Olha Kozmenko (Ukraine), Olha Kuzmenko (Ukraine)

Modeling the stability dynamics of Ukrainian banking system

Abstract

The article is stressed on the stability indicator of the banking system as binary variable, which takes a single value in unstable condition and non-zero value otherwise. It is offered to explore stability dynamics of Ukrainian banking system as time series, suggested to perform stability indicator on the basis of stationary time series verification by adaptation of the Forster-Stewart method to the peculiarities of the research subject. In the article it is relevant to identify the main factors of stability indicator formation, realize decomposition of a system - forming components of the variable to be explained on the base of autoregression trend-seasonal additive or multiplicative models.

Keywords: stability index of the banking system, stability dynamics, time series, decomposition analysis, regression analysis.
JEL Classification: G10, G21.

Introduction

Liberalization of economic relations and expansion of globalization caused the rapid development of consumer and financial markets. At the same time, mentioned factors adversely affected the financial market and its segments, especially the banking system, because banks play the most important role in the financial market and are major financial intermediaries in our country. Besides, the fluctuation in banking sector can also be the reason of economic circumstances instability in the country. Therefore, it raises the question of necessity to carry out research and develop economical mathematical model, which could make possible to identify the factors of banking system stable development and find out the mechanism of its regulation on the basis of regression and decomposition analysis.

1. Research results

Modern literary analysis in the context of the banking system stability detection and evaluation [2, 5, 10, 13, 15] allows to systematize the existing approaches and consider this category as the ability of the system to maintain stable basic characteristics in time in condition of insignificant market fluctuation, to accept and resist the influence of external factors adequately, and to maintain the condition of a long-term dynamic equilibrium [1.12, 1.14]. Based on the above-mentioned approach, it is suggested to transform the stability of the banking system as its ability to maintain state for a long-term dynamic equilibrium. Therefore, the purpose of this article is modeling the dynamics and forecasting stability of the banking system on the example of Ukraine.

Achieving this purpose involves the formulation and solution of the following objectives:

- offer a quantitative estimation (indicator) of the banking system stability characteristics;
- identify major factors of the dynamic stability concept formation and explore its main trends and regularitis;
- formalize the relationship between the seasonality (cyclicity) factors of the banking system stability and the integral indicator;
- to determine the influence of the stability indicator on the basic of characteristics of the the banking system functioning;
- forecast the stability of Ukrainian banking system within 2014-2015.

Studying the stability of the banking system requires using the input information base, which consists of the following time-series data [1.6, 1.7]: the equity capital, assets, credits and liabilities, interest incomes and net profit/(loss) during 2009-2012 years in the context of the quarterly data. These statistical data are presented in Table 1.

Let us look at the diagram of dynamics of characteristics indicators of the Ukrainian banking system, presented in Figure 1. In this illustration we can see two scales: the left one is used to display the data in the form of the bar graph, the right one – respectively, in the form of the dynamics schedules. Analysis of above-mentioned figure allows to make conclusions about the oscillation trends regarding such indicators as interest incomes and net profit/(loss), while in the context of other indicators the ongoing trend is observed. The indicated fact can be the cause of violation of the banking system stability of Ukraine.

Table 1. Input information base, thousand UAH

Time period	Equity capital	Credits and liabilities (loans)	Assets	Net profit/loss	Interest income
01.01.2009	119263048	741815978	926086498	7304241	88370294
01.04.2009	117081585	737913200	870633535	-7019821	32440838
01.07.2009	112597492	735094597	864694968	-14321422	61849586

Table 1 (cont.). Input information base, thousand UAH

Time period	Equity capital	Credits and liabilities (loans)	Assets	Net profit/loss	Interest income
01.07.2009	112597492	735094597	864694968	-14321422	61849586
01.10.2009	117968018	747775459	889958533	-20943905	91832989
01.01.2010	120207619	726295788	873449574	-31491841	119083052
01.04.2010	126646323	720948800	874964709	-4423405	28204679
01.07.2010	127162304	719569876	885255711	-8306141	55334622
01.10.2010	132802031	744082347	917497465	-9998904	84739672
01.01.2011	137725113	750536379	942083994	-13026584	113334120
01.04.2011	138434527	768065850	995033185	-210766	28123028
01.07.2011	147816550	789549434	1019811043	-1062004	54907633
01.10.2011	151866259	815319860	1029162518	-5641491	82993044
01.01.2012	155486926	813863749	1054272287	-7707548	113352487
01.04.2012	162236166,3	670016569	1082473105	1724830,4	28027985,26
01.07.2012	163775906,4	676956093,8	1104395259	1552033,4	56296229,75
01.10.2012	165810129,5	686335697,4	1117445882	2775150,2	88377226,86
01.01.2013	170196261,8	694381044,8	1127179379	4898805,5	119278015,7

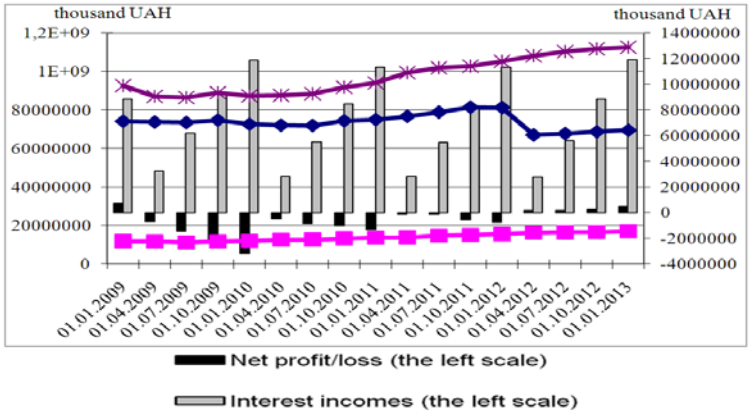

Fig. 1. Diagram of the dynamics of input data indicators

Modeling the dynamics stability of the banking system is suggested to perform on the basis of stationary time series verification by adaptation of the Forster-Stewart method to the peculiarities of the research subject. Therefore, the stationary time series is a process, which is characterized by constant mathematical expectation and variance (without trends), autocorrelation function depends on two subsequent periods of time, but not from a specific time period. It is recommended to analyze the stages of the proposed approach practical implementation in more details with consideration of the mentioned definition.

Stage 1. Creation the research information base by collecting statistical data in the context of the relevant indicators dynamics of quantitative estimation of the stability of Ukrainian banking system (see Table 2); comprehensive analysis of their basic regularities. Such indicators are: the rate of growth of net profit/loss; the capital adequacy of banks, interest margin, ROA (return on assets), ROE (return on equity) (Figure 2).

Table 2. Relevant indicators of quantitative estimation of the Ukrainian banking system stability

	The rate of growth of net profit/loss,%	The capital adequacy of banks, proportion (10^{-2})	Interest margin, proportion (10^{-2})	ROA, proportion (10^{-2})	ROE, proportion (10^{-2})
01.01.2009	-	12.88	11.91	0.79	6.12
01.04.2009	-1.96	13.45	4.40	-0.81	-6.00
01.07.2009	1.04	13.02	8.41	-1.66	-12.72
01.10.2009	0.46	13.26	12.28	-2.35	-17.75
01.01.2010	0,50	13,76	16,40	-3,61	-26,20
01.04.2010	-0.86	14.47	3.91	-0.51	-3.49
01.07.2010	0.88	14.36	7.69	-0.94	-6.53
01.10.2010	0.20	14.47	11.39	-1.09	-7.53
01.01.2011	0.30	14.62	15.10	-1.38	-9.46
01.04.2011	-0.98	13.91	3.66	-0.02	-0.15
01.07.2011	4.04	14.49	6.95	-0.10	-0.72

Table 2 (cont.). Relevant indicators of quantitative estimation of the Ukrainian banking system stability

	The rate of growth of net profit/loss,%	The capital adequacy of banks, proportion (10^{-2})	Interest margin, proportion (10^{-2})	ROA, proportion (10^{-2})	ROE, proportion (10^{-2})
01.10.2011	4.31	14.76	10.18	-0.55	-3.71
01.01.2012	0.37	14.75	13.93	-0.73	-4.96
01.04.2012	-1.22	14.99	4.18	0.16	1.06
01.07.2012	-0.10	14.83	8.32	0.14	0.95
01.10.2012	0.79	14.84	12.88	0.25	1.67
01.01.2013	0.77	15.10	17.18	0.43	2.88

The necessary condition for the application of Forster-Steward method for modeling the stability dynamics of the banking system is the homogeneity of the considered time-series data levels.

Homogeneity means the absence of atypical, anomalous observations, as well as the distortion of the trend. Anomalous level is a separate value of the time series, which does not correspond to the potential of the economic system, being studied, and which, while remaining the level of the time series, has a significant influence on the values of the basic characteristics of the time series. For detection of the anomalous levels of time series it is proposed to use the Irwin method. This method is based on the comparison of the time series neighbor values and the calculation of its characteristics λ_t. The calculated values are compared with the critical value, λ_α and if they do not exceed critical, then the corresponding levels are considered to be normal. In Table 3 the anomalous levels of the studied time series are marked with bold, which should be avoided by calculating the average value among the previous and the next relatively anomalous levels of the corresponding time series.

Table 3. The anomalous levels checking of the studied time series by means of Irwin method

	The rate of growth of net profit/loss, %	The capital adequacy of banks, proportion	Interest margin, proportion	ROA, proportion	ROE, proportion
01.01.2009	-	-	-	-	-
01.04.2009	-	0.80	1.69	1.44	1.50
01.07.2009	1.81	0.60	0.91	0.77	0.83
01.10.2009	0.35	0.33	0.87	0.63	0.62
01.01.2010	0.02	0.71	0.93	1.13	1.04
01.04.2010	0.82	1.00	2.81	2.81	2.80
01.07.2010	1.05	0.15	0.85	0.39	0.38
01.10.2010	0.41	0.15	0.83	0.14	0.12
01.01.2011	0.06	0.20	0.84	0.27	0.24
01.04.2011	0.78	0.99	2.58	1.23	1.15
01.07.2011	3.03	0.82	0.74	0.08	0.07
01.10.2011	0.16	0.37	0.73	0.40	0.37
01.01.2012	2.38	0.01	0.84	0.17	0.15
01.04.2012	0.96	0.34	2.20	0.81	0.74
01.07.2012	0.68	0.22	0.93	0.02	0.01
01.10.2012	0.54	0.01	1.03	0.10	0.09
01.01.2013	0.01	0.37	0.97	0.17	0.15

Obtained anomalous values (in Table 3) can be explained as follows:

- Interest margin, ROA, ROE on 01.04.2009, and the rate of growth of net profit/loss on 01.07.2009 are explained by the beginning of the crisis in the Ukrainian banking system, and getting much smaller or even negative values of profit.
- The anomality of values of interest margin, ROA, ROE on 01.04.2010 can be explained by a certain improvement of the situation in the Ukrainian banking sector, especially the significant reduction of the banks expenses.
- Interest margin on 01.04.2011 is explained by the fourfold decrease of interest incomes in connection with a significant decrease of credit activity of banks. At the same time the anomality of this indicator on 01.04.2012 is connected with the crisis recovery of the national system and the achievement of a much bigger level of interest income compared to the previous period.
- The anomality of values of the growth rate of net profit/loss on 01.07.2011 and 01.01.2012 is linked. In the first case, with the increase in the volume of damage, and in the second case, on the contrary, with the transition of the domestic banking system to the profitable operation.

♦ The comprehensive analysis of time series, presented in Figure 2, allows to determine the main tendencies in change of the national banking system index stability. Therefore, clear linear trend of development is observed in the context of capital adequacy and the return on assets of banking institutions, while the seasonal variations are typical for such indices as interest margin and return on capital. The above-indicated variations of the mentioned indicators cause the oscillation trends in the dynamics of the banking system stability indicator.

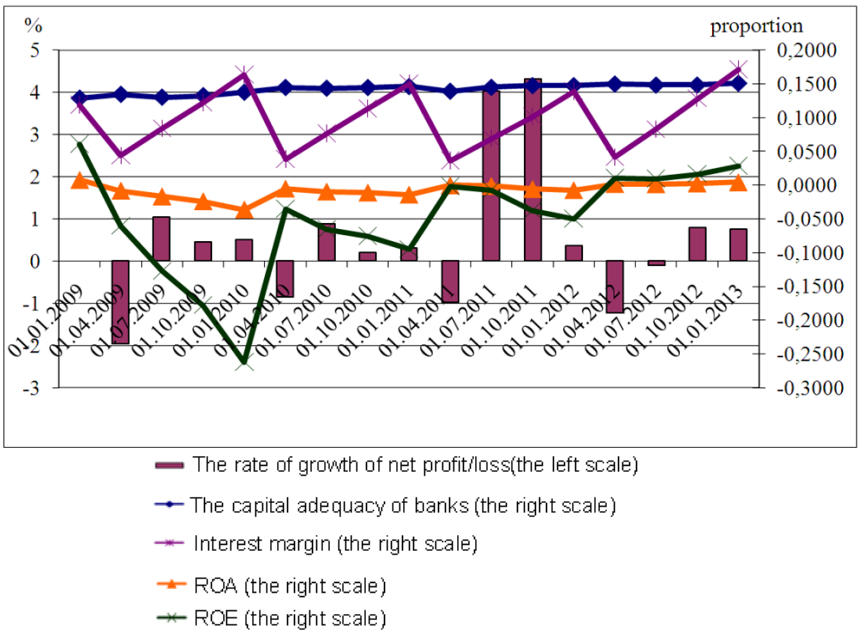

Fig. 2. Diagram of the relevant indicators dynamics of quantitative estimation of the Ukrainian banking system stability

Formalization and quantification of the revealed laws is proposed to realize with the use of mathematical methods by decomposition of the considered time series filtering trend ($F(t)$), seasonal (cyclic) (S) and random components.

The autoregression trend-seasonal multiplicative model of return on equity:

$$ROE_t = a + \beta \times ROE_{t-m} + F(t) \times S = 0{,}002 + 0{,}31 \times$$
$$\times ROE_{t-4} + 0{,}60 \times (0.01t - 0{,}16) \times (-0{,}24)_{d1} \times 0{,}98_{d2} \times \quad (1)$$
$$\times 1{,}26_{d3} \times 1{,}99_{d4},$$

where ROE_t is the return on equity at time moment t; d_1 (d_2, d_3, d_4) is the indicator of the first (second, third, fourth) quarter, which takes the values: "1", if time moment of calculation corresponds to the first (second, third, fourth) quarter; "0" otherwise.

Figure 3 below presents graphical representation of equation (1).

The trend-seasonal additive model of interest margin:

$$PM_t = F(t) + S = (-0{,}01_t + 0{,}10) + 0{,}41d_1 + 0{,}81d_2 + \quad (2)$$
$$+ 1{,}18d_3 + 1{,}51d,$$

where PM_t is the interest margin at time moment t.

Figure 4 below presents graphical representation of equation (2).

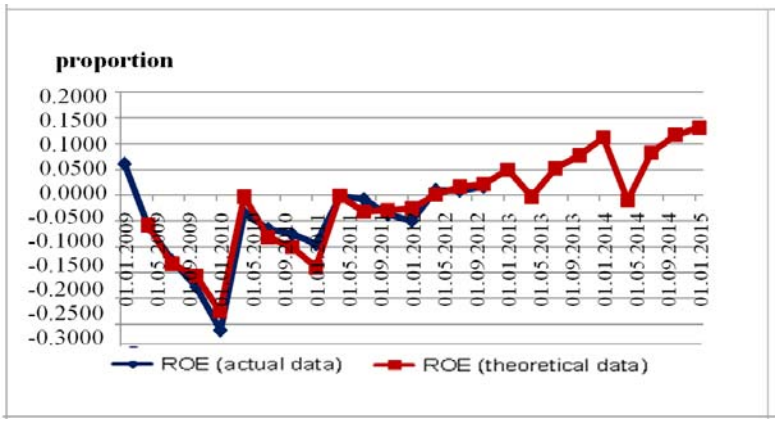

Fig. 3. Diagram of the actual and theoretical data comparison in the context of ROE

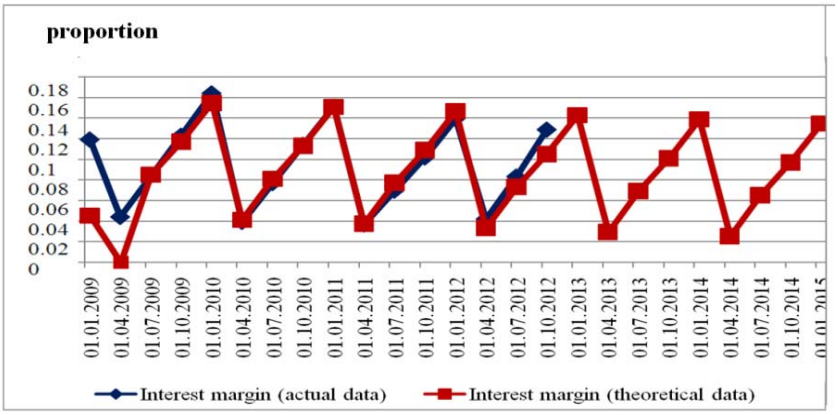

Fig. 4. Diagram of the actual and theoretical data comparison in the context of interest margin

The trend-seasonal multiplicative model of ROA:

$$ROA_t = 0,001 + 0,43 \times ROA_{t-4} + 0,22 \times (0,01t - 0,02) \times \times (-0,24)_{d1} \times 0,97_{d2} \times 1,26_{d3} \times 2,01_{d4}, \quad (3)$$

where ROA_t is the return on assets at time moment t.

Figure 5 below presents graphical representation of equation (3).

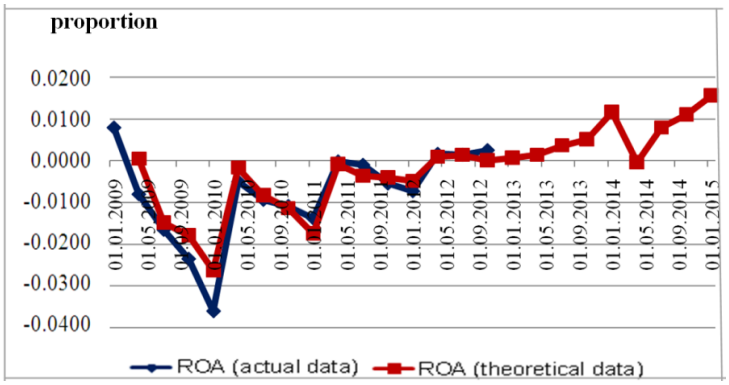

Fig. 5. Diagram of the actual and theoretical data comparison in the context of ROA

The trend-seasonal additive model of the rate of growth of net profit/loss:

$$RGP_t = F(t) + S = (8,39t + 4,40) - 71,52d_1 + + 91,59d_3 - 33,58ld_4, \quad (4)$$

where RGP_t is the rate of growth of net profit/loss at time moment t.

Figure 6 below presents graphical representation of equation (4).

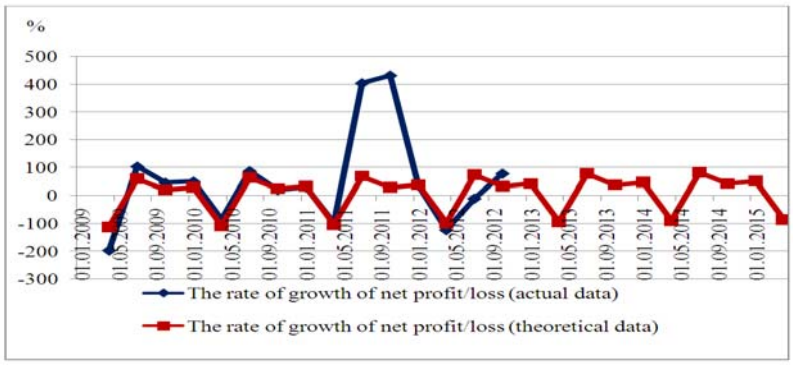

Fig. 6. Diagram of the actual and theoretical data comparison in the context of the rate of growth of net profit/loss

Stage 2. Determination of two numerical sequences k and l basing on the comparison of each input time series value (consistently one of a whole array selected indicators) with the previous one according to the following principle: in the context of the numerical sequence k – a single value, if the time series level (except the first one) is greater than all the previous ones, and a non-zero value otherwise, within the sequence l – a single value, if the time series level (except the first one) is less than all the previous ones, and a non-zero value otherwise. See Table 4.

Table 4. Monotonicity characteristics of time series of Ukrainian banking system stability relevant indicators

	The rate of growth of net profit/ loss	The capital adequacy of banks	Interest margin	ROA	ROE	The rate of growth of net profit/ loss	The capital adequacy of banks	Interest margin	ROA	ROE
01.01.2009										
01.04.2009	0	1	0	0	0	0	0	1	1	1
01.07.2009	1	0	0	0	0	0	1	1	1	1
01.10.2009	0	0	1	0	0	1	1	0	1	1
01.01.2010	0	1	1	0	0	1	0	0	1	1
01.04.2010	0	1	0	0	0	1	0	1	1	1
01.07.2010	0	0	0	0	0	1	1	1	1	1
01.10.2010	0	0	0	0	0	1	1	1	1	1
01.01.2011	0	1	0	0	0	1	0	1	1	1
01.04.2011	0	0	0	0	0	1	1	1	1	1
01.07.2011	1	0	0	0	0	0	1	1	1	1
01.10.2011	1	1	0	0	0	0	0	1	1	1
01.01.2012	0	0	0	0	0	1	1	1	1	1
01.04.2012	0	1	0	0	0	1	0	1	1	1
01.07.2012	0	0	0	0	0	1	1	1	1	1
01.10.2012	0	0	0	0	0	1	1	1	1	1
01.01.2013	0	1	1	0	0	1	0	0	1	1

Stage 3. Calculation of the monotonicity characteristics (variables *c* and *d*), fading or slacking off each time series of relevant indicators of quantita tive estimation of the Ukrainian banking system stability:

$$c = \sum_{t=2}^{n} (k_t + l_t)\, d = \sum_{t=2}^{n} (k_t - l_t), \qquad (5)$$

where k_t (l_t) is the value of the numerical sequence *k* (respectively, *l*) at time moment *t*.

Stage 4. The comparison of *t*-relations actual values-with a critical one and making conclusions regarding confirmation (if the calculated value exceeds the-critical one) or reject the hypothesis about trends in average and in the dispersion of the corresponding time series (Table 5). Formulas take the form of:

$$PM_t = F(t) + S = (-0,01_t + 0,10) + 0,41d_1 + .. \\ +0,81d_2 + 1,18d_3 + 1,51d_4, \qquad (6)$$

where μ is the assessment of the mathematical expectations time series; σ_1 is the assessment of the mean-square deviations for the value *c*; σ_2 is the assessment of the mean-square deviations for

Table 5. The dynamics of stability indicator of the Ukrainian banking system

	c	*d*	t_c	t_d	t_c	t_d	*R*
01.01.2009							
01.04.2009	4	-2	0.7982	0.9109	0	0	0
01.07.2009	5	-3	0.1303	1.3663	0	0	0
01.10.2009	5	-3	0.1303	1.3663	0	0	0
01.01.2010	5	-1	0.1303	0.4554	0	0	0
01.04.2010	5	-3	0.1303	1.3663	0	0	0
01.07.2010	5	-5	0.1303	2.2772	0	1	1
01.10.2010	5	-5	0.1303	2.2772	0	1	1
01.01.2011	5	-3	0.1303	1.3663	0	0	0
01.04.2011	5	-5	0.1303	2.2772	0	1	1
01.07.2011	5	-3	0.1303	1.3663	0	0	0
01.10.2011	5	-1	01303	0.4554	0	0	0
01.01.2012	5	-5	0.1303	2.2772	0	1	1
01.04.2012	5	-3	0.1303	1.3663	0	0	0
01.07.2012	5	-5	0.1303	2.2772	0	1	1
01.10.2012	5	-5	0.1303	2.2772	0	1	1
01.01.2013	5	-1	0.1303	0.4554	0	0	0

Stage 5. Determination of the dynamics banking system stability indicator (*R*) as a time series, the elements of which are calculated as the amount of *t*-relations in the moment of time *t*. The practical implementation of the above-mentioned approach allows to identify time intervals, during which

Ukrainian banking system is characterized by insufficient level of stability (Figure 7). So, the stability indicator takes a value "1" (the fact of an unstable condition) in the second half of 2010, the second quarter of 2011 and during almost the whole year in 2012.

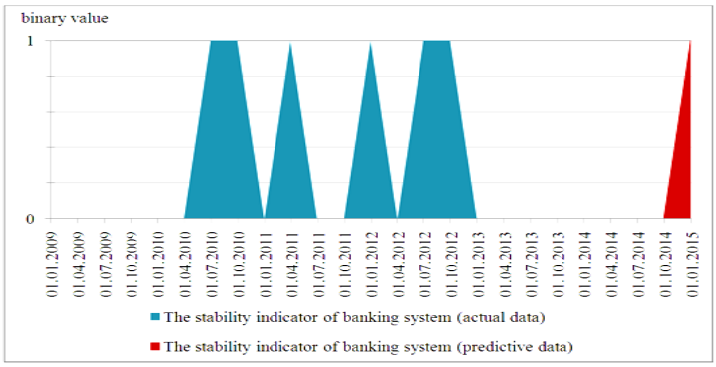

Fig. 7. Diagram of the actual and theoretical data comparison in the context of the stability indicator of banking system

The results, presented in the diagram, entirely confirm the economic model adequacy. So, it is reasonably to say that from 10.05.2010 to 1.09.2012 the Ukrainian banking system was unstable. Exactly during this period the destructive factors of the financial crisis influenced the liquidity of the national banking system most of all. Undoubtedly, during this period there were quarters, when the system managed to return to equilibrium, but this stage was short-continued. Only in the beginning of 2013 the recovery period started.

It should be noted that on the basis of the prediction calculations, we can see a new wave of the crisis in the beginning of 2015. These results are especially interesting because in 2015 the presidential elections will be held in Ukraine. And for our country the relationships between the financial sector and political events are important. In addition, it is obvious that by 2015 the NBU will keep the currency exchange risks in check and provide assistance to troubled banks. So, the seasonal nature of relevant indicators and the cyclical development of repressor of the banking system stability, established at the previous stages of the research, provide the opportunity to get quite adequate predicted results of Ukrainian banking system formation.

Stability of the banking system is determined by a lot of indicators and influences on the formation of the main banking sector indicators. In the research it is relevant to determine the direction and nature of the link between the regressand and the size of equity capital, liabilities and assets for the banking system as a whole [1.12, 1.14]. Therefore, quantification of the regressor on the stability indicator is proposed on the basis of an econometric approach, which presupposes the construction of the multiple nonlinear regression equations in such a form [1.9]:

$$R = -91783.33 - 44754.38 \ln OC - 338405.6 \ln E + 385645.31 \ln A + 1260.82 \ln^2 OC + 8606.86 \ln^2 E - 9744.91 \ln^2 A,$$

where R is the indicator of banking system stability; OC is the equality capital; E are the liabilities; Aare the assets. Analysis of the equation parameters (5) allows to make the following conclusions. With the increase of the banks equity capital to the amount 177,48 billion (18% of GDP) the level of banking system stability will gradually reduce. Increase of the equity capital above the specified value will cause the revive of Ukrainian banking system stability. A similar tendency is characterized by the liabilities (critical value of 196,59 billion – 19.94% of GDP), in contrast to assets, the influence of which on the effective sign is opposite. Therefore, as the relationships between the stability indicator and assets are presented in the form of polynomial second order branches down, the increase in the assets to the level of 197,87 billion (20.07% of GDP) is accompanied by increase of the variable to be explained. The excess of this factor of specified value gradually leads to the loss of the banking system stable state.

The accuracy and adequacy of revealed regularities are confirmed: by Fisher's test, the actual value of which 3.52 exceeds a critical permissible level of 3.41; by coefficient of determination at the level of 70, 10%; by statistically significant parameters of the regression equation (t-criterion) [1.11].

Conclusions

Thus, modeling the dynamics stability of the Ukrainian banking system allows to define the stability indicator, explore its dynamics as time series, identify the main factors of its formation, realize decomposition of the system – forming components of the stability indicator.

The practical value of the conclusions and recommendations is the following aspects: application of the proposed model approach allows to get an early signal about the imperfection of the existing financial resources management in the context of the banking system and the correction necessity; above-established seasonality of the main factors of the banking system stability provides the opportunity to get a basis for confirmed decision-making; the linear and nonlinear regression dependencies provide the ability to describe quantitatively the regularities and prospects for achieving stability of the system.

References

1. Anderson T.W., Hsiao C. (1981). Estimation of dynamic models with error components, *Journal of the American Statistical Association*, 76, pp. 598-606.
2. Andrews, D. (1993). Tests for parameter stability and structural change with unknown change point, *Econometrica*, 59, pp. 817-858.
3. Bollerslev T. (1986). Generalized autoregressive conditional heteroscedasticity, *Journal of Econometrics*, 31, pp. 307-327.
4. Box G.E.P. and Pierce D.A. (1970). Distribution of residual autocorrelations in autoregressive-integrated moving average time series models, *Journal of the American Statistical Association*, 65, pp. 1509-1526.
5. Chen, Y. (1999). Banking panics: The role of the first-come, first-served rule and information externalities, *Journal of Political Economy*, 107 (5), pp. 946-968.
6. Fama E.F. (1970). Efficient capital markets: A review of theory and empirical work, *Journal of Finance*, 25, pp. 383-417.
7. Filler W.A. (1976). *Introduction to Statistical Time Series*, Wiley, New York, pp. 366-382.
8. Granger C.W.J. (1969). Investigating casual relations by econometric methods and cross-spectral methods, *Econometrica*, 37, pp. 424-438.
9. Granger C.W.J. and Newbold P. (1974). Spurious regression in econometrics, *Journal of Econometrics*, 2, pp. 1045-1066.
10. Kaufman, H. (1986). Debt: the Threat to Financial Stability, in Debt*, Financial Stability, and Public Policy*, Kansas City, Federal Reserve Bank of Kansas City.
11. Keuzenkamp H.A. and Magnus J.R. (1995). On tests and significance in econometrics, *Journal of Econometrics*, 67, pp. 5-24.
12. MacKie-Mason J.K. (1992). Econometric software: A user's view, *Journal of Economic Perspectives*, 6 (4), pp. 165-187
13. Mishkin, F.S. (1991). Anatomy of a Financial Crisis, NBER Working Paper 3834.
14. Pindyck R., Rubinfeld D. (1991). Econometric models and economic forecasts, Mc. Grow- Hill, Inc. USA, 596 p.
15. Timmermans, Th. and Delhez, Ph. (1999). Restructuring of the Belgian Banking Sector and Financial Stability, BIS Conference Papers 7, March, pp. 55-69.