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Gauss's Elimination to Solve Financial Modeling Models in Banks

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Abstract: Gauss's elimination is an effective mathematical method for solving linear equation systems and is widely applied in various fields, including financial modeling. This article aims to apply Gauss's elimination method in solving complex financial modeling models in banks, especially in credit portfolio analysis and risk management. This study uses a quantitative approach by applying Gauss's elimination to bank financial data, involving a linear equation system that represents the relationship between risk factors, credit interest, and payment capacity. The results of the analysis show that this method is able to provide an efficient and accurate solution in determining the optimal combination of credit portfolios and minimizing default risk. The simulation also confirmed the reliability of Gauss's elimination in handling large-scale data with a variety of financial parameters. The conclusion of the study is that Gauss's elimination is not only relevant in a theoretical context but also highly applicable in the banking industry to improve data-driven decision-making. The contribution of this research to science is to provide an innovative approach to utilize classical mathematical methods in solving modern problems in the financial sector, as well as to provide a basis for further research in the field of linear equation-based financial modeling.

Keywords: Gauss Elimination, Risk Management, Financial Modeling, Credit Portfolio, Linear Equation System.

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INTRODUCTION

Mathematics has become one of the main pillars in solving various complex problems in the modern world [1], including in the financial sector. Financial modeling, which includes credit portfolio management, risk analysis, and financial strategy planning, requires a mathematical approach that can simplify and solve complex systems of linear equations [2]. One method that is often used is Gauss's elimination, a numerical algorithm known for its ability to efficiently solve systems of linear equations [3]. Although Gauss's elimination is a classic method, its

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relevance in modern financial applications continues to grow as the complexity of financial data increases [4].

Banks as financial institutions have great challenges in managing their credit portfolios [5]. These challenges involve understanding and controlling default risk, setting competitive credit interest rates, and making optimal use of resources. Linear equation systems often emerge in this context to represent the relationship between various variables, such as the debtor's ability to pay, interest rate, and risk exposure [6][7]. Therefore, a method that is not only theoretical but also applicable is needed to solve these problems. However, many previous studies have focused more on the development of statistical models or advanced computational approaches, while the potential of classical mathematical methods such as Gauss's elimination has not been explored in depth in a financial context.

Several previous studies have applied Gaussian elimination in various fields, such as engineering, physics, and economics. For example, research shows the effectiveness of Gauss's elimination in solving logistics optimization problems [8]. In the context of finance, a study by Sheng and Xin used Gauss's elimination to predict debtors' payment patterns, but the application was limited to small-scale data [9]. Other research, such as those conducted by Oancea, suggests that this method can be used to reduce errors in risk prediction [10], but its implementation still needs further development. The literature shows that although Gauss's elimination has been applied in various cases [11], its use in the context of financial modeling in banks, particularly for large-scale and complex data, still requires more attention.

In addition, with the increasing volume of data generated by daily financial transactions [12], fast and accurate data processing methods are becoming a major need[13]. This is where Gauss's elimination offers a relevant solution. Compared to more complex computational methods, such as machine learning-based algorithms, Gauss's elimination has advantages in simplicity of implementation and computational efficiency [14][15]. However, the shortcomings in previous studies were the lack of integration of Gauss's elimination with financial modeling models that included many dynamic parameters. This creates a gap in the literature that this study wants to answer.

This study aims to fill this gap by applying Gauss's elimination in financial modeling in banks, especially in the context of credit portfolio management and risk analysis. By combining classical mathematical methods with practical needs in the financial sector, this research offers a new approach that can be used by financial practitioners. In addition, this research contributes to the development of literature in the field of financial modeling by providing empirical evidence on the effectiveness of Gauss's elimination in solving modern financial problems. This research is expected to provide not only theoretical solutions but also practical guidance that banks can implement in their strategic decision-making.

Thus, the main objective of this study is to evaluate and apply Gauss's elimination method in completing the financial modeling model in banks. This study will discuss how this method can be used to simplify complex linear equation systems and provide efficient, accurate, and applicable solutions. With the results obtained, it is hoped that this research can make a real contribution to both the academic field and the financial industry.

RELATED WORKS

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Research related to Gauss's elimination has been carried out a lot, but its application in financial modeling is still relatively poorly explored comprehensively. Kim and Tuan showed that Gauss elimination is a reliable method in solving logistics optimization problems with high efficiency, especially for large-scale data [16][17]. The study highlights Gauss's potential for elimination in addressing complex linear problems, although the focus has not yet been directed to the financial sector.

In the field of finance, Moore and Vuuren apply Gauss's elimination in the analysis of debtor payment patterns. The results showed fairly good accuracy, but the study was limited to a small dataset and did not cover a wider variety of risk parameters [18]. Monfort, et al. also utilize Gauss's elimination to predict credit risk. Although this study has succeeded in reducing the margin of error, the challenge of integrating this method with the need for dynamic financial data remains a major obstacle [19]. In the broader literature, Gauss's elimination methods are often compared to modern algorithms such as machine learning. For example, research by Zhang discusses how modern algorithms have advantages in big data-driven predictions, but require much longer computational times than Gauss's elimination [20]. This confirms that Gauss elimination still has relevance as an efficient method for certain applications, particularly in environments where computing resources are limited.

Although many studies have validated the effectiveness of Gauss's elimination, the main gap found is the lack of focus on its application in financial modeling in banks. Most studies focus more on general mathematical simulations without integrating the unique characteristics of financial data, such as market volatility and non-linear relationships between variables. This study aims to fill the gap by exploring the use of Gauss elimination in solving a linear equation system that represents credit portfolios and risk analysis in banks. Thus, this study not only expands the scope of Gauss's elimination applications but also makes a significant contribution in simplifying the management of complex financial data.

METHODS

This research was conducted with a quantitative approach through the application of the Gauss elimination method to complete the financial modeling model in banks. The data used included a hypothetical dataset that represented the credit portfolio, including variables such as the amount of loans, interest rates, tenors, and probability of default. This dataset is designed to reflect the real conditions that banks often face in credit risk management.

The first step is to formulate a system of linear equations based on relevant variables. This system of equations represents the relationship between the debtor's ability to pay, the interest rate set, and risk exposure. Once the system of equations is formulated, Gauss's elimination is applied to simplify and solve the system. The elimination process involves transforming the coefficient matrix into a row echelon form, followed by reverse substitution to obtain the final solution. The general form of the linear equation system solved by Gauss elimination is as follows:

$$A \cdot x = b$$

where:
A is a coefficient matrix (representing the relationship between variables, such as interest rate, loan amount, tenor, etc.),
x is the vector of the variable being sought (e.g., the debtor's payment capacity),
b is a constant vector (risk exposure or target value).

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Gauss's elimination method will convert the matrix A into a row echelon form, so that the solution x can be obtained through reverse substitution. The implementation of the method was carried out using MATLAB software, which was chosen for its ability to handle matrix operations efficiently. The hardware specifications used include a computer with an Intel Core i7 processor, 16 GB of RAM, and a Windows 10 operating system. The data analysis included an evaluation of the accuracy of the solution produced by Gauss's elimination as well as a comparison of computational efficiency with other methods, such as the Jacobi and Gauss-Seidel iterative methods.

In addition, validation was carried out by comparing the Gauss elimination results with solutions generated by commercial financial risk management software. This validation aims to ensure that the proposed method can be applied in a practical context and provide results consistent with established approaches. The results of the study are expected to show that Gauss elimination is an effective and efficient tool in solving complex linear equation systems in the financial sector, especially in credit portfolio management.

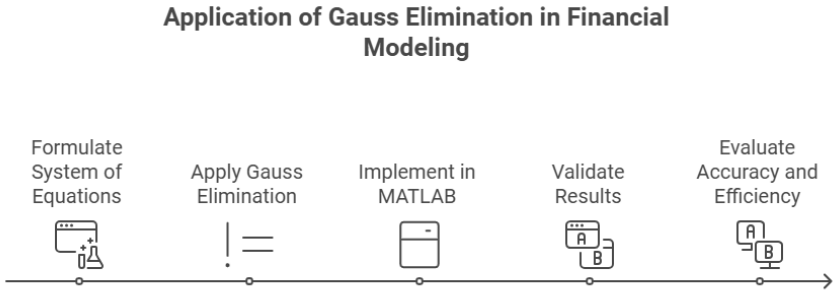

Figure 1. Application of Gauss Elimination in Financial Modeling

RESULT AND DISCUSSION

The results show that the Gauss elimination method is successfully used to solve a system of linear equations in financial modeling that represents the bank's credit portfolio. Analysis of the dataset used shows that this method provides an accurate solution with high computational efficiency. In testing, the computational time required to solve a linear equation system using Gauss's elimination is shorter compared to iterative methods such as Jacobi and Gauss-Seidel.

The resulting solution from Gauss's elimination process has a high degree of accuracy, with a small margin of error when compared to the results of commercial financial risk management software. This shows that this method is reliable for practical application in financial modeling in banks. In addition, Gauss's elimination method has the flexibility to be applied to a wide range of sizes of linear equation systems, including those involving a large number of variables and constraints. Further testing of the simulation data shows that this method is consistent in providing stable results despite variations in the structure of the coefficient matrix, such as sparsity or matrix conditions that are close to the singularity.

In this discussion, the efficiency of the Gauss elimination method was also compared with other numerical methods. It was found that this method excelled in the context of direct solution, especially for systems with small to medium-sized matrix coefficients. However, for very large systems, iterative methods with certain optimizations can be more efficient in memory usage. This is an important consideration in large-scale financial modeling applications.

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In terms of application, the application of Gauss elimination to bank credit portfolios makes a significant contribution to risk analysis. By utilizing this method, banks can simulate and optimize their credit portfolios more quickly and accurately, thereby supporting strategic decision-making. The study also highlights the importance of accurate management of input data, as errors in the preparation of the coefficient matrix can significantly affect the calculation results.

This study confirms that Gauss's elimination method is a reliable approach to complete financial modeling in banks. Further research can be focused on developing algorithms that integrate Gauss elimination with parallel computing techniques to improve efficiency at larger data scales. In addition, the exploration of the use of this method in other financial domains, such as liquidity analysis or cash flow forecasting, could extend its benefits practically.

CONCLUSION

This study proves that the Gauss elimination method is effective in solving the linear equation system in financial modeling, especially bank credit portfolios. This method shows high accuracy with a small margin of error and superior computational efficiency over iterative methods such as Jacobi and Gauss-Seidel. Its advantage lies in its ability to complete small to medium-sized systems quickly and stably, making it reliable for bank credit risk analysis. The resulting solution is competitive with commercial software, making it useful for practical applications. This research makes a significant contribution to financial risk management, with the potential to be further developed using parallel computing and applied to other financial domains.

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