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The Process Of Fuzzy Model Development For The Case Of Polish Internet Mortgage Market

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1. Introduction

The ability of transforming past information and especially an experience into knowledge, and then to use it in the decision making processes, contributes in a substantial way to the general concept of “intelligent support systems”. This idea seems to be useful in the current financial processes. This paper represents a sample of such effort and its overall aim is to provide conceptual guidelines to develop a dedicated tool for smart decision support tool for Polish e-banking, concentrating directly on the part of the Internet mortgage market.

Polish e-banking market and especially the part of the market that this Chapter concentrates on, mortgage loans via Internet, consists of 4 main stages as shown in Figure 1 [1]. Figure 1 shows the connections that exist on the mortgage market. Banks are institutions that sell mortgage and offer the option to apply for it on their own web pages. Because the market is huge with great competition on it, banks allow their partners to sell their financial products on the partners’ pages to generate more sold products. These companies are typical brokers that receive the commission for every product that they sell; there are two main brokers in the polish e-market: Bankier.pl and Money.pl. They promote and sell banks’ products on their pages but they also create a network called “partner system” which allows the owners of

small web pages to sell the products of the banks on their own pages. The owners of private web pages do not sell enough products to cooperate directly with banks, which is the reason for their association with brokers. For each product sold on a partner web page, its owner receives commission from the broker, who in turn gets his from the bank. There are currently around 15000 partner web pages in the Internet and that shows this pages became a part of the market that might be used by banks in their plans according to selling mortgages in the Internet.

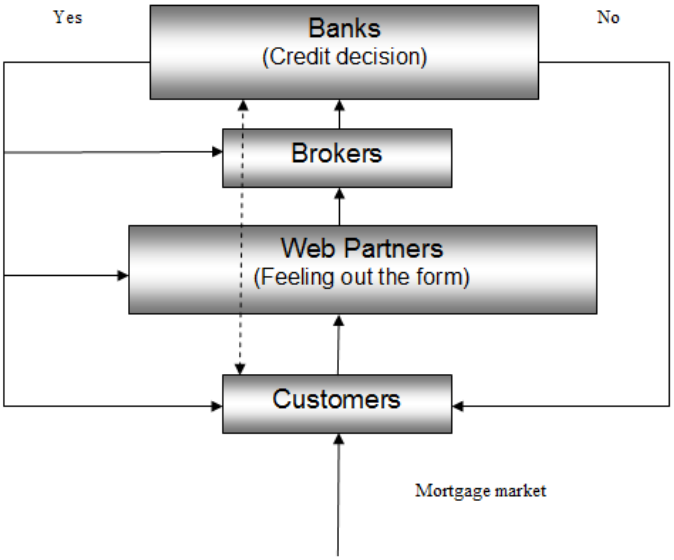

Figure 1: *Formal description of the model [1]*

Each level in Figure 1 represents a different participant in the market. It should be looked at in a top-down manner. In the first level there are banks, the second - brokers, level 3 consists of Partner web pages. Customers make up the lowest level. It was intend to describe the market from the customers' point of view. The model presumes numerous customers looking for mortgage using web searchers to find the best offer. Doing so, they reach partner web pages offering different mortgages. It needs to be pointed out that top search results are many times bought by the owners of private web pages. A customer chooses one of the web pages (mostly the top one in the web search) and moves to it. This web page provides information about the credit, often calculators that enable the customer to find out his credit rating. There is also a special link with an application for a loan in the chosen bank. While visiting the web page a customer fills out the application for the mortgage, which is subsequently sent to the broker with whom the partner has signed a contract. Next the broker sends this application to the bank with which the broker has signed the contract before. The bank begins the credit procedure, contacts the client, checks the credit rating and makes a decision.

The main problem of the described market is making the predictions about the number of sold mortgages, especially in the part of mortgages sold by web partners. Due to the fact that there are several variables influencing the market traditional statistical methods can't be used because they don't work properly. To solve the problem a special model for predicting the number of sold mortgages using web partners was created and will be presented in the next chapters.

2. Rule based model

In the initial approach to the problem of developing a proper prediction mechanism for the Internet mortgage market a dedicated rule based model was created [1]. The model included the total of 120 rules (complete model), 11 constraints, 4 variables and 2 scenarios (each scenario including 120 rules). The model, which was developed and embedded in times of

fast growing period of market and economy, did not work properly in the times of financial crisis that came later, so it was necessary to introduce some changes to this model.

During the last year there were made several changes in the model (adding new variables, later checking the correlation of variables etc.). There were tested several rules trying to find the proper balance of general economic indicators and the variables which are specific for the model background. On one of the steps the presented variables were proposed:

Production Rule:

IF variable_1 is value_1 AND variable_2 is value_2 AND variable_3 is value_3 AND variable_4 is value_4 AND variable_5 is value_5 AND variable_6 is value_6 THEN result will increase value_7 (1)

Each rule from the model consists of variables and its values presented below:

- Variable_1 = [Commission]
- Variable_2 = [Interest rates]
- Variable_3 = [Advertising]
- Variable_4 = [WIG]
- Variable_5 = [IbnGR]
- Variable_6 = [WNE]
- Result = [Selling mortgage in the Internet]
- Value_1 = [Small, medium, high]
- Value_2 = [Very small, small, medium, high]
- Value_3 = [Very small, small, medium, high, very high]
- Value_4 = [bad, average, good, very good]
- Value_5 = [bad, average, good, very good]
- Value_6 = [very bad, bad, average, good, very good]
- Value_7 = [Very small, small, medium, high, very high]

It was necessary to assess and verify the variables which appear in the model presented above. This process was performed in the following three steps:

1. Selection of the modified set of model variables
2. Verification of the variables
3. Analysis of the correlation between variables

Generally, the pre-defined initial group of six variables had unnecessarily strong representation of very general economic indicators which were highly correlated with each other. The first variable to go was WNE (Market sentiment indicator) as the one with the longest actualization cycle (it is published only 4 times a year). For the five remaining variables (commission, interest rate, advertising, WIG and IbnGR) the correlation level between them was evaluated. The findings of this process were presented in [2] with two variables (WIG and IbnGR) highly correlated suggesting that one of them should be deleted from the final list.

Because the Warsaw Stock Exchange main indicator level (WIG) is updated more often than IbnGR and has well defined numerical representation the IbnGR variable was deleted from the model.

Each step of works was documented and presented in the scientific articles. The rule based model reached the final version which is presented below

- Variable_1 = [Commission]
- Variable_2 = [Interest rates]
- Variable_3 = [Advertising]
- Variable_4 = [WIG]

- Result = [Selling mortgage in the Internet]
- Value_1 = [Small, medium, high]
- Value_2 = [Very small, small, medium, high]
- Value_3 = [Very small, small, medium, high, very high]
- Value_4 = [bad, average, good, very good]
- Value_5 = [Very small, small, medium, high, very high]

Production Rule:

IF variable_1 is value_1 AND variable_2 is value_2 AND variable_3 is value_3 AND variable_4 is value_4 THEN result will increase value_5 (2)

The rules based model did not work as good as the users required. Due to the specific character of the mortgage market there are several variables, which influence on the market, that can't be described in numbers (crisp values such as general feelings about current situation) It was necessary to try a different method that's why the fuzzy modeling was suggested.

3. Fuzzy model

In the process of fuzzy model development the rule base was used consisting of 81 production rules. This number comes from the number of variables (four variables) in the model and values of these variables (three linguistic values for each variable):

$$3^4 = 81 \qquad (3)$$

Each rule in the rule base is developed using the IF... THEN logical construct consisting of four variables as in the following example:

Production Rule:

IF Commission is *small* **AND** Interest rates is *small* **AND** Advertising is *small*

AND WIG is *small* **THEN** Selling mortgage in the Internet is *small*
(4)

After defining the membership function with its fuzzy values for membership numerical degrees we can proceed with the process of formulating the mapping from a given input to fuzzy output. This is called fuzzy inference and provides a basis from which decisions can be made, or patterns discovered.

3.1. Fuzzy inference

The fuzzy inference process takes a fuzzy set as input and follows the model logic to arrive at the output [3].

To develop and train the inference engine for our case it is necessary to specify values of output variables for the existing 81 production rules. As it was not possible to automatically generate these output values, the expert market knowledge was applied for this purpose. Below we present illustrative examples explaining some parts of this process:

Example 1:
The lower the value of variable 'interest rate' is, the higher the value of 'selling mortgage in the Internet' should be. All other variables in the model (money spent on advertising, WIG, commission) work in the other direction: the higher values indicate increase of the output.
It should also be noticed that due to the fact that the model includes all mathematically possible combinations between variables and their linguistic values (the model is complete),

it includes also of rules which most probably will never appear in the real life applications. The example of such a rule is presented below:

Example 2:

IF Commission is *small* **AND** Interest rate is *medium* **AND** Advertising is *high*

AND WIG is *medium* **THEN** Selling mortgage in the Internet is *medium* (5)

When the commission for the sold product is small, the interest rate is medium and the stock exchange level (WIG) is medium, it is theoretically possible but highly improbable to invest money in promoting and selling mortgages in these conditions. However it was decided not to delete the rules as the one shown in the above example and use the complete model as in real life people may contradict the logic and common sense.

Whenever expert knowledge and heuristics are applied, it is necessary to provide justification and verification of such application. As this paper establishes technicalities and formal stages of the proposed fuzzy approach to mortgage market modeling, the verification aspect is left for further stages of this research.

3.2. Defuzzification

Defuzzification as the process of producing a quantifiable result is the last step in fuzzy logic based modelling process, and it delivers crisp output values. The Height Method (also know as Max-membership principle) was used in this step [4], [5]. This method has numerous advantages, the most important of which is the fact that the shape of the membership function has no influence on defuzzification and that it does not require complicated calculations. Some examples of the obtained crisp results are presented in Figure 2.

2	AND	Interest ra	is	0,2	AND	Advertisin	is	0,1	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0,0032	
3	AND	Interest ra	is	0,8	AND	Advertisin	is	0,1	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0,0128	
4	AND	Interest ra	is	0,8	AND	Advertisin	is	0,1	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	small	0,0512	
5	AND	Interest ra	is	0	AND	Advertisin	is	0,1	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
6	AND	Interest ra	is	0	AND	Advertisin	is	0,1	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	small	0	
7	AND	Interest ra	is	0	AND	Advertisin	is	0,1	AND	WIG	is	0	THEN	Selling mortgage in th	is	small	0	
8	AND	Interest ra	is	0,2	AND	Advertisin	is	0,9	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	small	0,1152	
9	AND	Interest ra	is	0,8	AND	Advertisin	is	0,9	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0,1152	
10	AND	Interest ra	is	0	AND	Advertisin	is	0,9	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
11	AND	Interest ra	is	0	AND	Advertisin	is	0,9	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	small	0	
12	AND	Interest ra	is	0,8	AND	Advertisin	is	0	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
13	AND	Interest ra	is	0	AND	Advertisin	is	0	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
14	AND	Interest ra	is	0,2	AND	Advertisin	is	0,1	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0,0008	
15	AND	Interest ra	is	0,8	AND	Advertisin	is	0,1	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0,0032	
16	AND	Interest ra	is	0,8	AND	Advertisin	is	0,1	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	small	0,0128	
17	AND	Interest ra	is	0	AND	Advertisin	is	0,1	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
18	AND	Interest ra	is	0	AND	Advertisin	is	0,1	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	small	0	
19	AND	Interest ra	is	0	AND	Advertisin	is	0,1	AND	WIG	is	0	THEN	Selling mortgage in th	is	small	0	
20	AND	Interest ra	is	0,8	AND	Advertisin	is	0,9	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0,0288	820
21	AND	Interest ra	is	0	AND	Advertisin	is	0,9	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
22	AND	Interest ra	is	0	AND	Advertisin	is	0,9	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	small	0	
23	AND	Interest ra	is	0	AND	Advertisin	is	0	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
24	AND	Interest ra	is	0,8	AND	Advertisin	is	0,1	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
25	AND	Interest ra	is	0	AND	Advertisin	is	0,1	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	
26	AND	Interest ra	is	0	AND	Advertisin	is	0,1	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	small	0	
27	AND	Interest ra	is	0	AND	Advertisin	is	0,9	AND	WIG	is	0,2	THEN	Selling mortgage in th	is	small	0	0,1152
28	AND	Interest ra	is	0,2	AND	Advertisin	is	0,1	AND	WIG	is	0,8	THEN	Selling mortgage in th	is	medium	0,0128	

Figure 2: *A screenshot from modeling process presenting crisp results of defuzzyfication process.*

The main purpose of applying the three steps of fuzzy modeling process illustrated above (fuzzification, fuzzy inference, defuzzification) was to test the possible applicability of purely technical aspects of the process. It was necessary to do this as the proposed in this appear application of fuzzy modeling has never been tested and reported in literature before.

3.3. GUI

For the created model there was made a Graphic User Interface. A user friendly visual application would help users to operate the model without making it necessary to understand the complexities of fuzzy modeling or advanced options of modeling platform. The actual platform used popular MS Excel software and all necessary coding was written in Visual

Basic. The user simply enters the required model input data (the 4 variables described in previous Chapters of the paper) and is eventually presented the model output

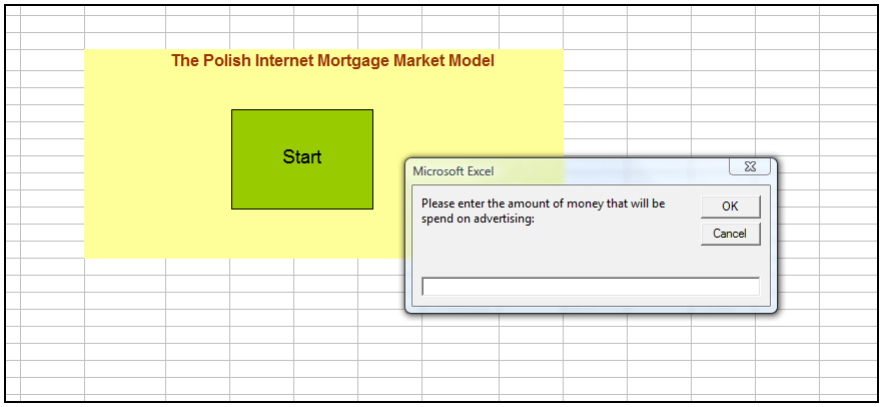

Figure 3: *A screenshot from modeling process presenting Graphic User Interface*

4. Conclusion and future works

This paper presents the idea of using the fuzzy modeling in the area of selling financial products in the Internet, concentrating on creating the special model for the partner web pages selling mortgages in the Polish Internet. This seems to become more and more important area due to the growing number of financial products which are sold in the internet and the necessity of planning these selling processes.

The first part of the paper describes the situation, processes and the main problems on the Polish Internet mortgage market. Later there is presented the idea of the solution, special model which help predicting the number of sold mortgages in case of current situation and indicators. First there was created a rule based model which was later modified in subsequent steps and finally fuzzyfied. The fuzzy process is presented in three steps: fuzzification, fuzzy inference, and defuzzification.

Now the model is being tuned. This process is basing on the ~20000 records from the years 2003-2010. One of the authors has been an owner of the partner web page and has gained the data representing all market conditions (grow, boom, crisis) and this data is being used now to tune the model.

To meet the ultimate aims of this research it will be necessary to create the group of three sub-models each one tailored for general economical circumstances that can be experienced; recession, moderate growth and fast growing market. Based on the past results it can be concluded that creation of one comprehensive model does not give proper results when the market changes. Each sub-model will have specific set of variables and their values due to the fact that in different market situations different indicators become important. This was confirmed very strongly by the last financial crisis 2008-2010.

The final research steps will include the process of verification and fine tuning of proposed models. For verification purposes it is planned to use the 2003-2010 data of one of the biggest polish internet brokers that would cover all three basic market situations: recession, moderate growth and economic boom.

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