Neutrosophic Sets and Systems

Volume 43 Article 3

6-8-2021

Comparative Mathematical Model for Predicting of Financial Loans Default using Altman Z-Score and Neutrosophic AHP Methods

Noha AlQorany Ibrahem

Haitham Elghareeb

Farahat Farag Faraha

Ahmed AboElfotouh

Neutrosophic Sets and Systems, Vol. 43, 2021
University of New Mexico

Comparative Mathematical Model for Predicting of Financial Loans Default using Altman Z-Score and Neutrosophic AHP Methods

Noha AlQorany Ibrahem[1], Haitham Elghareeb[2], Farahat Farag Farahat[3] and Ahmed AboElfotouh[4]

1,3 Information System Department, Sadat Academy for Administration Science, Egypt
noha.hassan2020@sadatacademy.edu.eg1 , Farahat.Farag@sadatacademy.edu.eg3

2,4 faculty of computers and information sciences, Mansoura University, Egypt
helghareeb@mans.edu.eg2, elfetouh@mans.edu.eg4

Abstract: The current system in the bank depends only on the client's failure to pay monthly installments for three consecutive months to start moving and take the necessary actions towards the client. This routine system is the basic reason of happening the problem of loans default. In this paper the researcher presents a comparative mathematical model to predict the default of clients, as well as to devise a modern parallel model to measure the degree of credit risk criteria that guides the bank in the following-up of the client. Altman model is one of the famous methods for default prediction, formula is used to predict the probability of loan default by using Z-scores. The Z-score is a linear combination of five coefficient-weighted common financial criteria. The researcher applies the Neutrosophic Analytical Hierarchy Process (NAHP) model on the same five common financial criteria which the bank can using them to provide constant following-up of the uses of the granted loan to guarantee that all terms set by the bank are met. The information was gathered in the form of neutrosophic data sets and evaluated using a novel Neutrosophic Analytic Hierarchy Process (NAHP) model. The researcher applies the proposed model in the credit department of one of the private Egyptian Banks (QNB) choosing random samples of real clients.

Keywords: Credit Risk, Loans Default, Altman Model, AHP Model, Neutrosophic AHP, Decision Making.

1. Introduction

Credit managers in Egyptian banks are grappling with the issue of bad loans. Banks' exposure to real credit problems would erode trust in the banking sector, because the consequences of such problems do not affect only the distressed banks, but also the rest of the banking sector in the country and the economy as a whole.

The subject of forecasting loan defaults is one of the issues that researchers and bank executives are most interested in since it is critical in minimizing default and its negative consequences for banks, borrowers, and the overall economy. According to credit rating agencies such as Moods Institution and others, the issue of defaulting loans has a major impact on the state's credit indicators globally.**[1]**

The issue varies from one country to another, and even within a single country, from one bank to another. The issue changes from time to time, both within the bank and through the banking sector as a whole. Bank credit is typically governed by policies and guidelines aimed at minimizing potential credit risk, but no bank can achieve zero credit risk in practice because bank credit is often followed by loans risks. The first of these risks comes from the fact that the credit is based on the borrower's or project's financial statements, which are not completely covered since they will be collected in the future.

Even though banks perform studies before issuing loans in compliance with the correct rules and basics, the risk of the borrower defaulting and his failure to pay remains uncertain, even because of the probability of incidents or consequences that prevent the borrower from committing to his obligations to the bank; if this possibility is met, the bank's financial rights become in a dangerous situation. The model compares the results of the two approaches (Altman Model and NAHP Model) and calculates the weight of each sub-criteria.

The Altman Model and the Neutrosophic Analytical Hierarchy Process Model are compared in this study, these models are compatible with bank's system because they are working on the factors which the bank used to evaluate the clients. This research contributes to highlighting the Neutrosophic set's accuracy in decision-making. It also underlines the need of using multi-criteria (criteria and factors) in decision-making models, particularly in information systems with numerous factors for a single aspect.[2]. The details of Altman Model is introduced in section 2, section 3 and 4 is explaining all rules of NAHP model, the result of the model case study is discussed in section 5 and 6.

Literature Review

Kulalı applied the Altman Z-Score model on financial data to 19 companies which suffered from bankrupt when trading in the BIST in the years between 2000-2013. When applying the Altman Z-Score model to predict the financial failure of these companies, the result of financial failure was estimated by 95% one year 90% two years earlier. This presented the success of the Altman Z-Score model in predicting the financial failure. [3]

Bağcı presented a study of Altman Model to measure the financial situation of the firms in textile industry to understand the situation of these firms to can face a possible economic crisis. He used the financial data of 24 companies in the textile industry area traded on BIST between 2008-2013, the financial situation of firms was examined by employing Altman Z-Score model. Z-scores were calculated by using the financial ratios of the textile industry. According to the observed results, suggestive Z-Scores between 2008-2013 were 0.63, 0.57, 0.60, 0.62, 0.63, 0.67 respectively which showed that the industry was exposed to high risk in terms of financial failure. [4]

Mişu and et al measured the integration of Analytic Hierarchy Process (AHP) into Delphi framework in neutrosophic environment. They presented a new technique of NAHP for checking consistency and calculating consensus degree of expert's opinions. They used neutrosophic technique to overcome the confusion of experts in evaluating the available alternatives due to the multiplicity of criteria associated with those alternatives. they found that the effectiveness of the AHP can be increased by adding Delphi technology with neutrosophic theory to reduce noise resulting from individual concerns instead of focusing on solving the problem, and increasing the degree of agreements around the standards presented.[5]

Fernando and et al proposed a methodological framework design to modify trade-offs between evaluation criteria to provide decision makers with more clear mortgage risk evaluation system**.** The result of this study showed that the AHP approach has the potential to increase the existing credit scoring systems of Portuguese banking firms. Also AHP can be used to assist banking institutions in managing new evaluation criteria feature and holding type.[6]

Kaygisiz Ertuğ and Girginer presented a research to develop an evaluation integrated model to consider the quantitative and qualitative criteria for the selected firms that demanded commercial loans for both public and private banks**.** The researchers combined the AHP model and Grey Relational Analysis (GRA) into a one evaluation model**.** The results appeared that, whereas firm honesty and reports criteria are the main criteria with the highest priority, sale and marketing constructions are the main criteria with the lowest priorities for both public and private banks.[7]

After reviewing a number of previous researches in the same field that were chosen in the research, the researcher deducts that the NAHP model have been used in a specific problems of credit risks introduced by the banks. This paper provides all types of loans which the bank is offering to the clients especially medium and long-term loans, which are always the cause of a client's financial failure due to the length of the period of repayment for the loan by following up the client using the weight of credit financial indicators which are presented in the client's financial statements in the beginning of applying the loan.

2. Altman Model

Altman was one of the first researches where developed financial forecasting models. He used 33 financial ratios and examined each ratio separately. He then used the method of statistical analysis and limited his model to the five most important financial ratios: [8]

X_1 = Working Capital / Total Assets

X_2 = Retained Earnings / Total Assets

X_3 = Profit before interest and tax / Total Assets

X_4 = Market value of Equity / Total Liabilities

X_5 = Total Sales / Total Assets

He then assigned a relative weight to each element of the model, different from each other, and each ratio has its own value according to its relative importance in the model. [8]

He Used (1.2) Factor For the ratio of X_1, (1.4) Factor For the ratio of X_2, (3.3) Factor For the ratio of X_3, (0.6) Factor For the ratio of X_4 and (1.0) Factor For the ratio of X_5.
The final form of the model equation became as follows:

$$Z = 1.2 * X_1 + 1.4 * X_2 + 3.3 * X_3 + 0.6 * X_4 + 1.0 * X_5$$

Altman classified customers according to Z score as follows:

1- Green zone if $Z \leq 1.8$, which means the client is excellent and pays all his installments in their due dates.

2- Yellow Zone $2.9 > Z > 1.8$, which means the client is good although he can't pay few installments in some months but do his best to do that.

3- Red Zone $Z > 2.9$, which means the client is in a danger because he stopped to pay the installments and the bank must take an action with him. [8]

In this paper the researcher develops a new Neutrosophic AHP model to discover the client fraud by using credit risk criteria, and derive a new sub-criteria in studying the cases of clients to facilitate the function of the credit officer in detecting the manipulation of the client in the financial statements before starting to take the scheduling procedures. This procedures are vary from bank to bank and from one client to another according to credit officer evaluation.

This model aims to study and follow the position of the client from the day he got the loan till the final installment is paid. The researcher applies the Neutrosophic AHP model on the clients to can predict if they will complete the all installments to pay off the entire loans in there due dates or not. The result will compare with Altman classifying model to can judge if the model is working well or not.

3. Basic definitions of Single Value Neutrosophic Number

Neutrosophic theory is a better choice to emulate the human thinking which has the capability to handle the indeterminacy. The decision-making process still keeps to rely not only on true values, but also on false ones as well as on indeterminacy membership. Thus neutrosophic logic makes the chance to emulate the human thinking and deal with the problems which have the probability of true, false and indeterminacy at the same time, to can be applied in the real world problems. [9]

A neutrosophic set <T, I, F> is composed of three parameters which are a degree of truth (T), a degree of indeterminacy (I), and a degree of falsity (F), where T, I, and F $\in$ [0,1].

Assume that X be the space of the objects, and x $\in$ X. A neutrosophic set A in X is defined by three functions: truthfulness-membership function TA(x), an indeterminacy-membership function IA(x) and falsehood-membership function FA(x).

Definition 1: Assume that $N_1 = (T_1, I_1, F_1)$ AND $N_2 = (T_2, I_2, F_2)$ are two single value neutrosophic numbers, Then, their operations are defined as follows [10]

$$N_1 + N_2 = (T_1 + T_2 - T_1T_2, I_1I_2, F_1F_2) \tag{1}$$

$$N_1 \times N_2 = (T_1T_2, I_1 + I_2 - I_1I_2, F_1 + F_2 - F_1F_2) \tag{2}$$

$$N_2 \,/\, N_1 = (T_2/T_1, I_2 - I_1/1 - I_1, F_2 - F_1/1 - F_1) \tag{3}$$

Definition 2: Assume that $N_1 = (T_1, I_1, F_1)$ is a single value neutrosophic number and A is an arbitrary positive real number, Then, their operations are defined as follows [10]

$$A \times N_1 = \left(1 - (1 - T_1)^A, {I_1}^A, {F_1}^A\right), A > 0 \tag{4}$$

$$N_1/A = \left(1 - (1 - T_1)^{\frac{1}{A}}, {I_1}^{\frac{1}{A}}, {F_1}^{\frac{1}{A}}\right), A > 0 \tag{5}$$

Definition 3: Assume that $N_1 = (T_1, I_1, F_1)$is a single value neutrosophic number, then its score function is defined as $S(N_1)$ as follows: [10]

$$S(N_1) = (3 + T_1 - 2I_1 - F_1)/4 \quad (6)$$

4. Neutrosophic Analytical Hierarchy Process

AHP which developed in the 1970s by Thomas Saaty is a decision-making method which has been designed in a structured form to analyze complex decisions. It works by dividing a problem into a hierarchy of criteria and sub-criteria which can be analyzed independently. This hierarchy chart is containing the decision goal, the alternatives for reaching it, and the criteria for evaluating the alternatives. [12]

AHP is a mathematical tool of problem solving that has been created after understanding the structure of a problem and the real limitation that managers face while solving it. .

The following phases are the procedure of the neutrosophic analytic hierarchy process:

1- The proposed NAHP method begins by defining the neutrosophic values, which correspond to the 1–9 Saaty scale and are used to compare various criteria.
2- The decision-making problem's criteria, sub-criteria, and alternatives are identified in the second phase, then starts the process of building the problem's hierarchy.
3- The neutrosophic preference is determined in the third phase by comparing each criterion and sub criterion pair-wise. Following that, the alternatives are compared under each criterion or sub-criterion.
4- The fourth phase tests the accuracy of each pair-wise comparison then the neutrosophic preference relation is constructed.
5- The neutrosophic relative weight of each preference relation is calculated, the relative weight is measured by adding each column in the matrix, then dividing each number in the matrix by the sum of its columns, and finally averaging across the rows.
6- The overall weights are evaluated in the final phase, and the best alternative is chosen by multiplying the structure of the number of alternatives by the number of criteria. [12]

Step 1: Determine the objective of your study; decompose problem hierarchy to represent the goal, criteria, and the possibility of alternatives.

Step 2: A set of linguistic variables used by decision makers and importance weight based on neutrosophic values are as shown in Table 1..

Table 1. The neutrosophic scale for comparison matrix **[12]**

Linguistic term	Neutrosophic set	Linguistic term	Reciprocal neutrosophic set
Extremely Highly Preferred	(0.90, 0.10, 0.10)	Mildly Lowly Preferred	(0.10, 0.90, 0.90)
Extremely Preferred	(0.85,0.20, 0.15)	Mildly Preferred	(0.15,0.80, 0.85)
Very Strongly to Extremely Preferred	(0.80, 0.25, 0.20)	Mildly preferred to Very Lowly Preferred	(0.20, 0.75, 0.80)
Very Strongly Preferred	(0.75,0.25, 0.25)	Very Lowly Preferred	(0.25,0.75, 0.75)
Strongly Preferred	(0.70, 0.30, 0.30)	Lowly Preferred	(0.30, 0.70, 0.70)
Moderately Highly to Strongly Preferred	(0.65, 0.30, 0.35)	Moderately Lowly Preferred to Lowly Preferred	(0.35, 0.70, 0.65)
Moderately Highly Preferred	(0.60, 0.35, 0.40)	Moderately Lowly Preferred	(0.40, 0.65, 0.60)
Equally to Moderately Preferred	(0.55, 0.40, 0.45)	Moderately to Equally Preferred	(0.45, 0.60, 0.55)
Equally Preferred	(0.50, 0.50, 0.50)	Equally Preferred	(0.50, 0.50, 0.50)

At a given level of the hierarchy, these pair-wise comparisons are stored into the following matrix.

Step3: De-neutrosophication of the neutrosophic numbers to crisp values using the score function as in Eq. (6).

Matrix M for (n=5) criteria :

$$\mathbf{M} = \begin{bmatrix} 0.5 & a_{12} & a_{13} & a_{14} & a_{15} \\ a^{-1}_{(21)} & 0.5 & a_{23} & a_{24} & a_{25} \\ a^{-1}_{(31)} & a^{-1}_{(32)} & 0.5 & a_{34} & a_{35} \\ a^{-1}_{(41)} & a^{-1}_{(42)} & a^{-1}_{(43)} & 0.5 & a_{45} \\ a^{-1}_{(51)} & a^{-1}_{(52)} & a^{-1}_{(53)} & a^{-1}_{(54)} & 0.5 \end{bmatrix} \quad (7)$$

$$\textbf{Sum(column)} \quad S_{c1} \quad S_{c2} \quad S_{c3} \quad S_{c4} \quad S_{c5}$$

Step4: Matrix M is then normalized according to:

$$a_{ji} = \frac{a_{ji}}{\sum_{i=1}^{n} a_{ji}} \quad (8)$$

For all i and j. Weights which identifying the priorities of compared elements for the specific level of the hierarchy are then calculated as:

$$W_i = \frac{\sum_{i=1}^{n} a_{ji}}{n} \quad i = 1, 2, \dots . n \qquad (9)$$

Step5: The weights are related to the pair-wise comparisons matrix M according to:

$$A * W = \lambda_{Max} * W \qquad (10)$$

Where **λmax** is a standard used as a reference index that helps indirectly to assess consistency of the values. So, a consistency index **CI** is defined as:

$$CI = \frac{\lambda_{Max} - n}{n-1} \qquad (11)$$

Step6: The consistency ratio **CR** is calculated as:

$$CR = CI / RI \qquad (12)$$

Where RI is the random index, which is a function of the number of compared elements n, as shown in Table 2. The consistency ratio is an important measure of the values' consistency. Usually, a CR is a range of less than 0.1 is showing the values of consistent **.** [11]

Table 2. Average of random inconsistency indices (RI) for n

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.46	1.49

Once the weights value of w is calculated for each level, the values are calculated to produce a set of overall priorities for the hierarchy. This is done by multiplying the elements' weights of the given level by the weight corresponding to the parent element in the upper or main level. Then, worthiness of the potential alternatives is accepted based on the produced weights corresponding to the considered criteria. Finally, a decision is made to achieve the goal set by selecting the alternative that gets the highest weight**.**

5. Result

5.1- The Implementation of NAHP Model

Multiple and conflicting criteria of decision-making are assessed in MCDM, a sub-field of process science. MCDM is a constant technique that can be used to choose the best choice from a set of choices in order to solve any problem that a decision-maker can face involving multiple criteria.[11]

The NAHP is a selection process that consists of following steps as shown in Figure 1:

1. Define the problem and objectives.

2. Structure the factors in criteria, sub-criteria and alternatives.

3. Construct a set of all problems in a square comparison matrix in which the set of elements is compared with itself by using the fundamental scale of pair-wise comparison shown in table.

4. Calculate weighting and consistency ratio.

5. Evaluate alternatives according weighting and get ranking.

Decision making operation is a procedure of choosing the most suitable alternative between the all-suitable alternatives, the alternatives should be studying in depth for the final implementation. In such cases decision maker should answer multi criteria decision making problem.[14]

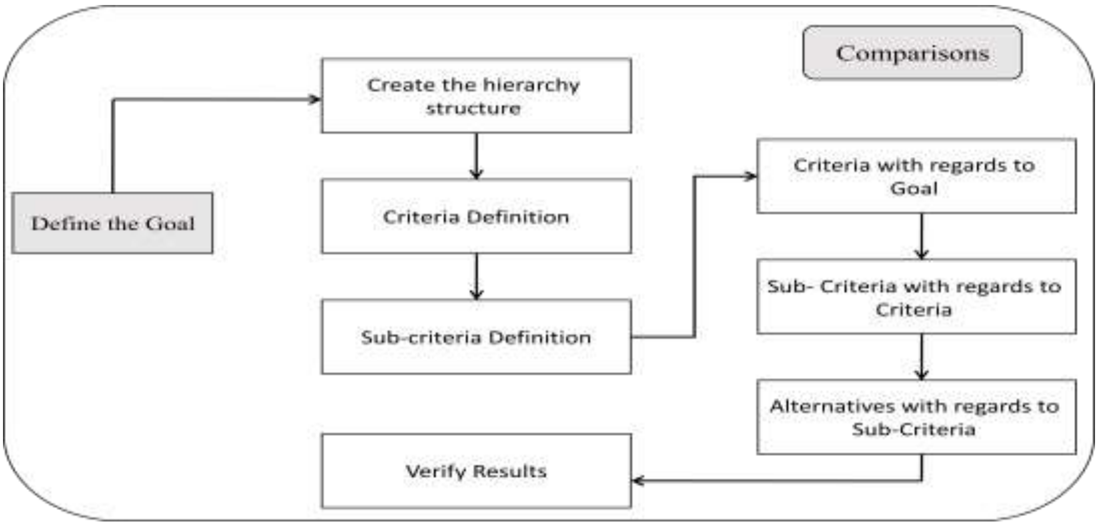

Figure 1: Steps for building an NAHP model

In this paper the researcher wants to present Neutrosophic Analytic Hierarchy Process (NAHP) as a support methodology for improving decision making processes. Also the researcher will focus on making strategy decisions in a bank with applying both basic and adjusted NAHP application models.

The researcher presents five major groups of banking rules criteria which are using to judge on clients. The NAHP provides an objective way for reaching to an optimal decision for both individual and group decision makers with a limited level of inconsistency.

It makes it possible to select the best alternative (under several criteria) shown in Figure 2 from a number of alternatives through carrying out pair-wise comparison values.[13]

Overall priorities for ranking the alternatives are being calculated on the basis of pair-wise comparisons.

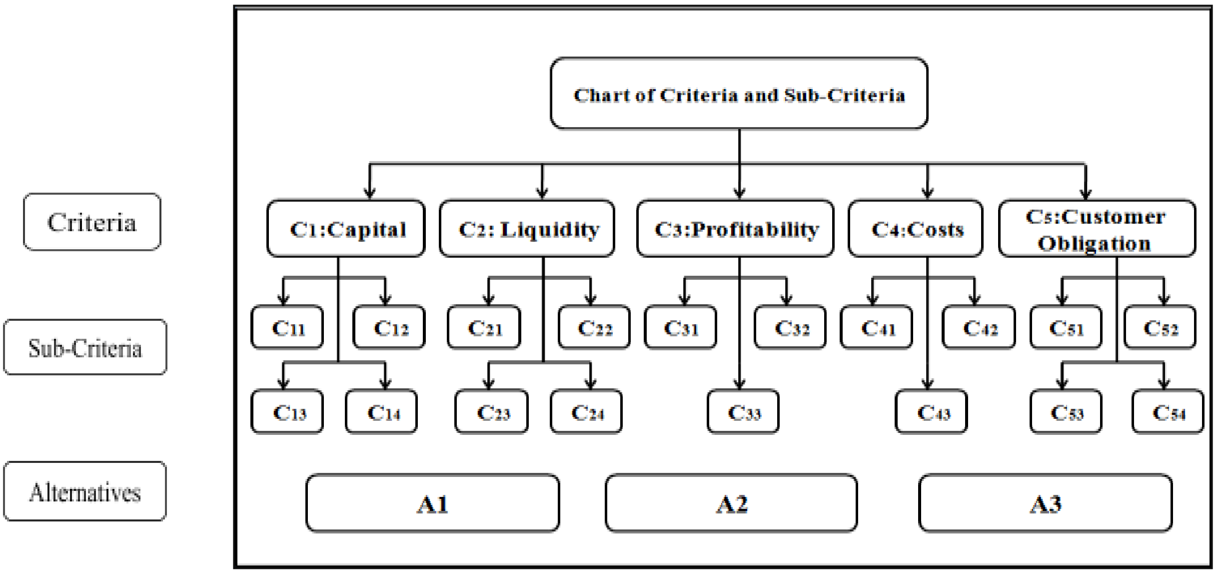

Figure 2 : The Hierarchy Chart of NAHP Model

5.2 - The Alternatives for NAHP Bank Decision Model

In the process of following up the client who obtained the loan, the decision maker in the credit sector has some alternatives which he should taking if any shortage happened from the client During the loan repayment period. They can be as following:

A1- Avoiding bad loans by following effective procedures and reliance on adequate guarantee and cash flow to repay the loan. (Green Area)

A2- Providing suggestions and alternatives to help the client in the project operations, and reducing payment terms, delay interest and scheduling loans. (Yellow Area)

A3- The bank declares the client bankruptcy immediately, and selling the pledged assets to the bank to liquidate the client's property. (Red Area)

5.3- Criteria and Sub-criteria of NAHP Model

The division of each criteria into sub-criteria are showed in the following Table 3:

Table 3. Criteria and Sub-criteria of NAHP Model.

Criteria	Sub Criteria
Working Capital(C_1)	C_{11} : Decreasing business amount and selling part of current assets. C_{12}: Using borrowing for covering the financial deficit. C_{13}: Decreasing profits annually. C_{14}: Stabilizing growth rates.
Liquidity(C_2)	C_{21} : Appearance of unplanned payment obligations in the project. C_{22} : Slow rate of assets turnover for the project. C_{23} : Constant increasing in the cost with lower sales. C_{24} : Inefficient using of production methods.
Profitability(C_3)	C_{31} : Sales decline. C_{32} : Increasing sales with lower profits. C_{33} : A gap between total profits and income net.
Costs(C_4)	C_{41} : Continues operating losses. C_{42} : High percentage of expenses to sales. C_{43} : Increasing the percentage of damaged production.
Customer Obligation(C_5)	C_{51} : Issuing checks that exceed the loan account. C_{52} : Failure to pay the due payments more than once. C_{53} : Decreasing the borrowing client accounts in the bank. C_{54} : Sudden changes to the timing of withdrawals and deposits.

To examine the related criteria of nonperforming loans problem, the researcher uses MCDM in AHP to evaluate the controlling factors of NPL in Egyptian banks and then make a comprehensive evaluation of them.

An aggregated pair-wise comparison matrix represents the average preferences and judgments of decision makers and, modeled in the form of neutrosophic scales as mentioned in Table 4.For simplicity, the aggregated pair-wise comparison matrix has been converted into crisp values using Eq. (6) and results represented in Table 5.

Table 4. Neutrosophic pair-wise comparison matrix of criteria.

Criteria	Working Capital(C_1)	Liquidity (C_2)	Profitability (C_3)	Costs (C_4)	Customer Obligation(C_5)
Working Capital(C_1)	**(0.50,0.50,0.50)**	**(0.55,0.40,0.45)**	**(0.45,0.60,0.55)**	**(0.80,0.25,0.20)**	**(0.70,0.30,0.30)**
Liquidity(C_2)	**(0.45,0.60,0.55)**	**(0.50,0.50,0.50)**	**(0.45,0.60,0.55)**	**(0.90,0.90,0.90)**	**(0.70,0.30,0.30)**
Profitability(C_3)	**(0.55,0.40,0.45)**	**(0.55,0.40,0.45)**	**(0.50,0.50,0.50)**	**(0.75,0.25,0.25)**	**(0.60,0.35,0.40)**
Costs(C_4)	**(0.50,0.50,0.50)**	**(0.50,0.50,0.50)**	**(0.50,0.50,0.50)**	**(0.50,0.50,0.50)**	**(0.30,0.70,0.70)**
Customer Obligation(C_5)	**(0.30,0.70,0.70)**	**(0.30,0.70,0.70)**	**(0.50,0.50,0.50)**	**(0.70,0.30,0.30)**	**(0.50,0.50,0.50)**

Table 5. Crisp values of judgments of neutrosophic pair-wise matrix.

Criteria	Working Capital(C_1)	Liquidity (C_2)	Profitability (C_3)	Costs (C_4)	Customer Obligation(C_5)
Working Capital(C_1)	**0.5**	**0.757**	**0.425**	**0.775**	**0.7**
Liquidity(C_2)	**0.425**	**0.5**	**0.425**	**0.9**	**0.7**
Profitability(C_3)	**0.757**	**0.757**	**0.5**	**0.75**	**0.625**
Costs(C_4)	**0.225**	**0.1**	**0.25**	**0.5**	**0.3**
Customer Obligation(C_5)	**0.3**	**0.3**	**0.375**	**0.7**	**0.5**

After that, the normalization illustrated to normalize the crisp value, the criteria's corresponding normalized weights mentioned using Eq. (9):$W_1 = 0.243, W_2 = 0.222, W_3 = 0.268, W_4 = 0.103, W_5 = 0.164$. According to the previous step, the total of criteria weights will be as the following: $\sum W_i = 1$. and the arrangement of criteria with respect to priorities is C_3, C_1, C_2, C_5 and C_4 respectively.

After calculating the weight of each sub-criteria for each main criteria, the researcher concluded that the most important criteria for the bank and which reflected the situation of the client in paying the monthly installments of the loan in their due time is profitability of the project, then working capital and the liquidity as shown in Table 6. So, the decision maker will depend on these criteria to predict the clients' condition through the following up of loan repayment.

Table 6. Rank of Main Criteria.

Criteria	**Sum of Weight of Sub-criteria**	**Rank**
C_1	0.243	**2**
C_2	0.222	**3**
C_3	0.268	**1**
C_4	0.103	**5**
C_5	0.164	**4**

5.4- Sub – Criteria of each Criteria

By applying the same steps on all sub criteria of main criteria, we concluded the following results as shown in Tables (7 – 11).

Table 7. Sub-Criteria of C_1

Capital	C_{11}	C_{12}	C_{13}	C_{14}	W
C_{11}	0.50	0.70	0.68	0.78	0.31
C_{12}	0.30	0.50	0.43	0.63	0.21
C_{13}	0.33	0.76	0.50	0.63	0.25
C_{14}	0.50	0.50	0.50	0.50	0.24

Table 8. Sub-Criteria of C_2

Liquidity	C_{21}	C_{22}	C_{23}	C_{24}	W
C_{21}	0.50	0.70	0.63	0.68	0.31
C_{22}	0.30	0.50	0.30	0.76	0.22
C_{23}	0.50	0.70	0.50	0.70	0.29
C_{24}	0.33	0.43	0.30	0.5	0.19

Table 9. Sub-Criteria of C_3

Profit	C_{31}	C_{32}	C_{33}	W
C_{31}	0.50	0.70	0.68	0.41
C_{32}	0.30	0.50	0.76	0.32
C_{33}	0.33	0.43	0.50	0.27

Table 10. Sub-Criteria of C_4

Cost	C_{41}	C_{42}	C_{43}	W
C_{41}	0.50	0.63	0.70	0.38
C_{42}	0.50	0.50	0.63	0.34
C_{43}	0.30	0.50	0.50	0.27

Table 6. Sub-Criteria of C_5

Customer	C_{51}	C_{52}	C_{53}	C_{51}	W
C_{51}	0.50	0.30	0.63	0.76	0.25
C_{52}	0.70	0.50	0.70	0.68	0.31
C_{53}	0.50	0.30	0.50	0.76	0.24
C_{54}	0.43	0.33	0.43	0.50	0.20

After calculating all equations of all NAHP process, the final weights of alternatives will be as shown in the Table 12:

Table 7. Alternatives of Bank Solutions

Alternatives	A1	A2	A3	Weight(X)
A1	0.50	0.63	0.70	0.410
A2	0.38	0.50	0.68	0.341
A3	0.30	0.33	0.50	0.249

When the researcher applies the same method which using by Altman Model, the weight of alternatives can be compared as the following :

IF X > = 0.410 Then the alternative will be the first one A = A1 (Green Area).

IF 0.410 > X > = 0.341 Then the alternative will be the second one A = A2 (Yellow Area).

IF 0.341 > X > = 0.249 Then the alternative will be the third one A = A3 (Red Area).

5.5- Applying Altman Model and NAHP Model

5.5.1- User Interface

The researcher uses the GUI tools to create, edit, and monitor the model. In the proposed model, the interface consists of a set of forms built in Visual Studio.NET 2016 because it is considered a flexible and a common software. The user can input the raw of data needed for a consultation. Figure 3 and Figure 4. Show samples of the used criteria model in application. The user may have information regarding a specific result and the interface can provide additional explanations about how the model reached to the conclusion.

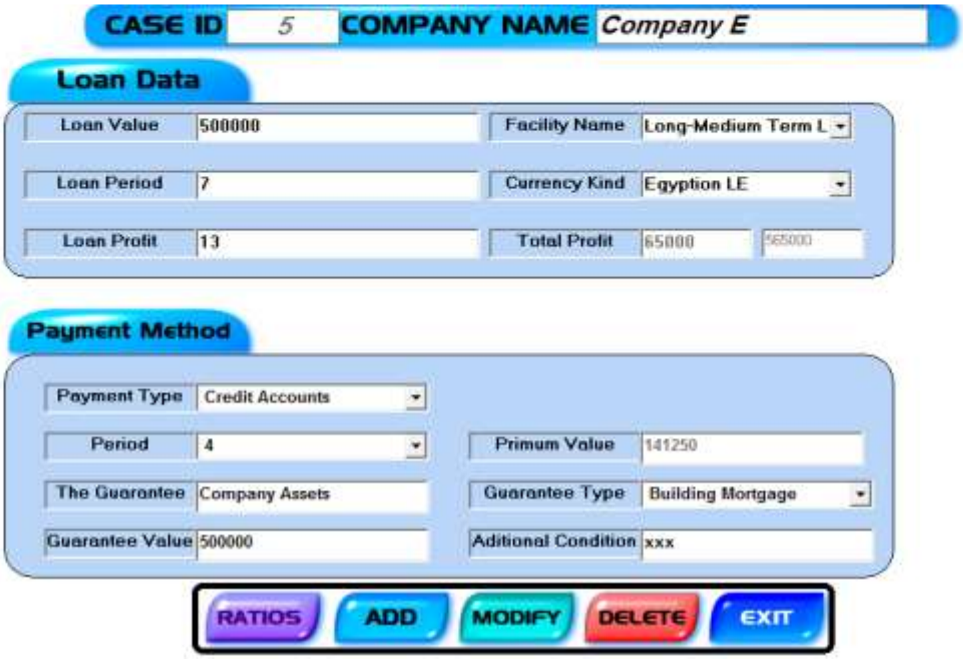

Figure 3: Snapshot of Client's Data

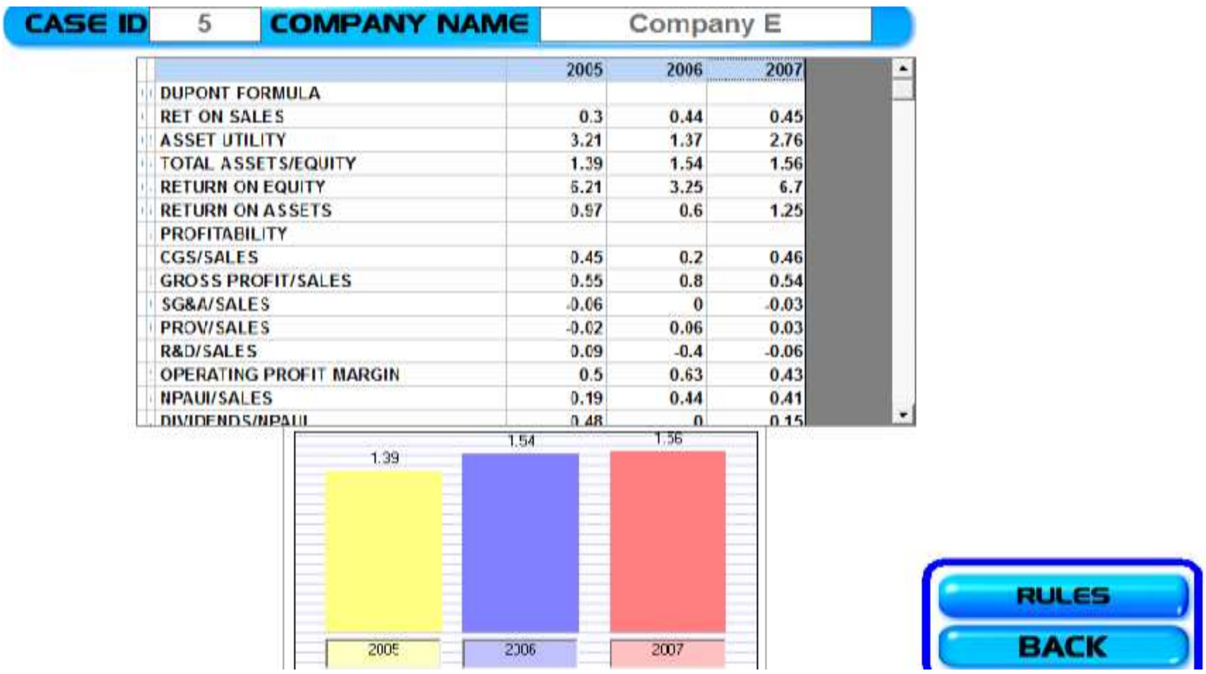

Figure 4 : Snapshot of Model criteria

5.5.2- Result of Applying Model

It was difficult to deal with any of public banks to use the proposed model practically in the credit loan department due to many considerations like laws forbidden, security issues … etc. The bank's administration allows the researcher to obtain and study the historical data of previous year, and only offers a set of available historical clients' cases (200 bank's clients). By applying the proposed model on these clients for testing the model, the researcher deducts the following results. Table 13 shows the numbers of classified clients sample and Figure 5 shows the difference between bank clients, Altman model clients and NAHP model clients.

Table 8. Numbers of Clients Samples

	Previous Actual Clients	Altman Model	NAHP Model
Green Area	100	120	140
Yellow Area	50	45	40
Red Area	50	35	20
Total of Success Payment	135	165	180
Total of Defaulted Payment	65	35	20

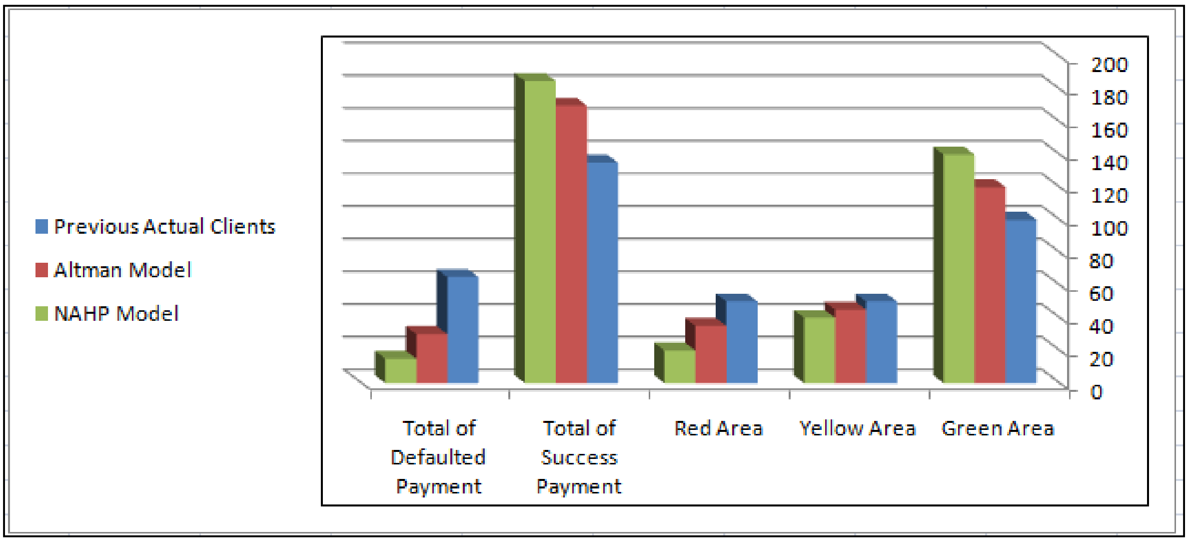

Figure 5 : Difference between bank clients, Altman model clients and NAHP model clients.

6. Discussion

Based on the analysis of the previous results that have been reached, the researcher concludes that:

The actual number of the clients which the bank approved are 200 clients, divided as follows :

1- 100 clients who reached to full success payment (Green Area).

2- 60 clients who showed payment fluctuation between the payment of monthly installments and the delay in paying some installments. (Yellow Area)

3- 40 clients who stopped to pay the monthly installments for 3 months or more (Red Area).

The total number of success payment clients are 135 clients (who repaid the total loan to the bank) ,and the total number of the clients who were unable to pay the fixed installments on their due dates are 65 clients.

When applying Altman model to the same number of actual clients specified by the bank, the previous numbers change to the following results and are divided as follows:

1- The number of clients in the (Green Area) increased to 120 clients after 20 clients increased from the (Yellow Area) as a result of close and accurate examination of the client's commitment to pay on due dates without any delay.

2- The number of clients in the (Red Area) decreased to 35 clients who moved to the yellow area, as a result of being controlled and helped to overcome the emergency crises to ensure that they repay the loan installments.

The total number of success payment clients increase to 165 clients (who repaid the total loan to the bank) ,and the total number of the clients who were unable to pay the fixed installments on their due dates decrease to 35 clients as shown in Table 13.

After applying the NAHP model to the same criteria used before, the number of clients who repaid the entire loan increased to 180 clients, being divided as shown in Table 13, and the number of defaulting clients decreased to 20 clients only, which is the highest percentage reached by the model compared to the existing system in the bank.

7.Conclusion

The study shows that all criteria which the bank is using to judge on the clients through the process of following up their obligation in paying the installments, are not used in such an effective way that can be a helpful factor to the credit officer to make the right decision at the right time.

In this paper, the researcher applies two models on these criteria, Altman Model and Neutrosophic-AHP Model. The paper provides a comparative analysis for them to show that we can use the same criteria used by the bank in very clear calculations to handle the criteria of evaluating the clients.

The paper proposes criteria for judging the clients and studies consistency of these criteria. This study also analyzes criteria and factors by calculating their weights based on the properties of the alternatives. The paper also measures the accuracy of decision by comparing the consistency of using multi-criteria and criteria for decision model.

The paper proves that Neutrosophic-AHP is more accurate rather than Altman Model and bank traditional Model. It also shows the effect of using criteria and its factors on the accuracy of the decision made.

References

1- MOODY'S INVESTORS SERVICE, Rating Action 28/8/2018, 2018 , www.moodys.com/research.

2- Saliha Karadayi-Usta, " Neutrosophic Analytic Hierarchy Process for Evaluating a New Servicizing Business Model of Transportation", International Symposium of the Analytic Hierarchy Process, December 2020, DOI:10.13033/isahp.y2020.046.

3- Kulalı, İ., " Altman Z-SkorModelinin BİST Şirketlerinin Finansal Başarısızlık Riskinin Tahmin Edilmesinde Uygulanması", Uluslararası Yönetim İktisatve İşletme Dergisi, 2016, Vol.12, No.27, pp. 283-291.

4- Bağcı, E, "Türkiye Tekstilve Hazır Giyim Sektörünün Finansal Durum Analizi. Marmara", Üniversitesi İktisadiveİdari Bilimler Dergisi, 2015, Vol.37, No.2, pp. 83-100. https://doi.org/10.14780/iibd.83811.

5- Mişu, N.,B., & Codreanu, E.,S., " Analysis and Prediction of the Bankruptcy Risk in Romanian Building Sector Companies". Ekonomika, Vol.93, No.2, pp. 131-146.(Erişim:14.11.2016).

6- Fernando A. F. FERREIRA, Sérgio P. SANTOS, Vítor M. C. DIAS, " AN AHP-BASED APPROACH TO CREDIT RISK EVALUATION OF MORTGAGE LOANS", International Journal of Strategic Property Management, 2016, doi:10.3846/1648715X.2013.863812.

7- Zeliha Kaygisiz Ertuğ; Nuray Girginer, " Evaluation of banks' commercial credit applications using the Analytic Hierarchy Process and Grey Relational Analysis", S. Afr. j. econ. manag. sci. vol.18 n.3 Pretoria, 2015. http://dx.doi.org/10.17159/2222-3436/2015/V18N3A2.

8- Fábio M. Soares, Olavo S. Rocha Neto, " A Simple Fuzzy System Applied to Predict Default Rate", Fuzzy Logic - Tool for Getting Accurate Solutions, INTECH open science, 2015, http://dx.doi.org/10.5772/60079.

9- Nouran M. Radwan, M. Badr Senousy, Alaa El Din M. Riad, " Neutrosophic AHP Multi Criteria Decision Making Method Applied on the Selection of Learning Management

System", International Journal of Advancements in Computing Technology 8(5):95-105 (IJACT), Volume8, Number5, Dec. 2016.

10- Omar Bataineh, Dina Abu Hjeelah, and Sereen Arabiat, " Multi-Criteria Decision making Using AHP to Select the Best CAD Software" , Conference Paper in Advances in Intelligent Systems and Computing · September 2018. DOI: 10.1007/978-3-319-68324-9_12. https://www.researchgate.net/publication/320124270

11- Nemani Varalakshmi and M.M. Shanmugapriya, " A Fuzzy AHP Analysis for Regulating the Factors on NPAS in Indian Banks", International Journal of Pure and Applied Mathematics, Volume 117 No. 7 2017, 273-285.

12- A. M. Elhosiny, H. El-Ghareeb, B. T. Shabana and A. Abou-Elfetouh, "A Hybrid Neutrosophic GIS-MCDM Method Using a Weighted Combination Approach for Selecting Wind Energy Power Plant Locations: A Case Study of Sinai Peninsula, Egypt," INTERNATIONAL JOURNAL of FUZZY LOGIC and INTELLIGENT SYSTEMS, vol. 21, p. 12–28, 2021.

13- Kahraman, C., Oztaysi, B., & Cevik Onar, S. "Single interval-valued neutrosophicAHP methods: Performance analysis of outsourcing law firms", Journal of Intelligent andFuzzy Systems, 38(1), 749–759, 2020.

14- Amany A.Slamaa, Haitham A. El-Ghareeb and Ahmed Abo-elfetouh, " Comparative analysis of AHP, FAHP and Neutrosophic- AHP based on multi-criteria for adopting ERPS", Neutrosophic Sets and Systems, Vol. 41, 2021.

Received: March 1, 2021. Accepted: Jun 3, 2021