A Neural network and Z-score models` application to manage credit risk in Algeria banks
Case Study of BADR Bank- Saida Agency

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Abstract:
The process of granting bank loans is always accompanied with risks. In fact, there is no process without risks that differ in nature and degree of severity. The aim of this paper is to try to assess the risks related to loans in various developed countries using a statistical approach (credit scoring) and neural network, method has been applied on one of the first class banks in Algeria called BADR (Bank of Agriculture and Rural Development) Bank in Algeria. The example concerns loans given to 52 firms during the period of 2000-2011. The failed firms(bad) were 10 whether the healthy(good) were 42 firms.

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1.Introduction

Risk is inherent in all aspects of a commercial operation, However for all banks and financial institutions, especially most of the banks are interested in providing high quality financial aid which is ''**Credit**'' to their customers to contribute to the growth of gross domestic product of the country without forgetting to take into consideration the relation between the credit and its risk. The Credit risk is: `` the possibility that a borrower of counter party will fail to meet its obligations in accordance with agreed terms.``[1]Elimination of credit risk is impossible as long as credit forms an integral part of the economy. This is why all financial organization should manage the credit risk with reliable methods in such a manner not to be spiral out of control.

There are several methods to measure the credit risk. They are divided in two groups; the first group is the traditional method of making credit decisions that relied mostly on human judgment. The second group are the statistical models that involve qualitative or quantitative methods in order to accept a customer, also to predict the likelihood of defaults among customers who have already been accepted and to

predict the likely amount of debt that the lender can expect to recover. Ideally the bank relies on qualitative methods to decide whether to grant a loan or not. The most well-known and recognized quantitative method is "**credit scoring**" and "**neural network** "subject of this papers.

The aim of this paper is to apply the Z-score model and neural network approach in the Algerian banks to asses credit risks. The focus of this article is on the empirical approach, by finding the proper Algerian banks Z-score model and trying to apply the neural networks trained on real-world data.

The paper is organized as follows. The paper begins by giving an overview on the main principles and characteristics of the Z-score model and neural networks. In section 2 the models are described, developed and tested, 52 companies have been selected as samples and assigned to one of the two groups: a "good" one, which means that the economic and financial situation is good, and a "bad" one, is close to default. Section 3 discusses the experimental settings and the results obtained, The paper concludes with a discussion of advantages and limitations of the solution achieved and the future recommendations.

2. Literature Review

2.1 What is the Credit Scoring?

The term **credit scoring** or **Z-score models** [2] or **Scorecard** [3] can be defined on several conceptual levels fundamentally, credit scoring means applying a statistical model to assign a risk score to a credit application or to an existing credit account. On a higher level, credit scoring also means the process of developing such a statistical model from historical data, the term also refers to monitoring the accuracy of one, or many, such statistical models and monitoring the effect that score-based decisions have on key business-performance indicators.[4]Whilst Loretta Master1997 defined as:" a method of evaluating the credit risk of loan applications Using historical data and statistical techniques, credit scoring tries to isolate the effects of various applicant characteristics on delinquencies and defaults" [3]. So the method produces a "score" that a bank can use to rank its loan applicants or borrowers in terms of risk.

The Credit Scoring History:[5]

When we talk about the history of Z-score model we should review the two models which appear to be particularly significant on this subject.

- **Univariate model**: William Beaver reported his univariate model in october1968.

Univariate model uses a single variable. Such a model would use individual financial ratios to forecast financial failure. The Beaver study classified a firm as failed when any one of the following events accoutred in the 1954-1964 period: bankruptcy, bond default, an overdrawn bank account, or nonpayment of a preferred stock dividend. Beaver paired 79 failed firms with a similar number of successful firms drawn from Moody`s Industrial Manuals. For each failed firm in the sample, a successful one was selected from the same industry. The Beaver study indicated that the following ratios were the best for forecasting financial failure (in the order of their predictive power): cash flow/ total debt net income/ total assets total debt/ total assets.[6]

- **Multivariate model** [7,8]: in 1966 Edward I.Altman developed a multivariate model to predict bankruptcy by select a sample of 66 corporation, 33 of which had filed for bankruptcy in the past 20 years and 33 of which were randomly selected from those that had not. Altman calculated 22 common financial ratio for all 66 corporations, his goal was to choose a small number of those ratio that could best distinguish between bankrupt firm and a healthy one. Finally, after using the multiple discriminate analysis MDA, he reached model uses five financial ratios weighted in order to maximize the predictive power of the model. The model produces an overall discriminate score, called a Z score. The Altman model is as follows:

$$Z= 0.012X_1+ 0.014X_2+ 0.033X_3+0.006X_4+0.010X_5$$

X_1 : Working capital / total assets
X_2: retained earnings / total assets
X_3 : Earnings before interest and taxes /total assets
X_4: Market Value of Equity/ book value of total debt
X_5: Sales/ total assets.

In a later study that covered the period 1970-1973, a Z-score of 2,675 was established as a practical cut-off point, firms that scored below 2,675 are assumed to have characteristics similar to those of past failures.

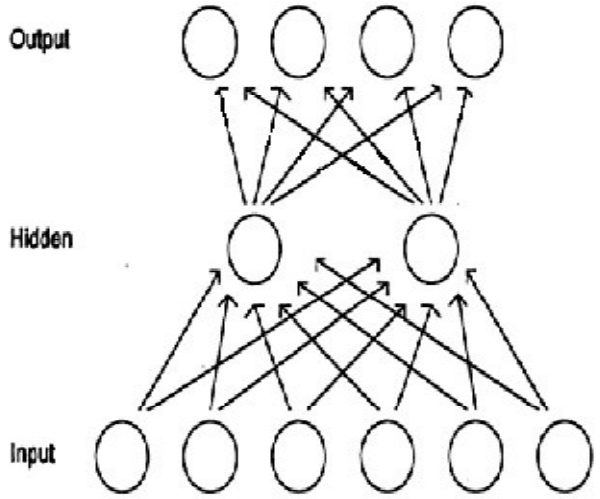
2.2What Z-score Model Can and Cannot Do? [9]

Z-score model cannot predict individual loan loss; rather it predicts the likelihood or odds of a "bad" outcome, as defined by each bank – usually this will be some level of average or total days in arrears at which associated costs make the loans unprofitable. Nor should a credit scoring system alone approve or reject a loan application; rather the underwriter must decide how he or she will incorporate the credit score into the loan review. Finally, credit scoring is not meant to increase approval rates; rather, it promotes consistency and efficiency while maintaining or reducing historic delinquency rates. It also allows the users to focus their attention and time on applications that are not obvious approvals or obvious declines.

2.3What is Neural Network?[10]

A neural network (or an artificial neural network) is an information processing paradigm that is inspired by the way of biological nervous systems, such as the brain to process information. The key element of this paradigm is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements (neurones) working in unison to solve specific problems. Neural networks, like people, learn by examples. That is, neural networks learn by experience, generalize from previous experiences to new ones, and can make decisions. The most common type of neural networks consists of three layers of units as fig 1 show: input layers, hidden layers, and output layers. It is called multilayer perceptron (MLP) McCulloch and Pitts are generally recognized as the designers of the first neural network in 1943 [11]

Fig.1. Tree-layer Network



Source: Timothy Masters, Practical Neural Network Recipies in c++, Academic Press 1993 usa.P44

2.4 Advantages and Disadvantage of Neural Network:[12,13]

Artificial neural networks are most likely to be superior to other methods because of its flexibility it can treat large numbers of problems and give good results can be classified and analysed, also the ability of generalization and adaptation through efficient training make it as likelihood tools comparison with others as statistics and decision three, without forgetting it is easy to obtain especially with the presence of many Assistance programs(SOXON, Neural Consection, Clementine, Intelligentminer, SAS, Uthaught,.....). All this advantages don't prevent some disadvantage like: data encoding and risk to give false results because of the range using is unclose between 0,1, also the size determination where the neural network demands a huge number of examples(as input) which do not always exist.

3. Methods

3.1 Data and Methodology

The major statistical model have been applied in other similar studies multiple discriminate analysis (MDP). In this study also the methods are applied with using SPSS program.

To attain the aims of this paper we choose the sample which consists of 52 firms who take credit from BADR bank during the period 2000-2011. The failed firms were 10 whereas the healthy was 42 firms.

3.2 Z- score Model Application

The variables used to build the regression have two forms Accounting variable (significant financial ratio) and qualitative variable as show in the following table:

Table 01: The Variables Used to Z- score Model Application

	Variables	**Definition of variable**
Accounting Variables	R1	Capital stock / total debt
	R2	Current assets / short term debt
	R3	Working capital / Marketable securities+ net receivable
	R4	Income / income before interest and tax
	R5	income before interest and tax / net receivable
	R6	Net income / capital stock
	R7	working capital requirement / income before interest and tax
	R8	Inventory / costumed inventory
	R9	Accounts receivable / turnover excluding tax
	R10	Cash equivalents / short term debt
	R11	Cash equivalents + marketable securities /short term debt
	R12	Operating expenses / total expenses
	R13	Short term debt / working capital requirement
Qualitative Variables	Statut	1-limited liability company 2-partnerships 3-sole proprietorship
	Sector	1-industry 2-commercial 3-sevice 4-agriculture
	Guaranty	1-personal guarantees 2-real guarantees 3-both
	Age	Age= date of demanding credit – date of firm recognize
	Anc	Seniority= date of demanding credit – date of starting relation with bank
	Credit typ	1-cash credit 2-credit by signature 3-both
	Etat	0- failed firm 1-heathly firm

We build the Z-score model through 3 steps as follow:
Step1: uses the accounting variables only.Step2: uses the qualitative variables only.Step3: uses both types of variables.

Step1: after input all accounting variables and with the help of the SPSS Statistical Package, we find the discriminate point which is R3,from this result the final estimated functions(Z-score model) classifies the samples in to good and bad firms :

Z_1=0.414R3- 0.545

This regression permits to rate all firms that have requested credit. This rate must belong to the determinant range of classification:

If $Z_1 \geq 0.304$ the firm consider as failed(bad) if $Z_1 \leq 0.130$ the firm is healthy(good)

If $0.130 \leq Z_1 \geq 0.304$ dubious firm. in this case we must calculate the separate point between failed and healthy firms let it $Z_1^* = n1^- Z_1^1 + n2^- Z_1^2 / n1+n2$ while:

$^- Z_1^1$: mean discriminate for the healthy firms n1: numbers of healthy firms

$^- Z_1^2$: : mean discriminate for the failed firms n2: numbers of failed firms

After the application of last equation we find **cut-off point Z_1^*=0.146**. now we evaluate results of the finding model Z_1 as show in the customization table.

Table 02: The Results of Z_1 Model

Original set	Customized set		Total
	0	1	
Numbers of failed firms	5	5	10
Numbers of healthy firms	0	42	42
Percentage of failed firms	50%	50%	100%
Percentage of healthy firms	0%	100%	100%

Step2: The same way but with using qualitative variable the discriminate point changes and will be age(age) and Seniority (Anc). So the new model will`:

Z_2=0.241Age+0.487Anc-2.946

The determinant ranges of classification are:

If $Z_2 \geq$ -1.247 the firm is healthy. if $Z_2 \leq$ -1.308the firm consider as failed

If -1.308$\leq Z_2 \geq$ -1.247dubious firm as we do in the step1 we calculated as the same way the **separate point we find it :Z_2*= - 1.256**. Now we evaluate results of the finding model Z_2 as show in the customization table

Table 03: The Results of Z_2 Model

Original set	Customized set		Total
	0	1	
Numbers of failed firms	7	3	10
Numbers of healthy firms	1	41	42
Percentage of failed firms	70%	30%	100%
Percentage of healthy firms	2.40%	97.60%	100%

Step3: now we use all variables (accounting and qualitative) the new model with new discriminate points will be:

Z_3= -0.076R2+3.210R4-2.130R6+0.561R7+0.243Age+0.555Anc-2.67

The determinant ranges of classification are:

If $Z_3 \geq$ -1.212 the firm is healthy. if $Z_3 \leq$ -1.695the firm consider as failed

If -1.212$\leq Z_3 \geq$ -1.695 dubious firms. **the separate point:Z_3*= - 1.286**. Now we evaluate the results of the finding model Z_3 as show in the customization table

Table 04: The Results of Z_3 Model

Original set	Customized set		Total
	0	1	
Numbers of failed firms	8	2	10
Numbers of healthy firms	0	42	42
Percentage of failed firms	80%	20%	100%
Percentage of healthy firms	0%	100%	100%

3.3 Neural Network Application

The program of the neural network was prepared by units of recherch this program works under c^{++} system.

A. **Converting Database**:

Before starting, we must convert our database through confining it between 0-1(the values under 10 was divided by 10, the higher values (more than 10) was divided by 100. negative values were considered by the absolute values).

B. **Creating &Engineering Neural Network**: as we see the most artificial network used is tree-layer network, so we also use it. in our case the numbers of input layers is 19(all variables accounting and qualitative), the numbers of output layer is 01 either 0= failed firm or 1= healthy firm. Finally the numbers of hidden layer is 03.bonding strength between cells is 60(19*3) +3) and numbers of cells is 23(19+3+1).

C. **Training Phase**: in this phase we give free numbers of example from database to the neural network in order to enable knowing the correct class for each record. The algorithm used is propagation algorithm because the phenomenon is non linear and this approved oriented training method.

So training phase pass by the following stages and takes in consideration some factors the numbers of attempts: 100000, the margin of error: 0.003, the numbers of examples input to train: free choice.

1-Input the data of 4 firms, 2-input the output for the last 4firm 3- after the training we find from the program used for each firm their true situation (bad 0.good 1).

We continue this stage until completing all the sample.

D- **Testing Phase**: in this phase, we suppose that we are testing unknowns examples and compare them with the results of training phase to measure the accuracy of the model. But in our case we haven't do this because the sample of training is the same sample of testing (the lack of data).

4. Results & Discussion

After the application of Z-score model we concluded:

From the table 02: as we know previously the sample consist from 42 healthy firms & 10 failed firm. the model Z_1 which is use only the accounting variables find that 42 firm are really healthy (no error) so the rate of classification is 100% , but from 10 firm failed it classified 05 firms as healthy firm with rate of bad classification 50% , the remaining firms were classified true with rate of true(good) classification 50%. Through this, the global rate of classification for the model was 90.4%.

From the table 03: the model Z_2 which use only the qualitative variables find: from 42 healthy firms 41 only were healthy with rate of true classification and that give 97.6%(41/42*100), residual firms were classified as failed firms with rate of error classification 2.40%. for the failed firms the model classified only 7 from 10 as failed firms and the 3 others were classified healthy firms with error rate 30%, while the global rate of classification for the model was 92.3%.

From table 04: the model Z_3 which is mix between the accounting variables and qualitative classified 42 firms as healthy (no error) so the rate of classification is 100% and from 10 failed firms it classified 02 firms as healthy firms with rate of bad classification 20% ,while the global rate of true classification for the model was 96.2%. That's what makes it met for adoption

After the application of neural network, we conclude that the program used enables to training at 100% true answers.

5. Conclusion

Through this paper we have tried to apply modern methods used to manage the credit risks, in spite of the lack of a large data, We have reached a necessity to use the accounting and qualitative variables in the diagnosis of firms. Both the two methods (ZSCORE & NEURAL NETWORK) used in this study are

integrate and aims to discrimination, classification this is why we can't compare mechanically between them. The ability of our Z score model to predict credit risk was successful in 50 of the 52 companies under study with accurately predicted financial distress over 96.2% of the time.

Finally, the uses of these methods in the Algerian banks are implausible As long as there is no policy to encourage the abundance of the old methods.

As future work for improvement in the next times, we recommend to apply factorial analysis to manage credit risk and also maximize the sample by addressing all Algerian banks.

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