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The hybrid fuzzy - SOEKS approach to the Polish Internet mortgage market

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Abstract

The paper presents the hybrid fuzzy- SOEKS approach to the Polish Internet mortgage market, which is treated as an example of a fast changing market. Firstly, the market and market problems are described. Then, the first approach to the market problems is presented: the complete fuzzy model which was built basing on the rules. The fuzzy model is presented on one real data case. Next, the new approach, called Set of Experience Knowledge Structure (SOEKS) is adopted and presented basing on the same data. Instead of using data stored in the rules (fuzzy model), the market is presented using the experience stored in SOEKS. Finally, both approaches are compared with regard to their respective advantages and disadvantages, and some future works are described.

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1. Introduction

The Polish Internet mortgage market is an example of a fast changing market that reflects a current economic situation. The authors have been observing the market and have actively participated in it (being one

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of the leading sellers) for more than 8 years, in which time several researches were made and published. First the general rule- based model for the market predictions was created. The model was complete and the aim of it was to help owners of the web pages selling mortgages with the key management functions: prognosis and planning. The initial idea of the model was worked out a few months before the financial crisis of 2008. The created model did not work properly (the prognoses generated by the model were very different from the real results observed on the market in the time of crisis) in the new market situation, so changes had to be introduced into the model.

As the authors decided to change the structure of the model, in particular, altering the number and type of variables used in the it. After several attempts, the obtained results were still not satisfactory, so it was decided to change the type of modeling.

The main challenge facing this market is making accurate predictions concerning the number of mortgages to be sold. Because several variables (quantitative and qualitative) influence the market, traditional statistical methods did not produce expected results, which is important, in case a number of variables, such as "current market feelings", cannot be expressed numerically. As stated in [5] after [6] the complete description of a real-life system often requires far more detailed data than a human being could ever simultaneously recognize, process, or understand, so it was decided to use fuzzy modeling.

A general fuzzy model was about to be created; the model was based on the original idea of developing a single model to represent the market reality. While constructing it, first problems appeared during the process of selecting the variables for the model; it seemed impossible to find variables representing the whole market described by data from various time periods, in which different variables represented the market conditions. Basing on past results (data from the years 2003-2012), one can conclude that the creation of one comprehensive model does not yield proper results, especially when the market changes (as it did in the time of financial crisis). Due to this fact, it was decided to divide the model into three separate sub-models suitable for different market conditions.

Referring to the theory of economic cycles, it was decided to compose a general model consisting of three sub-models representing three main market conditions: a fast-growing market (boom), a recession, and moderate/stable growth, which are the most distinct stages of the economic cycle. As it was important to keep a proper balance between the number of proposed sub-models and the level of differences influencing the market, the three sub-models seemed a proper solution[1]. The fuzzy model which was finally created and verified (replicative and prognostic verification) is presented in Section 2.

As the authors were still trying to enhance the model, the idea of using a new approach appeared. Bearing in minds the imperfections of the fuzzy model (presented in detail below), especially the differences between the output variable and real values observed on the market, the idea of using experience of the users appeared. Consistently, the methodology of Set of Experience Knowledge Structure (SOEKS) seemed to be an interesting option to be used. This new approach (SOEKS) is presented in Section 3. Next, both the fuzzy model and SOEKS approach are compared, the results and future ideas are presented in section 4.

2. The market and fuzzy description

The changeability of the market and lack of tools to support the management processes on the Polish Internet mortgage market (especially those for prognosis) pushed the authors towards the idea of creating a model dedicated to supporting decision-making on the market.

The Polish Internet mortgage market consists of 4 main sectors: banks, brokers, partner web pages and customers. Banks are institutions that sell mortgages and offer the option to apply for them on their own web pages[7]. Because the market is substantial in size and is characterised by fierce competition, banks allow their partners to sell their financial products on the partners' web pages in order to generate bigger sales. They act as

typical brokers that receive commission for each product they sell. Moreover, they promote and sell bank products on their pages, but also create a network called a "partner system", which allows the owners of small web pages to sell bank products on their own pages. Because the owners of private web pages do not sell enough products to cooperate directly with banks, they associate with brokers. For each product sold on a partner web page, its owner receives a commission from the broker, who in turn gets his from the bank.

There is a need to support management processes of the partner web pages, as currently there are around 16 000 web pages of that kind, with no, or very limited tools supporting their management processes. The next sections present the ideas of the fuzzy model and SOEKS dedicated to that group of entrepreneurs. Next the fuzzy description for described market is going to be presented.

For the market presented above, the complete fuzzy model was created. The process of building a fuzzy model was presented in three steps: fuzzification, fuzzy inference**,** and defuzzification[12]. Example explaining some parts of the fuzzy inference process can be found below:

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.

The details of the fuzzification, fuzzy inference and defuzzification were presented by the authors in[14].

The model consisted of three sub-models, which will be presented later in this section. In the process of fuzzy model development the production rule base, consisting of 81 production rules, was used. The number of rules comes from the number of variables (four, presented in the production rule) in the model and values of these variables (three linguistic values for each variable) [8] .

Each rule in the rule base is developed using the IF... THEN logical construct consisting of four variables as in the following example[11] :

Production Rule:

IF Commission is *small* **AND** Interest rates are *small* **AND** Advertising is *small* **AND** WIG is *small* **THEN** Selling mortgage in the Internet is *small*

To develop and train the inference engine for our case, the specification of values of output variables for the existing 81 production was necessary[9]. As it was not possible to automatically generate the output values, the expert market knowledge was used for this purpose. For defuzzyfiaction, the Height Method (also known as Max-membership principle) was used. Finally the fully developed fuzzy model was created, and basic tests were made[2].

When the model was completed and divided into three sub-models (as described above) it turned out that it needed to be tested. Basing on the data records (more than 10 000) there was replicative verification done. Next, in cooperation with leading market mortgage seller, Bankier.pl, prognostic verification was done.

The subsequent part of the paper presents an example of one sub-model (fast growing market) with a real input market data.

All the created and verified sub-models are to be found in[1]. Because of the need to compare two different approaches, the authors decided to choose one sub-model for the fast-growing market, which was verified with the greatest number of cases (different input data) to be presented below.

The market situation called "fast-growing market" was observed on the Polish mortgage market between the third quarter of 2006 and the end of 2007. Below (table 1) it will be verified against the data recorded at that time (real input data from October 2006.)

Table 1. Data from October 2006

3. Variable	4. Value
5. Commission	**6. 0,58%**
7. Interest rate	**8. 4%**
9. Advertising	**10. 600 PLN**
11. WIG	**12. 47393 points**
13. Average mortgage value	**14. 155524 PLN**

For the presented input values, three evaluations were made. In the first one, the granulation level was set at 3, and 243 rules were generated. The model produced the output variable (Selling mortgage in the Internet) of 1443,65 PLN (currency, polish złoty), which was 15,7% lower than the real value recorded at that time.

The second test was based on the same input variables, but the granulation level was set at 4, and 1024 rules were generated. The model generated the output variable of 1560,87 PLN, which was 8,8% lower than the real value recorded at that time.

The third test was based on the same input variables, but the granulation level was set at 5, and 3125 rules were generated. The model gave the output variable of 1656,85 PLN, which was 3,3% lower than the real value.

It can be concluded that a difference of 10% and lower is quite acceptable, which means that the granulation levels of 4 and 5 seem to be proper for future research[1]. However, the results are much different depending on the granulation level, which is a problem for the user of the fuzzy model. The results can be compared with real data but only after the user has adapted the input variables in the real business usage (e.g. the user will spend the exactly declared amount of money on advertising). The problem is that when results are finally compared with real market data only observation can be done because the knowledge gained in that way does not support the fuzzy model in the future works. Due to that the authors decided to try to use a different approach which is presented in the next section.

3. SOEKS - the new approach to the market

The approach presented above was created, fully tested and might still be improved in the future, but the authors started considering the option of using other approaches to the same market situation. One of the most valuable intellectual assets seems to be the experience accumulated during processes and experience acquired in while making a decision[4] . Thus the idea of incorporating the element of experience in the model became appealing while observing the market, and the reaction of previously used model. Even Albert Einstein said that "The only source of true knowledge is experience." [1] 3.

The Set of Experience Knowledge Structure (SOEKS) is "… a model based upon existing and available knowledge, which must adjust to the decision" [3] It has been developed to store formal decision events in an explicit way. In SOEKS, there are four basic components that surround decision making events: variables, functions, constraints, and rules. These are combined to represent a formal decision event. "Set of experience can be used in platforms to support decision-making, and new decisions can be made based on sets of

experience." [3] . The idea seemed to be the answer to what the authors were looking for so basing on SOEKS, the new approach to the internet knowledge market is going to be presented.

SOEKS requires a different outlook at the process, as the fuzzy model required full, completely defined model, here it is going to be presented with respect to the four basic components of which SOEKS consists.

As it was presented above, one of the SOEKS elements are variables. Because SOEKS is going to represent the same market situation (fast growing market) as the previously defined fuzzy model, the authors were wondering which variables are to be taken into consideration. The variables are supposed to represent the market in current conditions. The whole process of choosing and verifying variables representing the fast growing market was done and presented in the previous papers [5], [10] of the authors. Due to that they decided to use the same input variables which are presented below (Table 2).

Table 2. SOEKS – variables

Variable_1 = [Advertising]	The input variable "advertising" presents the amount of money spent on advertising mortgage by the owners of private web pages. In theory: the more money is spent on advertising, the higher the value is of sold mortgages is.
Variable_2 = [Commission]	The input variable "commission" presents the percentage of the mortgage value that the seller receives as a salary for sold mortgage. The higher the commission is, the higher output variable (selling mortgage in the Internet) should be: ceteris paribus.
Variable_3 = [WIG]	WIG is Warsaw Stock Exchange's main indicator. It was assumed that the higher its value is and the more it tends to grow, the higher is the expected value of mortgages sold (output value).
Variable_4 = [Average_Mortgage_Value]	The input variable presents the average value of mortgages sold in presented time period. The higher the average value is the higher output variable should, ceteris paribus.
Variable_5 = [Interest rate]	The higher the interest rate, the lower the amount of mortgages sold should be (output variable).
Variable_6 = [Selling mortgage in the Internet]	The output variable represents the value of sold mortgages in a given period of time. The result is presented in Polish zloty (PLN).
Variable_7 = [Assessment]	The variable which is added to each group of variables (variable 1-6);it is added by the user of the model when the real results can be compared with the results foreseen by the model. The user comments the relationship between the expected result and the real result observed on the market.

Comparing SOEKS with the previously presented fuzzy model, the authors decided to add another variable: "assessment" to the group of variables represented in SOEKS. This variable is described by the expert when the real recorded data about the number of sold mortgages are avoidable, the expert estimates how well the prognosis fits the real results and that is included in variable "assessment". Here the users experience is going to be stored. Next rules included in SOEKS are going to be presented.

Below, an example of the rule which the SOEKS consist of, is presented . It is typical IF THEN rule, including five input variables (described above), one output variable (variable_6 described above as well). In the process of SOEKS creation another output variable is added (variable_7); consistently, there are two output variables and five input variables.

The number of rules depends on the number of observation from which the experience is gained. In the presented case, four rules are presented.

IF	Z1	Z1	Z1	Z4	Z5	THEN	Z3

Z1-Z5 represents values of variables (input variables 1-5 and output variable 6)
Finally, when variables and rules are described, constraints and functions in SOEKS need to be presented.

In the discussed case no constraints and no functions were taken into consideration, as there was no need to define formal constraints for the presented market situation. The SOEKS structure allows for no constrains or functions

The next SOEKS to be presented was created for the same market situation as the fuzzy model presented in the previous section. To make the comparison of both SOEKS and fuzzy model possible the same input data (October 2006) were used.

Case presented in Table 3 has one rule used, always the same input values of variables (variable 1-5) but each time a different output value of variable (variable_6) was recorded - rules become contradictory. Because of that, 4 rules in one SOEKS were recorded. Contradictory rules are unacceptable in fuzzy models but are accepted in SOEKS, because the main goal of SOEKS is to store experience. Consistently, variable_7 was used, the user of SOEKS for the same values of input variables has four different values of output variables, to each of the results there is an assessment added. Basing on the assessment, the users' experience is stored because each value of output variable (variable_6) has a comment how true the prognosis was.

Table 3. SOEKS – data from October 2006

Input variables					**Output variables**	
variable_1	variable_2	variable_3	variable_4	variable_5	variable_6	variable_7
Advertising (PLN)	Commission (%)	WIG (points)	Average_mortgage_market (PLN)	Interest rate (%)	Selling mortgage in the Internet (PLN)	Assessment
600	0,58	47393	155524	4	1712,99	True
600	0,58	47393	155524	4	1443,75	Very low
600	0,58	47393	155524	4	1560,87	Low
600	0,58	47393	155524	4	1656,85	Too low

Variable_7 can be added after the time, when real market data are available. Due to that the experience can be gained, when the time for which the prognosis (variable_6) was made, passed. It cannot be used for that time period (because it passed) but it might be used in the future when the same or similar market conditions will appear and basing on gained experience (stored in variable_7) the SOEKS user will choose the proper set of variables (1-6).

4. Conclusions and future works

The present paper describes Polish Internet Mortgage Market using two approaches: a dedicated fuzzy model and a specially created Set Of Experience Knowledge Structure (SOEKS).

The fuzzy model consists of three sub-models, up to five variables and 3125 rules (this is a complete model). The result of every rule is an output variable which presents the predicted value of sold mortgages in the selected time period. The rules in the model are not contradictory, which means that each rule can have only one output variable. Having one possible output variable makes the usage of the model easy, as it does not require any evaluation of the results or checking any other data. However, the same aspect has its disadvantages: if the output variable is not similar to the real result observed on the market, the user can only try to change the model structure; there is no possibility of storing the experience gained from the comparison of real life results with those generated by the model. Thinking about changing model structure it is possible to set different granulation level and based on that the number of rules that are generated.

The idea of using experience rather than fuzzy model was possible to be implemented using Set of Experience Knowledge Structure (SOEKS), which consists of four components: variables, rules, functions and constraints. However, not all of them have to be included in SOEKS. For the Polish internet mortgage market no functions or constraints were defined. The presented example of SOEKS consists of four rules, each with the same input variables but different output variable (value of sold mortgages), and an extra variable which is defined when the real values from the market are available; a variable assessment presents the difference between real results and the results which were foreseen. In this way experience is stored in SOEKS and it also marks the main difference between the fuzzy model and SOEKS.

Both the fuzzy model and SOEKS were presented for the same market – Polish Internet Mortgage Market. By definition, SOEKS makes it possible to store the experience, but there arises a question: how the experience might be used. If for the same input data, four different results are obtained, and an additional variable stating how true the result was still the decision has to be taken by the SOEKS user. The proper use of SOEKS requires also regular checking of the real values which were observed on the market, looking back at the rules which were created and adding variable “assessment”, which is time consuming.

The fuzzy model does not include the component ‘experience’ but presents the user only one result, which can be easily used by anybody on the market, as it does not require any special knowledge on the part of the user. If the fuzzy model produces results (output variables) which are too different from real values, changes need to be introduced into the model by the expert who created it, but later it can be used by anybody.

It seems to be very interesting to match functions from both, the fuzzy model and SOEKS, in order to make it possible that basing on the stored experience, model by itself will present one output variable (variable_6) which will not require any special knowledge from the user. Bearing in mind that the model is dedicated to a mass customer (more than 16 000 potential users), it is important to build the tool which does not require expert knowledge from the user, so future works will concentrate on matching the functions of SOEKS and the fuzzy model.

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