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Estimating the Risk Capital under Basel Approaches to Develop a Credit Risk-Adjusted Return: Evidence from a Saudi Bank

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Abstract:
The study aims to quantify the risk capital, also known as economic capital, required to absorb credit risks and calculate credit risk-adjusted returns on this capital, using the parameters of the probability of default, loss given default, and exposure at default. The study employed a case study method to estimate the risk capital model for a leading bank in Saudi Arabia, which adopted both the internal rating-based approach (IRB) and the Standardized approach, as the bank made the necessary disclosures for estimating the risk capital model for the period 2018-2022. The study utilized the R programming language and a Monte Carlo Simulation to generate the parameters of risk capital, which included both expected losses, measured by the average, and unexpected losses, measured by the tail distribution. The study used the estimated parameters of the expected and unexpected losses to develop credit risk-adjusted returns. The results showed that the estimated expected credit losses exceeded the actual allocations for loan losses calculated by the bank, indicating that the bank was under-provisioning for loan losses. However, the bank's regulatory capital under the Standardized approach was greater than the estimated risk capital. Therefore, the bank was over-capitalized. If both provisions for loan losses and regulatory capital are considered complementary, the bank is well capitalized. The study is original because it discusses the concepts of capital in banks, where regulatory capital is calculated according to the first pillar of the Basel I Accord, risk capital is calculated according to the second pillar of the Basel II Accord in parallel with regulatory capital, and then accounting capital is subject to accounting standards. Based on the study's results, it is recommended that banks adopt the concept of risk capital, allowing them to avoid holding excess capital at a high cost.

Keywords: *Probability of Default – Loss Given Default – Exposure at Default- Expected Losses – Unexpected Losses- Allocations for Loan Losses.*

INTRODUCTION

Risk capital, also known as economic capital, is defined by Sweeting (2011) as the surplus of assets or cash flows that can address potential shortages in assets or increases in liabilities over a specified period with a certain level of confidence. The Basel Committee on Banking Supervision (2009) defined risk capital as the procedures a bank follows to measure risks resulting from high-risk activities and to absorb the financial impact of these risks. Therefore, risk capital can be viewed as a measure of the overall risk or the risk associated with business units, rather than a measure of the capital buffer. Risk capital is also known as capital at risk or internal capital. Matten and Bankowym (2000) defined risk capital as a measure of future risks, rather than the capital held by banks. The European Central Bank, (2010) Criticized the use of the return on equity by banks, as the return on equity is ineffective in an environment of high volatility; it does not reflect the bank's long-term strategy, it is insensitive to risks, it is a short-term indicator, and it is not affected by seasonality. Tran & Phan (2020) indicated that credit risks negatively affected profits. On the other hand, the return on risk capital is the best measure of performance, as it links risk-adjusted returns to the amount of risk capital invested.

To measure risk capital, it is necessary to distinguish between expected losses and unexpected losses, as expected losses are considered the costs of doing business and are not considered risks because banks expect them to occur. Therefore, the statistical probability of bank collapses due to these losses is zero. The expected losses are absorbed by adding margins when pricing the bank's products; therefore, no additional capital is required to cover these losses. The regulatory capital corresponds to the expected losses of a recurring nature, while the risk capital corresponds to the unexpected losses and serves as a measure of risk. The literature review revealed several concepts of capital, including capital set by external credit rating agencies, regulatory capital set by regulators, risk capital, and accounting capital. The regulatory capital is essentially the same as normal financial leverage. i.e., expressing the capital as a ratio of total assets or the risk-sensitive financial leverage. i.e., expressing the capital as a ratio of the risk-weighted assets. From the perspective of external rating agencies, the concept of capital is particularly relevant to the debt market, given that estimating the risk structure of banks is a complex process. The work of external credit rating agencies primarily focuses on the possibility of failure to repay debts, rather than assessing capital adequacy. As for accounting capital, it is merely a non-risk-sensitive form of financial leverage. However, the risk capital concept focuses on the capital needed to absorb risks assumed by banks. All of the aforementioned capital concepts, except for the concept of risk capital, do not aid in developing credit risk-based performance indicators or support risk-based decision-making.

This study focuses on the risk-adjusted performance derived from the risk capital model, as outlined in the Basel II framework. To the researcher's best knowledge, no study in the Kingdom or the Middle East Region has dealt with quantifying risk capital from a Basel's perspective to develop credit risk-adjusted performance. Therefore, the study aims to fill this gap in the current literature. Specifically, the Saudi Central Bank requires banks to use both Standardized and internal rating-based approaches Saudi Central Bank Banking Supervision Department, June 2006). The current study aims to answer the following question: Is the bank under study overcapitalized? Is the bank under study under-provisioning? Is the credit risk-adjusted return better than the non-credit risk-adjusted return? The study aims to clarify the distinction between the concepts of capital in banks, with a focus on risk capital as a measure of credit risk.

The study quantifies the risk capital required to absorb credit risks at the loan portfolio level. Then it develops the credit risk-adjusted return derived from the outputs of the risk capital model, as per the Basel II framework. Using the case study approach, the study developed the following sub-objectives: estimating the probability of default parameter, the loss given default parameter, the exposure at default parameter, and the value at risk, as well as unexpected losses and the credit risk-adjusted return on risk capital. The results of quantifying the risk capital are crucial in determining whether the bank's regulatory capital exceeds its risk capital. If the regulatory capital is less than the risk capital, banks must increase the capital or decrease the risk-weighted assets. Andrle et al. (2017) suggested that undercapitalized banks could reduce the size of risk-weighted assets or increase equity by issuing new shares, limiting cash distributions to shareholders, and enhancing retained earnings through improved operational efficiency and lending margins.

Based on the above, the outputs of risk capital models differ from those of other capital adequacy models, as the results of risk capital models are expressed in absolute monetary values. The research gap is the absence of any study in the Kingdom or developing countries that addresses the quantitative measurement of credit risks for banks under the Basel II requirements. The study also tests the argument of whether banks that apply the concept of risk capital achieve advantages in maintaining less capital compared to the capital adequacy ratios required by the regulatory capital concept. The study contributes to the existing literature by developing the practice of quantitatively measuring credit risk. In addition, it is the first of its kind, not only in the Kingdom but also in developing countries, as it highlights the importance of risk capital in comparison to other forms of capital.

The study is organized as follows: Section 2 presents the literature review, Section 3 discusses the methodology and empirical results, Section 4 examines the results, Section 5 presents the conclusions and future studies, and Section 6 discusses the empirical implications.

LITERATURE REVIEW

The Risk capital is estimated using the Value at Risk (VaR) approach to absorb unexpected losses and determine the risk-adjusted return on capital. Risk capital differs from the concept of regulatory capital, which represents the existing capital levels established by the Basel Accord as a percentage of risk-weighted assets. Carina (2005) stated that Basel II addressed the concepts of risk capital and regulatory capital. The second pillar of Basel II aimed to set minimum capital adequacy requirements that were sensitive to risks, thereby bringing the regulatory capital in the first pillar closer to the risk capital. The second pillar of Basel II included supervisory review to determine capital adequacy, i.e., the risk capital to absorb unexpected losses, through banks' internal ratings of risks. Therefore, banks must maintain both the regulatory capital and the risk capital. The regulatory authorities determine the regulatory capital, while the banks estimate the risk capital to remain financially solvent. The objective of risk capital is to maximize shareholders' wealth, while regulatory capital meets the interests of the bank's depositors, and the goal is to minimize potential risks.

The concept of risk capital links capital with risk based on probabilistic estimates of potential future losses. Therefore, risk capital is a forward-looking measure of risk than traditional capital adequacy measures. Bandyopadhyay (2023) indicated that Basel III addressed the shortcomings of the regulatory capital. As it implemented significant reforms on risk-weighted assets, allowing banks to use their internal data instead of relying on external credit rating agencies to measure the parameters of PD, LGD, and EA, while taking into account specific regulatory controls to quantify risk capital or internal capital. In addition, Nenada and Rana (2021) stated that the Basel Committee on Banking Supervision has published further reforms on risk-weighted assets to calculate the capital adequacy ratio, allowing banks to use the standard approach to assess credit risk based on risk-sensitive weighted assets. Kaplan et al. (2018) noted that risk capital is a measure of risk, as banks quantify the capital required to absorb unexpected losses in their credit portfolios. The risk capital model is stochastic, referring to the difference between the quantile and the distribution of losses, which is calculated using a Monte Carlo simulation. Das (2007) noted that Basel II considers two types of losses: expected and

unexpected. Determining the regulatory or risk capital must adhere to the concept of both types of losses and suggest using the value at risk (VaR) model as an information system to identify inherent risks by explicitly modeling the distribution of losses. The result of the modeling is the best estimate of capital adequacy. Hull (2018) stated that regulatory authorities aim to protect depositors and debt holders from the risks of banks' default. Therefore, regulatory authorities require banks to maintain a minimum amount of capital to absorb losses resulting from lending activities, which is the primary source of these losses. The amount of capital required to absorb credit losses with a specific level of confidence over a certain period. Loan pricing policies must cover the expected losses by increasing interest rates. As for the unexpected losses, they are calculated as the difference between the total value at risk and expected losses. Banks must absorb those losses by maintaining risk capital, which is the most widely used measure to calculate the risk-adjusted return on equity.

Research in the field of credit risk is relatively recent, as noted by Gordy (2000), who observed that significant improvements have been made in credit risk modeling at the portfolio level. Giese (2005) emphasized the importance of credit modeling, as credit risk is the primary driver of risk capital in banks. The development of credit risk measurement models dates back to the Merton (1974) model, which assumed that a company's assets play a crucial role in determining its risk of default. A default occurs when the market value of the assets is less than the liabilities. Based on Merton's (1974) model, other models emerged, assuming the default may occur before the maturity date of the obligations. Therefore, default occurs when the bank's liabilities exceed its assets. Accordingly, the recovery rate upon default is an exogenous factor that does not depend on the company's capital. Recently, other models have emerged, assuming that recovery rates upon default do not rely on the probability of default and that credit risk can be measured based on a stochastic process. Amelia (2012) noted that, in light of the 2008 global financial crisis and its repercussions, including the collapse of major financial institutions with high regulatory capital adequacy ratios, attention was drawn to the effectiveness of regulatory capital in preventing financial crises. Amelia (2012) noted that weaknesses in risk-based decision-making plagued the regulatory capital model. Therefore, Amelia (2012) suggested that risk capital serves as an alternative to regulatory capital, facilitating risk-based decision-making and encouraging banks to adopt adequate internal controls for risk management.

Yao & Song (2021) investigated the impact of bank size on the level of risk capital in China from 2011 to 2019. The study results indicated that large state-owned commercial banks have advantages in terms of size, capital, and experience compared to medium-sized and small banks. The results revealed negative correlations between the bank's size and its risk capital level. Krebs & Nipple (2021) estimated risk capital to absorb credit risks, considering it equal to unexpected losses based on the rules of the Basel Convention and the risk capital based on net profits. The results indicated that the risk capital calculated based on unexpected losses is greater than the risk capital based on net profit. Barboza et al. (2016) quantified the risk capital using data from PD and LGD for different credit ratings. The results indicated that banks could improve their rating based on the credit quality of borrowers by lending to borrowers with low rates of PD and LGD. The study used the simulation method to compare the risk capital of banks with different ratings. Elizaldea & Repelled (2007) analyzed the determinants of regulatory, economic, and actual capital. The study used the single-factor model under Basel II. The results indicated that the interest margin—the difference between interest income and interest expense—and the cost of capital contributed to significant deviations between the economic and regulatory capital. In contrast, the actual capital was close to the regulatory capital. The results also indicated that banks maintain high regulatory capital as a buffer to absorb potential future losses. Regarding market discipline, the results indicated that the deposit insurance rate led to an increase in both risk capital and actual capital. Biotas & Solek (2010) noted that, according to Basel II, regulatory capital is calculated to absorb credit risks by multiplying on-balance-sheet assets and off-balance-sheet liabilities by 8%. According to Biotas & Solek (2010), Credit risk can be measured using one of three approaches. The standard approach assigns risk weights to assets based on external rating agencies' assessments; in the absence of these ratings, the regulatory authority determines the risk weights. At the same time, the Internal Rating-Based Approach (IRB) enables banks to utilize their internal rating systems to assess borrower risks and determine the probability of default, provided the supervisory authority determines the loss given default. The Advanced Internal Rating-Based Approach (Advanced IRB) enables banks to estimate both the probability of default and the loss given default, as outlined in the following table.

Basel Approaches to Measure Credit Risk

	Standard Approach	Foundation Internal Rating-Based Approach	Advanced Internal Rating-Based Approach
Rating	External	Internal	Internal
Estimation of Probability of Default	N/A	By Banks	By Banks

Estimation of Loss Given Default	N/A	By Regulators	By Banks
Estimation of Exposure At Default	N/A	By Regulators	By Regulators
Risk Mitigation For Guarantees and Services Characteristics	By Regulators	By Regulators Via PD, LGD, EAD	By Banks Through PD, LGD, EAD

Source: Biotas & Solek (2010)

Kumar (2023) noted that Risk-adjusted performance indicators have recently gained significant importance in the banking industry, particularly in light of opportunities for external expansion, intensified competition, and challenges posed by non-performing assets. This concern arises because traditional performance measures, such as return on assets or equity, lack a forward-looking perspective and cannot provide shareholders with valuable information. Therefore, there is a need for credit risk-adjusted performance based on the risk capital concept. Majeed & Bindman (2001) noted that Risk-adjusted performance indicators help improve budgeting decisions, reduce adverse selection risks, and effectively allocate resources. Shareholders are interested in measuring banks 'profitability using the return on equity, the ratio of costs to income, and the return on assets. However, the return on equity is insensitive to risks, as the primary source of the increase in the return on equity is attributed to higher financial leverage. Accounting leverage is insensitive to risk because it is based on capital and assets that are not risk-weighted. Therefore, risk capital is the most suitable for calculating financial leverage because it directly relates to risk.

Kumar, (2023) showed that the emergence of risk-adjusted performance indicators dates back to the 1970s to identify risks inherent in loan portfolios and determine the capital required to absorb risks depositors and lenders are exposed to in the event of default, as well as determine the capital needed to support the operational activities of banks. Le et al. (2020) used non-performing loans to measure risk when evaluating the risk-adjusted efficiency of banks; however, this indicator does not accurately reflect the magnitude of the risks. On the other hand, Klaassen & Eeghen (2015) proposed a system for evaluating bank performance based on the Du Pont system, which combines the return on equity, the return on assets, and the risk-adjusted return on capital. Return on equity overlooks risks because they can accompany profits. Culp (2000) noted that the importance of risk-adjusted returns has increased due to the rise in competition and the narrowing of financial intermediation margins in the banking sector. In the 1970s, Trust Bank proposed the risk-adjusted return as a method to allocate capital based on risk. The risk-adjusted return can be used ex ante to allocate capital and absorb risks, and it can be used ex post to evaluate the actual performance of banks. However, using this indicator to allocate capital ex post raises several problems. Rossi (2011) emphasized the importance of risk-adjusted return on capital for comparing the returns and risks of each product in the loan portfolio and recommended that banks should abandon the traditional return on equity in favor of risk-adjusted performance, investing in data and information technology to estimate risk capital reasonably.

Carter et al. (2004) evaluated the risk-adjusted returns of commercial loans, calculated by subtracting provisions for doubtful loans and risk-free rates from the gross returns for small and large banks from 1996 to 2001. The results indicated that small banks achieved greater risk-adjusted returns than large banks, after considering concentration risks, the cost of funds, and other factors that affect returns. Starch (2004) investigated the relationship between the diversification of small community banks and their risk-adjusted returns. The results indicated that focusing on activities that generate non-interest income was associated with a decrease in risk-adjusted performance. Diversity may lead to managers' involvement in activities for which they lack sufficient experience or competitive advantages. The results also indicated that the determinants of risk-adjusted returns in small banks differ from those in large banks. Weisman (2002) stated that the interest in risk-adjusted returns was attributed to investors' need for an effective tool for evaluating performance, taking into account the risks borne by managers, and determining the best option for capital allocation. The interest was also due to the regulatory framework of Basel II, which requires banks to maintain capital to absorb unexpected losses. Based on the literature review, risk-adjusted returns take into account expected losses, ignoring unexpected losses that are influenced by the economic cycle. This approach differs from provisions for loan losses shown on the income statement, as expected losses are calculated based on average long-term default rates and recovery rates. Therefore, expected losses reflect loan losses in the long term, rather than those affected by the economic cycle. Additionally, the risk-adjusted returns are linked to the capital at risk.

METHODOLOGY AND EMPIRICAL RESULTS

The study conducted an empirical study on the bank under study in Saudi Arabia to estimate its risk capital model for absorbing credit risks from 2018 to 2022. The necessary data to measure the variables of the risk capital

model were obtained from the bank's financial statements, published on its official website. The study aims to measure risk capital in accordance with the requirements of Basel II. The study employed a case study, a flexible research method in the social sciences, as the unit of analysis. The case study can be an individual, a group, or a phenomenon of interest as it involves the intensive and detailed examination of a real-life situation, whether quantitative, descriptive, retrospective, prospective, deductive, or inductive, in the development of theory—stake, (2000); Walshe et al., (2004). The study has chosen a leading bank as the unit of analysis for the empirical study because the bank has made sufficient disclosures regarding its credit portfolio, including products and risk structures.

Overview of the Bank under study in Saudi Arabia

The bank under study in Saudi Arabia was established in 1976 as a joint-stock company and commenced business in October of that year. The bank had 82 branches, 2,421 employees, and total assets of SAR 115.5 trillion as of 2022. The bank maintains a diverse loan portfolio in terms of products and risks. The bank applied the International Financial Reporting Standards, accounting standards issued by professional organizations related to the accounting and auditing profession in the Kingdom, including the Saudi Organization for Chartered and Professional Accountants (SOCPA), as well as the accounting standards issued by the Central Bank of Saudi Arabia. The bank under study in Saudi Arabia manages credit risks by monitoring the value at risk and diversifying lending in terms of product and customer diversity across different economic sectors, setting a maximum limit for the value at risk for each borrower. In addition, the bank required borrowers to provide additional guarantees in the event of a deterioration in borrowers' creditworthiness and to re-estimate the guarantees to determine the adequacy of the allocation for loan losses. Moreover, the bank compares the probability of default when granting loans with the probability of default when preparing financial statements for the remaining period of the loan's life to determine the adequacy of loan allocations and the capital adequacy ratio.The bank monitors the credit risk of borrowers by comparing the probability of default at the end of each financial period with the acceptable probability of default for the same period in the previous year to determine changes in credit risk. The bank employs internal, external, quantitative, qualitative, historical and forward-looking data from different sources such as borrowers' financial statements, external credit rating agencies, and customer records at the bank to determine the behavior of payments, the rate of utilization of credit facilities, and macroeconomic indicators such as economic growth rate, oil prices, unemployment rate, and inflation rate. The bank classifies its loan portfolio into three stages to measure credit risk, as required by IFRS 9, as follows: The first stage includes new loans granted by the bank or purchased from other banks, which are considered low-risk with an acceptable probability of default. As the bank builds the allocation for loan losses covering 12 months, this stage also includes loans reclassified from the second stage, which have witnessed improvements in credit risk. The second stage includes loans that have witnessed an increase in credit risk and require follow-up, but have not yet become credit-impaired, as the bank builds expected credit losses covering the remaining life of the loan. The second stage also includes loans reclassified from the third stage that are no longer credit-impaired. The third stage involves impaired loans, and the bank allocates funds to cover the loan's remaining life through loan losses. The bank estimates expected credit losses by determining the parameters of the probability of default, loss given default, and exposure at default. The bank derives the probability of default for all three stages referred to using internal statistical models based on internal and external, historical and forward-looking data, guided by Probabilities of defaults specified by Moody's. Loss given default (LGD) refers to the potential loss rate in the event of default. Due to data limitations, the Bank uses the regulatory LGD benchmarks. The bank utilizes the ratios approved by the Saudi Central Bank, by the Foundation's Internal Rating-Based Approach.

Table 1 presents the distribution of the loan portfolio by the bank's products, where commercial loans accounted for 75% of the total portfolio, followed by consumer loans at 41.4%. The remaining percentages were distributed among credit cards and other categories. That is, the loan portfolio is well-diversified

Table 1: Loan portfolio by-products

	Amounts In Millions	Relative Weight %
Credit Cards	829,400	1.1 %
Consumer	30,362,048	41.4%
Commercial	41,820,305	57%
Others	305,901	0.005%
Total	73,317,654	100%

Source: The Annual Financial Reporting 2022. P 56 https://www.banka leading bank in Saudi Arabia.com/ar-sa/About-Us/Corporate-Governance/Financial-Reports

Table 2 presents the distribution of the loan portfolio by its risk structure. High-quality loans in the first stage accounted for 91.3% of total loans, while loans that required follow-up and were included in the second stage accounted for 3.9%, and high-risk loans in the third stage accounted for 4.8%. That is, the portfolio is well diversified in terms of risk.

Table 2: Loan Portfolio by Risk Categories

	Amounts In Millions	Relative Weight %
12-month ECL	66,966,856	91.3%
Lifetime ECL not credit impaired	2,840,214	3.9%
Lifetime ECL credit impaired	3,510,584	4.8%
Total	73,317,654	100

Source: The Annual Financial Reporting 2022. P 57 https://www.banka leading bank in Saudi Arabia.com/ar-sa/About-Us/Corporate-Governance/Financial-Reports

Table 3 shows the geographical distribution of the loan portfolio. Loans granted to the Kingdom's economic sectors account for 99.1%, while loans to the rest of the world's countries account for 0.9%. That is, the loan portfolio is geographically concentrated.

Table 3: Loan portfolio by risk Geographical Concentrations

	Amounts In Millions	Relative Weight %
Kingdom of Saudi Arabia	70029847	99.1%
GCC and the Middle East	475,169	0.0067
Other Countries	93,993	0.0013
Total *	70599009	100%

Source: The Annual Financial Reporting 2022. P 110. Amounts net of allowances for loan losses https://www.banka leading bank in Saudi Arabia.com/arcs/About-Us/Corporate-Governance/Financial-Reports

Table 4 shows that the bank developed an internal credit rating system that included 10 probabilities of defaults, corresponding to the probabilities of defaults developed by Moody's. The internal credit rating system included six probabilities of default for good loans in the first stage, two probabilities of default for loans in the second stage, and two levels of probabilities of default for the third stage.

Table 4: Internal Credit Rating by A leading bank in Saudi Arabia

Risk Categories	Bank A, a leading bank in Saudi Arabia, Internal Grade (PD)	PD Upper Bound	Mapping To Moody's Master Scale	Moody's Master PD
Low – Fair Risk-First Stage	From 1A to 6A	From 0.010% to 2.300%	From A2 to Ba3	From 0.0109% to 2.8100%
Watch List-Second Stage	From 7A to 7C	From 8.000% to 100.000%	From B2 to Caa1	From 7.1600% to 17.3816%
Default-Third Stage	From 8 A to 9B	100.000%	C	100.000%

Source: The Annual Financial Reporting 2022. P 93
https://www.banka leading bank in Saudi Arabia.com/ar-sa/About-Us/Corporate-Governance/Financial-Reports

MODEL SPECIFICATION

The study followed the concept of credit risk, as defined by Gordy (2003) and McNeil et al. (2015), which is the loss resulting from a counterpart's default. Additionally, the study adhered to the parameters outlined by Altman (2006), who proposed the basic variables for measuring credit risk, namely PD, LGD, and EAD. According to Jordan and Zhang (2009), it is possible to infer the risk capital model using the parameters developed by Altman (2006). The study used the basic model of Basel II to quantify the risk capital required to cover credit risks depending on the parameters of both expected and unexpected losses.

The Probability of default is the probability that the borrower will fail to repay loans in full when they are due for payment. The Probability of default is calculated as a percentage based on the borrower's data, including, but not limited to, the current credit rating and the borrower's transaction history, as well as current market

conditions in the borrower's economic environment. The study used the probabilities of defaults developed by the bank under study, as explained in Table 4

The Loss given default refers to the loan losses incurred by the bank in the event of default, as banks cannot recover the loan's principal by liquidating the collateral. The loss given default is calculated using the following formula: 1 - the recovery rate, which represents the percentage of the principal loans that the bank expects to recover by liquidating the guarantees provided by the borrower. The study used the Loss given default ratios set by the regulator in the kingdom, which were 65%, 50%, and 50% for credit cards, consumer loans, and commercial loans, respectively. According to Eaten (2004), the global LGD rates, recorded at 40% for more than 3,700 default cases over 18 years, were used with a discount rate of 15% The exposure at default is the outstanding balance of loans on the default date, representing the maximum loss that the bank will incur at the time of the borrower's default.

The following equation calculates the expected loss.

$$EL=PD*LGD*EAD \quad (1)$$

EL refers to expected loss, PD to the probability of default, LGD to loss given default, and EAD to the exposure at default.

The risk capital can be estimated using the following formula:

$$RC(L) = VaR\ \alpha(L) - EL \quad (2)$$

Risk capital = value at risk - expected losses. Whereas EL refers to the expected loss, RC refers to the risk capital; value at risk (VaR) refers to the maximum loss that can be expected within a specific period with a particular level of confidence. According to Jordon (2006), VaR determines the risk tail of the loss and is defined as the size of the loss distribution, where α refers to the level of confidence.

The study employed the Monte Carlo simulation procedure to infer the loss distribution, and the model generates a loan portfolio loss distribution, which is divided into expected and unexpected losses. Antwi et al. (2014) stated that Monte Carlo Simulations have several advantages, including accurately determining the latent confusion in the loan portfolio, taking into account all the different risk characteristics of the loans within the portfolio, and enabling the calculation of the total portfolio losses. I.e., the value at risk. Table 5 presents the values of all variables used to estimate the expected credit losses for each risk level and each year separately (2018-2022).

Table 5: Parameters of Estimating Expected Losses and the Risk Capital

	Risk Levels	EAD	LGD	PD
2022	Low Fair Risk	66966856	0.65	0.04
2022	Watch List	2840214	0.5	0.08
2022	Default	3510584	0.5	100%
2021	Low Fair Risk	57840055	0.65	0.04
2021	Watch List	3429865	0.5	0.08
2021	Default	3802553	0.5	100%
2020	Low Fair Risk	48369969	0.65	0.04
2020	Watch List	4292091	0.5	0.08
2020	Default	3120959	0.5	100%
2019	Low Fair Risk	43319278	0.65	0.04
2019	Watch List	3862170	0.5	0.08
2019	Default	3080292	0.5	100%
2018	Low Fair Risk	35768046	0.65	0.04
2018	Watch List	4433404	0.5	0.08
2018	Default	1197813	0.5	100%

ANALYSIS OF RESULTS

The study utilized R software to estimate expected credit losses and the risk capital model, as R is considered one of the precise statistical programming languages due to its ability to handle data processing, display, and statistical analysis. The study employed R, a powerful statistical computing environment, to conduct a comprehensive Monte Carlo simulation. This approach enabled us to examine the variability and risk profile of the credit portfolio for the period from 2018 to 2022.

Table 6 presents the estimated risk capital model results from the Monte Carlo simulations for each year from 2018 to 2022, providing valuable insights into the expected credit loss EL and its variability. The mean EL

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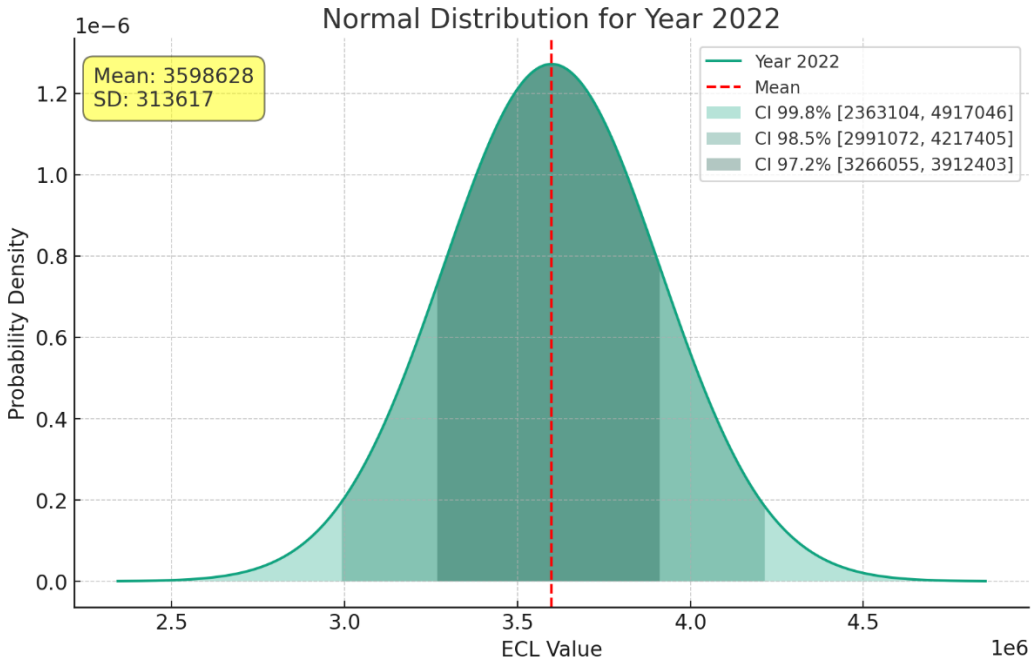
generally increases from 2018 to 2022. This trend could indicate a growing exposure or rising risk in the portfolio over time, possibly due to changes in portfolio composition, market conditions, or risk profile. On the other hand, the unexpected losses, i.e., the tail of the expected losses distributions.

Table 6: Results of the Risk Capital Model

Year	Mean ECL	SD(unexpected losses)	CI 99.8% Lower	CI 99.8% Upper	CI 98.5% Lower	CI 98.5% Upper	CI 95.5% Lower	CI 95.5% Upper
2022	3,598,628	313,617	2,363,104	4,917,046	2,991,072	4,217,405	3,266,055	3,912,403
2021	3,533,772	305,345	2,400,032	4,557,231	2,979,834	4,104,166	3,237,129	3,823,367
2020	3,001,673	248,180	2,098,749	4,031,433	2,537,666	3,471,414	2,761,365	3,237,230
2019	2,822,415	249,657	1,860,947	3,668,938	2,389,937	3,276,890	2,598,775	3,044,366
2018	1,697,657	1,116,207	1,116,207	2,282,511	1,384,300	2,018,513	1,537,930	1,860,228

Risk capital was sensitive to the confidence intervals. As there was an inverse relationship between them, i.e., lower interval levels resulted in higher risk capital, as shown in Table 6 and the figures below.
Results are represented using a bell-shaped distribution as follows:



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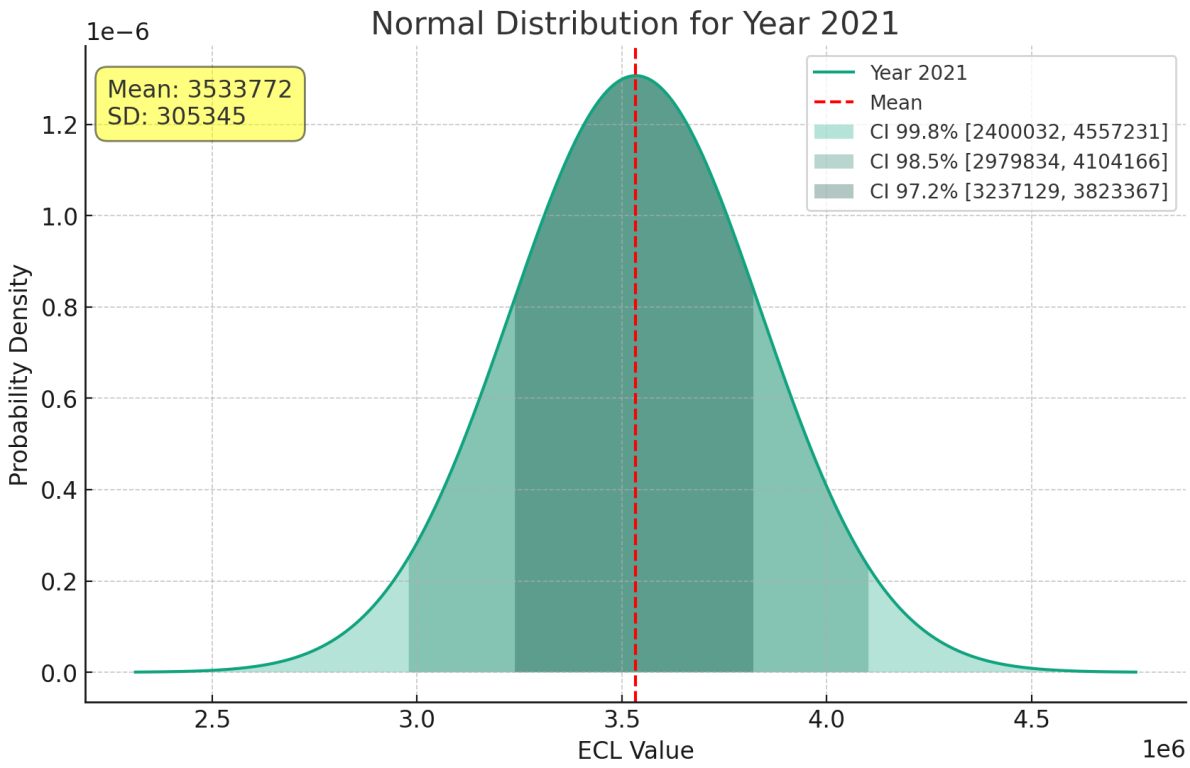

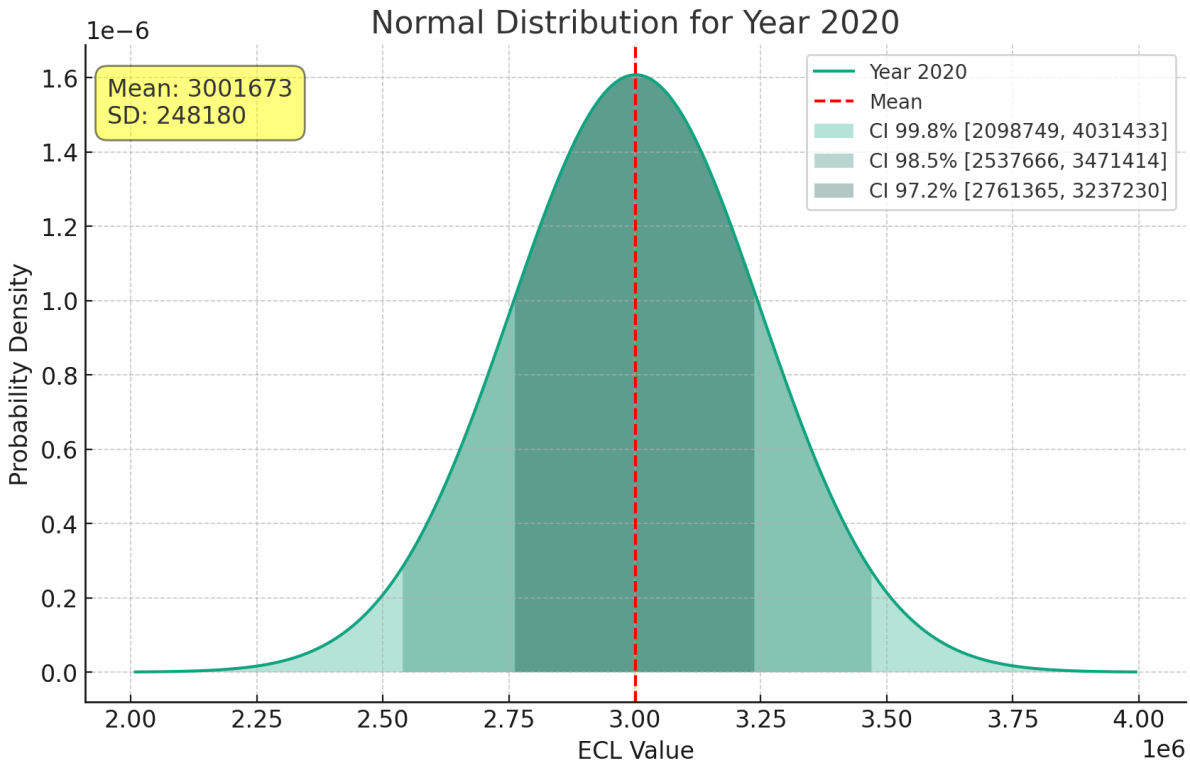

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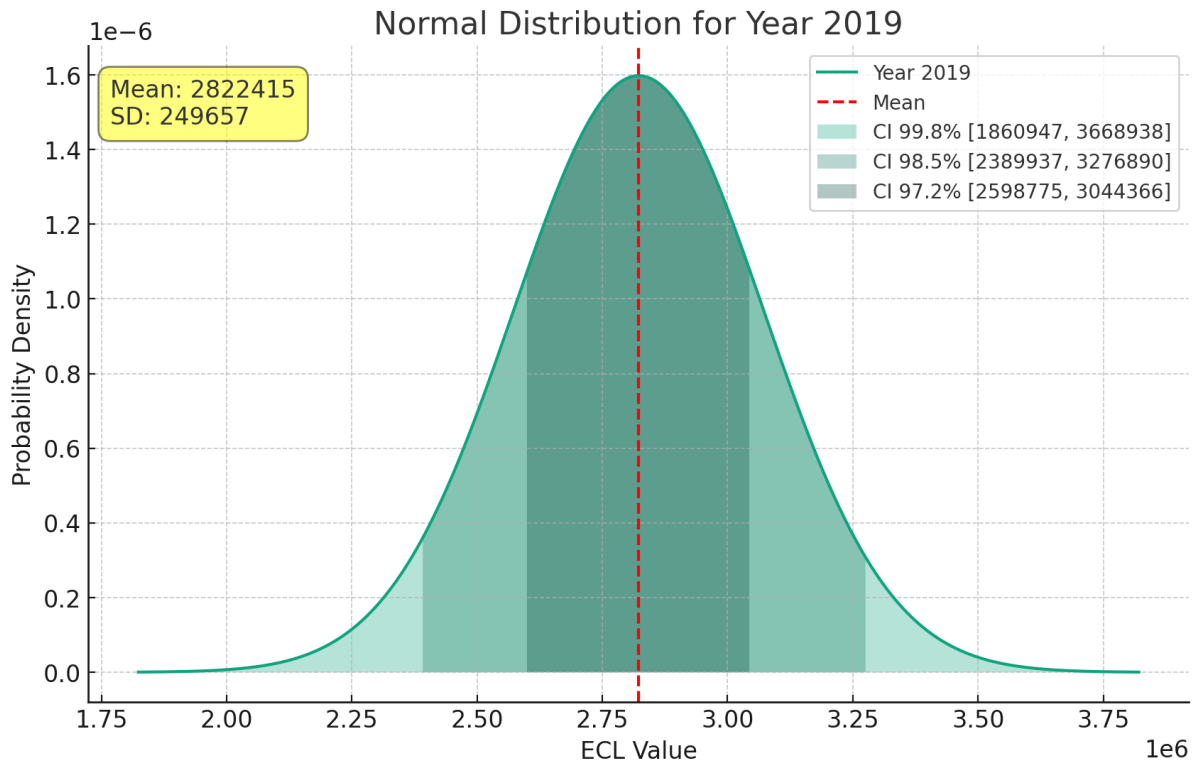

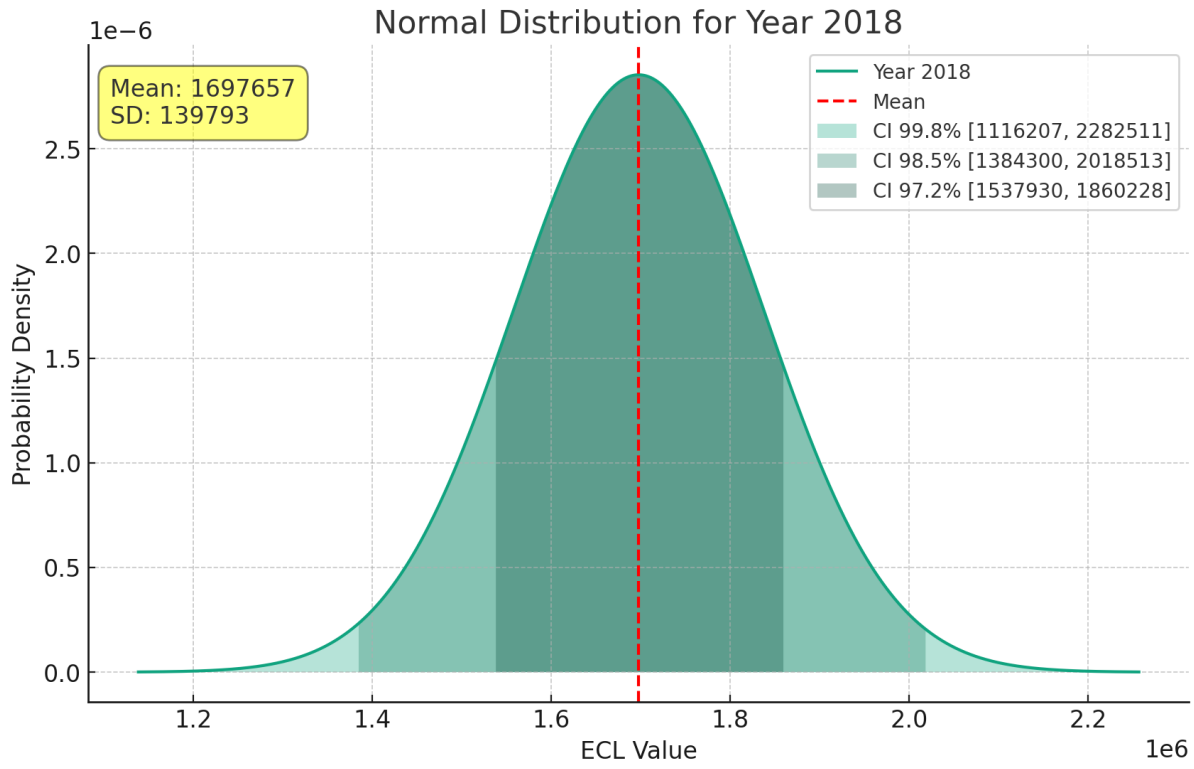

Table 7 showed that the expected losses exceeded their actual allocation for loan losses, indicating that the bank should have increased its allocations for loan losses from its revenues over the study period. That is, the bank was under Provisioning.

Table 7: Expected Credit Losses Vs Actual Allocations for Loan Losses

Year	Expected losses	Actual allocation for loan losses	Under Provisioning
2022	3,598,628	2718645	879,983
2021	3,533,772	2637997	895,775
2020	3,001,673	2192997	808,676

2019	2,822,415	1009167	1,813,248
2018	1,697,657	933505	764,152

CREDIT RISK-ADJUSTED RETURN ON RISK CAPITAL

The credit risk-adjusted return on capital is one of the most important performance indicators, as it is based on risk capital. As the study calculated the risk-adjusted return on capital as follows: RAROC = EI - (OE + IE) - EL / RC (3). Whereas RAROC = risk-adjusted return on capital. EI = expected income from interest income generated by the investment. OE =Operating expense, including all expenses assumed by banks except interest expenses and the allocation for loan losses. IE refers to interest expenses paid on the bank's deposits and interest-bearing liabilities. EL =Expected losses. RC = Risk capital based on the risk capital model. Calculating the net income on the loan portfolio to calculate the credit risk-adjusted return requires separate disclosure of the debit and credit interest of the loan portfolio, as well as calculating the loan portfolio's share of non-interest operating expenses. However, the bank under study did not disclose the details of interest income or expenses separately on the loan portfolio. Therefore, measuring the risk-adjusted return on risk capital for the bank under study is challenging due to data limitations. However, the study provided the basic data needed to estimate risk-adjusted returns, which represent expected losses that replace loan loss provisions, and unexpected losses that represent risk capital, which replaces accounting or regulatory capital. Table 8 showed that, under the standard approach using the concept of regulatory capital, the bank maintained allocations for loan losses and regulatory capital that exceed the sum of the expected losses and risk capital derived from the risk capital model. The regulatory authorities required banks to maintain a greater level of capital than internal capital to absorb credit risks and protect depositors. However, under the concept of risk capital, the bank had expected losses exceeding the allocated amounts for loan losses, and its risk capital was less than its regulatory capital.

Table 8: Standardized Approach vs IRB Approach

	Allocations for loan losses	Regulatory capital	Total	Expected losses	Risk capital	Total
2022	2,718,645	564,7921	8,366,566	3,598,628	313,617	3,912,245
2021	2,637,997	499,4758	7,632,755	3,533,772	305,345	3,839,117
2020	2,192,997	431,6897	6,509,894	3,001,673	248,180	3,249,853
2019	1,009,167	397,2810	4,98,1977	2,822,415	249,657	3,072,072
2018	933,505	327,1751	42,052,56	1,697,657	139,793	1,837,450

RESULTS

This study aimed to estimate the risk capital model to develop the credit risk-adjusted return on the risk capital. The literature showed many concepts of capital in banks. Accounting capital refers to shareholders' equity, as reported in the equity section of the balance sheet. Regulatory capital refers to the capital determined by regulatory authorities, including accounting capital and other relevant elements. The Risk capital derived from the internal models is required to absorb risks and protect against banks' default. Using accounting capital and regulatory capital to measure performance from risk perspectives did not preserve the banking system against collapse, nor did they distinguish between risks and losses. Therefore, the Basel II Accord required banks to calculate their risk capital in parallel with their regulatory capital. The study employed the case study method because its objective is to gain an in-depth understanding of the concept of risk capital, its calculation, and its applications. The empirical study was conducted on a leading Saudi bank to estimate the risk capital model for the period from 2018 to 2022. The study utilized R programming and Monte Carlo simulations to estimate the parameters of the risk capital model. R programming and Monte Carlo simulation generated the expected losses that the interest rate margin should cover, as well as the unexpected losses that should be covered by capital. The trend indicated an increase in credit risks during the study years, as reflected in the tails of the expected loss distributions, which represent unexpected losses. This indicates the risk capital required to absorb the credit portfolio risk. In addition, the expected losses estimated by the mean increased over the study period due to the increase in the credit portfolio volume. The study used expected and unexpected losses to develop credit risk-adjusted returns on the risk capital. Overall, the study's results showed that the bank under study is well capitalized if the regulatory capital and allocations for loan losses complement each other, as the bank has a regulatory capital and allocations for loan losses that exceed the expected losses and risk capital. In addition, the study highlighted the distinction between the concepts of capital and returns on capital, as the return on accounting capital equals net profits, as measured according to accounting standards, divided by accounting

equity. This return meets the needs of external users, while the Basel Accord standards require calculating regulatory capital to protect depositors against collapse – Pillar I. While the risk capital is calculated using internal quantitative models by the Basel Accord – Pillar II standards. Where risk capital is used to evaluate internal performance and allocate capital based on risk, risk capital allows for the Calculation of Risk-Adjusted returns by dividing net profits, based on the concept of expected losses, by risk capital, which represents unexpected losses.

CONCLUSIONS AND FUTURE STUDIES

The current study made an incremental contribution to the existing literature by advancing the practice of estimating credit risk and risk-adjusted returns. The study is the first in Saudi Arabia and the Middle East region to address this issue. The study's results motivate banks to adopt the concept of risk capital instead of traditional regulatory capital, as the risk capital derived from the risk capital model is less than the regulatory capital. , which allows banks to avoid the cost of holding excess capital, especially since the cost of capital is greater than the cost of borrowing, as tax laws allow banks to deduct borrowing costs when preparing the tax returns. In contrast, they do not allow banks to deduct cash dividends or imputed interest on capital for tax calculations. In addition, the study contributed to the current literature by laying the foundation for future studies on measuring risk capital and calculating risk-adjusted returns. Regarding the limitations of the study, it employed the case study method. Despite its advantages in conducting an in-depth study of the phenomenon, the current study's findings are limited in external validity, as they are non-generalizable to banks within or outside Saudi Arabia, due to each bank having a unique risk structure. As a result, the current study encourages future research to expand on its scope by conducting cross-country studies. Regarding recommendations, the study suggests that Saudi banks should disclose the necessary data to help investors estimate credit risks and calculate risk-adjusted returns. Additionally, banks should adopt risk capital instead of regulatory capital.

STUDY'S IMPLICATIONS

The results of the study have practical and scientific implications for several stakeholders such as banks, regulatory authorities and investors in the financial markets, as the study addressed the quantitative measurement of credit risks, considering that it constitutes the most significant proportion in the structure of banks' risks compared to market risks and operational risks. In addition, the study provides practical evidence confirming the advantages of risk capital, which reduces the capital required. It also serves as a basis for developing risk-adjusted performance measures to overcome the shortcomings of non-risk-adjusted performance measures, such as return on equity.

REFERENCES

1. Altman, E. I., (2006). Default recovery rates and LGD in credit risk modeling and practice: an updated review of the literature and empirical evidence. Tech. rep., New York University. https:// citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=f07920544cb9d2ba1daf21fbfa5419bff48ade5d
2. Amelia Ho (2012).Weaknesses in Regulatory Capital Models and Their Implications. https://web.actuaries.ie/sites/default/files/erm-resources/ho_paper_03_23_12.pdf
3. Andrle, M. Tomšík, V. and VlčekBanks, J. (2017). Banks' Adjustment to Basel III Reform: A Bank-Level Perspective for Emerging Europe. IMF Working Paper-WP/17/24 https://doi.org/10.1080/001 28775.2018.1483202
4. Antwi, O.; Mensah, A. C.; Amoamah, M.O; Joseph. (2014). Measuring risk capital using loss distributions. International Journal of Economics, Finance and Management Sciences; 1(6): 406-412 DOI: 10.11648/j.ijefm.20130106.29
5. Araten, M. (2004).Current Issues in Estimating Risk Capital for Credit Risk. The RMA Journal.PP38-43. https://cms.rmau.org/uploadedFiles/Credit_Risk/Library/RMA_Journal/Loan_Loss_Reserves/Current%20Issues%20in%20Estimating%20Economic%20Capital%20for%20Credit%20Risk.pdf
6. Bandyopadhyay, A. (2023) .Why Indian Banks Need to Adopt the Basel III Internal Ratings-based Approach. Economic & Political Weekly- June 3, 2023 vol .l Viii no 22. https://www.nibmindia .org/documents/213/Why_Indian_Banks.pdf
7. Bank for international settlements. IFRS (9) and expected loss provisioning – Executive Summary https://www.bis.org/fsi/fsisummaries/ifrs9.pdf
8. BARBOZA .F; KIMURA, H.; BASSO.L.F.C. SOBREIRO.V.A. Vinicius, A. (2016). Risk capital and Rating: Analysis and Minimum Requirements. Revista ESPACIOS | Vol. 37 (Nº 14) Año. https://ww.revistaes pacios.com/a16v37n14/16371409.html
9. Basel Committee on Banking Supervision (2009).Enhancements to the Basel II framework. Bank for International Settlements. https://www.bis.org/publ/bcbs157.pdf
10. Białas, M. and Solek, A. (2010). Evolution of Capital Adequacy Ratio. Economics. & Sociology, Vol. 3, No 2, pp. 48-57. https://www.proquest.com/docview/1039084766?pq-origsite=gscholar&fromopenview=true
11. Carter, D.A.; McNulty, J.A. & Verbrugge, J.A. (2004). Do Small Banks have an Advantage in Lending? An Examination of Risk-Adjusted Yields on Business Loans at Large and Small Banks. Journal of Financial Services Research, vol. 25, pp. 233–252. https://link.springer.com/article/10.1023/ B:FINA.0000020663 .21079.d2
12. Caruana, J (2005). Monetary policy and Basel II. https://www.bis.org/review/r050517b.pdf
13. Culp, C.L. (2000). RAROC Revisited Ex Ante vs. Ex Post RAROC. The Journal of Lending & Credit Risk Management, PP 5-57.

https://cms.rmau.org/uploadedFiles/Credit_Risk/Library/RMA_Journal/Other_Topics_(1998_to_present)/RAROC%20Revisited%20-%20Ex%20Ante%20vs.%20Ex%20Post%20RAROC.pdf

14. Das, S. R., (2007). Basel II: Correlation Related Issues. Journal of Financial Services Research 32 (1-2), 17–38. https://link.springer.com/article/10.1007/s10693-007-0011-6
15. Elizaldea, A. and Repullo, R. (2007). Economic and Regulatory Capital in Banking: What Is the Difference? International Journal of Central Banking. Vol. 3 No. 3 https://www.ijcb.org/journal/ijcb07q3a3.htm
16. Giese, G., 2005. The impact of PD/LGD correlations on credit risk capital. Risk 18 (4), 79–84. ciadmin,+Journal+manager,+1-8340+van+Vuuren (1).pdf
17. Gordy, M. B., Jan (2000). A comparative anatomy of credit risk models. Journal of Banking & Finance 24 (1-2), 119–149. https://doi.org/10.1016/S0378-4266(99)00054-0
18. Tran, D.TT. & Phan, H.T. (2020). Bank Size, Credit Risk, and Bank Profitability in Vietnam. Malaysian Journal of Economic Studies, Vol. 57, No. 2, Dec 2020: 233-251. https://search.informit.org/ doi/abs/10.3316/INFORMIT.586174661438166
19. Hull, J.C. (2018). Risk Management and Financial Institutions. (5th ed.), Wiley, Hoboken (2018) https://scholar.google.com/scholar?q=19.%09Hull,+J.C.+(2018).+Risk+Management+and+Financial+Institutions.+(5th+ed.),+Wiley,+Hoboken+(2018)&hl=en&as_sdt=0&as_vis=1&oi=scholart
20. Jorion, P. (2006). Value at Risk the New Benchmark for Managing Financial Risk. 3re Edition, the McGraw-Hill Companies, Inc., New York. https://thuvienso.hoasen.edu.vn/handle/123456789/10569
21. Jorion, P., Zhang, G., Oct (2009).Credit Contagion from Counterparty Risk. The Journal of Finance 64 (5), 2053–2087. https://doi.org/10.1111/j.1540-6261.2009.01494.x
22. Kaplan; Z.T.; Li, Y.and Nakayama, M.K. (2018). Monte Carlo estimation of risk capital. WSC '18: Proceedings of the 2018 Winter Simulation Conference December 2018Pages 1754–1765. https://researchwith.njit.edu/en/publications/monte-carlo-estimation-of-economic-capital
23. Klaassen, P. and n Eeghen, I v. (2015). Analyzing bank performance – linking RoE, RoA and RAROC: U.S. commercial banks1992–2014. The Journal of Financial Perspectives-Volume 3 – Issue 2, pp 1-22 https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3083577
24. Krebs, M. and Nippel, P. (2021). Unexpected loss, expected profit, and risk capital: A note on risk capital for credit risk incorporating interest income. Volume 38, January 2021, 101481. https://doi.org/ 10.1016/j.frl.2020.101481
25. Kumarhttps, K. (2023). Risk-Adjusted Performance Measurement: Gain deeper insight to take on high risk and earn high returns. https://www.linkedin.com/pulse/risk-adjusted-performance-measurement-gain-deeper-insight-kamal-kumar
26. Le.C. Sevic, A.; Tzeremes, P. & Ngo.T. (2020). Bank efficiency in Vietnam: Do scale expansion strategies and non-performing loans matter? International of Finance and Economics. https://doi.org/10.1002/ijfe.2179
27. Majeed, A.; Andrew Bindman, B. (2001) .Use of risk adjustment in setting budgets and measuring performance in primary care II: advantages, disadvantages, and practicalities. BMJ 2001; 323. doi: 10.1136/bmj.323.7313.607
28. McNeil, A.J.; Frey, R. and Embrechts.p (2015). Quantitative Risk Management: concepts, Techniques and Tools (rev. ed.), Princeton University Press, Princeton - https://press.princeton.edu/book s/hardcover /9780691166278/quantitative-risk-management
29. Merton, R. C. (1974) .On The Pricing of Corporate Debt: The Risk Structure of Interest Rates. The Journal of Finance 29 (2), 449–47 https://citeseerx.ist.psu.edu/document?repid=r ep1&type=pdf&doi=6e58 d9ead2f4db1e180d00cede61a582ea742c46
30. Nehrebecka, N. (2023).Distribution of credit risk concentration in specific sectors of the economy and risk capital before and during the COVID-19 pandemic. Economic Change and Restructuring volume 56, pages129–158 https://link.springer.com/article/10.1007/s10644-022-09412-5
31. Nenada, M. Srđan, R. (2021). Expected effects of the revised exposure to banks Basel credit risk weighted assets standard. Strategic Management, 2021, vol. 26, br. 3, str. 49-60 https://scindeks.ceon.rs /article.asp x?artid=1821-34482103049M
32. Rossi, C.V. (2011).Risk-Adjusted Performance: Lessons from the Financial Crisis. The Journal of Structured Finance. DOI10.3905/jsf.2011.17.2.028
33. SAMA Banking Supervision Department June, (2006). Basel II – SAMA's Detailed Guidance Document. https://www.sama.gov.sa/en-US/Laws/Documents/Section%20B/Basel%20II%20SAMAs%20Detailed%20Guidance%20Document.pdf
34. Stake R.E. (2000) .Case studies. In Handbook of Qualitative Research, 2nd edn. (N. Denzin & Y. Lincoln, eds), Sage, Thousand Oaks, CA.Google Scholar. https://www.scirp.org/(S(351jmbntvnsjt 1aadkposzje))/ reference/ReferencesPapers.aspx?ReferenceID=1807338
35. Stiroh, K. J. (2004). Do Community Banks Benefit from Diversification? Journal of Financial Services Research volume 25, pages135–160 (2004) https://link.springer.com/article/10.1023/B:FINA .0000020657.59334.76
36. Sweeting.p. (2011). Financial Enterprise Risk Management (International Series on Actuarial