

Value at Risk:
Applications for Analysis and Disclosure in the U.S. Banking Sector

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Abstract

The purpose of this paper is to encourage banks to extend existing market risk management analysis and disclosure via the well-known Value-at-Risk (VaR) methodology. An extension from trading book VaR to structural VaR is developed. In addition to the standard benefits of VaR measurement, two lesser-known benefits of the VaR process are highlighted:

- ☐ Efficient selection of portfolio-specific "worst case" stress test; and
- ☐ Determination of directionality in interest rate risk management

In order to help equity analysts and investors better understand the market risk tradeoffs inherent in banking the efficacy of disclosing Earnings-at-Risk (EaR) measures in conjunction with VaR is discussed.

The author would like to thank Thomas S.Y. Ho for his suggestions and comments on an earlier presentation of this paper. The author would also like to thank the staff and managements of certain regional banks for providing data and invaluable assistance during our work together as they migrate to Value- and Earnings-at-Risk analyses and disclosures.

Market Risk Reporting Requirements

The Securities and Exchange Commission (SEC) requires reporting banks to disclose quantitative and qualitative information about market risk (SEC, 1997). Three disclosure formats are suggested:

- ☐ *Tabular presentation of future cash flows with related fair values.* This usually takes the form of a liquidity GAP table (circa 1980) and Fair Value disclosures proscribed by SFAS 107 (circa 1990).
- ☐ *A sensitivity analysis disclosing earnings, cash flows, or value changes* based on hypothetical rate changes (e.g. +/- 100, 200, 300 basis points). This format is similar to the requirements of Thrift Bulletin 13, promulgated in 1987.
- ☐ *A probabilistic Value at Risk (VaR) analysis disclosing earning, cash flow, or value changes* emanating from market movements.

Compliance among the very largest financial firms has been quite high (Blankley, 2000). At non-bank financial firms, this has evolved into the generalized use of VaR disclosures. Within the banking sector, at the largest of banks, the VaR disclosure is typically used only for the trading book, comprising a small portion of assets. Most banks disclose their market risk positions using the cash flow or sensitivity measures, based on static or deterministic interest rate scenarios.

An abridged VaR disclosure for one of the ten largest banks in the U.S. reads as follows: “Our 1-day VaR limit for 2000 was \$30 million... we calculate 1-day VaR at the 97.5 confidence level... there were no days with losses greater than the VaR projections (First Union, 2000).”

Table 1

VaR Profile by Risk Type: 2000

In millions

Risk Category	High	Low	Average
Interest Rate	15.3	1.2	8.9
Foreign Exchange	3.3	0.3	1.3
Equity	7.8	0.3	4.0
Aggregate	15.5	5.5	10.2

This probabilistic disclosure, infrequent as is it in the banking sector, deals only with the trading book of the bank, comprising approximately 5% of assets. The remaining 95% of assets, all liabilities, and capital are ignored in this VaR disclosure. The remainder of the bank, or the structural bank, as it is commonly referred to, is covered in the less rigorous sensitivity analysis disclosure format utilizing deterministically based, implausible parallel yield curve shifts. Prior to reviewing our structural VaR approach, a brief review of VaR methodology is presented.

VaR Methodologies

As is well known, there are three primary VaR calculation methodologies:

- 1) Parametric methods variously referred to as the correlation-covariance method, or the delta-normal or delta-gamma approaches. J.P. Morgan standardized this as RiskMetrics in 1994. This is typically a closed-form process and is used by some financial firms to analyze and disclose market risk.
- 2) Historical simulation, or extreme event stress tests. This methodology replicates market risk factors including:
 - ☐ The 1987 U.S. equities market crash.
 - ☐ The 1998 Russian, Asian, and Long Term Capital Management crises.
 - ☐ Rapid interest rate increases, in the following years:

- 1994, when the Fed Funds rate increased 250 basis points.
- 1977-1981, when the Fed Funds rate increased over 1500 basis points in forty-eight months.

F6 Rapid interest rate decreases, in the following years:

- 2001, when the Fed Funds rate decreased by 250 basis points in six months.
- 1991-93, when the Fed Funds rate decreased 500 basis points in twenty-four months.

3) Monte Carlo or Quasi- Monte Carlo methods, perhaps more correctly a stochastic process. At its simplest, Monte Carlo simulation is the procedure by which random future rate paths are generated and used to derive path dependent cash flow schedules. It uses stochastically generated rate paths and associates cash flows to value interest rate contingent financial instruments (Linsmeier, 2000 and Rahl, 2000).

VaR Benefits

Given the relatively large resource commitment to implementing a VaR process, it is doubtful that financial institutions utilize their VaR-based risk analyses and reporting solely for regulatory compliance. Rather the implementation of a VaR-based market risk system has significant benefits, with regulatory compliance an ancillary benefit. These include:

- F6** A way to describe the magnitude of likely losses in a portfolio.
- F6** The likelihood of those losses.
- F6** A method to monitor, manage and control risk (Linsmeier, 2000 and Rahl, 2000).

Stakeholders in publicly traded banks should favor and benefit from the increased risk-management capabilities that the VaR process provides, as well as their disclosure.

Market Risk Analysis for the Structural Bank Balance Sheet

Most VaR-based market risk disclosures utilize a VaR process based on closed-form solutions and focus on the very short-term, usually one to thirty days. In the banking sector, market risk disclosures utilize an opposite, and perhaps apposite approach, focusing on the effective lives of assets and liabilities utilizing simulation analysis. In addition, banking market risk disclosures tend to focus solely on the interest rate risk component of market risk, as does this article. Note that this approach can be readily extended for joint or separate consideration of credit, liquidity and other risk types (Bangia, 1998 and Ho, 1999).

Trading portfolio assets tend to have well-defined cash flow characteristics, with standardized cash flow mapping, and readily available correlations and cross-correlations. Bank balance sheets, in comparison, are replete with financial instruments with either indeterminate and/or interest rate contingent cash flows. More intricate examples include credit card and line of credit loan types, also seen in investment portfolios in securitized equivalents and non-maturity deposits. Due to the predominance of option-laden instruments on bank balance sheets, closed-form solutions are not typically used for the structural bank, except in stylized examples (Ho, 1999).

Extensive discussions of instrument-level modeling specifics are outside the scope of this paper, but a brief explication of the approach rendered is germane. For financial instruments with active

public, secondary marketplaces, industry-standard valuation approaches (e.g. Discounted Cash Flow, Option Adjusted Spread and matrix pricing, etc.) are utilized. Modeling and valuing structural balance sheets can be problematic, as one class of financial instruments, non-maturity deposits (e.g. demand, savings, and money market deposit types) comprise up to fifty percent of bank liabilities. Lacking a public market, there is no general consensus regarding appropriate modeling and valuation methodologies among marketplace participants, regulators and academia for non-maturity deposits.

Partial details of the approach utilized by the author to value non-maturity deposits have been presented elsewhere, but the full explication is in pre-publication status (Poorman, 2000 and 2001-2). A relevant analogy to our proprietary method would be to refer to Bloomberg Financial's use of prepayment estimates from various models and methodologies to develop a median market consensus estimate (Hayr, 2000). In general, it is worth noting that most observers agree that bank non-maturity deposits exhibit sticky, asymmetric behavior pricing behaviors, while disagreeing on standard financial instrument metrics including duration, fair value, and sensitivity to interest rate changes (Hawkins, 2000 and Poorman, 2001-2).

Disclosures utilizing the sensitivity analysis format typically use pre-programmed deterministically generated scenario analysis to simulate possible exposures and outcomes. Banking regulators and bankers use the concept of Economic Value of Equity (EVE) to refer to the net fair value of assets, liabilities, and off-balance sheet positions, similar to the use of surplus in the insurance sector (FFIEC, 1996).

Within the banking sector, the primary method for analyzing and managing market risk is usually referred to as Asset/Liability Management (A/LM). A/LM has been defined as: “The coordinated approach to the management of loans, investments, deposits, borrowing, capital, and liquidity in order to achieve the institution’s objectives within prudent risk limits (Essert, 1997).” The goal of successful A/LM is seen as “ensuring that net interest income and the net economic value of the balance sheet remain positive and stable under all probable scenarios (Essert, 1997)”. Correspondingly, bank market risk models are frequently referred to as A/LM models.

Some of the more advanced vendor-built A/LM models used by the banking sector are capable of producing VaR analyses utilizing historical and/or stochastic process approaches. A necessary and integral component of a VaR-based bank A/LM approach is a suitable interest rate model.

Minimum requirements for utilization of a stochastic interest rate model include:

- ☐ Creation of arbitrage-free forward term structures of interest rates.
- ☐ Capability of utilizing historical or implied market volatilities.

Numerous interest rate models have been proposed for evaluating rate-contingent financial instruments. The model used and discussed herein is the well-known continuous single factor Black-Derman-Toy (B-D-T) model (Black, 1990). In this VaR analysis, the B-D-T model is modified for user-defined selection of:

- ☐ Long volatility;
- ☐ Short volatility; and
- ☐ The speed of the reversion process, via selection of the long and short periods.

The strengths and limitations of the B-D-T model are well known, which is of benefit to marketplace participants (Kazziha, 1997). As such, the B-D-T model is commonly used to model fixed income securities and derivatives. For example, it is used in Bloomberg Financial's Option Adjusted Spread (OAS) analysis to benchmark fixed-income values, including those derived via bank A/LM models.

The selection of a stochastic rate component is equally important in generating and valuing rate-contingent cash flows (Payant, 1995). The primary choices include:

- ☐ A random Monte Carlo simulator; or
- ☐ A lattice based model, primarily:
 - Binomial (rates go up or down), or
 - Trinomial (rates go up, down, or remain stationary).

The model utilized to generate interest rate scenarios is referred to as linear path space (LPS), which is a sampled 360-month binomial lattice imposed on a 360-month trinomial lattice (Ho, June 1992). Essential to this sampling reduction process is the notion of key rate durations (Ho, Sept. 1992). For interest rate modeling, and thus VaR analysis, rates for terms out to 360-months are represented by seven points along the full yield curve. In the sensitivity analysis disclosure format, there is a sole source of interest rate sensitivity – unrealistic parallel yield curve shifts. In the VaR format presented herein, there are now seven sources of interest rate risk, based on the key rate durations, which may be specific to the bank (Ho, 1999). Furthermore, due to the user-defined volatilities and reversion speed, all seven points have their own volatility.

The sampling reduction is important as computation time, and resultant analytical time, are non-trivial, as a 360-month binomial lattice has 2^{360} interest rate paths. The sampled linear path space represents 89.9% of the 2^{360} paths, reduced to a more manageable, and probability-ranked, 269 paths. Further, the implementation reviewed herein uses 101 of the highest probability LPS paths, which is equivalent to 91.3% of the linear path space, and is in excess of 80% (89.9 x 91.3) of the 2^{360} binomial lattice. This reduction approach is congruent with the notion of Pareto optimization, known as “the 80/20 rule in A/LM” (Uyemura, 1993).

Suggested VaR Disclosure Format

At a minimum, our suggested disclosure format follows the abbreviated example of *Table 1*, but includes the entire balance sheet and uses the “lifetime VaR”, rather short-term VaR (Arnold, 1998). The suggested format also uses percentages of EVE at risk, congruent with regulatory and industry practice used for the sensitivity disclosure format (FFIEC, 1997). Our examples utilize two banks scaled to a common size (\$20 billion assets), with balance sheets, interest rates and implied swaption volatilities as of March 2001.

A sample market risk disclosure should read: Our lifetime VaR limit for the Economic Value of Equity is 25% ... we calculate lifetime VaR... at the 99% confidence level (two tailed).

Table 2

VaR Profile: March, 2001

Lifetime VaR%	Quarter-end
Interest Rate Risk	16.8%

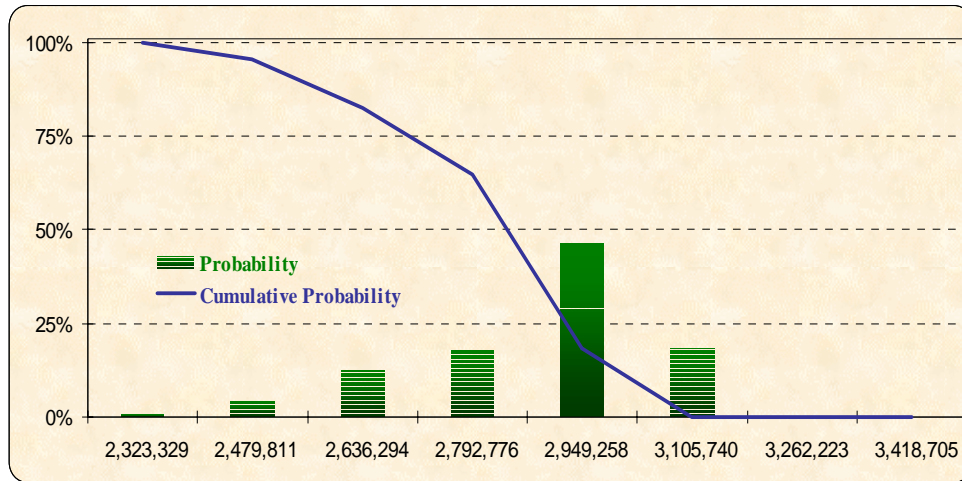
Next, add a more complete VaR profile for internal reporting, and possibly for external disclosure purposes, including at a minimum:

- ☐ Tabular, or numerical descriptions of the probability distributions; and
- ☐ Graphical depictions of the same.

Chart 1

VaR Profile: March, 2001

\$ 000



Standard deviations	<-3	-3 to -2	-2 to -1	-1 to mean	mean to +1	+1 to +2	+2 to +3	+3 to +4
Market Value	2,323,329	2,479,811	2,636,294	2,792,776	2,949,258	3,105,740	3,262,223	3,418,705
Probability	1%	4%	13%	18%	46%	18%	0%	0%
Cumulative Probability	100%	96%	83%	65%	18%	0%	0%	0%

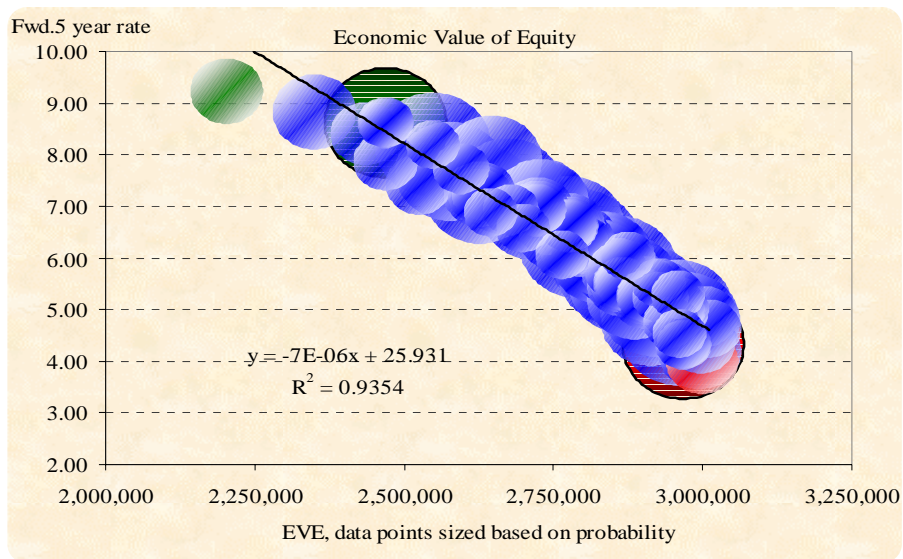
A fuller set of probabilistic disclosures allows for a more comprehensive analysis of the VaR profile, including skewness and kurtosis. In the example above, the outcomes are skewed to the left or toward unfavorable results, consistent with the negative convexity of many bank assets and leveraged balance sheets. Disclosure of this profile would allow investors to more carefully select suitable bank equity investments, based on their individual utility functions, as expressed by risk/return preferences.

In the banking sector, it is customary to refer to a bank's market risk exposure to interest rates by referring to them as either asset- or liability-sensitive. This shorthand jargon emanates from the use of GAP analysis and disclosure in the early 1980s; nonetheless, it is still commonplace. The so-called asset-sensitive bank benefits from increasing rates, whereas the liability-sensitive bank benefits from decreasing rates. An indication of directional exposure to interest rate changes is the focus of the sensitivity analysis disclosure format, but this is frequently excluded from VaR disclosures. Therefore, supplemental analysis and disclosure may be useful to the investing public:

- ☐ A measure of directionality;
- ☐ A valuation benchmark; and
- ☐ The goodness of fit, or R^2 , of the measure.

The following example uses the average (lifetime) five-year swap rate as a benchmark. The use of this benchmark rate is precisely analogous to the concept of key rate duration (Ho, 1992). A simple linear regression of the benchmark rate, or key duration, versus EVE suggests that there is strong linear relationship between variables, with an unadjusted $R^2 = 0.9354$. Furthermore, in this example, the most negative outcome is based on the most extreme increasing rate scenario (identified by the color-coded data point). Deterministic, or historic stress test scenarios endeavor to mechanistically identify extreme scenarios (Wee, 1999). Our suggestion is that a more efficient and parsimonious approach is to utilize a VaR process, as outlined herein, to identify potentially perilous scenarios, including those that exceed policy guidelines (Breuer, 2000). Risk mitigation strategies, including off-balance sheet hedging, may be custom-engineered for scenarios that exceed policy or risk tolerances.

Chart 2
VaR Profile: March, 2001
 \$000



In this VaR construct, the use of volatility shocks, or alternative volatility scenarios, may serve as another variant of stress testing. Combined with goal-seeking methodologies, subject to real world constraints, the VaR toolkit may be expanded to include value optimization for the structural bank.

Earnings-at-Risk (EaR) measures

Although VaR has received much academic and marketplace attention, it is arguable that both bank managements and investors remain focused on earnings-based approaches. The use of VaR and EaR disclosures is not an either/or proposition, rather it is, or should be, an “and” proposition. Our EaR analysis and sample disclosures use the same format and bank previously used for the VaR analysis. A sample EaR disclosure should read: Our first year EaR limit for Net Interest Income (NII) is 10% ... we calculate first year EaR ... at the 99% confidence level.

Table 3

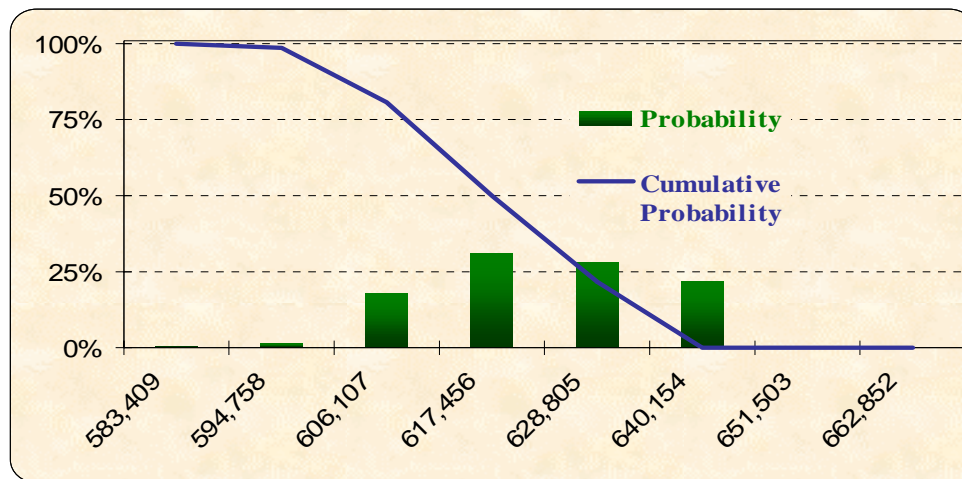
EaR Profile: March, 2001

First year EaR %	Quarter-end
Interest Rate Risk	5.5%

Chart 3

VaR Profile: March, 2001

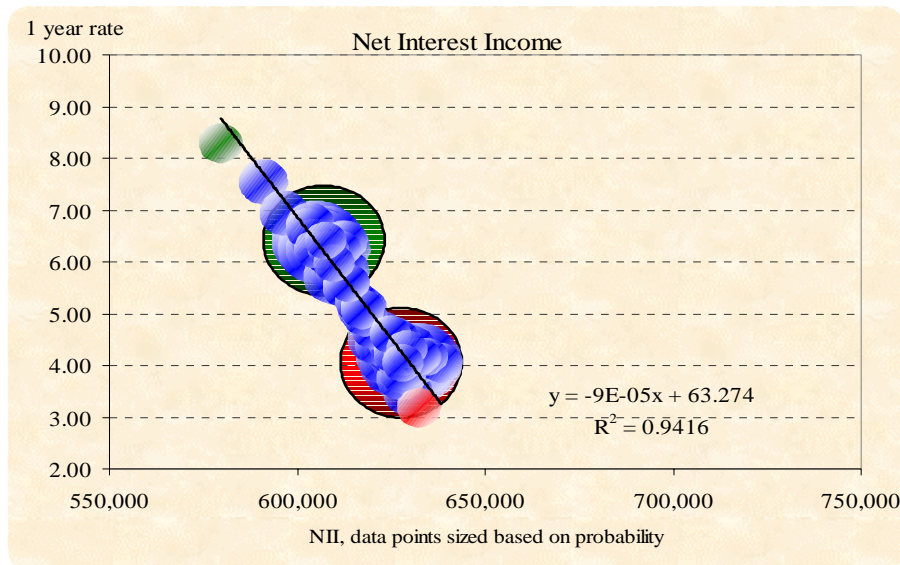
\$ 000



Standard deviations	<-3	-3 to -2	-2 to -1	-1 to mean	mean to +1	+1 to +2	+2 to +3	+3 to +4
Net Interest Income	583,409	594,758	606,107	617,456	628,805	640,154	651,503	662,852
Probability	1%	1%	18%	31%	28%	21%	0%	0%
Cumulative Probability	100%	99%	81%	50%	21%	0%	0%	0%

A fuller set of probabilistic disclosures allows for a more comprehensive analysis of the EaR profile, including skewness and kurtosis. In the example above, the outcomes are somewhat normally distributed, with slight kurtosis. Disclosure of this EaR profile, in conjunction with the VaR profile, would further allow investors to select suitable equity investments, based on their individual utility functions. As with the VaR disclosure, an EaR disclosure indicating directional sensitivity should be included.

Chart 4
VaR Profile: March, 2001
 \$000



The above example uses the average (earnings horizon) one-year swap rate as a benchmark. A simple linear regression of the benchmark rate, or key duration, versus EVE suggests that there is a strong linear relationship between variables, with an unadjusted $R^2 = 0.9416$. It may be of interest to note that the most negative outcome is based on the most extreme increasing rate scenario (identified by the color-coded data point). The same scenario that results in the most unfavorable long-term results, as measured by VaR, results in the “worst case” scenario from an earnings standpoint. Several points are worth highlighting:

- ☐ A short-term rate decrease is favorable from an earnings and a valuation standpoint. Note that this is not necessarily always the case
- ☐ The selection of risk mitigation strategies, including off-balance sheet hedging may be dependent on income/value tradeoffs.
- ☐ Different benchmarks, or key rates, may be significant for value and earnings measures, and for different banks.


Comparative Analysis and Investor Utility

Bank A, in isolation, provides a case study for structural VaR and EaR analysis and disclosure. Investment decisions, including stock selection, are usually not made in isolation without consideration of inter- and intra-sector alternatives. Many, especially so-called active investors and managers, believe that security selection, rather than sector- or asset class-allocation, is the primary performance determinant. It is only by comparison to investment alternatives that utility preferences, or unique risk/return profiles are established. To establish the utility preference hierarchy, or the “optimal frontier,” the VaR and EaR profiles of Banks A and B are presented (Schirripa, 2000).

Table 4
EaR & VaR Profiles: March, 2001

Comparative Analysis	EaR (99%)	Directional risk: EaR	EaR R²	VaR (99%)	Directional risk: VaR	VaR R²
Bank A	5.5%	Increasing short rates over 1-year horizon	0.94	16.8%	Increasing intermediate rates over long-term horizon	0.94
Bank B	10.5%	Decreasing short rates over 1-year horizon	0.99	2.6%	Uncertain	0.14

With disclosure of EaR and VaR measures, including interest rate directional exposure, investors can select suitable investments based on their risk preferences and views on prospective interest rate changes. In the context of utility and optimal frontier theory:

 Bank A would be favored over Bank B by those investors preferring less EaR volatility.

- ☐ Investors preferring less VaR volatility would prefer Bank B to Bank A.
- ☐ Short-term, earnings-focused investors with a bias towards continued decreases in short rates would, ceteris paribus, prefer Bank A to Bank B.

The external disclosure of Value and Earnings at Risk data has important benefits for the investing public as it offers additional information to assist in the investment decision-making process. This methodology is perhaps even more valuable for internal analysis and decision-making at banks, as it can provide new insights into their unique risk profile. Equipped with this vital management information, banks may better manage their various business lines, as risk management is indeed the business of banking.

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