NIBM WORKING PAPER SERIES

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Working Paper

(WP34/2024)

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INDIA
February 2024

Citation Guideline:

Basu, Sanjay and Tasneem Chherawala (2024), "Risk Management in Banks and Financial Institutions in India: A Synoptic View". NIBM Working Paper WP34/February.

https://www.nibmindia.org/static/working_paper/NIBM_WP34_SBTC.pdf

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NIBM Working Paper No. 34
February 2024

ABSTRACT

This paper offers a nontechnical overview of risk management in banks and financial institutions, with special reference to India. It begins with the evolution of banks and risk management practices over several centuries. It describes the genesis of the Basel Accords, against the backdrop of global financial instability during the 1970s. The transition from Basel I to Basel II is explained in the context of a series of financial crises. The article proceeds to describe the salient features of Basel III, in light of the global financial meltdown from 2007 onwards. It discusses the progress made by Indian banks, towards the implementation of the Basel Accords. It describes the important techniques and concepts for measurement of material risks and outlines the Indian experience. It concludes with a snapshot of the emerging risks, and underlines the need for due weightage to the traditional ones.

JEL Code: G21, G23, G28

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> But ships are but boards, sailors but men; there be land rats and water rats, water thieves and land thieves—I mean pirates—and then there is the peril of waters, winds, and rocks. The man is, notwithstanding, sufficient. Three thousand ducats - I think I may take his bond.
>
> Shylock, *The Merchant of Venice*, Act 1 Scene 3.

Section I
Introduction

The word *risk* is derived from the early Italian *risco* (danger) and *rischiare* (run into danger). The etymology has two connotations – exposure and uncertainty. Unless agents choose to take positions, which lead to potential losses, there is no risk. For instance, a game of dice, in which a kingdom was at stake, led to the battle of Kurukshetra. Another roll of the dice, in Greek mythology, gave Zeus the Heavens, Poseidon the Seas and Hades the Underworld (Bernstein 1996).

The discipline of risk management has come a long way. The early probability models of Pacioli and Cardano, the binomial theorem of Pascal, utility theory, risk aversion and law of large numbers by the Bernoullis, the bell curves of De Moivre and Gauss, regression analysis of Galton (Bernstein 1996) and Monte Carlo methods of Ulam and von Neumann – the conceptual edifice has been created over many centuries. As the subject has progressed, its applications have expanded – from insurance to loan, bond, stock and derivative markets. Special institutions like banks have emerged to manage a diverse spectrum of risks.

In this paper, we discuss the evolution, regulation and techniques of risk management in banks and financial institutions, with particular emphasis on India. We argue that risk management tools, concepts and standards have developed in response to market turbulence. We illustrate how the scope of regulatory guidelines widened over time - between Basel I and Basel III – to address a broader set of risks. We describe the management tools for material risks and outline the progress made by Indian banks. In conclusion, we highlight some emerging risks that will engage banks and regulators, in India and abroad.

This article is structured as follows. In Section II, we summarize the history of risk management in the banking sector. Section III portrays the transition from Basel I to Basel III. In Section IV, we discuss the measurement techniques for Credit, Market, Operational and ALM risks. Section V concludes, with a synopsis of the emerging risks to the banking sector. We provide a glossary, in the Annexure, with definitions of the key risks faced by banks.

Section II
Evolution of Banks and Risk Management

Thirteenth-century Italy was a vibrant centre of trade and commerce, which attracted merchants from Asia and Europe. They found it difficult to choose between various projects with uncertain payoffs. At this juncture, Leonardo Pisano or *Fibonacci*, a young man trained in Hindu-Arabic arithmetic, wrote the *Liber Abaci* (Book of Calculations) in 1202. This remarkable treatise on business mathematics introduced not only the famous Fibonacci series, but also the concept of *present value* – the current worth of a stream of future cash flows (Goetzmann 2016). The first step towards risk measurement was taken.

The practice of usury – which lies at the heart of present valuation – was forbidden in all Abrahamic religions. Yet, Jews opted to focus on finance because international trade was dominated by Christians and Muslims[1]. They used a clause in the Old Testament, which allowed them to lend at interest to non-Jews. From the fourteenth century, they appeared in the Italian marketplace, on their benches or *bancos*, to accept deposits and make loans (Ferguson 2008). When deposits were lost, the benches were broken and they became *bankrupt* (from *banca rotta* i.e. broken bench). These benches were the precursors to modern banks.

Medieval bank loans were short-term overdrafts against deposits. Since borrower type was hard to verify, depositors were preferred. In turn, banks maintained high levels of capital adequacy (more than 50%), to signal their own quality (Rajan 1998). With the advent of the Industrial Revolution, in countries like Germany, Belgium and Italy, banks extended long-term loans, purchased bonds and shares of firms with long-term projects. These assets were funded with equity capital, rather than short-term deposits (Da Rin and Hellmann 2002). Such a strategy reduced liquidity risk for banks. Hence, banks had to manage credit risk, market risk, asset-liability mismatch and capital adequacy, to finance rapid industrialization in continental Europe, during the nineteenth century.

The high noon of globalization, from the second half of the nineteenth century, was also scarred by recurrent financial crises. As a result, the Federal Reserve System was established in 1913, to regulate banks and provide lender of last resort facilities. Deposit Insurance was introduced in 1933, after a spate of US bank failure during the Great Depression. The Bretton Woods agreement, which tied the US Dollar to gold after World War II, led to prolonged macroeconomic stability. In tranquil markets, there was no need for risk management. The collapse of the Standard in 1971, and the oil price hike by OPEC in 1973, ushered in two decades of unprecedented global turbulence.

This period was characterized by spikes in interest rates and instability in equity prices, exchange rates and commodity prices. Banks collapsed due to wide asset-liability mismatches and high default rates, the Latin American debt crisis occurred, junk bonds flourished and failed and the Dow Jones index crashed in October 1987. New models for risk measurement were introduced while structured products and derivatives were developed to manage potential losses. At the same time, capital adequacy ratios (CAR) plummeted, to a range of 4% - 6%, at large US banks. Most Japanese banks had capital-

[1] For instance, a group of North African Jewish (Maghribi) traders had to devise innovative punishment strategies, to preserve their coalitions, in the eleventh century (Greif 1993).

deposit ratios of around 4%. The domain of risk management was ripe for Basel regulations, which is described in the next section.

Evidence of professional banking in India has been found at least from the fourth-century BC. Kautilya's *Arthashastra* provided explicit rules for asset liquidation, in case of loan default. The system of *hundis* or bills of exchange had been prevalent, at least since the twelfth century AD. The creation and merger of three Presidency banks in Calcutta, Bombay and Madras in the nineteenth century, along with the establishment of several *Swadeshi* banks, laid the foundation of modern banking in India. The Reserve Bank of India was founded in 1934, in the wake of the Great Depression. The sector was jolted by the Second World War and the partition of the country (RBI 2008).

The first decade after independence was marked by a sharp decline in capital-deposit ratio (from 9% in 1950 to 4% in 1960), widespread bank failure, merger and amalgamation. Deposit insurance was introduced in 1962 and banks were nationalized in 1969 and 1980. However, the capital-deposit ratio for public sector banks fell further to 2% by 1991. NPAs soared to 23.2% of domestic advances in 1993, based on revised income recognition and asset classification norms. Hence, despite the sharp reduction in CRR and SLR, banks switched to safer assets like government securities, during the 1990s (RBI 2008). However, concomitant interest rate deregulation not only put pressure on Net interest Margins, but also exposed their investment portfolios to large MTM losses. Stock market anomalies were also bared during this decade. The East Asian crisis of 1997, and the Russian default a year later, aggravated exchange rate volatility as well. In sum, elevated market turbulence, high levels of NPAs and low capital adequacy provided fertile ground for implementation of global regulatory standards, after financial sector reforms were introduced in India.

Section III
Evolution of the Basel Standards

In the aftermath of bank failure in US and Europe (particularly, Bankhaus Herstatt in West Germany), the need to focus on financial stability brought together the central bank Governors of the Group 10 countries in 1974. The Basel Committee on Banking Supervision (BCBS) was formed under the aegis of Bank for International Settlements. This committee reached a consensus on a uniform set of standards for bank capital norms. In July 1988, it released the first guidelines in a series of capital adequacy norms, known as the Basel Capital Accord (popularly Basel I). Over time, revised, upgraded and enhanced versions of the Basel norms have been issued, and adopted virtually worldwide. The progression of the Basel Standards has traced key financial market developments. Major amendments have typically been triggered by regulatory lessons from successive financial crises.

Basel I instituted a minimum CAR of 8 percent, estimated as the ratio of regulatory capital (Tier 1 capital comprising primarily equity and reserves and Tier 2 capital comprising subordinated debt and other eligible funds) to risk weighted assets (RWA) of on and off-balance sheet credit exposures of banks as follows:

$$CAR = \frac{Tier\ 1\ Capital + Tier\ 2\ Capital}{Risk\ Weighted\ Assets\ (on\ and\ off-balance\ sheet)} \geq 8\%$$

The initial capital requirements were prescribed only for credit risk. Despite the taxonomy, the risk weights were broad-brush, subjective and did not differentiate risks in loan portfolios. In 1996, the framework was refined to incorporate market risks for forex, equity and interest rate exposures in the trading book. Banks could choose between standardized and internal models to estimate their market risk capital requirements. The Reserve Bank of India introduced Basel I for commercial banks in April 1992. The minimum CAR for Indian banks was raised to 9 percent in 1998.

The uniformity of CAR, across rating classes, created opportunities for regulatory capital arbitrage, under Basel I, with strategies like asset securitization. Furthermore, other risks like operational risk, liquidity risk, credit concentration risk, reputation risk were not considered in the framework. This necessitated the revision of existing norms. Hence, Basel II was introduced in June 2004. It was founded on three pillars of capital adequacy assessment, supervision and disclosures. Pillar 1 continued to stipulate a minimum capital to risk weighted assets ratio of 8 percent. However, the coverage was enhanced to include operational risk, over and above credit and market risks. The Pillar 1 CAR formula was thereby revised as:

$$CAR = \frac{Tier\ 1\ Capital + Tier\ 2\ Capital}{Credit\ RWA + Market\ RWA + Operational\ RWA} \geq 8\%$$

The standardized risk weights (especially for credit exposures) were modified to improve their risk-sensitivity. More importantly, banks were incentivized to make continuous improvement in risk management through migration from standardized and prescriptive risk weights to internal capital models (Table 1). Under Pillar 2, banks had to conduct an internal capital adequacy assessment process (ICAAP), for risks beyond those captured in Pillar 1 and stress test their current and future capital requirements. The Pillar 2 risk assessment was principles-based and flexible rather than prescriptive. ICAAP was included under the Supervisory Review and Evaluation Process (SREP) of Pillar 2, which enabled authorities to evaluate the internal capital assessment process and initiate timely intervention to reduce risks, strengthen controls and prevent capital shortfall. Detailed risk related disclosures were introduced under Pillar 3 to improve transparency of banks' risk profiles and strengthen market discipline.

[Table 1]

The New Capital Adequacy Framework (NCAF), aligned to the Basel II guidelines of BCBS, was made effective for Indian commercial banks from March 2008 onwards. RBI initially permitted only the standardized approaches for measurement of risk weighted assets under Pillar 1. Subsequently, guidelines were issued for transition to the Internal Models Approach (IMA) to market risk (April, 2010) and the Internal Ratings Based Approach (IRB Approach) to credit risk (December 2011). Assessment of India's compliance with Basel regulations (RCAP, 2015), by the BCBS, revealed that till end-September 2014, fourteen banks had applied for migration the IRB Approach and five banks had applied for migration to the IMA. However, none of the banks had received regulatory approval for adoption of advanced approaches. Thus, during the entire Basel II era, regulatory capital adequacy in India was driven by standardized methods.

The occurrence of the global financial crisis (GFC), between 2007 and 2009, coincided with the phased implementation of Basel II in many countries, including India. Widespread bank failure and fallback on central banks for liquidity support and federal governments for bailouts, during the crisis, suggested that existing Basel standards had failed to ensure financial stability. First, many of the risks in banking businesses were underestimated under Basel II. Secondly, the financial system as a whole and the systemically important banks, in particular, were overleveraged, under-capitalized and lacked adequate liquidity buffers. Thirdly, unconstrained interconnectedness among financial institutions could make losses contagious. Finally, the Basel II capital formulae were procyclical, i.e. regulatory capital charges escalated during downturns rather than in a pre-emptive manner. The Basel Committee faced twin challenges: to (i) strengthen regulations which address micro-prudential risks of individual financial institutions and (ii) introduce macroprudential overlays that counter systemic risk.

In December 2010, BCBS issued the first version of Basel III endorsed by the G20 (revised in June 2011), which included two parts – *Basel III: International framework for liquidity risk measurement, standards and monitoring* and *Basel III: A global regulatory framework for more resilient banks and banking systems*. Figure 1 summarises the key components of these guidelines.

[Figure 1]

Under micro-prudential measures, Basel III increased the minimum Common Equity Tier 1 (CET1) capital to 4.5% of RWAs, since it has the best loss absorbing capacity vis-à-vis other regulatory capital funds. Capital Conservation Buffer (CCB), prescribed at minimum 2.5% CET1 of RWA, added another cushion to absorb losses during financial and economic stress and protect available capital by restricting earnings distribution when breached. Thus, the effective minimum CAR under Basel III became 10.5%, within which minimum CET1 ratio is 7%.

$$CAR + CCB = \frac{Tier\ 1\ Capital + Tier\ 2\ Capital}{Credit\ RWA + Market\ RWA + Operational\ RWA} \geq 8\% + 2.5\%$$

New features like loss absorption trigger and point of non-viability trigger, were mandated for non-equity capital instruments. Additional deductions were applied to CET1 funds to improve the quality of regulatory capital. The risk measures for derivatives and 7ecuritization exposures were enhanced and made more conservative. A Leverage Ratio (LR), wherein Tier 1 capital is at least 3.5% of a bank's total assets and off-balance sheet exposures (without risk weights), was introduced as a backstop to the CAR. Regulatory liquidity requirements were stipulated, for the first time, through the introduction of 1) a minimum 100 percent Liquidity Coverage Ratio (LCR) intended to provide adequate cash and near-cash assets which cover outflows over a 30-day stress period, and 2) a longer-term Net Stable Funding Ratio (NSFR) which addresses structural balance sheet mismatches. These elements of Basel III became effective in a phased manner over a transition period between 2013 and 2019.

Under macroprudential reforms, interconnectedness among financial institutions was discouraged. Exposures like investments by banks in the capital instruments of other banks, financial institutions and insurance companies, as well as interbank over-the-counter (OTC) derivative exposures which are not cleared through central

counterparties, were subject to higher capital charges. Bank regulators could also introduce a system-wide countercyclical capital buffer during periods of excessive credit growth, to prevent the buildup of credit risk, which can be drawn down after the busts. Furthermore, Systemically Important Banks (SIBs), specified by regulators, were subjected to additional requirements including higher CAR and LR to safeguard against moral hazard incentives, which stem from their too-big-to-fail status.

While the initial Basel III norms had retained the previous methods of RWA estimation under Pillar 1, as part of the post-crisis Basel III reforms (also sometimes referred to as Basel IV), BCBS implemented new rules in December 2017 (for credit and operational risk) and January 2019 (for market risk), which became effective from January 2023. In the revised methods, the risk-sensitivity, granularity and robustness of the standardized approaches for credit and operational risk were enhanced. The internal model-based capital charge for operational risk was disallowed. The revised IRB Approach for credit risk was subject to a capital output floor based on the standardized approach. The Fundamental Review of the Trading Book (FRTB) stipulated fresh rules for market risk estimation under both the standardized sensitivity-based metrics as well as internal models approaches, in which the focus is on tail risks. These measures are expected to restore credibility of RWA estimation and facilitate comparability of bank capital ratios.

Perhaps one of the biggest lessons from the financial crisis was that there had been a widespread failure of risk governance at the troubled banks and financial institutions. In many cases, risks were not managed at the enterprise level and not accounted for in corporate strategy. Risk management was isolated from business operations and perceived as a compliance obstacle. Worse still, bank boards were often ignorant of the risks facing the organization. As a consequence, under Basel III, the Pillar 2 and 3 expectations and guidance became more comprehensive and rigorous. The supervisory framework for measuring and controlling large exposures (referred to as the Large Exposure Framework or LEF) was revamped after more than two decades to ensure a common minimum standard for measuring, aggregating and controlling single name concentration risk. There was greater supervisory emphasis on board and senior management involvement in risk oversight. In particular, this entailed the development of an effective Board-approved risk appetite framework, aligned to the business strategy and capital plan and integrating it to decision-making processes, through appropriate risk limits and internal controls.

Thus, the finalized Basel III framework, as it stands at the end of December 2022, comprises comprehensive standards and guidelines (summarized in Figure 2) which encompass conservative assessment of a wide range of banking risks based on updated methodologies, and address risk governance, capital planning and disclosure requirements by banks.

[Figure 2]

India, as a member of the G20 nations, was represented by the RBI on the Basel Committee deliberating the revised standards. Hence, it was committed to Basel III implementation for Indian banks. Within two years of the publication of Basel III capital standards by BCBS, RBI had issued its own circular in May 2012, which came into force for all scheduled commercial banks from 1st April 2013. The first domestic version

broadly conformed to the international standards and introduced key capital reforms, including the capital conservation buffer. RBI's initial transition timeline for the phased increase in the minimum CAR and CCB was more aggressive – expected to be completed in five years as compared to the seven-year transition period of BCBS. Later, it got postponed by three years due to the impact of Covid-19. The higher overall CAR of 9% (11.5% including the CCB) vis-à-vis 8% percent (10.5% including CCB) prescribed by BCBS was retained, while increasing the minimum CET1 to 5.5% (8% including CCB). Banks were directed to start measuring their Leverage Ratio against an indicative benchmark of 4.5%, which was later relaxed to 3.5%. Liquidity risk standards and minimum requirements of LCR and NSFR were introduced in a phased manner. The large exposure framework (LEF) was introduced in 2016.

However, in terms of alignment to the revised risk estimation methodologies of Basel III, RBI has lagged behind the BCBS timelines. Guidelines for the new Standardized Approach for Operational Risk and Interest Rate Risk in the Banking Book (IRRBB) were issued in 2023, while the revised approaches for counterparty credit risk (SA-CCR), credit valuation adjustment (CVA), credit risk and market risk have not yet been initiated. In addressing systemic risk, RBI has been more proactive. The framework of identification of SIBs subject to higher capital buffers and the countercyclical capital buffer norms were issued in 2014 and 2015. Table 2 below summarizes the RBI timelines of adoption of Basel III and its final version.

[Table 2]

Section IV
Risk Management Tools

This section presents a concise discussion on the measurement and management techniques, for material risks. We omit items like strategic and reputation risks, for the sake of brevity.

IV.1. Credit Risk

Credit risk is a key business threat for banks and FIs since the major share of their business comprises on-balance sheet loans and advances and investments in instruments like bonds and debentures, non-fund-based credit facilities like loan commitments and guarantees and positions in derivative instruments – all of which are subject to the risk of default and impairment of assets. Credit risk management represents the process by which the cause of credit risk is identified, the severity and frequency of losses are measured and decisions on credit risk mitigation, control and management are taken. Over the last few decades, banks across the world have developed sophisticated models to measure and manage credit risk.

There are three drivers of credit risk for individual obligors. First, the likelihood of default by the obligor (also known as the Probability of Default or PD); secondly, exposure to the obligor which is subject to credit loss (also known as the Exposure at Default or EAD) and thirdly the loss rate (also known as the Loss Given Default or LGD) which depicts the proportion of exposure that cannot be recovered by the bank through liquidation of collateral or any other workout measures, if default occurs. Furthermore,

concentration of exposures and credit correlations are also determinants of portfolio level losses.

Credit risk can be measured both at the obligor and portfolio level by the metrics Expected Loss (EL) and Unexpected Loss (UL) over a future horizon, which, for the purpose of regulatory capital estimation, is one-year. Expected Loss is that which is anticipated on a credit portfolio due to average default rates and average recoveries during the normal course of business. Prudent accounting and regulatory practices require banks to create and hold provisions that can sufficiently cover for EL.

At the i-th obligor level, the EL in nominal amount is measured as

$$EL_i = PD_i \times LGD_i \times EAD_i \quad \text{..... (1)}$$

The portfolio expected loss (EL_P) is the mathematical sum of the individual ELs

$$EL_p = \sum_{i=1}^{n} EL_i \quad \text{..... (2)}$$

On the other hand, Unexpected Loss is the loss beyond EL, incurred in any given period, due to larger than average and correlated defaults, lower than anticipated recoveries and higher exposures. To protect against the adverse financial consequences of large unexpected losses, estimated at a given confidence level (also known as Credit Value-at-Risk or CVaR), banks should hold enough credit risk capital.

At the i-th obligor level, the UL is a function of the volatility (σ) of PD, LGD and EAD.

$$UL_i = f(\sigma_{PDi}, \sigma_{LGDi}, \sigma_{EADi})$$

For the portfolio, the unexpected loss (UL_P) is an aggregation of individual ULs, taking into consideration default correlations (ρ_{ij}) across obligors.

$$UL_P = \sqrt{\sum_{i=1}^{n} UL_i^2 + \sum_{i,j;i\neq j}^{n} \rho_{ij} \times UL_i \times UL_j} \quad \text{..... (3)}$$

The CVaR can then be derived either from the portfolio loss distribution or by multiplying the ULp with a scalar associated with the confidence level.

Credit risk measurement tools focus on the models for PD, LGD, EAD for individual obligors and default or asset correlations in the portfolio, for aggregation into portfolio EL and UL. The earliest approaches for PD, LGD and EAD estimation used actuarial analysis of historical default, recovery and limit utilization data of pre-specified credit portfolios / pools of homogenous borrowers. After the publication of the Altman Z-score model (Altman, 1968), empirical and heuristic credit rating or scoring models became popular tools to differentiate between good and bad obligors. Subsequently, PDs and LGDs were calibrated to borrower and facility ratings.

Structural approaches like the Black-Scholes (1973) model and Merton's contingent claims analysis (1974) provided an alternative way to predict defaults on corporate liabilities by linking them with market prices of traded bond or equity instruments. The KMV (later Moody's KMV) EDF™ became a popular commercial

application of Merton's framework, which derived expected default frequencies (EDF), a market-based measure of PD, for public and private companies. Vasicek (1987) and Gordy (2003) further expanded on Merton's approach to model borrowers' conditional default probabilities from asset returns linked to a single common risk factor (correlation with the macroeconomy or system). This Asymptotic Single Risk Factor Model (ASRF), as it was called, was later adopted by the Basel committee to design the formula for measuring regulatory capital charge, under the IRB Approach, for a granular credit portfolio given an appropriately conservative value (at 99.9% confidence level) of the systemic risk factor.

LGD and EAD models were also evolving, through the use of statistical techniques that incorporated information on instrument, firm, industry and economy. LossCalc™ (2002) was one of the earliest such approaches developed by Moody's. Furthermore, structural models were also adopted to measure implied market based LGDs from defaulted or junk bond prices or from risky credit spreads (Gupton et al. 2000).

Academic and practical studies to model portfolio credit risk by incorporating sectoral default correlations had gained parallel traction. CreditMetrics™, originally envisioned in 1997 by JP Morgan research, was a mark-to-market measure of credit value-at-risk, which simulated credit losses due to both correlated defaults as well as credit deterioration. The CreditRisk+ Model, developed by Credit Suisse First Boston (1997), applied obligor default rates and default rate volatilities for a portfolio of correlated credit exposures to generate the credit loss distribution. These models provide the basis for measuring economic capital, inclusive of concentration risk which is an important Pillar II item.

The application of credit risk models has enhanced banks' ability to manage credit risk through various risk-based strategies. Internal loss buffers of provision and capital can be created and allocated to business lines based on their credit risk profile. Credit concentration limits can be set to achieve optimal portfolio diversification. Loan pricing can be linked to borrower and facility level credit risk estimates. Risk adjusted performance measures like Risk Adjusted Return on Capital (RAROC) can be implemented to manage the performance evaluation of credit business lines, products and portfolios. Figure 3 below summarizes the landscape of credit risk measurement and management tools.

[Figure 3]

In India, it was only after the deregulation of interest rates on advances, in 1994, that banks started to apply credit rating models, for borrower assessment and addition of differential credit spreads. These models were mostly heuristic; combining financial and non-financial parameters, to derive qualitative credit ratings. During the Basel I regime, since capital charge was prescriptive and non-risk sensitive, there was no incentive for banks to develop sophisticated credit risk models. After the Basel II framework gave them the opportunity to measure credit risk capital, under the IRB Approach, larger public and private sector banks started to build models for PD, LGD and EAD based on historical data. Today, these models have also become critical for the measurement of expected credit loss based provisions as mandated under the International Financial Reporting Standards (IFRS), which will be implemented for Indian banks in the near future.

IV.2. Market Risk

As long as financial markets were stable and risk factors predictable, between 1945 and 1970, market risk was minimal. However, with higher market volatility, it was necessary to capture the impact of interest rate shocks on bond prices, equity index movements on the value of stock portfolios and exchange rate dynamics on forex positions. This made the *sensitivity* methods popular - banks and financial institutions began to estimate the impact of a unit change in risk factors on the value of their exposures. For instance, **modified duration** was used to measure the percentage change in the value of fixed income instruments for a 100 basis point shift in interest rates. **Beta** was employed to capture the percentage change in the value of stocks for a one percent change in equity market indices. **Option delta** would estimate the effect of a unit change in the price of the underlying assets on the value of non-linear derivatives. Equation 4 below captures the formula for computing Market Risk losses based on sensitivity approaches.

Market Risk Loss = Market Value of Exposure × Sensitivity × Size of Shock..... (4)

For instance, if the size of the bond portfolio (i.e. MV of exposure) is Rs. 10000 Crore, sensitivity (i.e. modified duration) is 4 and the rate shock is assumed to be 200 basis points per year, the annual loss estimate is Rs. 800 Cr. The bank can plan to raise (or hold) Rs. 800 crores of capital to absorb the potential losses. Otherwise, the Net Worth of the bank (stock of reserves and surplus) will be eroded if and when such losses occur.

However, the first and foremost difficulty with sensitivity analysis is that the likelihood of loss is not known. In other words, the shocks and losses are arbitrary. For instance, we do not know, from the previous example, whether a capital buffer of Rs. 800 Cr. will be enough to absorb losses under normal or stressed conditions. This brings us to the concept of Value-at-Risk (VaR), which captures not only the severity but also the likelihood of losses. **VaR is the maximum loss over a target horizon such that there is a low, pre-specified, probability that the actual loss will be larger (**Jorion 2011)**.** A 10-day VaR estimate of Rs. 800 Cr., at the 95% confidence level, means that actual losses may exceed Rs. 800 Cr. with a probability of 5%, over the next ten days. If the bank holds a capital of Rs. 800 Cr., it should be able to protect depositors from 95% worst ten-day losses in the trading book.

The second issue is that the sensitivity measures are different for various segments like bonds, equities and currencies. Since the units of measurement are different, they cannot be aggregated to compute portfolio sensitivity. In contrast, the concept of VaR is applicable to all securities in the trading book and beyond. Hence, it is possible to compute correlations between pairs of assets, to arrive at portfolio VaR estimates which reflect diversification benefits. The relative risk profiles of all segments can also be compared in terms of VaR forecasts.

However, VaR is silent on extreme or tail losses. The VaR measure gives the risk manager an estimate of the maximum possible loss, at a given confidence level. But, it says nothing on the size of losses beyond that threshold. For instance, even if it is known that 95% 10-day portfolio VaR is Rs. 800 Cr., a risk manager will not be able to predict how large losses may be beyond Rs. 800 Cr. In fact, VaR may remain unchanged even as stressed losses worsen. This brings us to the concept of **Expected Shortfall** (ES), which

is the average of all losses beyond VaR. **ES** will increase, at higher degrees of stress, even though VaR is unaffected. Stressed ES, at the 97.5% c.l., has been chosen by the Basel Committee for computation of Market Risk capital charges under the Fundamental Review of the Trading Book – Internal Models Approach.

In India, given the dominance of government bonds in the investment portfolios, banks and FIs employ modified duration to measure trading book losses, set limits and compute regulatory capital requirements. Some banks also use VaR to forecast trading losses under normal and stressed conditions. However, the VaR-based loss estimates are utilized to calculate their internal, rather than regulatory, capital needs under Pillar II of Basel II.

IV.3. Operational Risk

The simplest measures of operational losses were based on exposure size – gross income, which is proportional to business volumes. However, more comprehensive measures are based on Operational VaR, which forecasts future shocks from historical loss data. VaR-based operational risk reflects the possibility that larger banks, with better systems, processes and controls, may incur smaller losses.

An important aspect of Operational Risk Management is Risk and Control Self-Assessment (RCSA). It is a process that identifies and monitors extant and emerging operational risks, assesses their frequency and severity, evaluates the effectiveness of internal controls and suggests new tools for risk management. The qualitative and quantitative operational risk drivers, highlighted through RCSA, are known as Key Risk Indicators (KRIs). KRIs provide early warning signals for operational risk management. Quantitative KRIs can be used to generate operational loss scenarios under normal and stressed conditions, fix operational loss limits for various segments and estimate operational losses for business lines in which historical data is scarce.

With more than a decade of experience in Operational Risk Management, most Indian banks have established effective mechanisms for RCSA, KRI and internal loss data collection. They have also put Operational Risk Management Frameworks in place. However, there is considerable scope for improvement in scenario analysis and stress testing practices as well as external loss data collection (Bajaj 2023). With the regulatory focus on gross income based loss estimates, estimation of Operational VaR-based losses has fallen out of favour.

IV.4. Asset-liability Mismatch Risks

ALM was introduced as a Pillar II item under Basel II. Asset Liability mismatches can cause two problems: (i) Loss in Net Interest Income (NII) and Net Worth due to adverse interest rate shocks OR (ii) an increase in net cash outflows due to asset and/or liability side events. NII continues to be the biggest source of income for banks in most countries. A sudden decline in short-term NII (over the next three months, six months or one year) can erode a large fraction of bank income. The potential loss in NII is known as Earnings-at-Risk (EaR). It is estimated with respect to a variety of *what if* scenarios – unequal rate changes across tenors, different rate shocks for assets and liabilities and/or effect of loan prepayment and premature deposit withdrawal. Banks maintain gap limits, in different time bands, to control their EaR.

The potential impact on Net Worth is measured in terms of changes in Economic Value of Equity (EVE). It is the difference between Market Value of Assets (MVA) and Market Value of Liabilities (MVL). Cash flows on all assets and liabilities are discounted, at relevant yields, to arrive at market values. A rise in MVA implies that a bank earns more than its peers and creates shareholder value. A rise in MVL means that the bank pays more than the market, to its outside creditors, and destroys shareholder value. The Basel Committee prescribes Pillar II Capital Charges, based on EVE, to manage Interest Rate Risk in Banking Book (IRRBB).

A spike in net cash outflows (i.e. liquidity risk) is one of the most important reasons for bank collapse. Hence, a balance between cash inflows and outflows is desirable, in short-term buckets up to at least once month. Gap limits have to be more stringent for shorter horizons. Banks should also monitor the ratio of liquid assets to volatile liabilities, up to one year, to judge whether they can redeem short-term liabilities, on a regular basis. In this regard, they should aim to limit dependence on unstable wholesale deposits.

Indian banks have conducted NII analysis, since the first decade of this century. They have assessed the impact of hypothetical 100 or 200 basis point shocks, on their NII, up to one year. To this end, they have used the Interest Rate Sensitivity Statements, in which assets and liabilities are classified in terms of maturity or reset dates across time bands. Towards the end of the decade, they began to use the EVE approach to compute capital charges for IRRBB, w.r.t a 200 basis point shock, under Pillar II. In February 2023, RBI released IRRBB guidelines which contained regulatory scenarios, for unequal rate shocks in different buckets, to compute NII and EVE impact for banks.

For more than two decades, Indian banks have also used Structural Liquidity Statements (SLS) to forecast and monitor gaps, between expected cash inflows and outflows, in different time buckets. The SLS has been used to track periodic changes in the maturity profile of assets and liabilities, compute and compare liquidity ratios, perform stress tests and fix internal liquidity gap limits. Indian banks also conduct regular behavioural analysis to understand how stable their non-maturity products (like CASA deposits and lines of credit) are. They also study premature withdrawal of deposits and loan prepayment patterns, as part of liquidity risk management.

Section V
Conclusion

Financial markets have been subject to seismic disruption, in the recent past, *inter alia* from large-scale digitalization, generative Artificial Intelligence (AI), introduction of sophisticated analytical models and climate change. While these developments embed potential opportunities, the incipient challenges also loom large. In conclusion, we highlight some of these risks. At the same time, we reiterate that traditional risks should not be neglected.

Banks across the globe are going through an unprecedented phase of digital transformation after the Covid-19 pandemic. Operations and processes, payment systems and customer channels are almost entirely driven by and dependent on IT systems and infrastructure. As repositories of large volumes of electronic funds and financial data of customers, banks are especially susceptible to cyber risks which emanate

from scams, cyberattacks and data theft. In 2016, hackers managed to steal $101 million from the Central Bank of Bangladesh, via the main electronic payment messaging system (SWIFT) around the world. After the Covid-19 pandemic, the financial sector has experienced the second-highest share of cyberattacks, behind only the health sector. This trend is expected to worsen as generative AI gets ready to exploit system vulnerabilities of banks. They will need to strengthen their IT systems and continuously update internal cybersecurity capacity, to counter digital threats.

In an environment of stiff competition, not only among banks but also with burgeoning fintech firms, financial intermediation has increasingly become model driven. Banks are applying both traditional econometric models and advanced but opaque machine learning algorithms to analyze vast quantities of customer and market data almost on real-time basis. The goal is to increase the pace and scope of customer acquisition through automated risk assessment and decision-making, accorded by such models. This has opened up a Pandora's Box of model risks wherein the use of a defective model or misuse of an effective one may result in substantial losses. In this context, banks will need to design appropriate model risk management frameworks, which include rigorous validation and documentation standards, to fulfil both internal and regulatory oversight requirements.

As global carbon emissions continue unabated, the adverse effects of climate change are expected to accelerate, in the coming years (IPCC 2023). Through macroeconomic and portfolio level transmission channels, climate risk has already crept into financial markets, although its severity is possibly underestimated. A number of central banks in developed countries of North America and Europe, like US, Canada and UK, have started conducting stress tests to monitor systemwide vulnerabilities from physical and transition risks, under various climate scenarios. In future, banks will need to account for climate losses on their credit and investment portfolios as well as operations, given escalating policy responses and changing market sentiments towards decarbonization.

In line with the growing complexity of banks and emergence of multifaceted risks, as discussed above, regulators are issuing an ever-growing set of guidelines and codes of conduct. These cover diverse areas like anti-money laundering (AML), know-your-customer (KYC), data privacy, consumer protection, financial reporting and financial stability. With more intense supervisory scrutiny and higher penalties on regulatory breaches, compliance risk has emerged as one of the biggest overall enterprise risks. Today, banks are expected to adhere to applicable rules both in letter and spirit, through effective compliance management systems.

However, greater focus on new risks should not be at the cost of the traditional ones. On March 10, 2023, Silicon Valley Bank (SVB) was closed by financial authorities in California. Almost 85% of its deposits had been withdrawn over the previous two days. The bank had widened its maturity mismatch between 2017 and 2021 - long-term government bonds were funded with zero-cost deposits – as market rates declined. While such a strategy increased its NIM and trading profits, the bank was vulnerable to a sudden rise in rates. The spike in policy rates from 2022 onwards led to large trading losses, erosion of Tier I capital buffer and massive deposit withdrawal. The spillover effect of SVB collapse was felt even in Europe, when Credit Suisse had to be taken over after its share prices plummeted within a week (BIS 2023).

Closer home, the NPA crisis devastated the Indian banking sector, for half a decade, from 2015 onwards. The GNPA ratio (to gross advances) shot up from 3.83% in 2014 to 11.18% in 2018. Public sector banks were hit harder – the GNPA ratio soared from 4.09% to 14.58%, during the same period. A number of factors, like the credit boom before the global financial crisis and the demand shock in its aftermath, weaknesses in bankruptcy and resolution mechanisms, low capital adequacy and concentration of low quality loans, contributed to the disaster (Chari et. al. 2019). Capital was wiped out, credit growth slowed down and GDP growth decelerated. Aggregate NPA ratio reverted to 2014 levels (around 3.87%) only in 2023, after the double whammy of a textbook credit crisis and the Covid-19 pandemic.

In sum, banks should have a well-defined appetite for each risk – whether new or old – to protect their capital and liquidity buffers. Their risk appetite should be supported by a strong risk governance framework, which constitutes a set of actions, systems and processes for shareholder value optimization. They should aspire to the golden mean between profit maximization and financial soundness.

Annexure

1. ALM risk: Potential loss from asset-liability mismatches inherent in financial intermediation

2. Climate related financial risks: Financial losses related to (1) the physical impacts of climate change (Physical Risk) and / or (2) transition to a lower-carbon economy (Transition Risk). Physical Risks may arise from increased frequency and severity of extreme weather events such as cyclones, hurricanes or floods (Acute Physical Risk) or from longer-term shifts in climate patterns that may cause sustained higher temperatures and rising sea levels (Chronic Physical Risk). Transition risk may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change.

3. Compliance risk: Risk of legal or regulatory sanctions, material financial loss, or loss to reputation a bank may suffer as a result of its failure to comply with laws, regulations, rules, related self-regulatory organisation standards, and codes of conduct applicable to its banking activities (BIS, 2005)

4. Credit risk: Potential loss associated with adverse credit events like standalone and correlated defaults by obligors or counterparties on their contractual obligations.

5. Cyber risks: Loss of confidentiality, integrity, or availability of information, data, or information (or control) systems and reflect the potential adverse impacts to organizational operations and assets.

6. Market Risk: Potential loss in portfolio value from market rate or price movements.

7. Model risk: Potential for adverse consequences from decisions based on incorrect or misused model outputs and reports

8. Operational risk: Potential loss due to inadequate or failed processes, people, systems or external events.

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Table 1
Approaches for Estimation of Risk Weighted Assets under Basel II Pillar 1 CAR

Basel II	Credit Risk – On and Off Balance Sheet Exposures in Banking Book	Market Risk – On and Off Balance Sheet Exposures in Trading Book	Operational Risk –All Business Activities
Simple Approach (Most Prescriptive, Limited Sensitivity to true risks)	**Standardized Approach (SA)** – Prescriptive Risk weights based on external ratings or regulatory portfolio categories; limited and pre-defined risk mitigants and standardized exposure norms	**Standardized Measurement Method (SMM)** - Prescriptive regulatory capital charge for interest rate risk, equity price risk and forex risk	**Basic Indicator Approach (BIA)** - Prescriptive multipliers on Gross Income **The Standardized Approach (TSA)** - Prescriptive multipliers on business line level Gross Income
Sophisticated Model Based Approach (greater Sensitivity to true risks)	**Foundation Internal Ratings Based (IRB) Approach** – Risk weights derived from internal models for default risk, with prescriptive recovery rates and exposure measures **Advanced IRB Approach** – Risk weights derived from internal models for default risk, recovery risk and exposure measures	**Internal Models Approach (IMA)** – Internal models for interest rate, equity and forex risks and incremental risk capital for credit risk in the Trading Book	**Advanced Measurement Approach (AMA)** - Banks' internal models on operational loss distribution

Table 2
Timeline of Adoption of Basel III and Finalised Basel III by RBI

Micro-Prudential Norms	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Capital Adequacy												
Min. CCB	Basel III	0	0	0	0.625%	1.250%	1.875%	1.875%	1.875%	2.500%	2.500%	2.500%
Min. CET1 + CCB	Capital	4.500%	5.000%	5.500%	6.125%	6.750%	7.375%	7.375%	7.375%	8.000%	8.000%	8.000%
Min. CAR + CCB	Regulations	9.000%	9.000%	9.000%	9.625%	10.250%	10.875%	10.875%	10.875%	11.500%	11.500%	11.500%
Leverage Ratio	Issued	4.50%	4.50%	4.50%	4.50%	4.50%	4.50%	3.50%	3.50%	3.50%	3.50%	3.50%
Liquidity												
LCR			Guidelines Issued	60%	70%	80%	80%	80%	80%	90%	100%	100%
NSFR							Guidelines Issued	Deferred	Deferred	Deferred	100%	100%
Risk Coverage												
SA-CCR	Current Exposure Method as per Basel II continues to apply											
Revised CVA	Capital Charge for CVA introduced under Basel III but the Revised CVA Framework of Finalised Basel III not implemented											
Revised SA for CR						Standardized Approach of Basel II with modifications continues to apply. Revised Standardized Approach of Finalised Basel III not implemented						
Revised Op. Risk												Guidelines Issued
Revised Mkt. Risk						Basel II Market Risk Approaches continue to apply. FRTB under Finalised Basel III not implemented						
IRRBB												Guidelines Issued
Large Exposure Framework					Guidelines Issued			Effective				
Macroprudential Norms	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
SIB Framework			Guidelines Issued	Effective								
Countercyclical Capital Buffer				Guidelines Issued	Effective but Never Triggered							

Figure 1
Key Components of Basel III

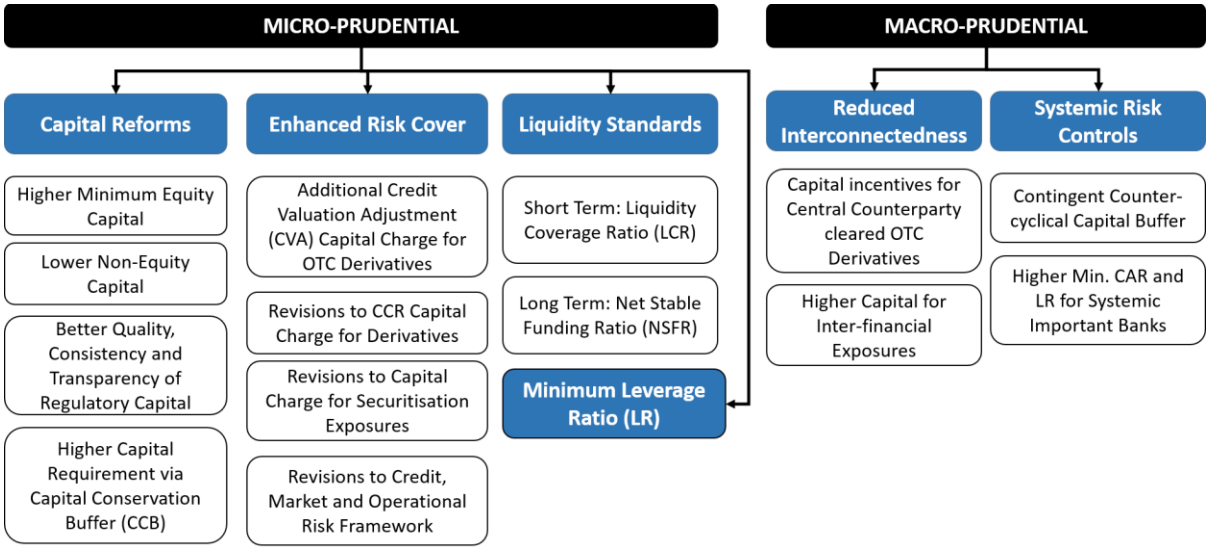

Figure 2
Components of the Three Pillars of Finalised Basel III

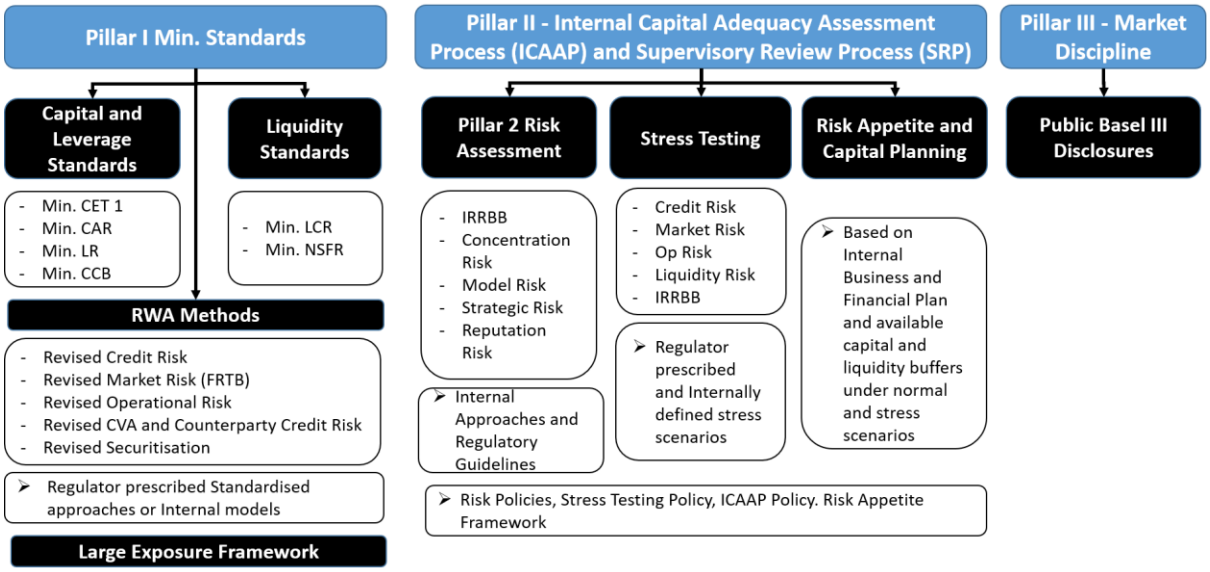

Figure 3
Landscape of Credit Risk Measurement and Management Tools