CLASSIFICATION OF THE ALGERIAN ECONOMIC COMPANIES USING LOGISTIC ANALYSIS

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ABSTRACT

This research aims to try to construct a mathematical model that helps to classify the Algerian economic companies to distressed and non-distressed companies depending on a sample consisting of 60 companies : half of them is distressed and the other half is non-distressed according to three financial ratios that have been selected among the financial ratios the most used by researchers, namely: sales to total assets, working capital to total assets and the ratio of equity to total assets, which have been calculated from financial data of the study's sample. Logistic regression method in the construction of the achieved model has been used, and the results were good; we have obtained a logistics model that has great ability in the classification of companies where the percentage of good classification of this model was 96.7%.

Keywords: Financial Distress, Logistic Regression, Classification of Algerian Economic Companies.

INTRODUCTION

Financial distress is one of the main problems that may face the company during the period of its activity, since the occurrence of such imbalances, especially if not treated early, can lead, in many cases, to the total collapse of the company. To avoid falling into the bankruptcy trap, it is necessary to search for effective ways to accurately know the financial structure of the company, and to predict the distress of the latter sufficiently in advance to take the appropriate actions to prevent the demise of this company.

The Algerian economic companies, like the other ones, are also prone to such disorders, especially since the Algerian economy has become more open and expansive than ever before, which has reduced the protection that was granted to these companies and makes the latter face many risks as a result of dealings with the outside world.

METHODOLOGY

STUDY'S PROBLEM

The study's problem stems from the possibility of constructing a model able to classify the Algerian economic companies to distressed and non-distressed companies in order to enable the parties interested in knowing the financial position of the company to easily make decisions. From this standpoint, the following question was asked:

Can we construct a mathematical model that works on the classification of the Algerian economic companies to distressed and non-distressed companies depending on logistic analysis? The following sub-questions are branched from this question:

- To what extent the achieved model can predict the distress of the economic companies active in the Algerian environment?

- What are the main independent variables (financial ratios) consisting in: (sales to total assets, working capital to total assets, equity ratio to total assets) that have a great ability to influence the dichotomous dependent variable (distressed and non-distressed)?

RESEARCH'S IMPORTANCE AND OBJECTIVES

The importance of this research consists in trying to help the Algerian economic companies to avoid the risks of financial distress through the construction of a mathematical model using one of the most prominent methods of discrimination: logistic regression in order to choose the necessary policies to avoid the problem of financial distress or choose the appropriate treatment to this problem. The research aims to:

- Defining the logistic regression method by addressing its characteristics, hypothesis and how to construct the binary logistic function.
- Constructing a mathematical model that works on the separation between the distressed and non-distressed Algerian economic companies.

HYPOTHESES

This study is concerned with the verification of the possibility of using the logistic regression to construct a model fits the Algerian environment and thus checking the following hypotheses:

- **The first major hypothesis**

The equity ratio has the greatest impact on the classification of the distressed and non-distressed Algerian economic companies.

- **The second major hypothesis**

The three selected ratios consisting in: (sales to total assets, working capital to total assets, equity ratio to total assets) have a positive effect on the dependent variable (distress).

- **The third major hypothesis**

The three variables consisting in: (sales to total assets, working capital to total assets, equity ratio to total assets) combined have great ability to classify the Algerian economic companies.

PREVIOUS STUDIES

There are two types of prediction of financial distress models; the first is univariate approach that explores the relationship between financial ratios individually and distress, the second is multivariate approach that employs financial ratios combined to predict financial distress (Leksrisakul and Evans, 2005).

The first studies that addressed the subject of prediction of the companies distress were conducted by Beaver by the year 1966; he adopted in this study the univariate method. Beaver is one of the researchers more influential in the field of research related to financial distress; he analyzed a sample of 79 distressed companies, 79 non-distressed companies and 30 financial ratios for the period 1954 to 1964. He concluded that the monetary flow ratio to total debt has great ability to classify companies, since the accuracy of this ratio in the classification reached 87% (Yazdanfar and Nilsson, 2008).

As for the multivariate method, Altman was pioneer in this area, and he applied Multiple Discriminant Analysis (MDA) in the field of predicting financial distress (Hu and Ansell, 2005); he got one of the most famous models for its ability to prediction and easy application, named z-Score Altman put in 1968. This study indicated the presence of four variables related to the balance sheet, income statement, as well as the additional stock market variable that all benefit and contribute to the prediction of financial distress in the companies. These selected variables are: liquidity ratios, profitability, financial leverage and solvency and activity, which are based on two different criteria: their literary popularity and importance in the study. Each company has value of Z-Score composed of the five financial ratios weighted by coefficients and constructed using discrimination analysis. Altman used in this model 66 US industrial companies listed on the stock exchange; 33 distressed and 33 non-distressed (Altman and Danovi, 2013).

Altman's study has been followed by many of the studies with various new statistical methods such as logistic regression, neural networks and branches tree…(Bardos, 2001).

Ohlson (1980) was the first one who used the method of logistic analysis to predict the companies distress. He used this method in order to cover the defects of discriminant analysis, and relied on a sample consisting of 2058 non-distressed companies and 105 distressed companies, as well as on nine financial ratios related to the period 1970-1976. The study's results indicate that the ratios of current liquidity, financial structure, company's performance and size are linked to the company distress within one year (Yazdanfar and Nilsson, 2008).

DEFINITION OF LOGISTICAL ANALYSIS

Logistic regression is a statistical method for the examination of the relationship between the dependent variable with nominal level and one independent variable or more that is sometimes called concomitant variables or explanatory variables so that independent variables are of any kind of measurement levels (Babtain, 2009).

The objective of applying logistic regression method is to seek the explanation of the probability of the occurrence or non-occurrence of a particular phenomenon. The dependent variable may be dichotomous qualitative variable, i.e., it may take two values, and it may be polytomous, i.e., it may take three values or more (Menard, 2010).

HYPOTHESES OF LOGISTIC REGRESSION

Logistic regression is based on a set of hypotheses represented mainly as follows (El-Abassi, 2011):

- The dependent variable is a descriptive dichotomous or polytomous variable, conditional expectation of this variable E (y / x) is a limited variable for the period (0,1), while the explanatory variables can be continuous or discontinuous, descriptive dichotomous or polytomous. It is also assumed that all variables are measured without errors.
- There is a significant relationship between the dependent variable and the explanatory variables. It takes the following image:

$$P_r(Y_k = 1/X) = \frac{\exp\,(\beta' X)}{1 + \exp\,(\beta' X)}$$

- The expected value of random error is equal to zero; random error variance is equal to $(\Pr(X)\,[1-\Pr(X)])$, and random error (μ_k) follows binomial distribution with a probability determined by the conditional average basis.
- There is no correlation between random errors (errors independence).
- There is no correlation between random error and explanatory variables.
- There is no complete correlation between explanatory variables, as the variables between which there is complete correlation should be deleted.

CARACHTERISTICS OF LOGISTIC REGRESSION

Logistic regression method has some characteristics distinguishing it from other methods namely (El-Abassi, 2011):

- This method does not put any preconditions on explanatory variables.
- Logistic regression method does not determine the population to which belongs new observation only, but it also determines the likelihood of this belonging, it also can be used to analyze dichotomous and polytomous descriptive dependent variable.
- Maximum likelihood method is used to estimate its parameters. Thus, quality requirements are available in these estimations.
- Ease of calculations used in the formulation of the model.

These characteristics make logistic regression one of the models more suited to the analysis of dichotomous and polytomous descriptive dependent variable.

CONSTRUCTION OF LOGISTIC MODEL

Logistic regression model is constructed in the case of two groups on a basic assumption that the dependent variable (y), response variable that is object of our study, is a dichotomous variable follows Bernoulli Distribution; it takes the value (1) the probability (p) and the value (0) with the probability q = (1 –p), i.e., to the occurrence and non-occurrence of response.

As we know in the linear regression whose independent variables and dependent variable take continuous values, the model linking variables is given as:

$y = b_0 + b_1x + e$

(y) is a continuous observed variable. Assuming that the average of observed or actual values of (y) at a certain value of the variable X is E (y), and the variable e represents error where:

$e = y - \hat{y}$

The model can be written as follows: $E(y/X) = \widehat{b_0} + \widehat{b_1}X$

It is known in regression that the right end of these models takes values from (-∞) to (+∞), but when one of the two variables we have is dichotomous (y), simple linear regression is not appropriate because (Ghanem and El-Jaouni, 2011):

E (y /x) = P (y=1)= $\grave{P}$

Thus, the value of the right end is confined between the two numbers (0, 1). On this basis, the model is inapplicable from the point of view of regression.

One of the methods to solve this problem is to introduce an appropriate mathematical transformation on the dependent variable (y); it is known that $0 \le P \le 1$, then the ratio $\left(\frac{P}{1-P}\right)$or $\left(\frac{P}{q}\right)$ is a positive amount confined between (∞ and 0), i.e., $0 \le \frac{P}{q} \le \infty$, and taking the natural logarithm of the variable $\frac{P}{q}$, the field of its values becomes confined between:

$.(-\infty \leq log_e(\frac{P}{q}) \leq \infty)$

Thus, the regression model can be written in the case of one independent variable in the following form:

$$log_e\left(\frac{P}{q}\right) = \widehat{b_0} + \widehat{b_1}X$$

If we have more than one independent variable, the model becomes in the form:

$$log_e\left(\frac{P}{q}\right) = \widehat{b_0} + \sum_{i=1}^{k} \widehat{b_j}X\,ij$$

Where:

i = 1,2,…… n ،j = 1, 2……… k

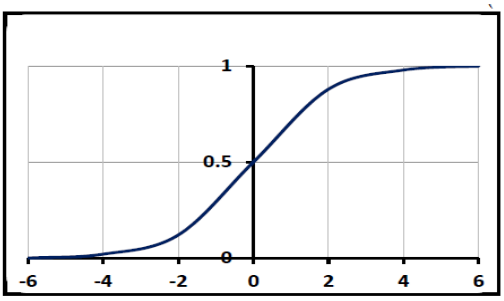
The previous equation can be transformed to the following form:

$$P = \frac{}{1 + \exp [-}$$

Where: exp is the inverse of the natural logarithm.

This model is called logistic regression model, and the transformation $log_e\left(\frac{P}{q}\right)$ or $ln\left(\frac{P}{q}\right)$ is called Logit transformation; logistic function is a continuous function takes the values (0-1) and (y) is closer to zero whenever the left end of the logistic function is closer to (-∞), while (y) is closer to one whenever the right end of this function is closer to (+∞), and it is a similar function when the right end of this function is equal to zero and the ratio ($\frac{p}{q}$) is called odds of success or the preference ratio of the desirable event, while the ratio ($\frac{p}{q}$) is called odds of failure, and the amount $log_e(\frac{P}{1-P})$ is called Log Odds Ratio or Logit.

Logistic function takes the following form:



It is necessary to note that the estimation of Logit model's parameters is done by the Maximum Likelihood Method (Kleinbaum, 2010) that is one of the most famous estimation methods in statistics. The function of maximum likelihood measures the observed probabilities for a number n of independent variables ($P_1, P_2 \ldots \ldots P_n$) located in the sample, the result of multiplying these probabilities represents the function of maximum likelihood:

M.L = prob($P_1, P_2 \ldots \ldots P_n$)

Likelihood function is written as follows (Kermadec, 2008):

$L(\theta) = \prod_{i=n}^{N} F(X_i\theta)^{Y_i}(1 - F(X_i\theta))^{1-Y_i}$

Thus, likelihood logarithm is as follows:

$logL(\theta)= \sum_{i=n}^{N} Y_i logF(X_i\theta) + \sum_{i=1}^{N}(1 - Y_i)log(1 - F(X_i\theta))$

$$= \sum_{i:Y_i=1} log$$

To construct a particular model, we compensate each time the F values by its given value and we estimate θ coefficient through the application of first-degree condition (absence of likelihood logarithm coefficient). Under certain conditions, the maximum likelihood estimator θ is symmetric and it is almost normally distributed; it revolves around the true value θ of parameters and the matrix of common variation is equal to the inverse of information matrix of Fisher I (θ).

STUDY'S RESULTS

Study's population and sample

The study's population consists in the Algerian economic companies, while the study's sample is 60 companies, 30 of which are distressed and 30 are non-distressed. Their financial information of the years 2011-2013 were extracted, and they are illustrated in the following table:

Table number (1): Distressed and non-distressed companies

Number	Successful companies	Number	Distressed
1	Boukhanoufa Mourad, L.L.C	31	Briqueterie de Fesdis, L.L.C
2	M.S Minoterie, L.L.C	32	U.P.R, EURLs
3	Groupe SONIMEX, L.L.C	33	C.A BATNA, J.S.C
4	Leather Undustry- J.S.C	34	FILTRES, L.L.C
5	SEBT Ben Ghezal, L.L.C	35	AIN SKHONA, J.S.C
6	Les Moulins des Aures, J.S.C	36	MOULIYA, EURLs
7	S.N.S, L.L.C	37	OULMI, L.L.C
8	S.B.G.D.E	38	AURES AGREGATS, L.L.C
9	BENPACK, L.L.C	39	DONG FUN, L.L.C
10	SOGEFLEX, L.L.C	40	PRO-AGRO, L.L.C
11	SAFI, L.L.C	41	MOU COMP, EURLs
12	FAN, L.L.C	42	SAT AURES, L.L.C
13	ALFATH, J.S.C	43	AISSAOUI, EURLs
14	KAMIDINE, L.L.C	44	SAADA, L.L.C
15	Aures Bois, L.L.C	45	GREPCO
16	EURL EZZAHIRI	46	AURDIS, partnership
17	Frères Mokrani, L.L.C	47	MEGA BATNA
18	PROTIMGAD, EURLs	48	Briqueterie Alnadjah, L.L.C
19	GIPLAIT BATNA	49	Société Briqueterie IMJ, L.L.C
20	N'GAOUS CONSERVE, J.S.C	50	BENJEHA, EURLs
21	FEREXCO, L.L.C	51	ANZAR, L.L.C
22	S.M.E.I, L.L.C	52	DEMANE, EURLs
23	TISSACIER, EURLs	53	INVES-LYAMINE, EURLs
24	CAPSUPLAST, L.L.C	54	BACH KHALED, EURLs
25	Moulins Guetianne, L.L.C	55	OUAHCHI, L.L.C
26	Moulin CHOUDJAANE, L.L.C	56	MOULIN LE LION, L.L.C
27	Guimel Mobilier, L.L.C	57	FRUIT TASARIFT, EURLs
28	PETROSAM, L.L.C	58	ARISCO, L.L.C
29	Tripode, L.L.C	59	ATTIA, L.L.C
30	Toufik, L.L.C	60	FILTRES, L.L.C

Distressed companies are companies that have achieved during three consecutive years a negative net result. Thus, we can say that each company made a loss during the years (2011, 2012, 2013) is considered distressed company that has been adopted in this study.

Dependent variable and independent variables

Before the construction of the logistic model, we must first define the dependent variable and independent variables involved in the construction of the model. The dependent variable is the qualitative indicator (distress); we assume that it holds the values 1 or 0 according to the situation of the company; if the company is distressed, it takes the value 0, but if the company is non-distressed, it takes the value 1. The independent variables are a set of financial ratios that represent the characteristics of each group of distressed and non-distressed companies. They are as follows: sales / total assets, working capital / total assets and equity / total assets.

To construct the logistic model, we used the software SPSS, V. 20, then we calculated the three financial ratios for all the companies of the study's sample, depending on the financial data of these companies for the year 2012.

Examination of the problem of multi-correlation between explanatory variables

It is necessary to accurately examine the problem of multi-correlation that may be between explanatory variables in order to avoid the inclusion of repeated information that may affect the credibility of the logistic model estimations coefficients. To examine this problem, we use the correlation matrix based on Pearson coefficient, which shows the extent of correlation between each two variables. The results are shown in the following table:

Table number (2): Correlation matrix between independent variables.

Correlations

		X1	X2	X3
X1	Pearson Correlation	1	.380**	.379**
	Sig. (bilateral)		.003	.003
	N	60	60	60
X2	Pearson Correlation	.380**	1	.191
	Sig. (bilateral)	.003		.144
	N	60	60	60
X3	Pearson Correlation	.379**	.191	1
	Sig. (bilateral)	.003	.144	
	N	60	60	60

It is shown through the table (2) that the three financial ratios do not suffer from multi-correlation problem since all Pearson coefficient values are less than 0.7. Therefore, we can say that all these variables are valid to construct the logistic model.

THE METHODOLOGY USED IN THE CONSTRUCTION OF THE LOGISTIC MODEL

Depending on the way ENTER available in the SPSS, V.20 software, we constructed the logistic model, and the results were as follows:

Table number (3): Iterations of logistic coefficient estimation

Iterations background

Iteration		-2log-Likelihood	Coefficients			
			Constant	X1	X2	X3
Stage 1	1	49.893	-.392-	.564	1.276	.305
	2	34.591	-.847-	1.272	2.648	.725
	3	24.448	-1.475-	2.130	3.366	2.433
	4	20.235	-2.043-	2.789	4.203	4.535
	5	19.202	-2.433-	3.254	5.076	6.092
	6	19.106	-2.595-	3.486	5.480	6.687
	7	19.105	-2.617-	3.524	5.532	6.755
	8	19.105	-2.618-	3.525	5.533	6.756

Source: Outputs of SPSS-20 software

The results of the table number (3) show that the software has undergone eight iterations to get the estimation of the best logistic function, as shown in the second column related to the estimation of the negative of the logarithm of the maximum likelihood function (-2log-likelihood); its value continues to drop to the value 19.105 after it was 49.893. The same table shows us the ability of the three variables to devaluate (-2LL) to be up to the ideal model where (-2LL) is in its smaller value.

ADJUSTMENT OF THE ACHIEVED MODEL

To confirm the validity of the achieved model, and to know the importance of the operation, it is necessary to do some statistics to test the hypotheses that would judge the significance extent of the proposed model. The results are shown in the following table:

Table number (4): Test of the statistical significance of the achieved model

Tests of the model's specification

		Khi-Chi-square	Ddl	Sig.
Stage 1	Stage	64.073	3	.000
	Bloc	64.073	3	.000
	Model	64.073	3	.000

The table number (4) shows us that the statistical value X^2 is 64.073, and when compared to the tabular value of X^2 with freedom degree of 3, we find that the value of the latter is less than the value that we have got, in addition to the value of significance level that is 0.000, i.e., less than 0.05. Therefore, we can confirm that there is at least one factor is not equal to zero can contribute to discriminate between the group of distressed companies and the other group of non-distressed companies. We can reject the null hypothesis that states that all the logistics function coefficients equal to zero.

To ascertain the extent of the significance of differences existing between the moral the value of -2LL at a certain stage with the value of -2LL in the previous stage, we use the tests described in the following table:

Table number (5): Explanation of the variables entering in the model

Stage	-2log-Likelihood	R-squared of Cox & Snell	R-squared of Nagelkerke
1	19.105[a]	.656	.875

a. Estimation was interrupted at the number of iteration (8) because parameters estimations changed under .001.

Source: SPSS-20 outputs

Determination semi-coefficients, amounted to 0.875 for R-squared of Nagelkerke, to 0.656 for R-squared of Cox & Snell, indicate that the financial ratios involved in the construction of the logistic model contributed by 65% (using the coefficient R-squared of Cox & Snell) and 87% (using the coefficient R-squared of Nagelkerke) in the explanation of distress (dependent variable). Therefore, whenever the values of R coefficients are higher, the quality of the model is better. Thus, we can say that we have obtained a model that has good discriminant ability.

To ensure getting a perfect model to which all variables contribute to the prediction, it is necessary to assess the significance of the estimated coefficients. To do so, we will rely on the Wald test as shown in the following table:

Table number (6): The variables included in the model construction

		B	E.S.	Wald	Ddl	Sig.	Exp(B)
Stage 1	x1	3.525	2.904	4.278	1	.031	33.942
	x2	5.533	2.403	5.300	1	.021	252.784
	x3	6.756	3.067	4.853	1	.028	859.414
	Constant	-2.618-	1.096	5.705	1	.017	.073

The table number (6) shows us that the estimations of the model's parameters are considered the most perfect and they are significant; the significance of all estimations reached values less than the adopted level of significance (0.05) with one degree of freedom. Thus, we can say, that the three variables involved in the construction of the logistic model are important in the explanation of distress of the Algerian economic companies.

For the third column that represents Wald Statistic, it can be noted that all test values are greater than four, meaning that all the significantly estimated coefficients are not equal to zero with probability of 95%. We can also say that all the parameters influence the company's situation.

The exponential function of coefficients in the sixth column indicates the direction of the relationship between the latter and the regression coefficient. If the value of the exponential function coefficient is greater than one, it means that the relationship is positive with the regression coefficient, thus the latter is positive. However, if the value of the exponential function coefficient is less than one, the relationship is negative with the regression coefficient, and the value of this coefficient is, therefore, negative.

Logit coefficients explained that the logarithm odds takes the value one if these coefficients increase or decrease by a certain amount whenever the independent variable increases by one unit. Logit coefficients have economic indications. ; logit coefficient($\widehat{\beta}_2$=3.525) related to sales ratio to total assets indicates that whenever the sales ratio to total assets increases by one degree, the value of the logit coefficient increases by 3.525 when adjusting the other independent variables.

The same thing with regard to the explanation of the ratio involved in the construction of the logistic model: working ration to total assets. Since the value of the logit coefficient of this ratio reached ($\widehat{\beta}_2$=5.533), it means that whenever working capital ratio to total assets increases by one degree, the value of logit coefficient increases by 5.533 with constancy of the other variables.

The same method is used to explain the third ration of the model: equity to total assets in which the value of logit coefficient is ($\widehat{\beta}_2$=6.756). The latter indicates that the increase of equity ratio by one unit will increase logit coefficient by 6.756 with constancy of the other explanatory variables.

Therefore, we can formulate the final logistic model that includes the best variables and most able to explain the distress or non-distress of companies as follows:

$$Log\left(\frac{\hat{p}}{1-\hat{p}}\right) = -2.618 + 3.525X_1 + 5.533X_2 + 6.756X_3$$

X_1: sales ratio to total assets.
X_2: working capital ratio to total assets.
X_3: equity ratio to total assets.

To test the extent of difference between the observed and expected values, we use Hosmer-Lemeshow test used in order to know the extent of success in obtaining a perfect logistic model where differences between the observed and expected values are absent. To achieve this aim, we depend on X^2 statistic. Therefore, its objective is to test the null hypothesis that states that the model is identical with the study's data. The results of this test are shown in the following table:

Table number (7): Hosmer-Lemeshow Test

Stage	Khi-Chi-square	Ddl	Sig.
1	8.375	8	.398

Source: SPSS-20 outputs

Through the table number (7), the value of X^2 is equal to 8.375 with freedom degree 8 and a level of statistical test significance 0.398 that is greater than the adopted level of significance ($\alpha = 0.05$) meaning that the test is not significant, i.e., we accept the null hypothesis that stipulates that the observed variables are equal to the expected ones. Thus, the quality of the achieved model and its great ability to well represent data.

CLASSIFICATION

Classification is one of many ways used to check the quality of the achieved models. To test discriminant ability of the achieved logistic model, we have prepared the following table of classification:

Table number (8): Efficiency of logistic regression model classification

Table of classification [a]

	Observations		Previsions		
			Companies		Correct percentage
			Bankruptcy	Sound	
Stage 1	Companies	Bankruptcy	29	1	96.7
		Sound	1	29	96.7
	Global percentage				96.7

Source: SPSS-20 outputs

The table number (08) shows us that the distressed companies that have been classified sound by mistake is 1, while the number of distressed companies correctly classified is 29. The number of sound companies classified by mistake within distressed companies is 1, while the number of sound companies correctly classified is 29, i.e., the percentage of good classification of distressed companies= $\frac{29}{30}$ 96.7%. The percentage of good classification of sound companies = $\frac{29}{30}$ =96.7%.

The percentage of good classification of the logistic model = $\frac{96.7\,\%+96.7\,\%}{200}$ =96.7 %

RESULTS AND RECOMMENDATIONS

Results

1- Equity ratio to total assets has the greatest impact on the dependent variable (distress). Therefore, it has greater ability to classify the Algerian economic companies.
2- The three variables involved in the construction of the logistic model have a high ability to classify the Algerian economic companies if combined.
3- Depending on the percentage of the good classification (96.7%), it can be said that the achieved logistic model has great ability in the classification of the Algerian economic companies a year before the occurrence of distress.

Recommendations

1- The achieved logistic model can be adopted and relied to predict the distress of the Algerian companies.
2- The accuracy of any model is related to the accuracy of information and data submitted by companies. Therefore, it is necessary to create active supervisory branches in order to verify the validity of the information provided by the source.
3- The proposed logistic model can be modified by adding new explanatory variables that might serve to increase the predictive ability of the model. These modifications are linked to the evolution of situation in the Algerian environment.
4- The need for more attention to the issue of distressed economic companies in Algeria by doing serious researches that add value in this area.
5- Trying to create a database bearing all the quantitative and qualitative information related to all active companies in the Algerian environment in order to facilitate access to this information whose obtaining is almost impossible in most cases.

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