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Operational Risk Management in Banks
Analysis of the impact of various banking factors on operational risk

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Abstract:

The article examines operational risk in banking, emphasizing its significance due to potential severe losses, particularly amidst technological advancements and competitive pressures. The purpose of the study is to identify banking factors influencing operational risk and analyze their relationships, thereby enhancing risk management practices.

The problem addressed is the impact of various factors on operational risk, seeking to determine which have the most significant effects and the best management strategies. The research focuses on 24 banking factors across 13 European banks from 2014 to 2016, employing regression analysis to evaluate their effects within different macroeconomic and microeconomic environments.

The methodology combines deductive and inductive reasoning, using both Advanced Measurement Approach (AMA) and Standardized Approach (SA) for analysis. It draws on case studies and secondary data from banks to maintain ethical standards and enhance validity.

Key conclusions indicate a significant relationship between operational risk and various banking factors, with the AMA approach capturing all potential losses and demonstrating significant correlations across all variables studied. In contrast, the Standard approach only highlights a few factors, suggesting it inadequately addresses operational risk. The findings advocate for improved resource allocation in operational risk management, emphasizing the need for banks to adopt comprehensive strategies to mitigate risks effectively.

Résumé:

L'article examine le risque opérationnel dans le secteur bancaire, en soulignant son importance en raison des pertes potentielles sévères, notamment dans un contexte d'avancées technologiques et de pressions concurrentielles. L'objectif de l'étude est d'identifier les facteurs bancaires influençant le risque opérationnel et d'analyser leurs relations, afin d'améliorer les pratiques de gestion des risques.

Le problème abordé concerne l'impact de divers facteurs sur le risque opérationnel, cherchant à déterminer lesquels ont les effets les plus significatifs et

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les meilleures stratégies de gestion. La recherche se concentre sur 24 facteurs bancaires au sein de 13 banques européennes de 2014 à 2016, en utilisant l'analyse de régression pour évaluer leurs effets dans différents environnements macroéconomiques et microéconomiques.

La méthodologie combine le raisonnement déductif et inductif, en utilisant à la fois l'Approche de Mesure Avancée (AMA) et l'Approche Standardisée (SA) pour l'analyse. Elle s'appuie sur des études de cas et des données secondaires provenant des banques afin de maintenir des normes éthiques et d'améliorer la validité des résultats.

Les conclusions clés indiquent une relation significative entre le risque opérationnel et divers facteurs bancaires, l'approche AMA capturant toutes les pertes potentielles et montrant des corrélations significatives entre toutes les variables étudiées. En revanche, l'approche standard ne met en évidence que quelques facteurs, suggérant qu'elle ne traite pas adéquatement le risque opérationnel. Les résultats plaident en faveur d'une meilleure allocation des ressources dans la gestion du risque opérationnel, en soulignant la nécessité pour les banques d'adopter des stratégies complètes pour atténuer efficacement les risques.

Keywords: Operational Risk, Banking Factors, Risk Management, Regression Analysis

Advanced Measurement Approach (AMA)

Introduction:

Operational risk is critical for banks due to its potential to cause severe losses. The article reviews various definitions of operational risk and highlights its increasing importance with technological advancements and competitive pressures.

The study delves into risk management theories, including top-down and bottom-up approaches. It discusses Basel II's framework for operational risk management, which includes three main methods: Basic Indicator Approach (BIA), Standardized Approach (SA), and Advanced Measurement Approach (AMA).

Five main components of operational risk are outlined: IT systems, processes, human factors, external events, and legal risk. The research also discusses how external factors like fraud, system failures, and natural disasters contribute to these risks.

The research focuses on an empirical study of 13 European banks from 2014-2016. Using regression. The introduction of the thesis focuses on how risk management, particularly operational risk, has become a strategic pillar for banks in today's fast-evolving financial and economic landscape. As competition, technological advancements, and banking transactions grow, banks face diverse risks, which vary in severity across institutions. Operational risk is highlighted as one of the most crucial, requiring close monitoring and regulatory measures to control and minimize potential losses.

The thesis underscores the importance of establishing regulatory frameworks and adopting optimal management strategies to mitigate these risks. It references Henry Fayol's early work in risk management, which evolved with Basel II's introduction of capital requirements, aiming to better allocate resources and manage operational risks in modern banking. The study seeks to analyze how different banking factors affect the evaluation and management of operational risks, using formalized calculation methods and approaches. risk management, which can lead to significant losses and harm a bank's market position. The rapid increase in such risks has made them a growing threat to banks. Therefore, it is essential for banks to develop strong knowledge and strategies to manage, mitigate, or eliminate these risks effectively.

The research aims to investigate the impact of various banking factors on operational risk, outlining the motivations, objectives, research hypothesis, and the methodology employed. By doing so, the study seeks to contribute to improving risk management practices within the banking sector . The research aims to demonstrate that operational risk in banks is influenced by various banking factors, each with a different impact. The study's significance lies in its potential to benefit both academic research and banking practices by reallocating operational risk management resources based on factor importance. This approach seeks to lower operational risk management costs by optimizing resource use in support functions and decentralizing risk management across operations and production units.

Furthermore, the research explores differences in the calculation of operational risk using both conventional methods (Standardized Approaches) and Advanced Measurement Approaches (AMA), enhancing risk management by involving those most affected by the losses. The findings will add value by improving the understanding, management, and reduction of operational risk costs in banks.

The banking sector routinely analyzes specific risk factors as part of its daily management activities. Its goal is to enhance financial system processes by considering both high and low-risk events and managing these risks to avoid financial difficulties related to various banking factors. However, the methods used to assess operational risks differ from one bank to another. Furthermore, despite several updates to global banking regulations, the Basel Committee has yet to fully standardize the calculation of operational risk. Operational risk management enables banks to respond to uncertainties while enhancing value creation. It helps banks avoid, transfer, or take on risks, particularly as non-financial income growth has increased operational risks (Bouider L, 2008).The Basel II framework recognizes operational risk as distinct from credit and market risks, pushing banks to invest in improving internal processes and risk management infrastructure. These improvements are critical for strengthening stability and risk management efficiency within the banking sector.

Objectif:

The aim of this project is to study the factors that explain operational risk in banking institutions. The research seeks to identify the banking factors that influence operational risk and analyze the relationship between these factors and the risk itself

Problematic:

The research problem focuses on determining the impact of various factors on operational risk in banks. It seeks to identify which factors have the greatest effect on this risk and aims to find the optimal method for managing it. The research focuses on studying 24 factors from 13 European banks over the period 2014-2016 to analyze their impact on operational risk. Using regression tests, the study will evaluate the macroeconomic and microeconomic environments' role in explaining operational losses. Additionally, the research will assess the relationships and correlations between these variables to understand their effect on operational risk.

hypothesis:

The hypothesis (H1) suggests that banking factors significantly influence the management of operational risk. These factors play a crucial role in shaping how banks handle and mitigate operational risks.

Methodology:

The research methodology aims to generate scientific knowledge by using both deductive reasoning (drawing conclusions from general rules) and inductive reasoning (developing general rules from specific observations) (David A, 2000). The study combines case analysis with banking activities, focusing on operational risk management. By analyzing data from 13 banks, using two methods (Advanced Measurement Approach (AMA) and Standard Approach), the research identifies the factors with the most significant impact on operational risk.

Results and discussion

The literature review emphasizes the significance of various banking factors on financial performance concerning risk management. According to (Assienin K, 2016) an analysis of operational risk management in non-financial companies in Côte d'Ivoire revealed a positive impact on financial performance measurement methods, utilizing a structured approach that included questionnaires, surveys, and data analysis. The findings aligned with research from the European Federation of Risk Management Associations (FERMA), which indicated that firms with developed risk management practices experience higher growth rates.

Additionally, various authors have highlighted that risk varies across domains due to environmental factors, defining risk as the probability of unforeseen events affecting enterprises (Spekman, 2004); (Cohen E., 2001); (Aubert, B.A. and Bernard, J.G. , 2004); (Embelmsvag, and Kjolstad, L.E. , 2002) (Mivhel, 2009)drawing on earlier works by (Penrose, 1959), (Wernerfel, 1984) and (Barney, 1991), notes that mobilizing human resources introduces specific risks that businesses must identify, evaluate, monitor, and manage to create value.

The theories section discusses two primary approaches for evaluating and measuring risk:

the top-down and bottom-up methods.

The top-down approach estimates risk at a macro level without specifying the causes of losses, focusing on global financial costs for the organization. In contrast, the bottom-up approach relies on detailed data from specific loss events categorized by line of business or type of loss. While top-down methods offer uniform measurements across various risks, they face challenges in accurately identifying all contributing factors (Hiwatashi, 2002).

further categorizes top-down methods into three approaches: indicator-based, where performance metrics like gross income assess operational risk exposure; the residual method linked to the Capital Asset Pricing Model (CAPM); and an approach that considers revenue volatility as an operational risk. The bottom-up methodologies include statistical measurement, scenario analysis, factor analysis, and Bayesian modeling to effectively quantify operational risk.

The Basel II

framework recognizes operational risk as a significant concern for banks, highlighting potential losses from various sources, such as system failures or external events like earthquakes or fires. A notable example is the substantial losses incurred by Crédit Lyonnais in May 1996 due to such risks. Currently, a key challenge is the lack of data on operational risk losses, which, once addressed, will lead to the gradual implementation of various measurement methods.

Basel II outlines three methods for calculating the required capital for operational risk, ranked from the simplest to the most complex [(1)]the Basic Indicator Approach

(1) Comité de Bâle sur le contrôle bancaire. « Convergence internationale de la mesure et des normes de fonds propres – Dispositif révisé – Version intégrale », Banque des règlements internationaux, juin 2006, par.

(BIA), the Standardized Approach (SA), and the Advanced Measurement Approach (AMA). Regardless of the chosen method, banks must ensure that their capital measures are robust, as each approach has specific calculation criteria

.The Advanced Measurement Approach (AMA) allows banks to determine their regulatory capital for operational risk based on internal risk measurement systems. This method utilizes both quantitative and qualitative criteria set by the Basel Committee and requires approval from national supervisors. Banks must gather data on losses from various events to calculate the necessary capital, initially set at 75% of the capital calculated using the Standardized Approach (SA).

Moreover, Basel II permits the use of insurance coverage to lower the required capital for operational risk, a provision not available for the SA and Basic Indicator Approach (BIA). For banks wishing to implement AMA, it is essential to demonstrate the accuracy of their internal models, which must incorporate internal and relevant external data, scenario analyses, and factors that reflect the business environment and internal control systems.

Definition:

Operational risk is broadly defined while allowing for precise identification of its covered elements (Darsa, 2013)According to Basel II, operational risk is described as the risk of loss resulting from inadequate or failed internal processes, personnel, and systems, or from external events. This definition encompasses legal risks but excludes strategic and reputational risks.

Operational risk can arise from poorly adapted internal operations, human errors, external incidents, system issues, or flawed procedures. It is crucial to recognize and manage these risks effectively, as noted by (King, 2001) who emphasizes that operational risk is linked to how a business operates rather than its financing

649. https://www.bis.org/publ/bcbs128fre.pdf.:

methods, he defines it as the deviation between the profit associated with a service and managerial expectations. (Dalla Valle, 2008) provide a more comprehensive definition, stating that operational risk includes both direct and indirect losses from insufficient or faulty procedures, human resources, and internal systems.

Several definitions of operational risk exist, highlighting various aspects such as human error, system deficiencies, and the risk of loss from inadequate internal practices. An example of operational risk is the significant losses experienced by Crédit Lyonnais due to a fire in 1996. Currently, a lack of data on operational risk losses remains a significant issue, but once sufficient data sources become available, various methodologies will be gradually implemented to address this gap.

Operational risk is a key focus under Basel II regulations, which were developed in response to the need for a more robust banking framework following the earlier Basel I standards introduced in 1988. In France, the Prudential Control Authority (ACP) oversees the implementation of these rules, which aim to align economic capital with regulatory requirements.

Basel II defines operational risk and incorporates it into a broader risk management framework consisting of three pillars:(1)

Minimum Capital Requirements: Establishes the necessary capital banks must hold against operational risk.

Supervisory Review Process: Focuses on how banks manage risk and capital.

Market Discipline: Enhances transparency through better financial communication and reporting.

The Basel Committee has emphasized the importance of understanding various

(1) Aue, F., et M. Kalkbrener. « LDA at Work », Deutsche Bank AG, février 2007, p. 12. http://kalkbrener.at/Selected_publications_files/AueKalkbrener06.pdf

risk sources, including strategic, internal, and external risks. Additionally, external loss data can be used to improve internal loss databases, refining risk models and enhancing the quality of risk assessment scenarios.

Overall, Basel II represents a significant evolution in banking regulations, aiming to create a more stable financial environment by addressing the complexities of operational risk.

Operational risk consists of five key components, as identified by Basel II, which are essential for effective risk management and value creation for shareholders, as highlighted by (W. Nocco and M.Stulz, 2006) components are:

-Risk Related to Information Systems (SI): This involves potential failures in tech-nical systems and -infrastructure necessary for conducting banking transactions.

-Process-Related Risk: Arising from failures to follow procedures correctly, this can include errors in transaction recording or instances of double-checking.

-People-Related Risk: This encompasses risks associated with human factors, such as fraud or absenteeism, and can stem from conflicts of interest or inade-quate training.

-External Event Risk: This includes risks from natural disasters, political crises, or changes in regulations that could impact banking operations.

-Legal Risk: This pertains to the uncertainties surrounding the enforcement of laws, which can lead to the inability to execute contracts and potential legal losses.

Understanding these components helps banks strengthen their risk management strategies, thereby enhancing their competitive advantage and overall value.

Definition of Each Factor Affecting Operational Risk

Risk management in financial institutions is not a new concept; it is closely tied to managerial activities, though formal education in this field only began in the 20th century. In 2002, Professor Robert Merton remarked at a conference in Geneva attended by 400 risk professionals that the model he developed in 1974 was already 28 years old. He emphasized the ongoing efforts by states to establish precise methods for calculating and evaluating operational risk. However, measuring regulatory capital to address this risk presents challenges, primarily due to the incomplete data collection processes and the difficulty in identifying key risk factors. Merton advised that a good risk model must be both useful and practical. To better address these challenges, a new study is proposed that accounts for internal developments within banks and production factors, offering innovative solutions for risk managers facing complex data collection issues.

Operational risks are a topic of ongoing discussion among researchers, and understanding how each banking factor impacts these risks opens new avenues for analysis beyond traditional human resource-dependent factors. The 24 financial indicators considered sufficient and effective are referenced in the literature, though some indicators may be excluded to avoid inaccuracies or the inclusion of non-scientific measures. Generally, the financial indicators often overlook important elements like innovation and customer satisfaction.

Total Risk-Weighted Assets: This represents the minimum capital required within a bank based on asset risk levels, helping to prevent excessive credit risk.

Market Risk-Weighted Assets: These assets determine the minimum capital banks must hold to mitigate insolvency risk, assessed for each type of banking asset.

Total Assets: This is the sum of all current and non-current assets, equal to the total liabilities plus equity.

Total Liabilities: The sum of all debts, including short-term, long-term, and off-balance-sheet obligations.

Total Equity: The value left to owners after all liabilities are paid, calculated as total assets minus total liabilities.

Bank Reserves: These are deposits held by commercial banks at a central bank, often subject to minimum reserve requirements.

Derivatives Assets: Financial contracts whose value is derived from an underlying asset, used for hedging or speculation.

Gross Total Loans: The total amount of loans issued by banks during an accounting period, indicating liquidity levels.

Mortgages: Loans used by property buyers, secured by the property itself, which can be repossessed if repayment terms are not met.

Allowance for Loan Losses: A reserve calculated based on estimated credit risk, reflecting potential loan defaults.

Total Operating Income: The net income generated from core business operations, excluding financial activities and taxes.

Net Loans: Total loans to customers, adjusted for potential defaults and unearned interest.

Net Interest Income: The difference between income from assets and interest expenses on liabilities, reflecting profitability.

Net Operating Income: Used for analyzing income-generating investments.

Net Trading Income: Earnings from trading activities, including realized and unrealized gains and losses.

Net Interest Income: The difference between income generated from bank assets and related interest expenses.

Net Fee and Commission Income: Fees related to loan establishment and other services.

Taxes: Mandatory charges levied on individuals or entities to fund governmental activities.

Operating Costs: Day–to–day expenses for maintaining business operations, not including capital expenditures.

Staff Expenses: Costs associated with employee expenses, including travel and entertainment.

The data collection process revealed that from the seventh enterprise onward, many selection criteria and sub–criteria repeated, indicating theoretical saturation as noted by (Glaser, B., G, and STRAUSS, A., L., , 1970).

In our study, we will employ a quantitative model aimed at analyzing the organization and function of operational risk management. This approach will involve examining the company's operational risk management framework, assessing the implementation of essential monitoring points and alert systems.

The analysis model comprises two types of variables: a dependent variable (to be explained) and independent variables (explanatory). These variables will be distributed across different time periods. The dependent variable focuses on the operational risk management process, while the independent variables influence the performance of the operational risk management system.

To construct this model, we will follow several steps:

Defining the operational risk framework: Establishing clear guidelines for what constitutes operational risk.

Mapping operational risks: Identifying and categorizing the various operational risks faced by the organization.

Measuring operational risks: Implementing methods to quantify the identified risks.

Managing operational risks: Developing strategies for mitigating and monitoring these risks.

Establishing a continuity plan: Ensuring decision-making processes support financial profitability in the face of operational risks.

Given that the model consists of one dependent variable and several independent variables, we propose using multiple linear regression analysis. This approach will facilitate a comprehensive understanding of the relationships between the variables and their impact on operational risk management performance

$$Y_i = a_0 + \sum_{i=1} a_i X_i + \epsilon_i, \quad i = 1, \dots n$$

In our study, the dependent variable, denoted as:

Y_i: is intrinsically linked to operational risk. The coefficient

a_i: represents the parameters of the multiple regression model, which are estimated using statistical methods. The error terms:

ϵ_i: captures the model's residuals, represented as independent random variables that follow a normal distribution with a mean of zero and a common variance.

To estimate the parameters , we will utilize the ordinary least squares (OLS) method, where i ranges from 1 to n, with n :n representing the sample size.

Once the multiple regression model is constructed, we will analyze the correlation between the explanatory variables and the dependent variable. Additionally, we will assess the impact of the explanatory variables on the dependent variable through statistical tests, allowing for a robust examination of the relationships within the operational risk management framework analysis:

To evaluate the impact of various factors essential for studying operational risk, we have chosen to focus on international banks that utilize two approaches to assess operational risk: the Standardized Approach (SA) and the Advanced Measurement Approach (AMA).

(YIN, 1994) posits that case studies can serve as theoretically generalizable experiments regarding hypotheses, but they are not representative of the entire population. Based on this perspective, our objective of validating our hypothesis will be well established. According to (EISENHARDT, M , 1989) the generalization of results from a case study cannot be statistical; rather, it is an analytical and theoretical generalization.

To study the impact of factors on banking operational risk, our database consists of 13 European banks covering a three-year period from 2014 to 2016[1].

(1) www.thebankerdatabase.com

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Table 1:Bank name and country of main branch

Bank Name	Country of Main Branch
Deutsche Bank	Germany
Groupe BPCE	France Paris
Credit Suisse	Switzerland
Intesa	Italy Turin
Nordea	Sweden
Danske	Denmark
Commerzbank	Germany|
RBS	UK, Edinburgh
Barclays	UK London
Banco Santander	Spain Madrid
LLOYDS	UK London
RABOBANK	Netherlands
SGBL	France Paris

Method of Calculating Operational Risk:

Standard: Banco Santander – Barclays – Credit Suisse – Danske

AMA: RBS – Deutsch Bank – Groupe BPCE – Lloyds – SGBL Intesa – Nordea – Rabobank – Commerzbank

Multiple Linear Regression Analysis

In our study, we employed multiple linear regression to analyze the quantitative factors affecting operational risk. The regression model consists of a dependent variable (the operational risk management process) and several independent variables (the 24 banking factors). The goal is to express the dependent variable in relation to the independent variables, allowing us to identify which factors most significantly impact operational risk and which have negligible effects.

The model is structured with the dependent variable as Operational Risk-Weighted Assets, while the independent variables include Total Risk-Weighted Assets, Market Risk-Weighted Assets, Credit Risk-Weighted Assets, Total Assets, Total Liabilities, Total Equity, Cash and Balance at Central Banks, Gross Total Deposits, Derivatives Assets, Deposits by Banks, Gross Total Loans, Mortgages, Allowance for Loan Losses, Total Operating Income, Net Loans, Net Income, Net Operating Income, Net Trading Income, Net Interest Income, Net Fee and Commission Income, Taxes, Operating Costs, and Staff Expenses.

To assess the overall significance of the model, we will first apply the Fisher test, followed by the Student's t-test to evaluate the influence of the independent variables on the dependent variable. Parameter estimation will utilize the least squares method, which aims to minimize the sum of squared errors (Min ∑_i =ϵ_i^2). We will use SPSS software to apply multiple regression analysis on our complete dataset (Model 1), and subsequently separate the dataset into two groups based on the operational risk calculation method used by banks: Advanced Measurement Approach (AMA) (Model 2) and Standard Approach (Model 3).

Collinearity Testing in Regression Analysis

Before commencing the regression model study, it is crucial to address the issue of collinearity among the variables. Collinearity, or multicollinearity, occurs when the explanatory variables in a regression model are correlated, which can inflate the variance of the estimated regression coefficients and make them unstable and difficult to interpret. Several tests can measure collinearity:

Variance Inflation Factor (VIF): This metric assesses how much the variance of an estimated regression coefficient increases due to collinearity. A VIF of 1 indicates no multicollinearity; values greater than 1 suggest correlations among predictors. If the VIF is between 5 and 10, the regression coefficient may not be accurately estimated.

Correlation Matrix: By examining the correlation matrix of the explanatory variables, we can identify correlations exceeding 0.5, indicating potential multicollinearity.

To detect and identify variables involved in multicollinearity, we will calculate the coefficient of determination $R2$, which measures how well our multiple regression model fits the observed data. The value ranges from 0 (no explanatory power) to 1 (perfect fit).

Additionally, we will consider the tolerance for each model, defined as $1-R2$. Tolerance serves as a filtering criterion for variables; if a variable's tolerance is below a predetermined threshold, it should be excluded from the model due to its negligible contribution and the risk of numerical issues.

The VIF is the inverse of tolerance and will also be calculated.

Using Ordinary Least Squares (OLS) to estimate the parameters of the multiple regression model allows for obtaining the Best Linear Unbiased Estimators (BLUE) if certain assumptions are met:

The number of observations must exceed the number of regressors.

The model is linear concerning the parameters.

The regression model is correctly specified.

The expected value of the error term (ϵi) is zero for given X values.

The variance of ϵi is constant (homoscedasticity).

The error term ϵi is normally distributed.

There is no autocorrelation among the errors.

Sufficient stability exists in the values taken by the regressors.

No exact linear relationships (multicollinearity) exist among the regressors.

Once these assumptions are validated, we can apply Student's t-tests to assess the statistical significance of the coefficients ai.

In the model, determining their significance levels (p-values) and interpreting the regression statistics without bias. These statistics, often provided automatically by statistical software like SPSS, include the coefficient of determination

$R2$ and the ANOVA (Analysis of Variance) table, which tests for linear relationships among all model variables (Fisher test).

To study the global model (Model 1), we will also verify the normality of the variables using the Kolmogorov-Smirnov test, with significance set at a 5% threshold. A significant p-value ($p<0.05$) would indicate a Gaussian distribution across all variables.

Table 2:KMO, Bartlett test

Kaiser-Meyer-Olkin Sampling Adequacy Measure.	
Bartlett's Test of Sphericity	0.681
Khi-deux	996,326
ddl	300
Bartlett Signification	,000

The three steps or conditions have been successfully met, so we can proceed with the factor analysis on our dataset:
The total explained variance (selection of the number of axes).

The number of principal components chosen to represent our dataset can be determined in different ways:

The selection based on the cumulative percentage of inertia shows that we represent 82.158% of the total inertia (as seen in the table below).

The selection of eigenvalues greater than 1, since each of the original variables has been standardized.

In the table below, it is noted that the first factor axis explains 67.74% of the total inertia, and the second axis explains 14.418%. Therefore, our factorial plane consists of two factor axes (axis 1 and axis 2), which together explain 82.158% of the total inertia (total variance). Thus, from the initial 24 dimensions (factors), we have reduced the phenomenon to 2 dimensions, with eigenvalues greater than 1 and a cumulative inertia percentage of 82.158%.

Table 3:Total Variance Explained

Component	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	16.258	67.740	67.740	16.258	67.740	67.740
2	3.460	14.418	82.158	3.460	14.418	82.158
3	1.121	4.672	86.830			
4	.927	3.862	90.692			
5	.535	2.230	92.922			
6	.411	1.712	94.634			
7	.337	1.405	96.039			
8	.233	.969	97.008			
9	.176	.732	97.740			
10	.156	.649	98.389			
11	.119	.495	98.884			
12	.088	.366	99.250			
13	.067	.280	99.531			
14	.033	.138	99.669			
15	.023	.097	99.765			
16	.019	.078	99.843			
17	.014	.056	99.900			
18	.010	.043	99.943			
19	.006	.026	99.969			
20	.005	.020	99.989			
21	.002	.008	99.997			
22	.001	.003	100.000			
23	4.204E-5	.000	100.000			
24	1.744E-13	7.267E-13	100.000			

.Extraction Method: Principal Component Analysis

Component Matrix Summary

The table below presents the variable–factor correlations. It shows that most vari–

ables contribute significantly to the construction of axis 1, while variables such as Derivatives (Assets), Mortgages, Allowance for Loan Losses, and Net Income are more aligned with axis 2. Overall, all variables are well represented across the two main axes, which capture 82.158% of the initial information. This is a highly satisfactory level for this type of analysis, making it feasible to perform a cluster classification based on the results from the factor analysis.

Table 4:Component Matrix

	Component	
	1	2
Total Risk-WeightedAssets	.974	.126
Operational Risk-Weighted Assets	.885	-.354
Market Risk-WeightedAssets	.754	-.450
Credit Ris-WeightedAssets	.936	.278
Total Assets	.954	-.189
Total Liabilities	.948	-.207
Total Equity	.975	.142
(Cash and Balance at Central Bank(s	.766	-.159
Gross Total Deposits	.950	.122
(Derivatives (Assets	.615	-.634
Deposits by Banks	.788	-.286
Gross Total Loans	.829	.459
Mortgages	.506	.517
Allowance for LoanLosses	.489	.577
Total Operating Income	.975	.098
Net Loans	.790	.487
Net Income	.318	.759
Net Operating Income	.982	-.081
Net TradingIncome	.553	-.377
Net Interest Income	.849	.359

Net Fee and Commission Income	.863	−.290
Taxes	.753	.439
Operating Costs	.884	−.399
Staff Expenses	.933	−.266

(Extraction Method: Principal Component Analysis (PCA

Descriptive Section

Upon reviewing the histogram and comparing the different types of risks, we observe that market risks account for the largest share among the three types of risks (Operational Risk-Weighted Assets, Market Risk-Weighted Assets, and Credit Risk-Weighted Assets). Operational risks follow as the second most significant type, highlighting the critical importance of managing operational risk within the overall risk framework.

	Operational Risk to Total RWA	Market Risk to Total RWA	Credit Risk to Total RWA
N	38	38	38
Missing	0	0	0
Mean		5.9854418555338	80.419556997551
Variance	41.663	13.700	73.078
Minimum	7.26402386052	1.45268088331	57.8000000000
Maximum	35.35294062230	16.19000000000	90.3000000000

We observe that credit risk is the most significant type of risk, with a mean of 80.41955 and a variance of 73.8000, reaching a maximum of 90.300. Operational risk shows higher results than market risk, with a mean of 12.83809, greater than the mean for market risk (5.98544), and a variance of 41.663, higher than that of market risk (13.700). Additionally, the maximum operational risk exceeds that of market risk (35.352940 > 16.19000).

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Graphical Representation and Interpretation

The table and the graphical representation below indicate that four variables (Derivatives Assets, Mortgages, Allowance for Loan Losses, and Net Income) contribute to axis 2. These variables are therefore considered as credit risk variables. In contrast, all other variables contributing to axis 1 are related to operational and market risks. Based on the literature, we can conclude that the relationship between operational risk and credit risk is weak.

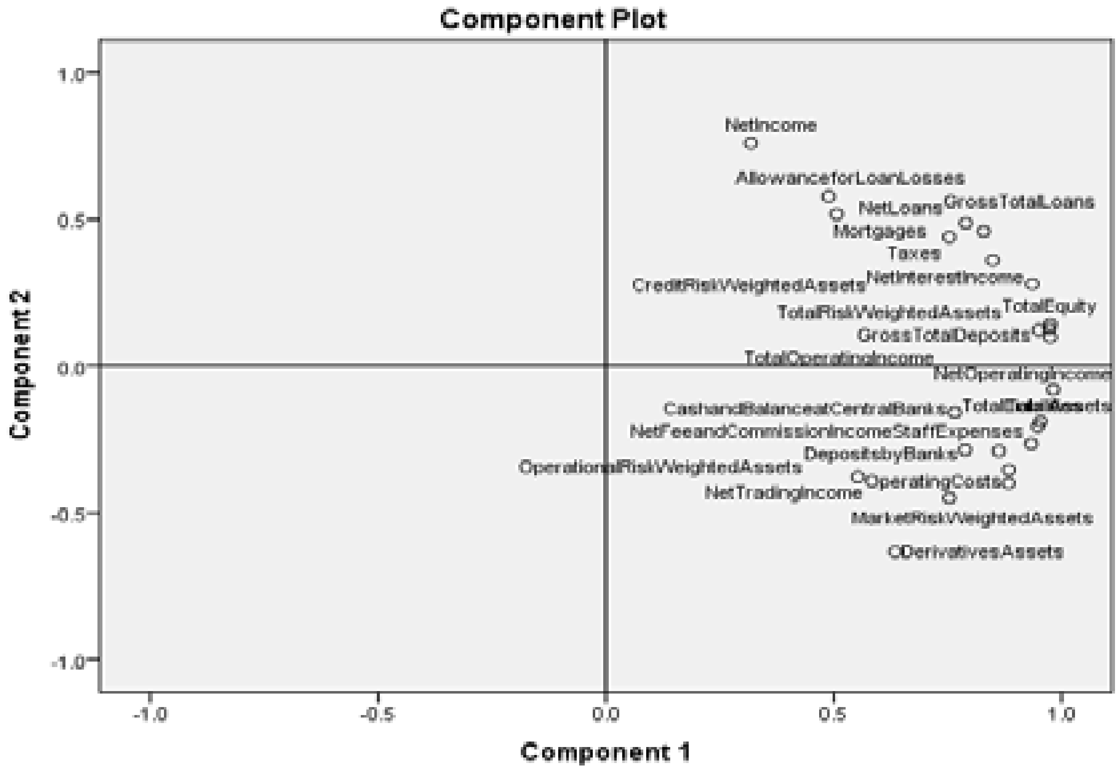

Table 5: The position of factors according to component 1 and component 2

Table 6:Correlation between operational risk and the 24 factors

Factors	Correlations	Signification
Total Assets	.869	.000**
(Derivatives (Assets	.726	.000**
Deposits by Banks	.731	.000**
Total Risk-Weighted Assets	.827	.000**
Market Risk-Weighted Assets	.823	.000**
Credit Risk-Weighted Assets	.723	.000**
Total Liabilities	.868	.000**
Total Equity	.811	.000**
(Cash and Balance at Central Bank(s	.774	.000**
Gross Total Deposits	.817	.000**
Gross Total Loans	.553	.000**
Mortgages	.282	.082
Allowance for Loan Losses	.210	.200
Total Operating Income	.864	.000**
Net Loans	.544	.000**
Net Income	-.060	.716
Net Operating Income	.914	.000**
Net Trading Income	.499	.000**
Net Interest Income	.651	.000**
Net Fee and Commission Income	.499	.000**
Taxes	.651	.000**
Operating Costs	.892	.000**
Staff Expenses	.488	.000**

Table 6 measures the correlation between operational risk and the various factors studied in Model 1. It indicates that there are three non-significant factors (Mortgages, Allowance for Loan Losses, and Net Income), while all other factors

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are significant (p–value < 0.05). From this, we can deduce that we have a strong model, and in this case, we can apply the Fisher test and the Student's t–test.

Multiple regression on our global dataset (Model 1): First, it is neces–sary to test for collinearity by calculating the VIF (Variance Inflation Factor).

Table 7:Collinearity between variables

Model	Collinearity Statistics	
Tolerance	VIF	
1 (Constant)		
Total Risk-Weighted Assets	.001	1983.806
Market Risk-Weighted Assets	.018	56.569
Credit Risk-Weighted Assets	.001	1078.862
Total Liabilities	.012	82.178
Total Equity	.006	171.286
(Cash and Balance at Central Bank(s	.065	15.320
Gross Total Deposits	.013	76.557
(Derivatives (Assets	.027	37.008
Deposits by Banks	.084	11.920
Gross Total Loans	.017	58.422
Mortgages	.074	13.563
Allowance for Loan Losses	.155	6.451
Total Operating Income	.004	251.798
Net Loans	.065	15.332
Net Income	.054	18.470
Net Operating Income	.001	871.468
Net Trading Income	.065	15.386
Net Interest Income	.047	21.202
Net Fee and Commission Income	.013	78.867
Taxes	.033	30.488
Operating Costs	.002	515.833
Staff Expenses	.009	113.397

Table7 measures the collinearity between the variables, showing that VIF > 5. This indicates the presence of collinearity between the variables, meaning that the explanatory variables are interpretable. However, to determine which factors are significant for interpretation, we refer to the table below.

Table 8: The coefficient of determination R^2.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.999[a]	.998	.996	1,776.730

Table 8: The ANOVA table and Fisher test calculate the coefficient of determination, yielding a result of 0.998, which is close to 1. Therefore, we can conclude that our overall model is good.

Table 9:ANOVA and Fisher test

Model 1	Sum of Squares	df	Mean Square	F	.Sig
Regression	29717411661.208	23	1292061376.574	409.298	.000[b]
Residual	47351561.561	15	3156770.771		
Total	29764763222.769	38			

The ANOVA and Fisher test allow us to test the following two hypotheses:

$H0$: All coefficients are zero.

$H\ 1$: At least one of the coefficients is non-zero.

Thus, the analysis of variance (ANOVA) for the regression indicates that there is a linear relationship among all variables in the model (Fisher test). We observe that sig=0<0.05, which means the overall model is significant. Next, we ap-

ply the Student's t-test to assess the significance of the independent variables.
Table 10:student test

Factors	t-student	Signification
Total Assets	10.706	.000
(Derivatives (Assets	6.429	.000
Deposits byBanks	6.518	.000
Total Risk-Weighted Assets	8.941	.000
Market Risk-Weighted Assets	8.817	.000
Credit Risk-Weighted Assets	6.373	.000
Total Liabilities	10.653	.000
Total Equity	8.429	.000
Cash and Balance at Central (Bank(s	7.444	.000
Gross Total Deposits	8.618	.000
Gross Total Loans	4.039	.000
Mortgages	1.787	.082
Allowance for Loan Losses	1.303	.200
Total Operating Income	10.439	.000
Net Loans	3.942	.000
Net Income	367.-	.716
Net Operating Income	13.746	.000
Net Trading Income	3.500	.001
Net Interest Income	5.212	.000
Net Fee and Commission Income	12.034	.000
Taxes	3.401	.002
Operating Costs	20.554	.000
Staff Expenses	16.914	.000

According to the Student's t-test, which assesses the significance of the independent variables, we can test the following two hypotheses:

$H0: ai=0$, i=1,...23

$H1: ai\neq 0, \ i=1,...,23$

We observe that all variables are significant, except for three variables (Mortgages, Allowance for Loan Losses, and Net Income) where sig>0.05. This indicates that all tested factors have an impact on operational risk, except for these three non-significant factors.

Since the calculation of operational risk in European banks is performed using both the AMA and Standard methods, it will be beneficial to examine Models 2 and 3. This will assist us in comparing the different results affecting operational risk based on the chosen method for calculating operational risk, whether it be AMA or the Standard method.

Model 2: We apply the multiple regression model on Model 2 (AMA).

Table 11:Dependent Variable: Operational Risk-Weighted Asset according to AMA.

Table 12:Dependent Variable: Operational Risk-Weighted Assets according to Standard

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	15990.698	2315.376		6.906	.000
	Credit Risk-Weighted Assets	.084	.032	.313	2.583	.025
	Total Liabilities	.079	.010	1.578	7.667	.000
	Total Equity	-1.210	.234	-1.098	-5.168	.000
	Derivatives (Assets)	-.083	.007	-.618	-11.674	.000
	Deposits by Banks	-.409	.082	-.618	-4.988	.000
	Gross Total Loans	-.060	.007	-.449	-9.192	.000
	Mortgages	-.070	.012	-.305	-5.971	.000
	Allowance for Loan Losses	-.598	.060	-.193	-9.984	.000
	Net Operating Income	7.411	.778	2.777	9.527	.000
	Net Trading Income	-4.623	.359	-.390	-12.883	.000
	Taxes	-14.865	1.313	-.398	-11.317	.000
	Staff Expenses	-4.484	1.495	-.705	-2.999	.012

Table 12: This table represents the factors affecting operational risk according to the AMA. Following the analysis of multicollinearity among the variables, we identified 12 significant variables by eliminating all non-significant variables from our model. Since the significance level is

sig<0.05, we can conclude that the calculation of operational risk using the AMA method provides a more accurate assessment of the influence of the studied factors on operational risk.

Model 3: We apply the regression model on Model 3 (Standard).

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
Ation	(Constant)	-17855.027	3292.703		-5.423	.032
	Market Risk-Weighted Assets	.650	.280	.460	2.320	.146
	Cash and Balance at Central Bank(s)	-.227	.180	-.295	-1.260	.335
	Derivatives (Assets)	.022	.031	.162	.699	.557
	Deposits by Banks	-.262	.192	-.349	-1.366	.305
	Gross Total Loans	.052	.013	.532	4.013	.057
	Mortgages	-.164	.029	-.645	-5.615	.030
	Net Loans	.171	.014	1.576	12.539	.006
	Net Income	2.100	3.167	.268	.663	.575
	Net Trading Income	-7.984	2.739	-.443	-2.914	.100
	Net Interest Income	-2.484	.256	-1.088	-9.706	.010
	Taxes	-10.889	8.975	-.469	-1.213	.349
	Staff Expenses	7.414	2.800	1.249	2.647	.118

We note that the variables (Mortgages, Net Loans, Net Interest Income) are non-significant using the Standard method, while most variables are significant when using the AMA method. This confirms the utility and importance of calculating operational risk using the AMA approach.

Conclusion

In this study, we opted for a case study approach to empirically validate our analytical framework, which proved to be the most suitable research method for our needs. This approach allowed us to flexibly handle the data, a benefit that would not have been possible with other methods that might not adequately address our research questions.

The viability of our study was enhanced by utilizing secondary data from leading banks, which was gathered in a fully ethical framework to access best practices. However, the confidential nature of risk management and the objective analysis of the data render secondary data more valid than primary data.

Based on the results obtained from the overall multiple regression model and the statistical tests conducted, we conclude that the relationship between the dependent variable (operational risk) and the independent variables (various banking factors) is significant, with the exception of three variables (Mortgages, Allowance for Loan Losses, and Net Income) related to credit risk, which are non-significant. Conversely, when separating banks according to the operational risk calculation method (AMA or Standard), and applying multiple regression models based on these methods, we find that all explanatory variables are significant using the AMA approach. This method accounts for all types of potential losses within banks, as specified by Basel II.

In contrast, the Standard method reveals only three significant variables (Mortgages, Net Loans, and Net Interest Income), indicating that this method relies on only 15% of the factors involved in calculating operational risk.

Ultimately, the AMA method proves to be more effective than the Standard method for calculating operational risk. However, when analyzing banking factors by risk type (credit risk, market risk, operational risk), we find that most credit risk variables do not significantly affect operational risk.

It is crucial to recognize that operational risk management is not solely the responsibility of the operational risk team; it should be integrated across various roles within the organization. We recommend establishing a specialized team to ensure overall compliance and encourage participation from all business units and functions. This approach will help decentralize the operational risk management function within banks and significantly reduce costs by enhancing the operational risk management system and personnel.

The strong connection between the Advanced Measurement Approach (AMA) and supervisory expectations for effective operational risk management underscores that AMA has specific qualification requirements that yield not only efficient and effective improvements to risk management but also:

A comprehensive risk assessment across all business units of the bank.

The development of techniques for identifying, measuring, and allocating capital to manage operational risk based on long-term best practices.

A more forward-looking risk assessment.

Most banking institutions must realize the imperative to strengthen the robustness and stability of their operational risk management practices by employing AMA analyses. If regulatory authorities emphasize the AMA, no bank or financial institution can afford to overlook it. The alignment between risk management and the adopted model is crucial for ensuring that successive adjustments align with operational risk management practices.

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