

# Banks Financial State Analysis and Bankruptcy Forecasting

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*Abstract- The problem of Ukrainian banks financial state forecasting under uncertainty is considered. For its solution fuzzy methods: fuzzy neural networks TSK, ANFIS and Fuzzy group method of data handling (FGMDH) are suggested. For estimation of their efficiency the numerous experiments were carried out using as input data financial indices of 170 Ukrainian banks. For estimation of the efficiency of the suggested methods they were compared with conventional methods: Kromonov's and aggregated multilevel index of bank state. During experiments the most adequate financial indices for banks bankruptcy forecasting were detected.*

**Index Terms** — banks financial state, bankruptcy risk, forecasting, fuzzy neural networks, fuzzy GMDH.

## I. INTRODUCTION

In a modern economy problem of banks financial state analysis and possible bankruptcy forecasting plays the significant role. The timely detection of features of coming bankruptcy enables top bank managers to adopt urgent measures for stabilizing financial bank state and prevent the bankruptcy. Up to the date there are a lot of methods and techniques of banks state analysis and determination of bank rating- WEB Money, CAMEL, Moody's S&P etc. [1,2]. But their common drawback is that all of them work with complete and reliable data. and cannot give correct results in case of incomplete and unreliable input data. This is especially actual for Ukrainian bank system where bank managers often provide the incorrect information about their financial indices that to obtain new credits and loans.

Due to aforesaid it's very important to develop new approach and technique for banks bankruptcy risk forecasting under uncertainty. The main goal of this paper is to develop and investigate novel methods of bank financial state analysis and bankruptcy forecasting under uncertainty and compare with classical conventional methods and approaches.

For implementation of this goal the quarterly data reports of main Ukrainian banks were used in the periods preceding the financial crisis of bank system in 2009.

As it is well known 2008 year was the crucial year for bank system of Ukraine. If the first three quarters were periods of fast grow and expansion the last quarter became the period of collapse in the financial sphere. A lot of Ukrainian banks faced the danger of coming default.

For our research the quarterly accountancy bank reports were used obtained from National bank of Ukraine site [1]. For analysis the financial indices of 170 Ukrainian banks were taken to the date 01.01. 2008 and 01.07.2009, that is about two years before crises and just before the start of crises.

The important problem which arose before start of the investigations is which financial indices are to be used for better forecasting of possible bankruptcy. Thus, another goal of this exploration was to determine the most adequate financial indices for attaining maximal accuracy of forecasting.

For analysis were taken the following indices of banks accountancy

- Assets;
- Capital.
- financial means and their equivalents;
- Physical persons entities;
- juridical persons entities;
- liabilities;
- Net incomes (losses).

The collected indices were utilized for application by fuzzy neural networks as well as classic crisp methods – method by Kromonov and method developed by association of Byelorussian banks. As output data of models for Ukrainian banks were two values:

- 1, if the significant worsening of bank financial state is not expected in the nearest future;
- -1, if the bank bankruptcy or introduction of temporary administration in bank is expected in the nearest future.

## II. THE APPLICATION OF FUZZY NEURAL NETWORKS FOR FINANCIAL STATE FORECASTING

For forecasting of banks bankruptcy risk it was suggested the application of fuzzy neural networks (FNN) ANFIS and TSK [3]. The application of FNN is determined by their advantages:

- 1) The possibility to work with incomplete and unreliable information under uncertainty;
- 2) The possibility to use expert information in the form of fuzzy inference rules.

A special software kit was developed for FNN application in forecasting problems enabling to perform Ukrainian banks financial state analysis using ANFIS and TSK.

As input data the financial indices of Ukrainian banks financial accountant reports were used in the period of 2008-2009 years [1]. As the output values were +1, for bank-non-bankrupt and -1 –for bank-bankrupt. In the investigations different financial indices were used, different number of rules for FNN and the analysis of data collection period influence on forecasting accuracy were performed.

**Comparative analysis of FNN ANFIS and TSK**

The results of experimental investigations of FNN application for banks financial state analysis are presented below. In the first series of experiments input data at the period of January 2008 were used (that is for two years before possible bankruptcy) and possible banks bankruptcy was analyzed at the beginning of 2010 year.

*Experiment №1.*

Training sample- 120 Ukrainian banks,

Test sample- 50 banks;

Number of rules = 5.

Input data – financial indices (taken from bank accountant reports)

- Assets;
- Capital;
- Cash (liquid assets);
- Households deposits;
- Liabilities.

The results of application of FNN TSK are presented in Table 1.

**Table 1. Results of FNN TSK forecasting**

<b>Results:</b>	
Total amount of errors	5
%% of errors	10%
First type of errors	0
Second type of errors	5

*Experiment №2.*

Training sample- 120 Ukrainian banks;

Test sample- 50 banks;

Number of rules = 5.

Input data – financial indices the same as in the experiment 1.

The results of application FNN ANFIS are presented in the Table 2.

**Table 2. Results of FNN ANFIS forecasting**

<b>Results</b>	
Total amount of errors	6
%% of errors	12%
First type of errors	0
Second type of errors	6

As one can see comparing results of Table 1 and 2, neural network TSK gives more accurate results than FNN ANFIS.

*Experiment №3.*

The next experiment was aimed at the detecting of influence of rules number on the forecasting results.

Training sample- 120 Ukrainian banks;

Test sample- 50 banks;

Number of rules = 10.

Input data – the same financial indices as in experiment 1.

The results of application of FNN TSK are presented in the table 3.

**Table 3. Results of FNN TSK forecasting**

<b>Results:</b>	
Total amount of errors	6
%% of errors	12%
First type of errors	1
Second type of errors	5

The similar experiments were carried out with FNN ANFIS

*Experiment №4.*

The next experiment was aimed at the detecting of influence of rules number on the forecasting results.

Training sample- 120 Ukrainian banks, test sample- 50 banks.

Number of rules = 10.

Input data – financial indices the same as in experiment 1

The results of application of FNN ANFIS are presented in the table 4.

**Table 4. Results of FNN ANFIS forecasting**

<b>Results:</b>	
Total amount of errors	7
%% of errors	14%
First type of errors	1
Second type of errors	6

The comparative analysis of forecasting results versus the number of rules is presented in the table 5.

**Table 5. Comparative analysis of FNN ANFIS and TSK in dependence on rules number**

Network / number of rules	Total amount of errors	% of errors	Amount of 1 type errors	Amount of 2 type errors
Anfis 5	6	12%	0	6
Anfis 10	7	14%	1	6
TSK 5	5	10%	0	5
TSK 10	6	12%	1	5

The next experiments were carried out aimed at investigation of influence of training and test samples size on accuracy of forecasting.

*Experiment №5.*

Training sample- 120 Ukrainian banks;

Test sample- 70 banks;

Number of rules = 10.

Input data – financial indices:

- Assets:
- Entity:
- Cash (liquid assets):
- Households deposits:
- Liabilities.

The results of FNN TSK are presented in the Table 6.

**Table 6 . Results of FNN TSK forecasting**

<b>Results:</b>	
Total amount of errors	7
%% of errors	10%
First type of errors	1
Second type of errors	6

The similar experiment was carried out with FNN ANFIS Experiment №6.

Training sample- 120 Ukrainian banks;

Test sample- 70 banks;

Number of rules = 10.

Input data – financial indices are the same as in the experiment 5.

The results obtained with FNN ANFIS are presented in the Table 7.

**Table 7. Results of FNN ANFIS forecasting**

<b>Results:</b>	
Total amount of errors	7
%% of errors	10%
First type of errors	0
Second type of errors	7

After analysis of the presented experimental results the following conclusions were made:

1. FNN TSK gives more accurate forecasting than FNN ANFIS.

2. The variation of the number of rules in the training and test samples doesn't influence on the accuracy of forecasting.

The next series of experiments was aimed at determining optimal input data (financial indices) for forecasting. The period of input data was January 2008.

*Experiment №7.*

Training sample- 120 Ukrainian banks,

Test sample- 70 banks;

Number of rules = 10.

Input data – financial indices (banks financial accountancies reports):

- Profit of current year;
- Net percentage income ;
- Net commission income;
- Net expense on reserves;
- Net bank profit / losses.

The results of FNN TSK application are presented in the Table 8.

**Table 8. Results of FNN TSK forecasting**

<b>Results:</b>	
Total amount of errors	13
%% of errors	19%
First type of errors	6
Second type of errors	7

*Experiment №8.*

Training sample- 120 Ukrainian banks;

Test sample- 70 banks;

Number of rules = 10.

Input data – financial indices (banks financial accountance reports):

- General reliability factor (Own capital / Assets);
- Instant Liquidity Factor (Liquid assets / Liabilities);
- Cross-coefficient (Total liabilities / working assets);
- General liquidity coefficient ( Liquid assets + defended capital + capitals in reserve fund / total liabilities) ;
- Coefficient of profit fund capitalization (Own capital / Charter fund)

The results of application of FNN TSK arte presented in the Table 9.

**Table 9. Results of FNN TSK forecasting**

<b>Results</b>	
Total amount of errors	7
%% of errors	10%
First type of errors	1
Second type of errors	6

Note that these financial indices are used as input data in Kromonov's method of banks bankruptcy [1], results of its application are considered below.

*Experiment №9.*

Training sample- 120 Ukrainian banks;

Test sample- 70 banks;

Number of rules = 5.

Input data – financial indices :

- ROE – Return on Entity (financial results / entity);
- ROA – Return on Assets (financial results / assets);
- CIN – incomes- expenses ratio (income / expense);
- NIM – net percentage margin;
- NI – net income.

The results of application of FNN TSK for forecasting with these input indices are presented in the table 10.

**Table 10. Results of FNN TSK forecasting**

<b>Results:</b>	
Total amount of errors	12
%% of errors	17%
First type of errors	5
Second type of errors	7

It should be noted that these indices are used as input data in method of EuroMoney [1].

*Experiment №10.*

Training sample- 120 Ukrainian banks;

Test sample- 70 banks;

Number of rules = 5.

Input data – financial indices (banks financial accountance reports):

- General reliability factor (Own capital / Assets);
- Instant Liquidity Factor (Liquid assets / Liabilities);
- Cross-coefficient (Total liabilities / working assets);
- General liquidity coefficient ( Liquid assets + defended capital + capitals in reserve fund / total liabilities);
- Coefficient of profit fund capitalization (Own capital / Charter fund);
- Coefficient entity security (Secured entity/ own entity).

The results of FNN TSK application with these financial indices are presented in the table 11.

**Table 11. Results of FNN TSK forecasting**

Results	
Total amount of errors	8
%% of errors	13%
First type of errors	1
Second type of errors	7

It should be noted these indices are also used in Kromonov's method. The comparative analysis of forecasting results using different sets of financial indices are presented in the table 12.

**Table 12. The dependence of forecasting accuracy on the sets of input financial indices**

Experiment	Total number of errors	%% of errors	1 type of errors	2 type of errors
Experiment № 5	7	1	6	10%
Experiment № 8	7	0	7	10%
Experiment № 9	12	5	7	17%
Experiment № 10	8	1	7	13%

Further the series of experiments were carried out aimed on determination of influence of data collection period on the forecasting results. It was suggested to consider two periods: January of 2008 ( about 2 years before the crisis ) and July of 2009 ( just before the start of crisis).

*Experiment №11.*

Training sample- 120 Ukrainian banks;

Test sample- 70 banks;

Number of rules = 10.

Input data – financial indices (banks financial accountance reports):

- General reliability factor (Own capital / Assets);
- Instant Liquidity Factor (Liquid assets / Liabilities);
- Cross-coefficient (Total liabilities / working assets);
- General liquidity coefficient ( Liquid assets + defended capital + capitals in reserve fund / total liabilities)
- Coefficient of profit fund capitalization (Own capital / Charter fund)

In the table 13 the comparative results of forecasting in dependence on period of input data are presented.

**Table 13. Accuracy of forecasting in dependence on data collection period**

Experiment/ number of rules	Total amount of errors	1 type of errors	2 type of errors	Total % of errors
01.01.2008 5 rules	7	0	7	10%
01.07.2009 5 rules	5	0	5	7%
01.07.2009 10 rules	7	3	4	10%

### III. THE APPLICATION OF FUZZY GMDH FOR FINANCIAL STATE FORECASTING

In the process of investigations fuzzy Group Method of Data Handling (FGMDH) was also applied for financial state of Ukrainian banks forecasting [3,4]. As input data the same indices were used as in the experiments with FNN TSK. As an output variable was variable  $\{-1,+1\}$ , where +1 means bank with good financial state, while -1 denotes bank with bad financial state ( potential bankrupt). In our work as a threshold we chose the middle of the output interval. In the table 14 the corresponding results are presented in dependence on input data period.

**Table 14. Comparative results of forecasting using method FGMDH in dependence on period of input data collection**

Input data period	Total error number	%% of errors	1 type of errors	2 type of errors
2004	10	14%	3	7
2005	9	13%	3	6
2006	8	11,4%	3	5
2007	7	10 %	2	5
2008	6	8,5%	1	5
2009	6	8,5%	2	4

If to compare the results of FGMDH with the results of FNN TSK one can see that FNN TSK gives better results if we use the input data for one year before possible bankruptcy while FGMDH gives better results using older input data and has advantages in long-term forecasting ( 2 or more years).

### IV. THE APPLICATION OF CONVENTIONAL METHODS FOR FINANCIAL STATE FORECASTING

In order to compare the results of application of fuzzy methods for banks financial state forecasting the conventional crisp methods were implemented. As the crisp methods of banks state analysis the so called Kromonov's method and aggregated multilevel index of bank state method developed by the Byelorussian banks association [2] were used.

**The results of Kromonov's method application**

In the first experiment the application of Kromonov's method was performed using quarterly data of Ukrainian banks at the beginning of 2008 year and checking the forecast on the middle of 2009 year using data of bank bankruptcy or introducing the temporary administration. The goal of the experiments was the exploration of influence of input data period on the forecasting quality. The results of analysis are presented in the Table 15.

**Table 15. Kromonov's method application results in dependence of data collection period**

	01.01.2008	01.07.2009
Total number of errors	34	24
%% of errors	20%	15%
1 type errors number	18	12
2 type errors number	16	12
Test sample size	170	170

As one may see the Kromonov's method gives false forecast for 34 banks of total number 170 that is 20 % of error when using the data on 01.01.2008r. While false forecast for 24 banks of 170 ( 15% of errors ) using the data on 01.07.2009. So the considerable improvement of forecasting accuracy using more fresh data is obtained. And this is not surprising. The types of errors were distributed uniformly in both cases.

**The results of application of aggregated multilevel bank state index method**

The second experiment in this series was the application of method developed by Byelorussian bank association (BBA) for bankruptcy risk forecasting using the Ukrainian banks quarterly data on the beginning of 2008 year and checking of the forecasting accuracy in the middle of 2009. Experimental results are presented in the Table 16

**Table 16. Byelorussian bank association method results using data on 01.01.2008 and 01.07.2009.**

	01.01.2008	01.07.2009
Total number of errors	27	24
%% of errors	16%	15%
1 type errors number	12	4
2 type errors number	15	20
Test sample size	170	170

As one may readily see in the table 16 Byelorussian bank association (BBA) method gives false forecast for 27 banks of 170 that is 16% of errors. This result for the data on the beginning of 2008 year is more preferable than Kromonov's method which had 20% of errors on this data. There are slightly more errors of the second type (15) as compared with first type of errors (12). Using data of the middle of 2009 year BBA method gives the false forecast for 24 banks (15%) that coincides with results of Kromonov's method.

**V. THE GENERALISED ANALYSIS OF CRISP AND FUZZY FORECASTING METHODS**

In the concluding experiments the comparative analysis of application of all the considered methods were carried out. The following methods were considered:

- Fuzzy neural network ANFIS;
- Fuzzy neural network TSK;
- Kromonov's method;
- Byelorussian bank association method .

As input data were entered the financial indices of Ukrainian banks on July 2007 year. The results of application of all methods for bankruptcy risk analysis are presented in the Table 17.

**Table 17. Comparative results analysis of various forecasting methods**

Method/ period)	Total amount of errors	%% of errors	1 type errors	2 type errors
ANFIS	7	10%	1	6
TSK	5	7%	0	5
Kromonov's method	10	15%	5	5
BBA method	10	15%	2	8

**VI. CONCLUSIONS**

Various methods for banks financial state forecasting were considered and investigated. The following methods were considered:

- Fuzzy neural network ANFIS;
- Fuzzy neural network TSK;
- Kromonov's method;
- Byelorussian bank association method.

As the input data the financial indices of Ukrainian banks were considered.

1. While experiments the adequate input financial indices were detected with which the best forecasting results for Ukrainian banks were obtained:

- General reliability factor (Own capital / Assets);
- Instant Liquidity Factor (Liquid assets / Liabilities);
- Cross-coefficient (Total liabilities / working assets);
- General liquidity coefficient ( Liquid assets + defended capital + capitals in reserve fund / total liabilities);
- Coefficient of profit fund capitalization.

2. It was established that FNN TSK gives much more accurate results than FNN ANFIS. The variation of rules number in training sample doesn't influence on forecasting results. While comparing the fuzzy forecasting methods it was established FNN give more accurate forecasting with more fresh data, that is are preferable for short-term forecasting.



The fuzzy GMDH gives better results using older data that is, more preferable for long-term forecasting (two or more years).

3. In general, the comparative analysis had shown that fuzzy forecasting methods and techniques give better results than conventional crisp methods while forecasting bank financial state and bankruptcy risk. But at the same time the crisp methods are more simple in implementation and demand less time for their adjustment.

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