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Mechanisms of the Discriminant Analysis Model for Predicting Financial Failure in Economic Enterprises

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Abstract:
This study aimed to highlight the importance and effectiveness of using discriminant analysis in order to build a standard model for predicting default, which is based on a set of financial ratios for early detection of failure of economic institutions and financial risks; based on a sample of 17 successful and 13 failed enterprises. The results of the study showed that one out of nine financial ratios has the ability to distinguish between failed and successful institutions, which are the total asset turnover rate. We were able to produce a model with an effective classification quality of 76.67%.

Keywords: Discriminant analysis, Predicting, Financial failure, Financial ratios.

1. INTRODUCTION

Predicting the failure of economic institutions is an important topic that has occupied many international bodies and accessions; has negative effects at the institution, investor and economic levels as a whole. It is mainly important for debtor creditors who may lose money in the event of financial failure. It is also important for auditors, management, employees and other relevant parties of the institution, whether internal or external, and has appeared to be interested in this subject since the 1930s. Researchers have used some financial indicators individually to predict the financial corruptions of institutions. Interest in this subject increased in the United States of America since the beginning of the sixties, in the wake of the major bankruptcy crisis that swept it after the Second World War. Major companies around the world, such as Enron, collapsed in which the Global Credit Crisis Global gliobcredit crunch to a global

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recession in 2009. Researchers conducting studies aimed at identifying indicators that can inform the prediction of financial failure, since then several studies emerged that developed highly predictable models based on financial indicators and use besides modern methods of financial analysis. From this logic, we will try to apply a discriminant analysis model to predict financial failure and judge the financial position of Algerian economic institutions.

The study Problem

Based on the above and given the importance of the content, the following main question can be asked as follow:

What are the discriminant analysis mechanisms for predicting financial failure in economic enterprises?

The main problem can be divided into sub-questions as follows:

- What is the style of the discriminant analysis model?
- What are the most effective financial ratios affecting the construction of the discriminant analysis model?
- What variables are affected by the discriminant function formula?

Study hypotheses

Based on the foregoing and as provisional answers to the sub-study questions, the following hypotheses can be formulated:

- A method of multi-variable analysis is to analyze the variables in the model in an interconnected manner, taking into account the interrelationships between these variables. It is also called the formation of a statistical model depicting the interrelationship between different variables.
- The financial ratios are all relationships that reflect the financial position of the institution and are studied in the model in order to build the function formula to predict financial failure.
- There are several variables influenced by the discriminant function, especially internal variables that are positively interconnected in the knowledge of the institution's financial position.

The significance of the study

The importance of this study is highlighted by:

- Analysis of the phenomenon of financial failure and control of its concepts.
- Testing the discriminant analysis model for early detection of the possibility of financial failure in economic institutions.
- Formulate a discriminant function that allows prediction of financial failure and links financial analysis tools to statistical analysis tools in financial decision-making within an economic institution.

The Aim of the study

This study aims to:

- Know the financial position of economic institutions using a set of financial ratios.

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- We aim to assess the potential for financial failure or success of the institutions selected to study and show how efficiently the discriminant analysis model is applied to Algerian economic institutions.
- Building a statistical model through discriminant analysis can predict financial failure through a set of financial ratios.

Method

The researcher used the analytical descriptive approach based on phenomena analysis by applying to a sample of institutions where a set of financial ratios is calculated; discriminant analysis model to predict the financial failure of economic institutions using SPSS-20 statistical programs.

All of these studies relied on identifying the necessary procedures to predict financial failure, while our study focused on the discriminant analysis model. In our study, we also used the analysis method as a basic tool for analyzing financial ratios in building the target model.

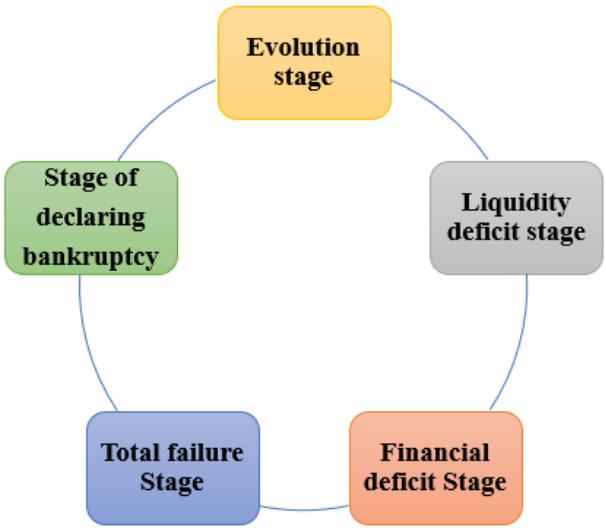
2. Theoretical Framework of the Study

Financial crises are defined as a complete financial collapse accompanied by the failure of a large number of financial and non-financial institutions with a sharp contraction in macroeconomic activity, or it is the sudden decline in the prices of one or more types of assets, either physical capital such as machinery and equipment, or financial assets such as stocks and savings accounts, and their characteristics include:

- The occurrence of the element of violent surprise when it explodes.
- Insufficient and inaccurate information on the part of those responsible for the crisis.
- Lack of control, i.e. outside the scope of the decision-maker.

The Chief Financial Officer must therefore avoid this crisis and predict the financial failure he/she will face; by analyzing the status of the institution and identifying any stage it has reached, the following figure shows this:

Fig.1. Stages of financial failure



Source: (Ammari, 2015, p.40)

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- Evolution stage (emergence): it is the first stage of financial failure, as some indications appear: (Ammari, 2015)

- The change in demand for products and the continuous increase in indirect costs.
- The large increase in operating costs, and poor efficiency and production methods.
- Approval of investment expansions without the availability of sufficient working capital to meet them and the lack of credit facilities.

- Financial deficit stage (liquidity deficit): in this stage, the institution suffers from its inability to meet current liabilities and its urgent need for cash despite the increase in fixed assets, and this is evident through the following aspects : (Bassam, 2004)

- The company's assets are greater than its liabilities.
- Difficulty converting assets into cash to cover outstanding debts.
- The institution's inability to meet its immediate cash needs.

- Financial insolvency: this stage lies in the institution's inability to obtain the necessary funds to cover its outstanding debts, and it appears in:

- An amendment to the financial policies of the institution or a change of management.
- Working on issuing additional shares or issuing bonds.

Most of the institutions that pass through this stage are successfully dealt with if the defect is discovered in a timely manner and appropriate measures are taken. As for the institutions that cannot carry out the necessary treatment in a timely manner, they move to the fourth stage, which is the stage of total failure. (Matar, 2010)

- Total failure stage (all insolvency): several indicators appear in this stage that warn of the possibility of bankruptcy of the company, including: (Ammari, 2015, p. 42)

- The company's dependence on borrowing and the deterioration of current assets and liquidity ratios.
- The continuous rise in the volume of debt and its rescheduling.
- Low profitability, faltering for consecutive periods, and the company's inability to compete.

This makes this stage a critical point in the life of the institution, when the administration's attempts to fight this total hardship achieved become futile.

- The stage declaring bankruptcy or confirm: this stage is characterized by the institution taking legal measures to protect the rights of the lenders, and the company is declared bankrupt ; i.e. the liquidation of the company, which is the final stage, and thus the company has reached the stage of failure. (Bassam, 2004, page 30)

After determining the stage of financial failure, the Chief Financial Officer proposes an effective strategy to avert this crisis through statistical models. Some models will be presented to predict the financial failure of economic institutions:

- ALTMAN Model: In 1977, it developed a ZETA model known as the second generation of institutions in the private sector by conducting the study on a sample of failed institutions and another successful one and using the first two methods of linear

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discriminant analysis and quadratic discriminant analysis and the form of the following formula:

$$\boldsymbol{Z = 0.717x_1 \quad + 0.847x_2 \quad + 3.107x_3 \quad + 0.420x_4 \quad + 0.998x_5}$$

- KIDA Model: 1980 is a modern model of financial failure forecasting and relies on the five most important independent variables of financial ratios; depends on the method of discriminant analysis to classify views into compatible items in order to differentiate economic units. The formula is as follows:

$$\mathbf{Z = 1.042x_1 \quad + 0.42x_2 \quad - 0.461x_3 \quad - 0.463x_4 \quad + 0.271x_5}$$

- SHERROD 1987: This model is based on 6 separate financial variables in addition to the relative weights of discriminant function transactions given to these variables according to the following formula:

$$\mathbf{Z = 17x_1 \quad + 9x_2 \quad + 35x_3 \quad + 20x_4 \quad + 1.2x_5 \quad + 0.1x_6}$$

2.1. The method used in the study to predict financial failure:

2.1.1. Discriminant analysis model: the discriminant analysis method is one of the quantitative statistical methods widely used for its ability to interpret the relationships that arise between the variables of a phenomenon and estimate its behavior, which has earned it an appropriate characteristic for its use in many scientific fields.

- **The definition of discriminant analysis:** Discriminant analysis is one of the important multivariate analysis methods. Under the use of these methods, the variables included in the model are analyzed in a correlated manner, taking into account the interrelationships between these variables. It is also called to form a statistical model that depicts the interrelationship between different variants. Its importance is mainly due to its effectiveness in distinguishing between observations by using many variables, by finding linear combinations for a group of variables called differentiation variables.

The discriminant analysis model depends on reaching the differentiation function that works to maximize the differences between the average groups and reduce the similarity between errors and classification at the same time, by finding a linear function for a set of variables. (Ali, 2015)

The discriminant analysis is a statistical method suitable for the dependent variable, whether qualitative or non-standard, and the independent variables are quantitative. This analysis aims to derive a linear combination of two or more independent variables based on the statistical decision rule represented by maximizing the variance between groups attributed to the variance within groups. The linear combination can be derived from the following equation: (Al-Sarraf, 2010)

$$Z = b_1x_1 + b_2x_2 + \ldots . b_nx_n$$

Whereas:

Z : characteristic function.

B : the distinguished score.

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X : the independent variables.

As for the statistical test for this analysis, it relies on testing the hypothesis of the equality of group averages. It should be noted that the number of centers equals the number of groups.

To test the significance of the discriminatnt function, we rely on the significance of the distance between the centers of the groups. It should be mentioned that the application of the discriminant analysis is similar to the regression analysis, that is, the linear combination of the quantitative values of two or more independent variables is used to describe the prediction of the behavior of the dependent variable, but the main difference is that the dependent variable is qualitative (nominal or non-quantitative) in the discriminant analysis where the variable in quantitative regression analysis.

- **The aim of discriminant analysis :** (Ali, 2015, pp. 37-40)
  - Designing linear combinations of variables that are better at distinguishing between the categories of the dependent variable.
  - Verifying whether there are significant differences between the groups with respect to the variables.
  - Determine which variables contribute the most to the difference between the function classes.
  - Divide the cases between the categories of the dependent variable based on the values of the independent variables.
  - Classification accuracy rating (percentage).

3. Field Study

3.1. Institutions under study: the sample of the study was selected from the study population, which consisted of 30 active institutions in the economic sector of the wilaya of Medea, and we divided this sample into two groups, the first group represented 17 successful institutions, while the second group represented 13 failed institutions.

The successful and failed institutions in the sample were selected and identified based on the following two criteria:

- Achieving a loss result in two consecutive years or more during the study period, with the year 2016 considered as the year of failure for the failed institutions.
- Achieving successive profits for three years during the study period for successful institutions.

3.2. Determine the variables of the study: it is represented in defining each of the dependent variables and the independent variables, which are as follows:

- The dependent variable: it is considered a qualitative indicator and is according to the status of the institution, where the value is 1 (one) if the institution is successful, and vice versa, if the institution is a failure, then the value is taken 0 (zero).

- Independent variables: they represent the quantitative variables in this study or what is known as the financial ratios that are used for comparison and measurement. In order to reduce the number of variables included in the discriminant function while preserving the variables that have the largest significant discriminant power and that give the least classification error, they are represented in the following table:

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Table 1. Financial ratios used in previous studies

Normative values evaluation	Financial ratio code	Financial indicator	Financial ratio type
R1>1Successful R1<0 Failed	**R1**	**Current ratio = Current Assets/ Current Liabilities**	Liquidity ratios
R2>0 Successful R2≤0 Failed	**R2**	**Cash ratio = (Cash + Cash Equivalents) / Current Liabilities**	
Achieving the greatest value	**R3**	**Asset Turnover = Net Sales / Average Total Assets**	Activity ratios
R4>0 Successful R4<0 Failed	**R4**	**Current Asset Turnover = Net Sales/Average Current Assets**	
R5<0 Successful R5>0 Failed	**R5**	**Debt to Asset ratio = Total Liabilities / Total assets**	Indebtedness ratios
R6(+)Successful R6(-) Failed	**R6**	**Working Capital = Current Assets - Current Liabilities**	Activity ratios
By net result value	**R7**	**Net working capital = net result/working capital**	Profitability ratios
R8<1 Successful R8>1 Failed	**R8**	**Inventory/Sales**	Activity ratios
R9>1 Successful R9≤0 Failed	**R9**	**Quick current ratio = (Current assets-Inventory)/Current Liabilities**	Liquidity ratios

Source: prepared by the researcher based on previous studies

3.3. Determining the study period: our study was limited to the period from 2014 to 2016, due to the difficulty of providing financial information for a longer period for some institutions. We have selected some failed institutions and successful ones and relied on the budget and results chart for three years. We used 2015 to predict 2016.

3.4. Study procedures, analysis and interpretation of the results of the study:

The procedures of the discriminant analysis are applied step by step, Stepwise, to the study sample in order to construct the discriminant function, which includes the most important financial ratios and the most capable of influencing the dependent variable that represents the failure of institutions, using the statistical program spss.v20. It is necessary to identify the steps of the study:

- Create a matrix of variables.
- Data entry and processing in the spss.v20 program after building the variables matrix.

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- Ensure the conditions that must be met for using the discriminant analysis by testing the normal distribution of the data and testing the condition of the two groups' naturalization.

With a difference in the covariance matrices that reflects a large value for the determinant of the logarithm, in this study the BOX'S M test is used, and we obtained the following results:

Table 2. Log Determinant

Log Determinants		
Financial ratios	**Rank**	**Log Determinant**
0	**1**	**-1,685**
1	**1**	**,180**
Pooled within-groups	**1**	**-,269**
The ranks and natural logarithms of determinants printed are those of the group covariance matrices.		

Source: SPSSV20 output

Through the results of the table, we notice a difference in the value of the log determinant of the covariance matrices; the rank column indicates that there is only one ratio out of 9 selected ratios that is the best and most able to distinguish and predict financial failure.

Table 3. BOX test results for equality of variance matrices

Test Results		
Box's M		9,794
F	Approx.	9,484
	df1	1
	df2	2226,583
	Sig.	,002
Tests null hypothesis of equal population covariance matrices		

Source: SPSSV20 output

Through the table, the hypothesis of homogeneity of variances can be tested by BOX 'S M test, where this test is done using the F. Fisher distribution. If the significance is less than 5%, we accept hypothesis H1, which states statistically significant heterogeneity, and the fact that the significance reached 0.002 means that we reject the null hypothesis H0 based on the homogeneity of the study variables between the two sections of the dependent variable.

Thus, the hypothesis of homogeneity between the two groups was not achieved, but this hypothesis can be bypassed because the discriminant function does not take into account the very weak data.

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- Test of equality of the averages of study variables: the equality of the averages of the two samples is conducted in order to determine the extent to which the financial ratios are able to distinguish between successful and failed institutions. To this end, the t-Student test, which helps to reach the answer to the question: Are the two calculations of the financial failure variable different from each other statistically significant? To answer this question, the SPSS program was used to determine morale.

- Variables entered: so as to include the discriminant equation on the best variables that follow a discriminant character the variables are reduced using a count and Wilks' Lambda that contributes to giving the best results and the following table shows this:

Table 4. Variables entered

Variables Entered/Removed[a,b,c,d]									
Step	Entered	Wilks' Lambda							
		Statistic	df1	df2	df3	Exact F			
						Statistic	df1	df2	Sig.
1	asset turnover rate	,709	1	1	28,000	11,513	1	28,000	,002
At each step, the variable that minimizes the overall Wilks' Lambda is entered.									
a. Maximum number of steps is 18.									
b. Minimum partial F to enter is 3.84.									
c. Maximum partial F to remove is 2.71.									
d. F level, tolerance, or VIN insufficient for further computation.									

Source: SPSSV20 output

The table shows that all variables are non-significant except for the variable R3, as this variable is considered one of the most important variables and the most capable of distinguishing between successful and failed economic institutions; as this variable has the largest value for the F rate and the lowest value for the Wilks' Lambda rate. Various non-significant variables will be excluded, and we conclude that the component variable for the model is R3 only, whose statistical value was 0.002, which is less than the significant value of 0.05.

Significance and strength of relationship test: Significance and strength of relationship are tested by calculating the eigenvalue and the Wilks' Lambda statistic.

Table 5. Eigenvalues

Eigenvalues				
Function	Eigenvalue	% of Variance	Cumulative %	Canonical Correlation
1	,411[a]	100,0	100,0	,540
a. First 1 canonical discriminant functions were used in the analysis.				

Source: SPSSV20 output

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The value of the canonical correlation shows the relationship between the discriminant point and the groups, where the closer the value of the canonical correlation is to one, the better the model. Through the table shown above, the obtained correlation value is 0.540, and this indicates the good discriminant ability of the discriminant function.

As for the eigenvalue, the greater it is, the greater the covariance involved in the linear combination of the variables, and thus the good performance of the discriminant functions. The eigenvalue in our study reached 0.411, which is an average value.

Table 6. Wilk's Lambda Statistics

Wilks' Lambda				
Test of Function(s)	Wilks' Lambda	Chi-square	Df	Sig.
1	,709	9,472	1	,002

Source: SPSSV20 output

The above table shows that the value of the Wilkes Lambda statistic amounted to 0.709, and this indicates that the variables collected in the discriminant function play a good role in discrimination. It shows that the obtained discriminant function represents a good set of financial ratios that perform the forecasting process accurately.

Standardized discriminant coefficients: based on the following table, the standard discriminant function can be written:

Table 7. Standardized discriminant coefficients

Standardized Canonical Discriminant Function Coefficients	
	Function
	1
Asset turnover rate	1,000

Source: SPSSV20 output

Non-normative discriminant coefficients: it is an estimate of parameters b0 and b1 shown in the following equation:

$$Z=b0+b1x1$$

where:

b 0= -1.127

b1 = 1.144

X1 = R3 Sales / Total Assets

Table 8. Unstandardized discriminant coefficients

Canonical Discriminant Function Coefficients	
	Function
	1
Asset turnover rate	1,144
(Constant)	-1,127

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Unstandardized coefficients

Source: SPSSV20 output

Thus, the standard discriminant function is: Z= -1.127+1.144R3

Determine the cut-off point: After compensating the values of the independent variables represented in the financial ratios involved in building the discriminant function using the financial data of a particular institution, we produce a discriminatory score for each institution, and this score is compared with the cut-off point in order to know the group to which the establishment belongs.

Table 9. Discriminant function coefficients

Functions at Group Centroids	
Financial ratios	Function
	1
0	-,708
1	,542
Unstandardized canonical discriminant functions evaluated at group means	

Source: SPSSV20 output

The table above shows that the failed institutions have an average discriminant score value of 0.708, but if the discriminant score is close to the value of the average discriminant score for successful institutions, which is 0.542, then it is classified as a successful one. In order to facilitate the classification process, it is better to build a base for decision-making ; where the cut-off point is calculated based on the following equation : (the average discriminant score for failed institutions + the average discriminant score for successful institutions)/2

Thus, the result is as follows : (-0.708 + 0.542)/2 = -0.083

Classification function parameters: two functions are recorded in reclassifying institutions into the failed category and the successful one.

Table 10. Classification Function Coefficients

Classification Function Coefficients		
	Financial ratios	
	0	1
Asset turnover rate	,480	1,910
(Constant)	-,781	-2,086
Fisher's linear discriminant functions		

Source: SPSSV20 output

Therefore, the classification functions take the following forms:

The function of rating successful institutions:

Z= -2.086+1.91R3

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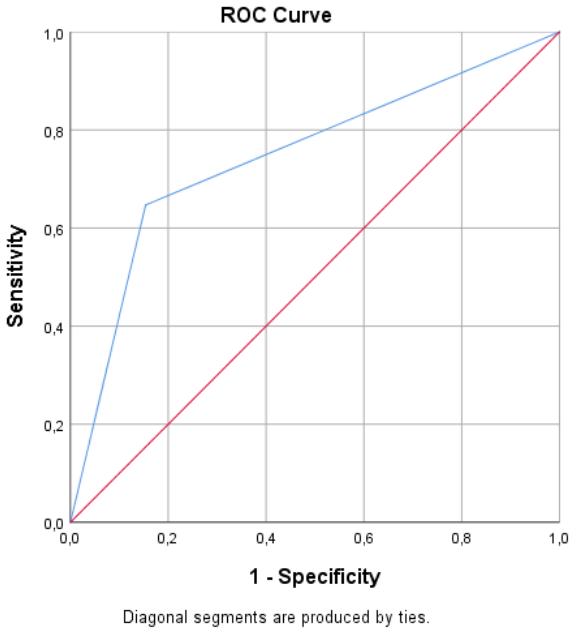
Failed Institutions Classification Function:

$$Z= -0.781+0.48R3$$

Testing and evaluating the effectiveness of the model: the aim of building a predictive discriminant function is to predict whether or not financial failure will occur in the near future. The study is based on the ROC curve.

Fig.2. The ROC curve of the results of the discriminant model



Source: SPSSV20 output

Through the ROC curve, we notice that the angle star on the left is attracted, and therefore it is very far from the diameter of the shell, which is confined under the area of 50%. Thus, it can be said that the discriminant model has a great ability to predict the failure of economic institutions, and the following table proves this:

Table 11. Area under the ROC curve of the discriminant model

Area Under the Curve				
Test Result Variable(s): Predicted Group for Analysis 1				
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
,747	,092	,023	,565	,928
The test result variable(s): Predicted Group for Analysis 1 has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.				
a. Under the nonparametric assumption				
b. Null hypothesis: true area = 0.5				

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Source: SPSSV20 output

The table shown above shows that the area under the ROC curve reached 0.74 at a significant level less than 0.05, and thus rejects the null hypothesis that states that the area under the curve is equal to the value of 0.5.

Evaluating the results of the model: the results of the model can be evaluated by comparing the discriminant function for each institution with zero. If the discriminant function is greater than zero, then the institution is successful but if it is less than zero, the institution is a failed institution.

In order to predict the status of the institutions for the year 2016, the discriminant function is calculated based on the ratio of R3 that makes up the model in order to reach the status of the institution, whether it was successful or failed. The following table shows that:

Table 12. The total number of successful and failed institutions during the years 2024-2025

Period	Successful institution	Failed institution	Total number
2024	11	19	**30**
2025	13	17	**30**

Source: SPSSV20 output

4. CONCLUSION

Through our treatment of the phenomenon of financial failure at the level of economic institutions in the wilaya of Medea, by applying the method of discriminant analysis in its steps using the SPSS V20 program, we reached the following results and recommendations:

Results:

- Based on the applied test, it was found that the asset turnover ratio is the one that affects the studied phenomenon out of nine financial ratios, which are selected from the active ratios.
- Through the study, it was found that the financial ratios have an important role in determining the position of the institution, as it occupies a very important rank in the field of predicting financial failure, and this proves the first hypothesis.
- The possibility of predicting financial failure for the year 2025 based on the discriminant function extracted, and this proves the second hypothesis.
- This study was able to produce a model with an effective classification quality of 76.67%, which is a good percentage.

Recommendations:

- Enriching the issue of predicting financial failure by conducting various researches on all bodies and institutions, especially the accounting field, so that researchers and interested parties can know the financial position of the institution.
- Search for factors other than financial factors that may affect the financial structure of the economic institution.

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- Resorting to governance as a tool that contributes to imposing control on all economic bodies and institutions.
- Integration of quantitative and qualitative variables to build a model capable of predicting financial failure.

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