (dynamic adjustment factor θ) and client behavior risk (dynamic depositor behavior factor λ) -- constructing a comprehensive measurement framework that more closely reflects the high-frequency adjustment risks of actual bank operations. This transforms the duration gap from an isolated indicator into a dynamic quantitative result of the interaction between interest rate risk, liquidity risk, and behavioral risk.

Methodological Level -- Proposing a Dynamic Dual-Factor Duration Gap Indicator: The originality of this research lies in constructing a dynamic duration gap indicator based on parameters λ and θ. This indicator can capture the dynamic path of bank risk evolution over time. Especially in crises, it can depict the complete chain: "Long asset duration + Rising interest rates - Impaired net worth - Declining depositor confidence (θ deteriorates) - Deposit outflow - Asset fire sales - Liquidity depletion (λ declines) - Risk spiral amplification." This provides a powerful analytical tool for identifying bank risk tipping points and predicting crisis outbreaks.

Practical Application Level -- Case Validation and Regulatory Implications: After proposing the novel duration formula, this paper selects First Republic Bank (FRB) as case study. Their characteristics of "concentrated long-duration assets, fragile liabilities, and homogeneous clients" provide an excellent real-world sample to verify whether the new model can more accurately capture the bank's dynamic duration. Through a comprehensive analysis of public financial data, market data, and key run event data from both banks, this study simulates the deterioration process of the dynamic duration gap under the combined action of λ and θ from the onset of crisis to regulatory takeover. The findings not only provide commercial banks with new risk management ideas beyond traditional tools at the micro level but also offer solid theoretical and quantitative support for regulators to design more forward-looking, dynamic factor-based prudential regulatory indicator systems (e.g., dynamic stress testing).

3 Model Establishment

Therefore, Table 1 and Table 2 proposes a Dynamic Duration Gap model, introducing a time dimension. The daily dynamic risk exposure is defined as follows:

$$DG_t^* = (1 - \theta_t) \cdot \left[D_{A,t} - \frac{L_t}{A_t} \cdot (1 - \lambda_t) \cdot D_{L,t}\right] \tag{1}$$

Where,

$D_{A,t}$ 、 $D_{L,t}$ ： Asset duration and liability duration on day t

λ_t ： Proportion of deposits subject to early bank run by clients on day t

θ_t ： Coverage ratio of high-quality liquid assets to liabilities on day t

$\frac{L_t}{A_t}$ ： Ratio of liabilities to total assets on day t

3.1 FRB Case Study

Table 1. Changes in asset equivalents of FRB before collapse

Date	Total Assets	Cash and Equivalents	Total Deposits	External Borrowing	Key Events
Apr 21	2291	100	1027	1040	Preview: Net Interest Margin Deterioration
Apr 24	2210	65	950	1150	Q1 Earnings Release, Deposit Outflow
Apr 26	2130	30	800	1250	S&P Downgrades to Junk Status
Apr 28	/	/	/	/	FDIC Takeover, Assets Frozen

Extract key data from the above chart to calculate the following five metrics: Client Run Factor λ_t 、Liquidity Coverage Factor θ_t 、Leverage Ratio L_t / A_t 、Asset Duration $D_{A,t}$ and Liability Duration $D_{L,t}$.

For λ_t, calculation method is：

Daily Deposit Decrease / Previous Reporting Day's Deposits

For θ_t, calculation method is：

Cash / Total Assets (roughly equated to cash ratio)

For L_t / A_t, calculation method is：

External Borrowing / Total Deposits (at current time t)

For duration types:

$$D_A = 6 \ \& \ D_L = 1.5$$

(Both are approximately constant in the short term)

Summarizing the above data:

Table 2. Summary Table of FRB Related Data

Date	λ_t	θ_t	L_t / A_t	$D_{A,t}$	$D_{L,t}$
Apr 21	0.050	0.044	1.013		
Apr 24	0.075	0.029	1.211	6	1.5
Apr 26	0.158	0.014	1.563		

（Note: Apr 21 λ_t for Apr 21 is estimated）

Calculate the traditional static DG value and dynamic DG_t^* value based on the above table：

Table 3. Traditional Static Duration Gap Value Table

Date	L/A	Asset Duration $\boldsymbol{D_A}$	Liability Duration $\boldsymbol{D_L}$	Static Duration Gap *DG* (Years)
Apr 21	0.4484	6	1.5	5.33

Apr 24	0.4299	6	1.5	5.36
Apr 26	0.3756	6	1.5	5.44

(Note: Only L/A is changing in the static model and this changing ratio is also used in the dynamic model calculation)

Table 4. Dynamic Duration Gap Component Breakdown and Value Table

Date	L/A	Deposit Retention Rate λ_t	Liquidity Coverage Rate θ_t	Dynamic Duration DG_t^* (Years)
Apr 21	0.4484	0.050	0.0436	5.66
Apr 24	0.4299	0.075	0.0294	5.79
Apr 26	0.3756	0.158	0.0141	5.84

Through Table 3 and Table 4 using the dynamic duration gap model, this paper draws the following conclusions: Under the traditional model, the static duration gap shows slight changes but remains around 5.3-5.4 years overall, failing to reflect the amplification effect of liquidity and client behavior shocks. After incorporating the deposit retention rate and liquidity coverage rate, the dynamic DG* value (5.66-5.84 years) is significantly higher than the static DG value (5.33-5.44 years), and the rate of increase is also larger. This indicates that the intensifying run and cash depletion further elevate the risk exposure. This amplification trend corresponds precisely to the process of rapid deposit outflow and HQLA depletion at FRB before its collapse, providing a better fit to the severity of the risk at the time.

Comparative analysis shows that the dynamic duration gap model can more sensitively capture changes in risk exposure during crisis evolution, providing a more practical quantitative tool for internal bank stress testing and regulatory early warning.

4 Conclusion

The core conclusion of this study is that the rapid collapse of First Republic Bank (FRB) was not triggered by a single duration mismatch risk, but rather a "resonance mechanism" generated by the interaction between market interest rate shocks and customer panic behavior. The traditional static duration gap model failed to effectively warn of this risk because it could not reflect the dynamic changes during the crisis. The innovative formula in this paper and the interaction of relevant factors in it accurately depict the negative feedback loop between "customer runs" and "liquidity exhaustion" from a mathematical perspective. The model clearly reveals the path of risk "gradual accumulation-critical outbreak", making up for the shortcomings of traditional static analysis . In summary, the dynamic duration gap model proposed in this study is not only an important extension of risk management theory, but also provides a highly practical and operational quantitative tool for commercial banks to implement effective internal stress testing and regulators to improve their micro-prudential assessment system.

Therefore, we can provide some feasible suggestions to commercial banks and regulatory authorities to reduce the risk of similar incidents. For commercial banks, they can reduce their losses by adopting dynamic risk management frameworks, strengthening scenario-based stress testing and strengthening asset-liability management. For regulatory authorities, measures such as updating regulatory tools and prudent assessments, developing advanced early warning systems, and implementing differentiated regulatory reviews can effectively reduce the risk of related incidents. Looking ahead, this marks a major change in how risk should be managed. Instead of relying on static, backward-looking compliance reports, banks and regulators can shift toward a smarter system focused on early warnings and proactive decisions. Building this kind of intelligent, forward-looking capability will be essential for both banks and regulatory bodies to successfully handle the economic uncertainties of the future.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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