Research on Risk Management in Banking System

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Abstract. Risk management equips a bank with the tools that risk managers can use to detect, analyze and resolve risks. Risk management enlightens a business on the different ways to deal with risks by providing a guideline for sound decision-making. Risk management involves several processes like assessment, communication, monitoring and valuation of risks. A company can ensure the security of their assets and prevent losses through these processes. Also, it enables the business to weigh the options of risks and make a sound decision on investments. This paper explores the impact of risk management in banking by analyzing the risk management process, strategies, types of risks, technologies and quantitative methods in banking.

Keywords: Risk Management; Banking System; Quantitative Methods.

1. Introduction

The banking system is prone to various risks, so risk management is vital in the sector. Risk management involves identifying, analyzing, assessing, monitoring and resolving risks. The banking system is associated with many operational, credit and market risks. The process of risk management ensures security for the banking sector and its instruments. The financial industry is the backbone of the economy, so risk managers should manage any risks early. Planning and anticipating the risks that can occur contribute to the efficient functioning of the sector. Quantitative methods of risk management aid in evaluating and managing the risks arising during operations and provides data useful for decision-making. Risk management is beneficial to the banking sector as it ensures asset management. It ensures that risk managers closely monitor and operate the bank's functions efficiently. Setting capital aside for risk management is essential to ensure effective governance.

2. Literature Review

Risk management is identifying, analyzing and prioritizing risks and response planning by applying economic resources to minimize the risks. Smith et al define risk as an undesired outcome of investment [4]. According to Leo et al risk management constitutes risk identification, monitoring, assessment, testing, reporting and oversight [1]. They argue that higher the anticipated returns, the higher the risk. There are different types of risks in the banking sector; operational, market, liquidity, technology and insolvency risk. Based on Leo et al research the main risks in the banking sector are credit, operational and market risks . Effective risk management is key to business performance. Although risk managers have established regulations to limit business exposure to risks, risk cannot be wholly avoided by the banks. Most risks require capital to manage, making them more draining to businesses. According to Samimi and Amir, banks can achieve risk management through communication, evaluation, control and monitoring of the risks [2]. They further argue that assessing the most vital risk in the banks can help make quick risk management its top priority. For instance, in the banking industry, credit risks have been the most significant risks facing them. Businesses should set capital aside for the management of anticipated risks and unforeseen risks. According to Leo et al, risk management ensures the profitability of the business by reducing the losses which could be accrued from the risks [1]. They postulate that risk management team should anticipate the risks associated with their industry and provide imminent solutions. Smith et al further argues that risk management in the banking industry is achieved through the use quantitative methods of risk management [4]. Banking industry needs more proficiency in the management of risks as it deals with broad economic sectors. Similarly, they prove that the desire to increase returns is accompanied

by an increase in risks. Risk management ensures that bank venture into profitable risks by advising on the probability of risk occurrence.

3. Main Risk Types in Banking

3.1 Credit Default Risk

It occurs when bank borrowers default to pay back their loans. It's the main risk because the bank writes off the loan after 90 days of nonpayment, which the bank pays from the reserves. Banks screen loan applications, request collaterals, diversify risks and conduct a credit risk analysis to reduce credit risks. This risk involves the borrower's behaviour, ability and willingness to repay the loan. Credit risk analysis is determined to analyze the risk posed by the borrower to determine the interest rate to be charged. The credit rating of the borrower depends on their statistical and personal information.

3.2 Operational Risk

This risk is associated with the banking instruments or equipment. This risk occurs when the machinery or buildings to run the banking exercise are damaged or destroyed. Most operational risks like property destruction are covered by insurance. Banks should, however, prevent such risks by continually conducting a risk assessment process. Monitoring the applications' operations, machinery, and buildings will help reduce operational risks. Good management is vital to ensure profits by enhancing healthy business practices. Operational risks result from failed internal processes. Operational risks can lead to greater losses if ignored, therefore the management team should be observant.

3.3 Market Risk

Market risk is the risk resulting from the vitality of the market forces. It involves interest rate, foreign exchange, commodity risk and equity risk and is measured by vitality. Market risk is essential to be monitored in the banking sector as it covers sensitive segments of the sector. Interest rates are vital for the operation of the banking sector, and its risk arises from the changes in interest rates, especially on assets and liabilities with variable rates. Similarly, the fluctuations of the currency exchange rates pose a risk to the banks and their holding currencies. Equity risks arise from changes in the prices of stocks.

4. Risk Management Process in Banking System

The risk management process involves four main steps: identifying, assessing, treating, and monitoring the risk. Process models, capability process assessment, and governance can help businesses improve their processes [3]. The first step of a risk management plan is risk identification which involves figuring out the risk. This step mainly involves brainstorming, whereby all employees contribute to identifying risks. The risks are then prioritized as all risks cannot be mitigated simultaneously; hence the more vital ones are solved first [4]. Risk identification is the most vital step, as it ensures that all risks are considered and arranged in order of priority. Identifying the risk associated with utilizing or owning a particular asset helps to ensure its safety. The risk should be occasionally identified and dealt with to prevent owners from losing assets. The first step is to identify risks, for instance, the operational and liquidity risks in the banking system.

The second step is risk assessment which involves analyzing the cause of the risk and its potential effect on the bank [4]. The process involves analyzing the facts about the risk and its drivers, which will help in determining the best solution to the problem. Risk assessment involves analyzing the prioritized risk to determine their severity and the potential areas they would affect. The team also determines the capital needed to solve the risk [3]. Discerning skills are required in the risk assessment step to understanding the risk. Also, calculating the value of the risk is essential at this stage. It gives

an insight into the probable costs to be accrued due to the risk occurrence [4]. The team determines the magnitude of the risk through the use of qualitative and quantitative methods.

Risk response involves devising a solution to handling the risks, which is the third step of risk management. It involves developing solutions to mitigate the risk and prevent it from occurring again [3]. This step involves devising the best solution to handle the risk cost-effectively. After the solution to the risk has been developed, its implemented in the system [4]. The team should weigh the cost of the solutions before implementing them based on the budget. The response that offers the most benefit to the company is implemented to prevent the harm the risk would have caused. The team decides whether to use an action plan or mitigation measures in responding to the risk [4]. They can choose to transfer, avoid or reduce the risk. Similarly, implementing contingency and prevention planning can help in mitigating the risk. At this stage, the team chooses the appropriate method to use. The chosen method should balance the benefit with the costs.

Finally, the last step involves monitoring the risk [3]. After implementing the response, the team monitors the risk to determine whether the solution performed its purpose. This step mainly involves evaluating the efficiency of the implemented solution on the risk [4]. When a solution is implemented, the company expects an increase in profits and effective business operation. After a series of observations, the risk managers prepare a report on the efficiency of the implemented solution. After the company successfully resolves a risk, it terminates the action plan and proceeds to the other risks. New risks are identified, and new action plans are implemented. During this period, communication with the product development team is vital to determine the solution's efficiency [4].

5. Risk Management Strategies in Banks

Risk management strategies are the ways and methods used in risk management. An appropriate risk management strategy should lead to closely matching profit targets and cost savings. The effectiveness of the implemented strategy is shown by its ability to achieve profits and save on costs [5]. Risk avoidance is a strategy whereby the company doesn’t involve in risky operations. It involves investing in opportunities that are not risky. A risk avoidance strategy ensures stagnation of the organization as the company doesn't venture into new opportunities. The higher the risk, the higher the returns; hence the absence of risks limits the number of benefits [6]. The strategy is mainly adopted in situations where the risk occurrence is inevitable, and its impact in case of occurrence is severe. For instance, the banking sector can avoid credit risks by avoiding issuing credit to customers [7]. The bank avoids some risks that seem sure to prevent getting liquidated.

Risk acceptance is another strategy that is used by businesses to manage risks, as it involves making zero effort to mitigate them [6]. It doesn’t involve preventing the occurrence of the risk or reducing the impact of the risk. Accepting and anticipating the risks is excellent for the company as it allows them time to develop ways to resolve them [5]. Accepting risks enables the company to learn how to deal with similar risks in future. Risk acceptance is a strategy that allows a company's growth but is essential for small risks that are easy to recover. With significant risks, risk acceptance may cripple the business, as in the case of losses, it may be a big blow to the business. For instance, a bank may accept risks in a situation where credit has been issued with collateral. The bank is still determining if the collateral will exist at the time of default of payment.

Also, risk reduction is a strategy that risk managers can use to manage risks. Reducing risks involves indulging in investments that are less risky compared to other risky investments [6]. The strategy reduces the weight of both the risk and also the benefits from the risks. The process requires some planning to balance the benefits and the risks. For instance, in the manufacturing sector, they employ a quality management system to reduce the risk of production of substandard products [5]. It is a good move, especially if the company faces some financial constraints, as this saves it more losses. However, the proportion of risk reduction is direct to the benefits reduction. Banks reduce risks by reducing increasing the requirements for credit qualification or by increasing the interest rates. That

way, only a few people will qualify for the loans, and the certainty level they will pay back will be high.

Lastly, transferring risks is a risk management strategy that involves spreading the risk among several parties. The risk can be distributed to other employees, insurance companies, or ventures [5]. For instance, in a travel agency, the travel insurance bears the risks of lost items rather ha nth travel agency. Risk sharing is efficient in that it accrues benefits at a lower risk. Also, in the case of losses, the aggregate loss per party is less compared to what an individual would accrue [6]. A company should choose the best strategy based on the risk assessment. Similarly, in the banking sector, risk transference is done when banks keep reserves with the central banks in case of liquidation. Similarly, they offer credit to customers spreading the risks to them as they are responsible for the borrowed funds.

6. Importance of Risk Management in Banking

Risk management equips a bank with the tools that risk managers can use to detect, analyze and resolve risks [3]. Risk management enlightens a business on the different ways to deal with risks by providing a guideline for sound decision-making. Risk management involves several processes like assessment, communication, monitoring and valuation of risks. A company can ensure the security of their assets and prevent losses through these processes. Also, it enables the business to weigh the options of risks and make a sound decisions on investments [6]. Risk management enables the company to anticipate risks and learn how to deal with them in case they occur.

It encourages the growth of the business by providing knowledge of risks, as the more the risk, the higher the returns [6]. Providing an analysis of the risks and their benefits enlightens banks on the benefit of investing in some risks. Similarly, it ensures the growth of the business by ensuring the retention of assets, as it helps avoid the losses which might have arisen from the occurrence of the risk [3]. Risk management enables a business to quickly determine the probability of risk occurrence and invest in the profitable risk. It also helps reduce losses due to its prediction power. Similarly, it provides valuable data for decision-making, enabling businesses' growth. Efficient decision-making ensures business growth as each effort is geared towards achievements. Additionally, banks act as advisors to their customers; therefore, the information gained during risk management is used to educate customers on risks.

Risk management increases business profitability. It helps analyze potential risks contributing to losses [3]. Risk management provides information and guideline on the best time to invest. For instance, risk management advises the best time to sell and purchase securities in securities investments. Also, it ensures the retention of assets by predicting the possible risks that would lead to the loss of the assets. The retained assets reduce the bank's cost to purchase new ones. Risk management provides helpful information in enhancing company profits [6]. The quantitative methods used in risk management provide useful information that risk managers can use to gauge benefits. Assessing the risk potential and analyzing the data using quantitative methods provides a guideline on the profitable investment. For instance, when securities are selling or buying high, the risk management team gives the go-ahead at the appropriate time to buy or sell.

Risk management enhances communication within the bank. During risk identification, all the employees contribute to identifying the risk [4]. The process of risk management requires communication between the top management and other employees. Communication during the risk management process is vital as it combines ideas and views on the operation. Banks need risk management information to flow within the organization efficiently to avoid losses. The flow of information across different departments enhances communication as it creates interdependence. Also, the teams handling the various risk assessment processes have to communicate. It is an exercise that requires teamwork, as the final report has to be reliable for decision-making.

Lastly, risk management ensures easy and accurate budgeting. The anticipation of the bank's additional costs in case of risk occurrence provides information needed in drawing a budget [6]. When

risk managers identify the risks, their accrued costs are estimated and set aside, awaiting the event of the risk. Clarity of information on the anticipated risks ensures close to an exact approximation of expected losses in case of risk occurrence. The banking system can refer to past reports to accurately determine the value of the systematic risks. Drawing the budget is simple, with everything analyzed, as it involves matching the activities with the amounts. Similarly, the banking system is advanced, so data collection and interpretation are more straightforward and accurate. Risk management is vital in budget drawing and asset allocation.

7. Risk Management Regulations on Banking System

The bank's board assumes all the responsibility for risk management. It should formulate well-designed procedures and policies after outlining the risk management strategy. Risk managers should develop risk management in a business way to enhance judgement on risk exposure in assessing and managing the bank's risk profile [8].

Individual business units or lines should account for the risk they are taking irrespective of the management function or separate risk review [8].

Risks should be measured quantitatively and reported whenever possible.

The function of risk review should be independent of risk takers.

Banks should formulate contingency plans in case of emergencies or abnormal scenarios.

7.1 Benefits

The guidelines ensure that management within the bank is efficient by allocating roles. For instance, the bank’s board is responsible for risk management [8]. The guidelines are set to ensure that everyone performs their function efficiently. The banking system is the backbone of the economy; hence, risk management duties are assigned to senior personnel. The guidelines are set to limit access to the vital information of the bank by other individuals. It also prevents the jokers' adoption of significant roles, which would lead to the bank's liquidation. Guidelines are put in place to show how things are to be done. The guidelines on risk management offer insight into the eligible members to manage the risk at the bank.

Also, they encourage the effective communication and measurement of risks [8]. Risk should be measured quantitatively and reported when possible. The guidelines give the framework for how the activity is to be conducted. The banking system requires an accurate report for decision making as a slight mistake can lead to its liquidation. However, the guidelines have emphasized using quantitative methods to analyze data to derive an approximate risk value. It also helps in determining different functions, for instance, risk review, which does not depend on risk takers [8]. The principles prevent policy maker from manipulating the risk-takers. When standards are set, justice is likely to be served. The guidelines are beneficial to the banking sector by offering a guide on how to conduct risk management.

The guidelines increase the bank's time before liquidation. Violating the principles can lead to severe consequences [8]. The guidelines advocate for banks to develop contingency plans in abnormal situations. It has effectively ensured most banks remain in the industry. The principles are set to provide fair business competition and prevent industry collapse. They guide the banks on customer service without exploiting them. The information in the guidelines also enlightens bank users to acquire quality services without getting intimidated. Guidelines are supposed to control the flow of events. The risk management principles have significantly contributed to stabilizing the banking system.

7.2 Challenges of Risk Management in Banking

Risk management in banking faces several challenges due to the nature of the industry. The presentation of forged cheques is a challenge that has been prevalent in the banking sector [7]. Risk managers cannot anticipate such risks because the bank believes its systems are designed to detect

errors. The presentation of false cheques incorporates an extra burden to the bank hence incurring losses. Granting unauthorized credits is another factor that poses a challenge to the banks' risk management [7]. Such actions are not anticipated by the bank and cause the bank losses. The issuance of funds by the bank without any record makes risk management challenging as the available data needs to be corrected. Therefore, decisions or predictions made using the recorded data are misleading to the bank.

The lack of communication between top management and others has posed a challenge to implementing risk management. For example, there is no communication between the central and commercial banks [7]. Most central banks have set the reserve rate for commercial banks, which they sometimes violate, leading to liquidation. When commercial banks exceed the reserve rate, it causes a risk management failure as money that banks should reserve is included in the analysis. Risk management should be accurate since it is used for decisions. Therefore, commercial banks including other funds in the process, which is not allowed, alter the authenticity of the data provided [9]. Most banks face the challenge of including money on the reserves in their prediction, contributing to the liquidation of most of them.

The banking system is mainly affected by financial crises like inflations, especially the Islamic banks that are highly dependent on oil prices [10]. The rise in the prices of commodities affects the demand for bank loans forcing them to increase their interest rates. Risks associated with a change in economic times are not easily predictable, making risk management difficult. Also, during financial crises, the banks don't have enough money to fund resolving risks that hinder their control [9]. Also, some bank debtors may default to repay the loan due to financial constraints. The banking system does not reasonably anticipate such risks. Most banks set up assets to solve the financial crises which push them to liquidation.

Lack of cooperation from non-bank financial institutions like micro finances, SMES and Sacco's [9]. The central banks do not govern these institutions and therefore do not follow the guidelines of the central banks. A united view on risks is needed to make risk management more straightforward. However, as they are part of the banking system, they lead to their decline due to poor risk management. Additionally, most no-bank financial institutions aim at acquiring profits despite the cost [7]. Most institutions issue loans and venture into economic activities without assessing the risks making them vulnerable. When they give loans at low-interest rates, the banks lose customers applying for loans hence granting them false data for risk assessment. The non-bank financial institutions last only a short time in the industry; therefore, customers return to the bank. The inconsistency of the institutions makes the accurate collection of data complex hence poor decision-making.

Also, the regulations set by the regulators may sometimes alter the operation of the banking system, making it collect false data. For instance, relieving customers of loan repayment by extending their repayment period [10]. Some decisions by the relators alter the systems operations. For example, if the regulators push the payback period to six months, banks won't have any cash inflows for the six months. During this period, the bank will record zero transactions which would not have been the case were they allowed to function without the regulations. The data collected during this period needs to consider some risks and be more accurate. The data could be used in quantitative risk management hence making unreliable decisions [10]. Considering that decision-making depends on past data, using the data where regulations had been put in place can mislead the bank as some operations had been omitted. Therefore, regulators should consider the effect of their regulations on risk management before imposing them.

8. Quantitative Risk Management Used in Banking

Quantitative risk management uses measurable data and objectives to make risk management similar. Data is used in determining the risk's probability of occurrence, with values like money used to determine the impact of the risks. However, quantitative risk management requires more data to

assess the risks and formulate procedures to solve them. However, several methods are used to manage risks in banking. Quantitative risk management methods use the available data on the banking system operation to predict the probability of the risk occurrence. However, the methods use formulas to create a relation between the data and risk occurrence. The practice is beneficial as it enhances certainty on the occurrence of risks. The certainty gives investors and other stakeholders confidence in the outcome of assessments. It also provides the data needed for beneficial decision-making and predicts future outcomes. Quantitative analyses create a more realistic target as they depend on raw data.

8.1 Quantitative Methods of Risk Management Used in Banking

8.1.1 Convexity

Convexity measures the degree of the curve or the curvature in the relationship between bond prices and bond yields. It is the measure between bond prices and interest rates and shows the rate of change of bond prices relative to interest rates [8]. Convexity is presented in graphical form, showing the relationship between two variables. Positive convexity is when duration rises as the yield declines, as prices will increase mainly due to a decline in yields than a price decrease due to increased yields [11]. Convexity is mainly used in securities like bonds. This quantitative method provides a guideline on the best bonds to invest in and at what period.

8.1.2 Duration

Duration is the percentage change in price per percentage change in interest rate. It explains how interest rate changes affect the price of bonds. High duration predicts a greater price vitality in case of rate movements [8]. Bond duration is affected by factors like the coupon rate, remaining time to maturity and yield. When the coupon and yield are lower, the duration of a bond will be higher. Also, when the duration is higher, the maturity period is more extended [11]. Similarly, this graphical method can help determine the risk associated with some bonds. Duration can be used in decision-making on the investment to make.

8.1.3 Risk to Net Interest Income

Net interest income is achieved by determining the profitability of bank assets and liabilities [12]. It shows the difference between the earnings from the bank's assets and expenses from interest-bearing liabilities. Banks calculate net interest income by deducting interest they must pay their clients from the revenue generated. It is computed in a quarterly or annual report. The value of the net interest income in a bank depends on the collective rates of interest different loans bear. It also depends on the loan portfolio quality and whether the loans have a variable or fixed rate [11]. Banks with variable asset and liability rates are more sensitive to changes in interest rates than those with fixed holdings. This method is beneficial in risk management as it explains the values and benefits of assets and liabilities. It can be used by bank mana to measure the progress of the bank's operations and its profits.

8.1.4 Value at Risk

It is the measure of the loss risk for investments. This method measures the extent of possible financial losses within a portfolio or firm during a specific period [8]. Commercial banks and investments mainly use it to determine potential loss probability in the banking portfolios. Risk managers use value at risk to control risk exposure [12]. It’s mainly used due to the probability of private trading desks unintentionally exposing the banks to highly correlated assets. It is a simple measure that risk managers must conduct to determine the certainty of risk occurrence. It is beneficial to risk managers by providing decision-making information.

8.1.5 The Economic Value of Equity

It is used to manage the bank’s assets and liabilities and measures the long-term economic aspect measuring the degree of exposure to interest rate risk [8]. It is the net present value of the bank's cash

flows on the balance sheet. This method is beneficial as it enhances the management of assets and liabilities and measures the economic value of the bank changes. It's the sensitivity of the bank to market rate changes. Financial regulators conduct the periodic economic value of equity calculation. This risk analysis method enables banks to anticipate the constantly changing interest rates and perform some tests. Risk managers can also use it to show the impact of interest rate changes on the total capital.

8.1.6 Full Valuation Approach

It's also known as scenario analysis and is the price of bonds depending on the interest rate. It's the addition of all future cash flows discounted by interest rate. Risk managers can use it to calculate interest rate risk by determining the price of bonds in case of changes in interest rates [12]. This method considers the loan portfolios and interest rates. The total value approach is suitable for option-free bonds as bonds with embedded options complicate the valuation. This method gives risk managers information on bond pricing, enabling them to decide when to invest. The process applies the values of all cash flows, providing reliable information for decision-making.

9. New Technologies of Risk Management in Banking

Technological advancements have introduced new trends in the banking industry. Machine learning is a technology that merges statistics, computer science and engineering. It aims to increase the baking system's efficiency [1]. Adopting machine earning is driven by the desire for cost reduction, improved risk management and increased production. Machine learning doesn't depend on assumptions as it analyses actual data. Although it may be efficient and reliable, machine learning can be challenging to interpret. Also, other technologies like cloud computing, big data analytics and mobile applications can be incorporated by ris into the financial sector to manage risks.

Technology advancements in the banking sector can help reduce risk exposure by increasing efficiency and reliability [1]. Automated machinery reduces errors in analyzing and collecting data which is helpful for decision-making. New technologies reduce the workforce required in the banking system, reducing the operational costs and the risks associated with it. The new banking technology enables them to remain stable as they can quickly and accurately anticipate and manage risks. Technology makes operation and management more straightforward and efficient as everything is automated. Similarly, it increases the security of the banks' money; for example, automating the money machines only to release money when the correct verification is entered prevents the loss of money through impersonation.

Also, new technology ensures the use of actual statistics and data [1]. Using accurate data increases the reliability of the information for decision-making. The banking system is susceptible to risk exposure, so sound decisions are vital for its operation. Also, technologies have made forecasting more superficial and accurate [1]. The technologies use actual data, which is best for forecasting as its reliable. It is independent of the estimation of the values of the data; it uses exact values. Using actual data helps the bank to develop the trends of their operations which are essential in future predictions. Lastly, new technologies have made monitoring the procedures more straightforward as machine earning can process data quickly. Most processes that several people would do are combined with a single machinery, making monitoring more straightforward [1]. Technological advancements have made monitoring of transactions simpler as the machines show the history of the preceding transactions making it simpler to generate reports.

References

[1] Leo, Martin, Suneel Sharma, and Koilakuntla Maddulety. "Machine learning in banking risk management: A literature review." Risks 7.1 (2019): 29.

[2] Samimi, Amir. "Risk management in information technology." Progress in Chemical and Biochemical Research 3.2 (2020): 130-134.

[3] “Risk Management.” Corporate Finance Institute, 27 Nov. 2022, https:// corporatefinanceinstitute. com/ resources/risk-management/risk-management/.

[4] Smith, Preston G., and Guy M. Merritt. Proactive risk management. Productivity Press, 2020.

[5] Glossop, Abbie. "What Is a Risk Management Strategy?" Ideagen, 2021, https://www. ideagen.com/ thought-leadership/blog/what-is-a-risk-management-strategy.

[6] Sadgrove, Kit. The complete guide to business risk management. Routledge, 2016.

[7] Adekunle, A. Owojori, R. Akintoye Ishola, and A. Adidu Felix. "The challenge of risk management in Nigerian banks in the post-consolidation era." Journal of Accounting and Taxation 3.2 (2011): 23-31.

[8] Haneef, Shahbaz, et al. "Impact of risk management on non-performing loans and profitability of banking sector of Pakistan." International Journal of Business and Social Science 3.7 (2012).

[9] Hassan, M. Kabir, Mustafa Raza Rabbani, and Mahmood Asad Mohd Ali. "Challenges for the Islamic Finance and banking post COVID era and the role of Fintech." Journal of Economic Cooperation & Development 41.3 (2020): 93-116.

[10] Hubbard, Douglas W. The failure of risk management: Why it's broken and how to fix it. John Wiley & Sons, 2020.

[11] James, Raymond. “Duration & Convexity: The Price/Yield Relationship.” Duration & Convexity - Fixed Income Bond Basics | Raymond James, 2023, https://www.raymondjames.com/wealth-management/advice-products-and-services/investment-solutions/fixed-income/bond-basics/duration-and-convexity.

[12] Mielus, Piotr & Mironczuk, Tomasz & Zamojska, Anna. (2016). Basis Risk and Net Interest Income of Banks. Folia Oeconomica Stetinensia. 16. 10.1515/foli-2016-0024.