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Credit Risk Assessment using Fuzzy Logic

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Abstract— The purpose of this paper is to develop a fuzzy logic model for credit risk assessment. Predicting of consumer bankruptcy, is imprecise and ambiguous. The failure process is affected by many internal and external factors. Risks are uncertainties. There are a large number of risks in the banking universe. With the use of fuzzy logic vague and ambiguous concepts can be defined, such as "high risk of bankruptcy" or "low risk of bankruptcy". Here fuzzy logic toolbox of MATLAB is used. In this paper, we used demographics variable, finance variable, and financial security variable. Based on these three evaluated inputs the model forecasts the final credit risk output.

Keywords— Fuzzy logic toolbox; consumer credit risk; demographical; financial variables

I. INTRODUCTION

The credit risk depends on many different factors. Risk may vary depending on the average income of a person, credit history, character of a person, stability of his job, concurrent credits from other banks, etc [11].
The information contained in this paper may be used in practice in several aspects:

- from the viewpoint of assessing the solvency of partners and customers,
- from the perspective of credit risk assessment by financial institutions,
- in the context of credit scoring the credit applications of consumers by banks,
- from the viewpoint of assessing the consumer bankruptcy threat [1].

In this study how to forecasted the issue of consumer credit risk by Fuzzy logic is explained and a case study is performed. In this case study, Fuzzy model Mamdani is used. We used the demographical and financial variables of 50 Albanian consumers who took consumption credit. The data were obtained by developing a questionnaire with consumers. The forecasts are interpreted, discussed and conclusion is drawn.

II. FUZZY LOGIC

Several methods exist to predict an output variable with different input variables. A common used technique is regression analysis. Any regression analysis requires a set of assumptions such as linearity, normality and homoscedasticity [12].
Moreover, regression techniques are not capable of digesting linguistic fuzzy data. The fuzzy set theory allows to include inevitable imprecision in the data records. Fuzzy inference is the actual process of mapping with a given set of input variables and output through a set of fuzzy rules. The essence of the modeling is to set up relevant fuzzy rules [13].
There are two fuzzy models used in practice. These are Mamdani fuzzy model and Sugeno fuzzy model. In this paper is used Mamdani fuzzy model.

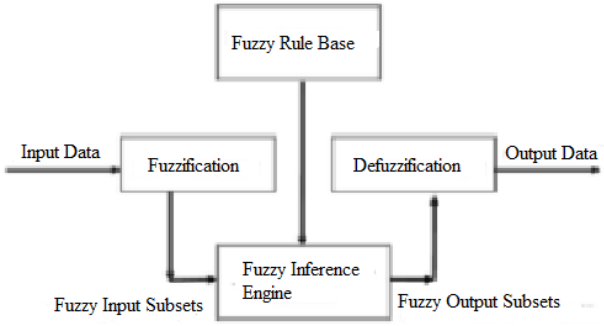

Figure 1: General structure of a fuzzy system

Fuzzy logic provides a great simple way to draw definite conclusions from vague, ambiguous or imprecise information. In a sense, fuzzy logic look like human decision making with its ability to work from approximate data and find precise solutions.
Nowadays, fuzzy logic is used to manage a wide range of systems, like cars, aircraft and railways. The main benefit of fuzzy logic is the opportunity to model the ambiguity and the uncertainty of decision-making. Furthermore, fuzzy logic has the ability to include linguistic instructions and to generate control strategies based on priori communication. The point in utilizing fuzzy logic in control theory is to model control based on human expert knowledge, rather than to model the process itself [14].

III. CASE STUDY

A. Fuzzy logic model

The model consists of four different rule blocks. Rule Block 1 "demographics" evaluates the consumer's demographical variables (age, education level, marital status, number of children in household).

Rule Block 2 “finance” evaluates the financial condition of the consumer based on three variables (monthly income, the length of employment, type of employment contract). Rule Block 3 “financial security” analyzes the financial strength of the customer and eventually the security for the granted credit. Rule Block 4 “the score” uses as entry variables the forecasted output of all three Rule Blocks, which are: demographics variable (there are three states of demographics forecasted at Rule Block 1: weak, average, strong), finance variable (there are three states of financial strength forecasted in Rule Block 2: weak, average, strong), and financial security variable (there are three states of security forecasted at Rule Block 3: weak, average, strong). Based on these three evaluated inputs the model forecasts the final credit risk output [1].

The model’s output is a variable representing a forecast of the financial situation of an audited consumer. This variable ranges from 0 to 1, while it is assumed that there are three levels of risk: high risk for values smaller than 0.3, medium risk for values from 0.3 to 0.7, and low risk for values larger than 0.7. Figure 2 presents the structure of the developed model.

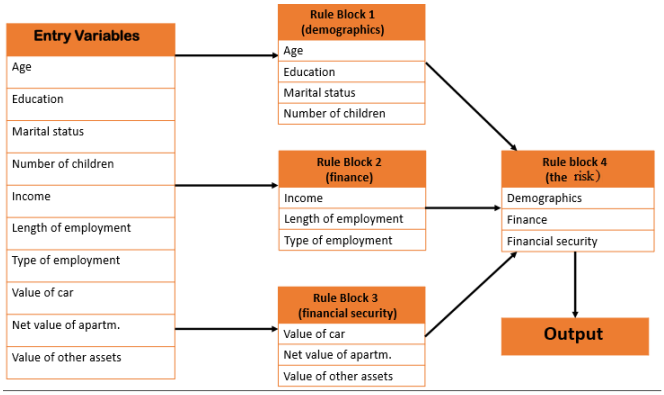

Figure 2: Structure of the Fuzzy Logic Model for Consumer Credit Scoring.

Level of education (values from 0 to 3) has a positive influence on the credibility of the credit applicant (the higher level of education the better). In the same positive way marital status (values from 0 to 1) affects the output of Rule Block 1. However, number of children in household (values from 0 to 5) has a negative influence on a consumer’s status. A client’s age in certain values (range of values for the middle aged category) has a positive affect on the output, and in other cases negatively influences the score (range of values for the young and old category). Monthly income and length of employment (values from 0 to 15 years) have a positive influence on the financial stability of the customer (the higher value the better). The type of employment contract, defines if the customer source of monthly income is stable. There are three types of the contracts specified: task job contract, limited duration contract, indefinite duration contract. The task job contract is considered to be the worst for the stability of the customer’s income. The best contract is indefinite duration one. In addition the net value of apartment/house is considered to have dominant role on the output of rule block 3, as it is characterized by the highest value and stability than two other variables. The outputs of rule blocks 1, 2, and 3 are considered as input variables to the Rule Block 4 “The Risk”. The model’s output “The Risk” is a variable representing a forecast of the financial situation of an audited consumer. The output variable ranges from 0 to 1, while it is assumed that there are three levels of risk: high risk for values smaller than 0.3, medium risk for values from 0.3 to 0.7, and low risk for values larger than 0.7.

B. Fuzzy logic controller

There are three principal elements to a fuzzy logic controller:

1. Fuzzification module (Fuzzifier)
2. Rule base and Inference engine
3. Defuzzification module (Defuzzifier) [7].

- FIS Editor

Figure 3 depicts the Mamdani type Fuzzy Controller.

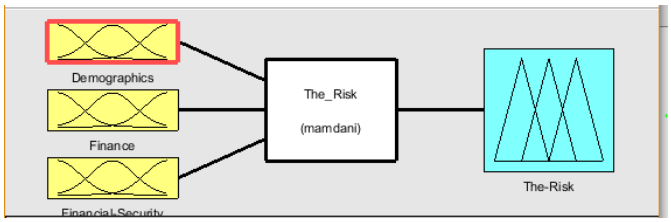

Figure 3: Mamdani type Fuzzy Controller

- Membership Function Editor

Figure 4 depicts the Membership Function of Input Variable Demographics.

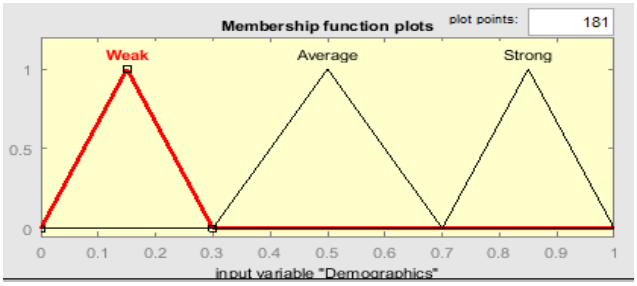

Figure 4: Membership Function of Input Variable Demographics

Figure 5 depicts the Triangular Membership Functions of Output Variable for The risk.

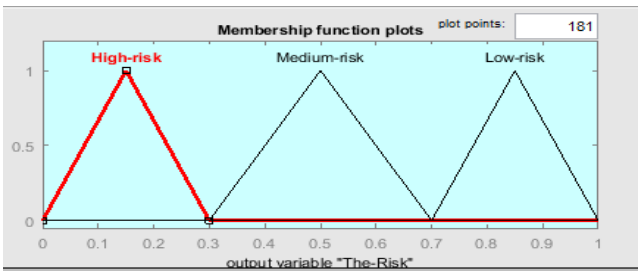

Figure 5: Membership Function of Output Variable

- Fuzzy Rule

Number of active rules = m^n, where m = maximum number of overlapped fuzzy sets and n = number of inputs. For this design, m = 3 and n = 3, so the total number of active rules are 27. Some of the rules are shown in table 1.

Table 1: Fuzzy Inference System Rules

11. If (Demographics is Average) and (Finance is Weak) and (Financial-Security is Average) then (The-Risk is High-risk) (1)
12. If (Demographics is Average) and (Finance is Weak) and (Financial-Security is Strong) then (The-Risk is Medium-risk) (1)
13. If (Demographics is Average) and (Finance is Average) and (Financial-Security is Weak) then (The-Risk is Medium-risk) (1)
14. If (Demographics is Average) and (Finance is Average) and (Financial-Security is Average) then (The-Risk is Medium-risk) (1)
15. If (Demographics is Average) and (Finance is Average) and (Financial-Security is Strong) then (The-Risk is Medium-risk) (1)
16. If (Demographics is Average) and (Finance is Strong) and (Financial-Security is Weak) then (The-Risk is Medium-risk) (1)
17. If (Demographics is Average) and (Finance is Strong) and (Financial-Security is Average) then (The-Risk is Low-risk) (1)
18. If (Demographics is Average) and (Finance is Strong) and (Financial-Security is Strong) then (The-Risk is Low-risk) (1)
19. If (Demographics is Strong) and (Finance is Weak) and (Financial-Security is Weak) then (The-Risk is Medium-risk) (1)
20. If (Demographics is Strong) and (Finance is Weak) and (Financial-Security is Average) then (The-Risk is Medium-risk) (1)
21. If (Demographics is Strong) and (Finance is Weak) and (Financial-Security is Strong) then (The-Risk is Medium-risk) (1)
22. If (Demographics is Strong) and (Finance is Average) and (Financial-Security is Weak) then (The-Risk is Medium-risk) (1)
23. If (Demographics is Strong) and (Finance is Average) and (Financial-Security is Average) then (The-Risk is Medium-risk) (1)
24. If (Demographics is Strong) and (Finance is Average) and (Financial-Security is Strong) then (The-Risk is Low-risk) (1)
25. If (Demographics is Strong) and (Finance is Strong) and (Financial-Security is Weak) then (The-Risk is Low-risk) (1)
26. If (Demographics is Strong) and (Finance is Strong) and (Financial-Security is Average) then (The-Risk is Low-risk) (1)
27. If (Demographics is Strong) and (Finance is Strong) and (Financial-Security is Strong) then (The-Risk is Low-risk) (1)

- *Response of Fuzzy Logic Controller using Rule Viewer*

When the value of the demographics is 0.355, the finance is 0.584 and the financial – security is 0.114 then the value of the risk is 0.5.

Figure 6 depicts the Fuzzy Logic Controller Using Rule Editor for the Risk.

Figure 6: Fuzzy Logic Controller Using Rule Editor for the Score

Figure 7 depicts the Fuzzy Logic Controller Using Rule Viewer for the Score.

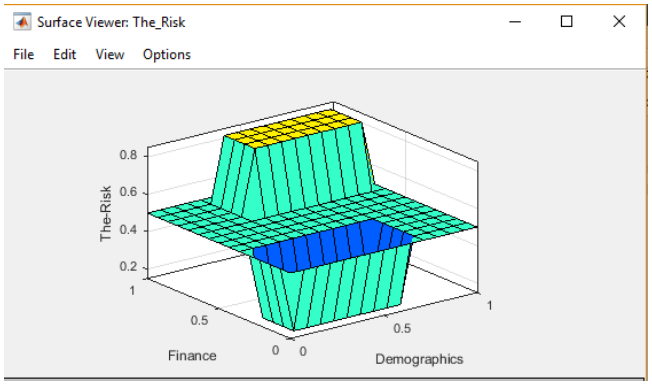

Figure 7: Fuzzy Logic Controller Using Rule Viewer for the Score

IV. RESULTS

In this study 50 Albanian consumers who took consumption credit are used to construct fuzzy model. The Fuzzy model was constructed according to Mamdani type. The model consists of four different rule blocks. Rule Block 1 “demographics” evaluates the consumer’s demographical variables (age, education level, marital status, number of children in household). Rule Block 2 “finance” evaluates the financial condition of the consumer based on three variables (monthly income, the length of employment, type of employment contract). Rule Block 3 “financial security” analyzes the financial strength of the customer and eventually the security for the granted credit. Rule Block 4 “the risk” uses as entry variables the forecasted output of all three Rule Blocks, which are: demographics variable (there are three states of demographics forecasted at Rule Block 1: weak, average, strong), finance variable (there are three states of financial strength forecasted in Rule Block 2: weak, average, strong), and financial security variable (there are three states of security forecasted at Rule Block 3: weak, average, strong). Based on these three evaluated inputs the model forecasts the final credit risk output. The fuzzy model calculations were performed using fuzzy toolbox in Matlab.

According to this model we get that 24 consumers (48 %) have low risk of bankruptcy, thus are with good financial condition (“non – bankrupt”) – they will repay the credit with no delays. 23 consumers (46%) have medium risk of bankruptcy (“non-bankrupt”) and 3 (6%) consumers have high risk of bankruptcy (“bankrupt”).

V. CONCLUSIONS

Credit risk assessment has attracted much research interests from both academic and industrial communities. This paper describes usage of fuzzy logic prediction system in credit risk assessment.

Fuzzy logic can be a very useful and powerful tool in financial analysis, even though the use of fuzzy logic in finance was practically unknown until 2006. Therefore, it is one of the attempts at using fuzzy logic to predict consumer bankruptcy in Albania. The developed bankruptcy prediction model presented in this paper can be easily used by financial managers as a decisional aid tool in the process of evaluating the financial situation of consumers.

In general, fuzzy logic prediction model can provide a promising solution to credit risk analysis and other prediction problems.

To summarize, this paper provides the reader a practical model that can be used in financial managment.This model is an useful tool that can be both updated with the passage of time, and adopted for individual needs.

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