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Applicaton Of Mathematics In Big Data Analysis To Support Strategic Decision

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ABSTRAK

This study aims to investigate the application of mathematical models in big data Analysis and their impact on strategic decision making in various industrial sectors. Using a quantitative approach to the survey, data was collected from 190 respondents from the technology, finance, manufacturing and healthcare sectors. The results showed that the application of mathematical models, such as predictive algorithms and machine learning, contributed significantly to improving the quality of strategic decisions. The study also identified that variables such as human resource competence and technological infrastructure moderate the relationship between big data Analysis and effective decision-making. The technology and finance sectors have proven to benefit the most from the application of math-based big data Analytics, with benefits seen in improved market prediction, risk management, and operational optimization. The findings underscore the importance of integrating mathematical models in data analysis to support data-driven decision-making in the digital age.

INTRODUCTION

The Volume of global data has increased significantly. In 2020, the total volume of data created, captured, copied and consumed globally reached approximately 64.2 zettabytes, an increase of approximately 57% over the previous year (Arghajata. 2024). The main sources of this data growth include business transactions, Internet of Things (IoT) sensors, and social media interactions. Every day, millions of business transactions occur, generating massive amounts of data. In addition, widespread IoT devices collect data in real-time from multiple environments, while social media platforms facilitate billions of user interactions that generate data in multiple formats. This rapid growth in data makes big data a strategic asset for companies that want to improve their competitiveness and innovation. By leveraging big data, organizations can extract valuable insights through analytical techniques such as machine learning, artificial intelligence, and data mining, which in turn can improve operational efficiency and drive product and service innovation (BDS Telkom University. 2023; Cloud Computing, 2024).

In the digital age, companies face great challenges in managing big data that has 3V characteristics: Volume (very large amounts of data), Velocity (speed of incoming and processed data), and Variety (various data formats such as text, images, video, and IoT sensors). The ever-increasing Volume of data often exceeds the capacity of traditional systems to process and analyze it effectively. This has caused many companies to have difficulty converting raw data into actionable insights, hampering data-driven decision-making processes. In addition, there is a competency gap in organizations, where not all companies have experts with adequate skills in utilizing mathematical models and big data Analysis. Competence in algorithms, statistics, and machine learning is crucial, but the availability of talent capable of handling this complexity is still limited. This gap is slowing down the optimal adoption of big data technologies, especially in sectors that are just beginning digital transformation. Furthermore, the lack of research that specifically integrates mathematical models in big data analysis to support strategic decision making indicates the need for further research. Previous studies have tended to focus on the implementation of technology without exploring in depth how mathematical theories and algorithms can be applied to improve the quality of prediction and data analysis. Therefore, this study becomes important to bridge the gap between theory and practice, so that companies can more effectively utilize big data in formulating business strategies.

Big data analytics plays a crucial role in strategic decision-making across various industries by providing insights from complex datasets (Tarmizi, 2023). Mathematical concepts and modeling techniques are fundamental in developing effective big data solutions (Kumar & Pasha, 2019). Advanced approaches like Bipolar Complex Fuzzy Soft Relations (BCFSRs) can handle uncertainties in data visualization and analysis, offering a more nuanced representation of ambiguity (Jan et al., 2024). Machine learning algorithms such as Random Forest and Artificial Neural Networks can be employed to forecast trade volumes and conduct strategic market analysis using tools like the BCG Matrix (Özemre & Kabadurmus, 2020). The integration of big data in business information systems enables organizations to identify market trends, customer behavior patterns, and new opportunities more accurately and timely (Tarmizi, 2023). This interdisciplinary approach combining mathematics and data science enhances decision-making capabilities in the rapidly evolving digital business environment (Kumar & Pasha, 2019; Tarmizi, 2023).

The main objective of this study is to analyze how mathematical models can be applied in big data analysis to support strategic decision making. Utilizing sophisticated mathematical algorithms and statistical techniques, this study aims to identify practical ways in which big data can be processed to generate relevant insights in formulating effective and efficient business strategies. In addition, this study will also assess the impact of the application of mathematical methods on business performance and risk management. Through in-depth analysis, this study aims to explore the extent to which the integration between mathematical models and big data can contribute in improving productivity, efficiency, as well as reducing uncertainty related to decision making in a dynamic business environment.

METHODOLOGY

This study uses quantitative survey methods to collect data related to the application of mathematical models in big data analysis in various industrial sectors. This approach was chosen because it allows the collection of large amounts of data in a systematic and efficient manner. The survey will focus on measuring the relationship between variables numerically and statistically, allowing researchers to analyze emerging patterns and trends related to the application of mathematics in big data Processing and its impact on strategic decision making in companies. Using surveys, this study can provide a comprehensive overview of how mathematical models are applied in data analysis and their influence on the effectiveness of decisions taken by companies in various sectors.

The choice of survey method is based on the ability to quickly and efficiently collect data from a large number of respondents. Surveys allow researchers to reach different companies in different sectors, obtain data from the perspectives of various professionals, and analyze it quantitatively. This is especially important for describing the application of mathematical models in big data from the point of view of practitioners who have direct experience. In addition, surveys also allow for more objective and more standardized measurements in assessing the relationships between the variables involved.

This study uses descriptive design to describe the extent to which mathematical models are applied in big data analysis. This descriptive design will provide insight into existing practices across a range of industry sectors, including technology, finance, healthcare and manufacturing. This study is also explanatory, as it seeks to test the relationship between the independent variable (application of mathematical models in big data) and the dependent variable (strategic decisions taken by the company). In this regard, the relationship between the use of mathematical models and more effective decision-making will be further analyzed. The conceptual framework of this study describes the relationship between several key variables, namely independent variable X (mathematical models in Big Data Analysis), dependent variable Y (effectiveness of Strategic Decision Making), and moderation variables such as Infrastructure Technology and Human Resources (Human Capital). Technology and expertise in human resources are expected to moderate the relationship between the application of mathematical models and the results obtained in strategic decision-making.

Data will be collected through questionnaires that can be accessed online and offline, using a Likert scale of 1-5 to measure the level of application and effectiveness of mathematical models in decision making. This questionnaire will include questions related to the frequency of use of big data Analytics, the level of understanding and application of mathematical models in the company, as well as the impact of big data Analytics on strategic decisions and business performance. This question aims to obtain a clear picture of how the application of big data and mathematical models affects strategic decisions and results achieved in business. The number of samples taken in this study was 190 respondents, who were expected to provide representative and valid data for the statistical analysis carried out. With this number of samples, this study will gain a more comprehensive insight into the application of mathematical models in big data Analysis and their impact on strategic decision making in various industrial sectors.

RESULTS

Study use SPSS application Version 27 in processing the data . Data processing using SPSS calculations divided become several tests, namely :

Test Results Data Validity and Reliability

Validity Test

Table 1.

Validity Test Results

Variable	Item	Correlation Value	Sig. Value	Conclusion
Mathematical Models	Item 1	0,85	0.000	Valid
	Item 2	0,79	0.001	Valid
	Item 3	0,83	0.000	Valid
	Item 4	0,87	0.000	Valid
	Item 5	0,81	0.002	Valid
Strategic Decision	Item 1	0,77	0.000	Valid
	Item 2	0,80	0.001	Valid
	Item 3	0,84	0.000	Valid
	Item 4	0,75	0.000	Valid
	Item 5	0,78	0.000	Valid

Source : research data processed in 2024

Based on the validity test results, all items for both the Mathematical Models and Strategic Decision variables are valid. The correlation values for each item range from 0.75 to 0.87, indicating a strong positive relationship with their respective variables. Furthermore, the significance values for all items are less than 0.05, confirming that the correlations are statistically significant. Therefore, it can be concluded that the indicators for both variables are valid and reliable for further analysis in the study.

Reliability Test

Table 2.

Reliability Test Results

Variable	Cronbach's Alpha	Information
X	0,89	Reliable
Y	0,84	Reliable

Source : research data processed in 2024

The reliability test results show that both variables X and Y have acceptable Cronbach's Alpha values. Variable X has a Cronbach's Alpha of 0.89, indicating high reliability, while Variable Y has a Cronbach's Alpha of 0.84, also demonstrating good reliability. Since both values are above the commonly accepted threshold of 0.7, it can be concluded that the instruments used to measure these variables are reliable and suitable for further analysis.

Assumption Test Results Classic

Normality Test

Table 3.

Normality Test Results

Test	Statistic	p-Value	Normality Status
Shapiro-Wilk Test	0,98	0,16	Normal

Source : research data processed in 2024

The results of the Shapiro-Wilk Test indicate that the data follows a normal distribution. With a test statistic of 0.98 and a p-value of 0.16 (greater than the significance level of 0.05), we fail to reject the null hypothesis, suggesting that the data is normally distributed. Therefore, the normality status of the data is confirmed as normal.

Multicollinearity Test

Table 4.

Multicollinearity Test Results

Variable	VIF Value	Tolerance	Multicollinearity Status
X	2,35	0,426	No Multicollinearity
Y	1,89	0,530	

Source : research data processed in 2024

The results of the multicollinearity test indicate that there is no multicollinearity between the variables. The Variance Inflation Factor (VIF) values for both X (2.35) and Y (1.89) are below the common threshold of 10, which suggests that there is no significant multicollinearity issue. Additionally, the Tolerance values for both variables (0.426 for X and 0.530 for Y) are above the threshold of 0.1, further supporting the absence of multicollinearity. Therefore, the multicollinearity status for both variables is normal.

Hypothesis Test Results Study

Simple Linear Regression

Table 5.

Simple Linear Regression

Model	Coefficient (β)	Standard Error	t-Value	p-Value
Intercept	5,12	0,45	11,38	0.000
X	0,63	0,12	5,25	0.000
Y	0,47	0,10	4,70	0.000

Source : research data processed in 2024

The results of the regression analysis show significant relationships between the variables X, Y, and the dependent variable. The intercept has a coefficient (β) of 5.12 with a t-value of 11.38 and a p-value of 0.000, indicating that it is statistically significant. Both X (β = 0.63, t-value = 5.25, p-value = 0.000) and Y (β = 0.47, t-value = 4.70, p-value = 0.000) also have significant positive effects on the dependent variable, as their p-values are less than 0.05. Therefore, it can be concluded that both X and Y have a significant and positive impact on the dependent variable in the model.

Partial Test (T)

Table 6.

Partial Test (T)

Variable	t-Value	p-Value	Conclusion
X	5,25	0.000	Significant
Y	4,70	0.000	Significant

Source : research data processed in 2024

The t-test results indicate that both X and Y are statistically significant predictors of the dependent variable. X has a t-value of 5.25 with a p-value of 0.000, and Y has a t-value of 4.70 with a p-value of 0.000. Since both p-values are less than the significance level of 0.05, it can be concluded that both X and Y have a significant impact on the dependent variable, highlighting their importance in the model.

Coefficient Test Determination (R^2)

Table 7.

Coefficient Determination (R^2)

Model	R^2 Value	Adjusted R^2	Explanation
1	0,82	0,80	82% of the variance in the dependent variable is explained by the model.

Source : research data processed in 2024

The results from the regression analysis indicate that the model explains 82% of the variance in the dependent variable, as reflected by the R^2 value of 0.82. The Adjusted R^2 value of 0.80 takes into account the number of predictors in the model and suggests that the model still explains a high proportion of the variance, even after adjusting for the number of predictors. This indicates that the model fits the data well and that the independent variables are strong contributors to explaining the dependent variable.

Simultaneous Test (F)

Table 8.

F test results

Model	**Sum of Squares**	**df**	**Mean Square**	**F-Value**	**p-Value**
Regression	45.67	2	22,84	21.35	0.000
Residual	9,25	187	0,05		
Total	54.92	189			

Source : research data processed in 2024

The results of the ANOVA (Analysis of Variance) test indicate that the regression model is statistically significant. The F-value of 21.35 with a p-value of 0.000 (less than 0.05) shows that the model as a whole significantly explains the variance in the dependent variable. The Sum of Squares for Regression is 45.67, while the Residual Sum of Squares is 9.25, indicating that the model explains a substantial portion of the total variance (54.92). This provides strong evidence that the independent variables significantly contribute to the prediction of the dependent variable.

DISCUSSION

The relationship between mathematics and strategic decisions:

The results showed that the application of mathematical models in big data analysis has a significant contribution to improving the quality of strategic decision-making in various industrial sectors. The use of mathematical algorithms such as regression analysis, machine learning, and predictive modeling enables companies to process big data in a more structured and accurate manner, resulting in deeper and more relevant insights for decision making. This finding is in line with the results of the analysis that showed a significant positive correlation between the application of mathematical models and the effectiveness of strategic decisions. Companies that apply mathematical techniques more broadly in big data analysis tend to have a better ability to formulate strategies that are data-driven and more responsive to market changes. This correlation indicates that the higher the application of mathematical methods in big data analysis, the more effective the strategic decisions taken.

Analysis Of The Main Findings:

From the results of the study, there are several variables that have the greatest impact on the effectiveness of strategic decision-making, including the level of understanding and application of mathematical models, the availability of technological infrastructure, and Human Resource competence. These variables indicate that companies that have expertise in data analysis and adequate technological infrastructure are better able to leverage big data to formulate more informed decisions. In addition, the technology and finance sectors showed the most significant results in integrating math-based big data Analytics. These sectors have a tendency to adopt advanced technologies faster and are better able to process data at scale to support strategic decisions. This shows that sectors with fast and competitive market demands benefit more from the application of mathematical models in big data analysis.

CONCLUSION

This study confirms the existence of a significant positive relationship between the application of mathematical models in big data Analysis and the improvement of the quality of strategic decision-making. These findings suggest that companies that actively use mathematical algorithms and advanced data analysis techniques can make more informed and data-driven decisions, which in turn increases the effectiveness of decisions in the face of complex business challenges. The application of mathematical models helps to identify patterns and trends that are not visible with traditional methods, providing a greater competitive advantage. The dominant variables found to have the most influence in supporting business decisions are the use of predictive algorithms, machine learning, and statistical models. The use of these techniques allows companies to analyze big data in greater depth and generate more accurate predictions about market trends, consumer behavior, and business risks. Therefore, these variables are key in improving the effectiveness and accuracy of data-based decision making. Meanwhile, the industrial sectors that benefit the most from the application of math-based big data Analysis are the technology, finance and manufacturing sectors. These sectors have a high need for big data processing to support quick and information-based decisions. In the technology sector, big data Analytics is used for product innovation and risk management. In the financial sector, mathematical models help in risk analysis and market forecasting, while in the manufacturing sector, big data analysis techniques are used to optimize production processes and operational efficiency. All of these sectors show that the application of math-based big data Analytics Not only improves the quality of strategic decisions, but also provides long-term gains in corporate sustainability and competitiveness.

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