The use of the Artificial Intelligence techniques in evaluating the credit risk in the commercial banks –the Artificial Neural Networks model-

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Abstract :

The goal of this paper is to study the possibility of applying the model of Artificial Neural Networks ANN in assessing the credit risk in the commercial banks in general. Therefore, we applied ANN on the data obtained from the Agriculture and Rural Development Bank BADR of Adrar. The study has been conducted on 172 companies (healthy companies and in deficit companies) that got one or more credits from the bank. The sample companies had been chosen at random from a population that included 933 companies.

After the application of ANN, we found out a positive relation between ANN and the credit evaluation. The correct classification rate of the model reached 97.71%. Finally, we recommend, the integration of ANN in banks because it is one of the modern tools that save time and effort and give exact data.

Keywords: AI ; ANN ; credit risk.

JEL Classification Codes : C55, C45,G29.

Introduction:

Banks are among the most important financial companies thanks to their role in supporting the economy and development. The banks aim at making a balance between the deposits and the credits. Due to the increase of the competition between the banks and to the modern developments in the field of banking and credits, the banks must evaluate the risks of credits because knowing the risks and managing them are among the most important factors for the success and profits making.

With the technological development and the development of modern techniques, the traditional tools of credits evaluation are no more valid. Hence, the goal of this study is to use the Artificial Neural Networks ANN model which has a wide interest by experts in

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solving problems in many fields. Based on what has been said, we find ourselves obliged to grapple with a paramount question that is: how do the banks evaluate the risks using ANN? Thus, sub-questions arise such as:

1. What are the risks facing credit granting?
2. What is the owork method of ANN in evaluating the credits?
3. What are the advantages of using ANN in evaluating the credits compared to the traditional tools?

Based on this, we hypothesize that:

1. There is a strong correlation between the prediction, testing, and risks of not paying back the credit.
2. ANN must be integrated in the software of credit evaluation in the banks mainly when the data are big.
3. The use of ANN in the agriculture and Rural Development Bank contributes greatly to the estimation and evaluation of the credit risks.

The importance of the study lies within the fact that the information technology is based on the use of AI in all the fields thanks to its ability to save effort and money with guaranteed exact data. In addition, the topic of the study is new and important for the banks because they deal with any companies that want credits.

To achieve the goals of the study, we relied on the analytical descriptive method in the theoretical section that tackles the AI, the credit risks, and ANNs. In addition, we used SPSS22 to analyze data and Alyuda NeuroIntelligence 22 to design a suitable model for credit risks evaluation.

1. Artificial Intelligence AI:

The concept of AI dates back to the period where the computer had been invented in 1938. The first use of the term “Artificial Intelligence” started from the workshop held by Marvin Minsky and Jhon McCarthy in the project of the Faculty of Dartmouth in 1956. The workshop aimed at finding tools that enable the machine from simulating the aspects of the human intelligence (Allag & Hanan, 2022, p. 709).

1.1. Definition of AI:

This expression is made up of two words that are “intelligence” which denotes the ability to understand and “artificial” which indicates something produced.

Thus, AI is one of the modern computer sciences that appeared lately. It is meant with finding developed styles to make works that require the human intelligence (Lairuere, 1987, p. 02).

In addition, AI refers to the systems and devices that simulate the human intelligence in doing tasks. These systems and devices can improve themselves based on the data they collect (Vrigine Mathivet, 2014, pp. 19-20). Besides, it can be defined as the intelligence shown by the machine and programs in a way that simulates the human mental abilities and the styles of their work such as the ability to learn, deduce, and interact. It is the ability of the machine to simulate the human mind and its ways.

1.2 The function of AI:

According to (Abu Zayd, 2017, pp. 14-15), AI has two types of functions:

1.2.1 The first type:

It is the functions of the intelligent life which means all the tasks that we can make in a regular basis in order to interact and behave in the world. This first type includes:

Seeing and understanding what we see;

the natural language that refers to the ability of the communication with the others through the language;

planning that refers to the ability to plan for a sequence of measures to achieve the target goals;

and the movement which includes acting and working in life to make the life requirements.

The intelligent systems rely on a big number of complex mathematic operations. The input pictures are processed. Then, the selection principle is chosen to choose the selection criteria. Later, they get calculated and compared to those stored in the database. Based on the results of comparison, the result is given.

1.2.2 The second type:

It is about the expert functions which means that AI focuses on the tasks made by the human and that it can be beneficial for the employees who need a comprehensive training because there may be a lack of experts. Examples of the expert systems include: medical diagnosis, devices maintenance, and financial planning.

In this type of systems, the decision is made based on the expertise input to the databases of the systems by expert people; not based on the data available in the 1st type of functions.

1.3 Systems of AI:

According to (Saidi & Fellag, 2021, p. 274), the main AI systems include:

1.3.1 The expert systems:

It is the process of collecting specialized data by human experts through complex accounting systems and putting them in a shape that enables the computer to apply these data on similar problems.

1.3.2 Artificial Neural Networks ANN:

ANNs are defined as systems of data processing in the same way of the human neural network. ANN contributes to finding highly competent solutions in many fields. It includes recognizing pictures, the ability to determine the similar pictures, and completing the pictures that lost parts of them.

1.3.3 The genetic algorithmic systems:

This technique relies on a practical notion of accounted software where the possible solutions compete. In addition, it is used in the financial, banking, and logistic activities, and in managing the movement of the materials.

1.3.4 Fuzzy logic systems:

This includes one of the increasing software of AI in actions. The systems of the fuzzy logic deal with unspecified vague data and the probability with a justification that resemble the human in a way that allows making deductions such as the case of the weather forecast.

1.3.5 The intelligent agent:

It is one of the software of looking for data on the internet or its databases. It works through a set of software that make specific tasks or duties that have a recurrent or forecasting nature. The electronic administration uses this system to answer the messages of the customers, meet their demands, and listen to their views about the quality of the services.

1.3.6. The robotics:

Robots are among the flexible mechanic devices that have the ability to take and transfer materials. They make tasks that are dangerous for humans and are characterized with exactness, speed, and force.

1.3.6 Natural languages processing:

It is a branch of AI that intervenes with linguistics and provides the necessary linguistic description for the computer. It is used in many fields like the automatic reading of texts, creating texts, automatic speech, translation, and proofreading of texts.

2. The definition of ANN:

It is among the most important types of AI that can be defined as a system designed to simulate the way the human mind makes specific tasks. ANN is a giant processor made of processing units called neurons (Naji & Kadhem, 2016, p.10). It addition, it can be defined as systems of data procession with a structural system that resembles the natural neural networks. It includes many simple units called neural cells. Each neural cell has an external function called neuron (Abdul Monim & Ghaleb, 2007, p. 12).

From the two previous definitions, we can say that ANN is a sophisticated statistical system that analyzes and processes data in a way that simulates the human neural net.

2.2 The characteristics of ANN:

According to (Bennour & Nayt Merzouq, 2019, p. 72), it is characterized with:

- The ability to derive meaning from complex and non-complex data.
- The ability to learn how to make tasks relying on data through training and testing.
- Working to create a special system that is characterized with the optimal representation of the data.
- The execution of calculations in a parallel manner.

3. Risks of bank credits:

The nature of the bank activity and diversity of its services make it subject to many risks related directly or indirectly to its activities.

3.1 Definitions of bank risks:

Economists and researches gave many definitions to this concept. (Vaughan, 1997, p.20) defines risks as the possibility of a deviation in the future that makes the target goals change. In addition (, Bessis, 1998, p.05) believes that risks are the undesirable effects resulting from many factors of uncertainty. In addition, he sees that measuring the risk requires shedding light on the undesirable effect. From these definitions, we can deduce that

the risk is always linked to the future uncertainty i.e. the possibility of a change that affects the profitability and has future effects.

3.2 The types of the banking risks:

They can be divided into:

- Risks related to the environment.
- Risks related to the activity of the bank.

3.2.1 Risks related to the environment:

They include many types of risks such as:

3.2.1.1 Liquidity risks:

Liquidity is among the most important elements of the bank. Settlement and revenues are two opposing factors in the activity of the bank. The excessive investment to achieve big revenues negatively affects the size of the financial liquidity. On the other hand, maintaining a high liquidity (reservation principle) fearing the deficit in liquidity deprives the bank from investment chances and from making possible revenues (Sylvie, 2005, p.107).

3.2.1.2 Risks of the actions:

They refer to the risks related to the daily work that the bank bears due to the mistakes in the execution of the actions such as embezzlement, fraud, money forgery, theft, and electronic crimes (Jayaram, 2007, pp. 12-13).

3.2.1.2 Credit risks:

The credit risks are linked to the credits and the account statement. They are the result of the debtor's inability to pay back the debt in due time or when the bank opens a letter of credit to import goods instead of the customer who is not able to pay for the goods when they arrive (Assarfi, 2007, p. 66).

4. Data collection and database making:

In order to carry out the study, we must have data and information that are the basis to make the database of the study model. The study model building goes through many phases that are:

4.1 Determination of the study population:

In order to carry out this study, we had to choose a big population so that we can choose the suitable sample. Hence, we targeted a set of private companies that borrowed from BADR of Adrar. These companies have been divided into:

4.1.1 Healthy companies:

They paid their debts in due time without any difficulties.

4.1.2 Companies in deficit:

They did not pay back the debts wholly or partially in due time.

5. Sample of the study:

Choosing the sample is important because it must represent the population of the study very well. Thus, we chose two random samples after dividing the study population namely: the healthy companies and the in deficit ones. The size of the sample had been determined at significance level 0.05. We relied on the statistical method through using Stephen Thompson equation in calculating the size of the sample according to the following equation:

$$\frac{N * P(1-P)}{\left[[N-1*(d^2 \div z^2)]+p(1-p)\right]}$$

Where N is the size of the population;

N: is the size of the sample;

d :is the error rate and equals 0.05;

P: is the rate of the availability of the specificity and neutrality and equals 0.50;

Z: is the standard degree corresponding to the significance level 0.95 and equals 1.96.

Because the size of the population is known and equals N=933, by substitution in the previous equation we find that:

$$n=\frac{933*0.50(1-0.50)}{\left[[933-1*(0.05^2 \div 1.96^2)]+0.50(1-0.50)\right]}$$

Thus,

Hence, **n=172**

The following table shows the distribution of the population according to the classification previously mentioned:

Table 01: the distribution of the study population

Class	**Size of the sample**	**Rate**
Healthy companies	541	57%
In deficit companies	392	43%
total	933	100%

Source: prepared by the authors

6. Study of the nature of the variables:

We relied on two variables that are the accounting and the extra-accounting.

6.1 The accounting variables:

They are metric variables that have digital values that represent the relation between two variables linked by a common characteristic and extracted from the accounting data of the financial lists (the financial budget and the table of the results calculations) of the companies under study. These variables are summed up in the following table and include the values of the financial rates that have been calculated with special accounting software of the bank.

Table 02: the accounting variables

Variable	**Name**
X_1	Rate of the independency= the private funds/ sum of the debts
X_2	Rate of the self funding= private funds/ fixed assets
X_3	Rate of the general liquidity= the traded assets/ short term credits
X_4	The rate of the payability= the sum of the assets/the sum of the debts
X_5	The rate of the trade= the traded assets/ the traded liabilities
X_6	The rate of the financial revenues= the total result/ the private funds
X_7	The rate of the commercial revenues = the total result/ the turnover
X_8	The rate of the total revenues = the turnover/ the sum of the assets

Source: prepared by the authors relying on the data of the bank

6.2 Extra-accounting variables:

They are variables with a qualitative nature that represent data extracted from the files of the credit applicants. With the scale of Deckart, we turned them into digital symbols in a way that allows using them in the study. They are classified as shown in the following table:

Table 03: the extra-accounting variables

Variable	Name	Designation
X_9	Age of the company= date of application for the credit – date of getting the credit	1- less than 5 years, 2- from 5 to 10 years 3- from 10 to 15 years, 4- more than 15 years
X_{10}	Type of the guarantee provided	1- material, 2- moral, 3- material + moral
X_{11}	The sector of the company's activity	1- industry, 2- agriculture, 3- services 4- entrepreneurship, 5- others
X_{12}	The legal shape of the company	1- SARL , 2-EURL, 3- SNC , 4- others
X13	Type of the funding demanded	1- self funding, 2- dual funding, 3- composite funding
X	The situation of the company	0- in deficit, 2- healthy

Source: prepared by the authors relying on Deckart scale

7. Data taxonomy:

After collecting the data obtained from the accounting software of the bank related to the provided credits, we made taxonomy of data that contains 12 columns that represent the accounting and extra-accounting variables and 200 lines that represent the companies that got credits.

Figure 01: The data taxonomy

X1……..…X12	Variables companies
	E1 ……. E200

Source: prepared by the authors

7.1 **Sampling:**

We divided the main sample into two models. The first shall be used to create the model while the second to measure its performance.

8. The statistical analysis of the study variables:

Through the database that we made, we can collect the risks of the credit provided to the company based on the qualitative variables.

8.1 The study of the risks based on the age of the company:

We analyze the risk based on the age of the company that can be calculated from the data of its establishment till the date of getting the credit. The following table shows that:

Table 04: The distribution of the companies according to the age

Companies	**Age**				**Total**
	Less than 05 years	**From 05 to 10 years**	**From 10 to 15 years**	**More than 15 years**	
In deficit	12	12	12	12	34
Healthy	65	65	65	65	138
Total	77	77	77	77	172

Source: prepared by the authors relying on the data of the bank

From the table above, we see that the companies that got credits are those whose ages are less than 05 years with a rate of 47%, those whose ages are between 05 to 10 years with 34%, those whose age are between 10 to 15 years with 10%, then those whose ages are more than 15 years with a rate of 9%.

In addition, we notice that the biggest rate has been by the in deficit companies whose ages are between 10 to 15 years with 41%, those whose ages are less than 5 years with 35%, then those whose ages are more than 10 years (i.e. the two remaining categories) with 23%. This indicates that the shorter the age of the company is, the higher the risk of not paying the debt is.

From the analysis of the above table, we find that the risk of not paying the debt is high for the young companies. To confirm this analysis, we conducted Chi-square test and studied the independency between the risk and the age of the company through the following hypotheses:

H_0: there is no relation between the risk of not paying the debt by the company and its age;

H_1: there is a relation between the risk of not paying the debt by the company and its age.

Table 05: Chi-square test for the age of the company

	Value	**ddl**	**Asymp-sig(2-sided)**
Reason Chi-square	**1.754[a]**	**3**	**0.625**
linear Association	**0.851**	**1**	**0.356**

Source: prepared by the authors relying on the outputs of SPSS 23

According to Chi-square test, we compare P-value to the significance level $\propto$ that equals 0.05. If P-value>$\propto$, we refuse the null hypothesis and accept the alternative, and vice versa.

From table 05, we see that P-value 0.625 is higher than $\propto$ 0.05 and, thus, we accept the null hypothesis and refuse the alternative, i.e., there is no relation between the risk of not paying the debt by the company and its age.

8.2 Study of the risks based on the economic activity of the company:

We can analyse the risk according to the activity of the company. The following table shows that:

Table 06: Distribution of the companies according to their activity

Companies	**Activity**					**Total**
	Industry	**Agriculture**	**Trade**	**Services**	**others**	
In deficit	7	10	5	6	6	34
Healthy	97	29	0	9	3	138
Total	104	39	5	15	9	172

Source: prepared by the authors relying on the data provided by the bank

From the table above, we notice that the agricultural and industrial companies are the most that got credits from BADR in Adrar because it is the first bank that supports the agricultural companies from one side, and from another side, we can say that the bank works to implement the state's policy of encouraging investment in agriculture and industry contrary to the other activities that have less interest by the bank and that are part of the projects funded by ANED, ANEM, and CNAC. Therefore, we can say that there is a relation between the activity of the company and paying back the debt because the bank

supports the agricultural projects in first place, and then come the other activities as we shall confirm with Chi-square test. From analyzing the above table, we can study the effect of the activity of the company on the possibility of paying the debts. We used Chi-square test to study this effect through the following hypotheses:

H_0: there is no relation between the risk of not paying the debt by the company and its activity,

H_1: there is a relation between the risk of not paying the debt by the company and its activity.

Table 07: Chi-square test for the activity of the company

	Value	**ddl**	**Asymp-sig(2-sided)**
Reason Chi-square	**48.640[a]**	**4**	**0.000**
linear Association	**34.458**	**1**	**0.000**

Source: prepared by the authors relying on the outputs of SPSS 23

From table 07, we see that P-value is less than $\propto$ 0.05. Thus, we refuse the null hypothesis and accept the alternative which says:

There is a relation between the risk of not paying the debt by the company and its activity.

8.3 Study of the risks based on the guarantees provided by the companies

We can analyze the risks based on the guarantees provided by the company as shown in table 08:

Table 08: the distribution of the companies according to the guarantees provided

Companies	**Guarantee provided**			**Total**
	Material	**Moral**	**mixed**	
In deficit	29	5	0	**34**
Healthy	126	12	0	**138**
Total	**155**	**17**	**0**	**172**

Source: prepared by the authors relying on the outputs of SPSS 23

From the table and figure above, we see that most of the guarantees provided to the bank are material as is the case in 155 companies, i.e. 90%. On the other hand, 17% of the companies provided moral guarantees, i.e. 17%, while 00 companies provided mixed

guarantees. Consequently, we infer that the in deficit companies are among those that provided material guarantees (29 companies with a rate of 19%).

From the analysis of the table above, we can study the effect of the guarantees of the companies on the possibility of paying back the debts. We used Chi-square test to study this effect through the following hypotheses:

H_0: there is no relation between the risk of not paying the debt by the company and the guarantees provided to the bank.

H_1: there is a relation between the risk of not paying the debt by the company and the guarantees provided to the bank.

Table 09: Chi-square test for the activity of the company

	Value	**ddl**	**Asymp-sig(2-sided)**
Reason Chi-square	**1.106[a]**	**1**	**0.293**
linear Association	**34.1.011**	**1**	**0.315**

Source: prepared by the authors relying on the outputs of SPSS 23

From table 07, we see that P-value is more than $\propto$ 0.05. Thus, we accept the null hypothesis and refuse the alternative which says:

There is a relation between the risk of not paying the debt by the company and the guarantees provided to the bank**.**

8.4 Study of the risks based on the legal shape of the company:

We can analyse the risk according to the legal shape of the company. The following table shows that:

Table 10: Distribution of the companies according to their legal shapes

Companies	**Legal shape**				**Total**
	SARL	**EURL**	**SNC**	**Others**	
In deficit	5	1	2	26	**34**
Healthy	10	12	2	114	**138**
Total	**15**	**13**	**4**	**140**	**172**

Source: prepared by the authors relying on the outputs of SPSS 23

From the table above, we see that most of the companies are individual companies that are classified as "others" in the table with 140 companies with a rate of 81%. 114 of them paid their debts in due time.

From the analysis of the table above, we can study the effect of the legal shapes of the companies on the possibility of paying back the debts. We used Chi-square test to study this effect through the following hypotheses:

H_0: there is no relation between the risk of not paying the debt by the company and its legal shape.

H_1: there is a relation between the risk of not paying the debt by the company and its legal shape.

Table 11: Chi-square test for the legal shape of the company

	Value	**ddl**	**Asymp-sig(2-sided)**
Reason Chi-square	**5.367[a]**	**3**	**0.147**
linear Association	**0.690**	**1**	**0.406**

Source: prepared by the authors relying on the outputs of SPSS 23

From table 11, we see that P-value is more than $\propto 0.05$. Thus, we accept the null hypothesis and refuse the alternative, meaning that:

There is no relation between the risk of not paying the debt by the company and its legal shape.

8.5 Study of the risks based on the type of funding demanded:

We can analyse the risk according to the type of funding demanded. The following table shows that:

Table 12: Distribution of the companies according to the type of funding demanded

Companies	**Legal shape**			**Total**
	Auto-funding	**Bilateral funding**	**composite**	
In deficit	1	6	27	**34**
Healthy	5	20	113	**138**
Total	**6**	**26**	**140**	**172**

Source: prepared by the authors relying on the outputs of SPSS 23

From the table above, we see that 114 (81%) companies have a composite funding. Thus, we notice that 113 (80.7%) companies managed to pay their debts in due time.

From the analysis of the table above, we can study the effect the type of funding demanded on the possibility of paying back the debts. We used Chi-square test to study this effect through the following hypotheses:

H_0: there is no relation between the risk of not paying the debt by the company and the type of funding demanded.

H_1: there is a relation between the risk of not paying the debt by the company and the type of funding demanded.

Table 13: Chi-square test for the type of funding demanded

	Value	**ddl**	**Asymp-sig(2-sided)**
Reason Chi-square	**0.236[a]**	**2**	**0.889**
linear Association	**0.036**	**1**	**0.850**

Source: prepared by the authors relying on the outputs of SPSS 23

From table 13, we see that P-value is more than $\propto$ 0.05. Thus, we accept the null hypothesis and refuse the alternative, meaning that:

There is no relation between the risk of not paying the debt by the company and the type of funding demanded.

9. Statistical analytical study of the variables:

In this phase, we calculate the arithmetic means and the standard deviation of the variables for the healthy and in deficit companies. We suppose that we have two independent groups:

G_0: the in deficit companies;

G_1: the healthy companies.

Table 14: the arithmetic means and standard deviations of the study variables according to the situation of the company

Variables	Arithmetic means		Standard deviations	
	Healthy	**In-deficit**	**Healthy**	**In-deficit**
X1	1.38	1.28	1.126	0.907
X2	1.31	1.48	1.041	1.021
X3	0.81	1	0.707	0.883
X4	1.35	1.20	1.148	0.889
X5	1.05	0.95	0.727	0.766
X6	1.06	1.17	0.794	0.965
X7	1.24	1.04	0.873	0.944
X8	2.92	2.35	3.679	3.1
X9	1.97	1.80	0.937	0.943
X10	1.15	1.09	0.359	0.283
X11	2.82	1.49	1.424	0.953
X12	3.44	3.59	1.106	0.925
X13	2.76	2.78	0.496	0.494

Source: prepared by the authors relying on the outputs of SPSS 23

In order to know the relation between the groups, we used the Equality of Group Means test through which we study G_0 and G_1. Hence, we make the following hypotheses:

$$\begin{cases} H0: \mu 0 \neq \mu 1 \\ H1: \mu 0 = \mu 1 \end{cases}$$

Where: $\mu 0$ is the mean of the variables in the in-deficit companies;

$\mu 1$: is the mean of the variables in the healthy companies.

Based on the Equality of Group Means test, we extract the value of SIG from the table presented in appendix 04 and compare it with the trust level α where if α < sig, we accept the null hypothesis and refuse the alternative, and vice versa.

We notice from the table presented in appendix 04 that the value of sig for the 1st variable α < X1, 0.05 < 0.608, i.e. we accept the null hypothesis which means the means of the two

groups are not equal. We compare the other variables and sum up the result in the following table:

Table 14: the results of the means test

Variables	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
Results of the test	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$	$\mu 0 \neq \mu 1$

Source: prepared by the authors relying on the outputs of SPSS 23

10. Building the model of ANN to estimate the bank credits:

The technique of ANN depends on the quality and quantity of the data used in the process of input. Finding a high quality model depends on the quality and exactness of the statistical data. To design a good model, we must use a bigger sample of more than 100 views. To apply this technique, there are many types of software that help in designing a good model. Thus, we chose Alyuda NeuroIntelligence 22 as shown in appendix 5 because it is the most suitable for the study. To design the model, we must divide the statistical study into phases as such:

10.1 Data input:

The 1st step for designing an ANN model is putting in the data of the companies that got credits from BADR of Adrar. These data are in a database made by Excel and shall be transformed to Alyuda 22 software.

10.2 Division of the sample:

The 2nd step is dividing the data into three groups to train the network. The distribution is in a random way as shown in the following table:

Table 15: The groups of neural networks software

Group	**Size of the sample (views)**	**Rate %**
Training group	118	68
Confirmation group	27	16
Test group	27	16
Total	**172**	**100**

Source: prepared by the authors relying Alyuda NeuroIntelligence22

10.3 Data processing:

To represent the data in the neural network, the software transforms the variables into a standard normal distribution either in a binary way (0.1) or bipolar (1, -1). The 2nd representation is the best.

Table 16: results of data processing

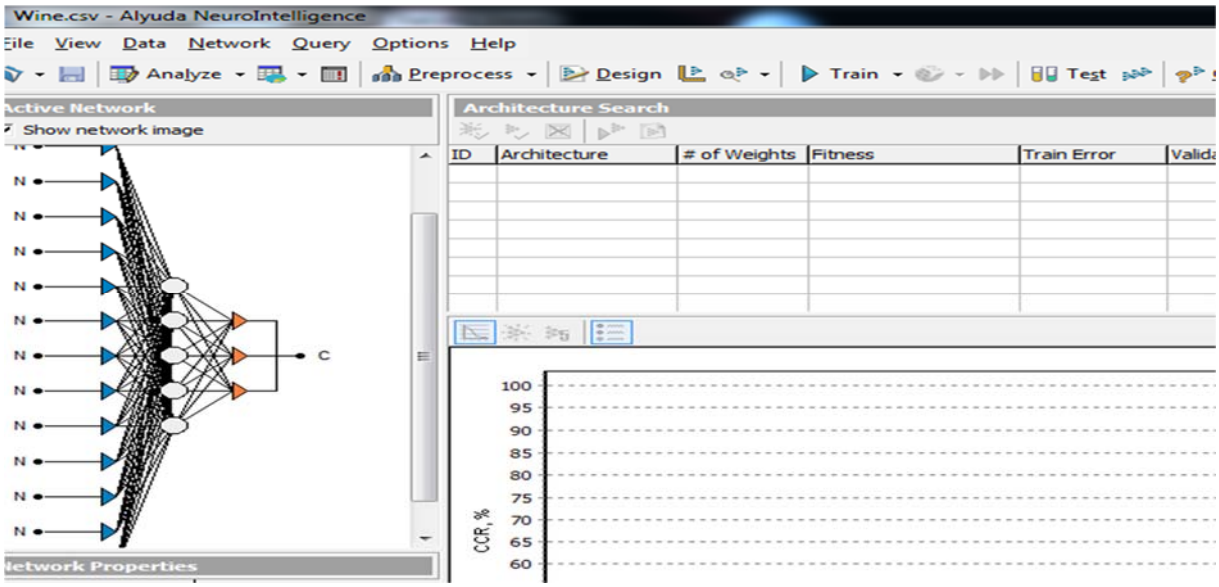
Parameter	**Value**
Column type	**I,put**
Format	**Numerical**
Scaling range	**(1-,1)**
Encoded into	**1 columns**
Min	**11.03**
Max	**14.83**
Mean	**13.009186**
Std. deviation	**0.817968**
Scaling factor	**0.526316**

Source: prepared by the authors relying Alyuda NeuroIntelligence22

10.4 Determining the study engineering:

Through Alyuda NeuroIntelligence22, the neural network had been engineered in the form of multilayer network that has a feedforward in a way that the information moves in one direction as shown in the following figure:

Figure 06: The engineering of the neural network



Source: prepared by the authors based on the outputs of Alyuda NeuroIntelligence22

10.5 The training phase:

It is the longest phase in the process of designing a neural network. The following table shows the characteristics of the final training process.

Table 17: the characteristics of the final training process

Characteristics		
/	training	validation
CCR %	98.347107	96.296296
Network error	0.095675	0
Error improvement	0	
Iteration	501	
Training speed. Iter/sec	227.727243	
Architecture	[13-6-3]	
Training algorithm	Batch back propagation	
Training stop reason	All iterations done	

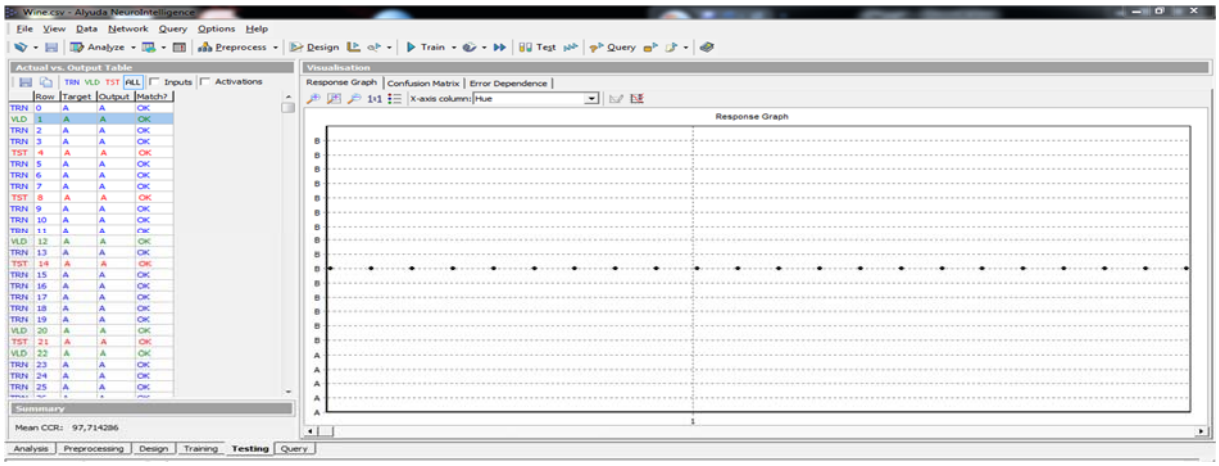
Source: prepared by the authors based on the outputs of Alyuda NeuroIntelligence22

Table 17 shows that during the training phase, ANN method achieved good results because the model managed to train on the suggested examples with 98% and an error rate of 0.095675. Since the error rate is too small, this indicates the quality of the model. Moreover, we notice that the final frequency was in frequency 501, i.e., the network had been trained to learn the network and achieve the lowest value of error rate after 501 trials.

10.6 The test phase:

After ending the training phase, ANN model had been installed to test its discriminating ability through applying it on the examples of the evidence sample to make sure of the achieved weights. Through the below figure, we notice that ANN model confirmed in the end its ability of discriminating the two types of companies; the correct classification rate was 97.71%.

Table 07: Results of the test phase



Source: prepared by the authors based on the outputs of Alyuda NeuroIntelligence22

11. Test and comparison of the results:

After analyzing and comparing the results, we must calculate the rate of the correct classification of the way followed by BADR.

The rate of the correct classification of the bank= (the number of the healthy companies X 100)/ the number of the total companies)

The rate of the correct classification of the bank=$\frac{138\times100}{172}$ = 80.23%.

Table 18: The results of the comparison

The rate of the correct classification of ANN model	97.71%
The rate of classification BADR	80.23%
The difference between the rates of classification	17.48%
Result of the comparison	+

Source: prepared by the authors

12. Conclusion:

Upon this study, we conclude that:

1. ANN is among the best ways that help the bank manage the decision of granting credits because it tests and trains the data many times with the least errors.
2. Testing and forecasting help set the potentials related to the risks of not paying back the debts through a statistical technique. This confirms the 1st hypothesis.
3. ANN techniques must be put in the software of evaluating the credit applications in the bank, mainly when the data are big.
4. The model obtained from the ANN is very good and expresses the real situation of the bank because it gave an exact and good classification rate according to the model and that is almost close to the classification rate used by the bank. This confirms the 2nd hypothesis.

Based on what has been said, we recommend:

1. Generalizing the use of AI models and styles in the financial companies and financial markets.
2. Raising full awareness of the employees about the importance of the neural networks and the privileges they provide such as time saving and the exactness of the information.
3. The necessity of using the styles of AI such as genetic algorithms thanks to their big importance in drawing the policy of the administration.

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