УДК 519.8:336.7

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FINANCIAL SYSTEM STABILITY ASSESSMENT: THE CASE OF UKRAINE

This paper describes the results of financial system stability assessment in Ukraine within the vector auto-regression framework. Financial risk factors of financial system instability are defined using variance decomposition analysis of total loan variable which is set to be a proxy for the state of financial system. Moreover, this paper provides the quantitative estimation of liquidity and exchange rate risks impact and suggests a set of measures for ensuring the stability of Ukrainian financial system.

Keywords: financial system, financial system stability, financial risks, vector error correction model, stress-testing.

Introduction and literature review. Financial crises of the second half of 20th century triggered an increased attention to financial system stability issues. Asian crisis was a crucial event which leaded to the acceleration of scientific researches in financial stability assessment in order to determine weaknesses of financial systems and prevent possible future financial crises. Financial crisis in 2008 indicated inefficiency of policy measures trough the world which were based on existing approaches [6]. Financial system of Ukraine was strongly affected by global environment which destabilized banking system and thereupon aggravated problems in real economy. Ensuring stability of financial system is an important part of monetary policy in Ukraine in order to overcome crisis and provide a stable economic growth [3].

Financial stability issues were investigated in works of domestic and foreign researchers such as A. Galchynski, V. Kovalenko, J. Van Horne, W. Blaschke, R. Barry Johnston, M. Čihák, O. Evans [1; 2; 4]. International Monetary Fund and other international institutions developed a set of tools and techniques for regular assessment of financial systems which is called macro-prudential analysis. Financial stability assessment requires the analysis of macroeconomic and financial indicators in dynamics which is supplemented by quantitative models [1]. Most of existing approaches are used partially and usually do not include significant variables or treat them exogenously which does not allow the consideration of the important endogenous interactions between financial system and the rest of economy [2; 4]. Thus, monetary policies based on such approaches often omit the whole effect of regulatory measures on financial system stability which leaded to the loss of banking sector profitability and their ability to ensure the continuous and adequate flow of financial recourses between household, government, enterprises, and other institutions, and eventually, caused the decline in economic growth. Although National Bank of Ukraine applies IMF approaches in regulating bank activities and maintaining the stability of financial system by providing an empirical analysis of macroeconomic and financial indicators in dynamic, the lack of quantitative researches based on modeling tools and techniques is a large palpable gap in designing relevant policies for ensuring financial stability. An important issue is to develop an efficient approach for financial system stability assessment in order to provide a quantitative analysis of financial instability factors.

Purpose of the research. The aim of the research is to indicate risk factors in Ukrainian financial system, quantitatively estimate the effect of shocks in the system, and provide a set of suggested measures for government and central bank for instant response on financial risk realization in order to avoid financial system instability and crisis.

Main research results. Despite an increased attention to financial crises issues there is no common definition of financial system stability. Scientists and researchers define financial stability and instability based on different understanding of problem and individual research questions [4, p. 34]. In this particular research we define «financial stability» as a state of the financial system when adverse internal and external shocks do not interfere with performing system's functions of financial exchanges between households, businesses, government, and financial institutions and do not cause disturbances and vulnerabilities of the economy [3, p. 1]. Adverse and unfavorable shocks arise due to the realization of financial risks, such as liquidity, exchange rate, credit, interest, and market risks [2, p. 2]. Exchange rate risk is the type of financial risk which occurs due to changes of exchange rate of one currency compared with the other. Credit risk can be defined as the possibility of losses due to the unpredictable changes in credit quality. Interest rate risk occurs due to the fluctuations of interest rates on loans and deposits. Liquidity risk is defined as the possibility of losses due to the inaccessibility of assets to cover liabilities. Market risk is the possibility of unfavorable and unpredictable changes of asset prices due to market fluctuations [6, p. 2].

Within a vector auto-regression framework the econometric model was developed where time series of total loans is as a proxy for the state of the financial system. Time series of fraction of non-performing loans in total loans is used to represent the direct effect of credit risk. Liquidity risk usually occurs due to the rapid deposit outflow, thus, time series of total deposits is used in the model. The representation of interest rate risk requires the use of average interest rates on loans and deposits. Interbank exchange rate of UAH to USD is chosen for exchange rate risk representation. Market risk is not presented in the model as this type of risk is not significant in Ukrainian financial system where security market is undeveloped. Vector auto-regression model allows the representation of endogenous relationships between variables which is important in order to estimate the effect of specific risk on other risk factors [5, p. 17].

Time series of total loans and total deposits are transformed to logarithms in order to avoid nonlinear relationships and unfavorable coefficients in equations. In order to avoid unbiased estimation of the model each time series variable has to be tested for a unit root existence. The Augmented Dickey-Fuller test confirms non-stationarity of each time series variable in levels and stationarity in first differences which is the first signal for cointegration testing. Cointegration of time series variables provides a common stochastic drift which in econometrics can be described as long-run relationship between variables. Cointegration occurs when each variable in time series sense are individually cointegrated but the linear combination of them has lower order of integration. The existence of long-run relationship transforms vector autoregression model to vector error correction model (VECM). The structure of VECM is similar to VAR in first differences with cointegration equation(s) $\hat{u}$.

$$\hat{u}_{k,t-1} = Y_{1,t-1} - \gamma_0 - \gamma_1 Y_{2,t-1} - \gamma_n Y_{n,t-1} \sim I(0).$$

here k – number of cointegration equation, γ_0 – intercept, n – number of equations in the model [5, p. 20].

The Johansen test confirms cointegration of time series at the 1 % significance level with two lag intervals including intercept with no trend which is expressed by cointegration equation in the model. Results of Johansen test are presented in table 1. Maximum eigenvalue statistics indicates 2 cointegration equations. In particular financial stability model only the most significant cointegration equation is presented. There are no established methodological tools in econometric modeling based on vector auto-regression or vector error correction models. It requires the use of creativity in modeling process. A set of tests indicated the optimal structure of the VEC model which includes two lags and one cointegration equation.

Table 1. **Johansen Cointegration test**

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.01 Critical Value	Prob.**
None *	0.421856	63.01223	45.869	0
At most 1 *	0.362594	51.79007	39.37013	0.0002
At most 2	0.240827	31.68543	32.71527	0.014
At most 3	0.139235	17.24235	25.86121	0.1609

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.01 level.

Model validation indicated that model is somewhat unstable to NPL variable as the coefficient to the cointegration equation which represents the speed adjustment to long-run equilibrium has positive value. Table 2 presents coefficients to cointegration equations of all variables.

Table 2. **Cointegration equations' coefficients**

Variable	Coefficient γ	Variable	Coefficient γ
EXR	- 0.022	LOGDEP	- 0.008
IRL	- 0.399	LOGLOAN	- 0.009
IRD	- 0.055	NPL	0.083

This means that NPL is not responsible for the return to equilibrium and is weakly exogenous which is confirmed by Granger causality test. The results of Granger test for NPL are presented in table 3.

Table 3. **Granger Causality test for non-performing loans fraction**

Dependent variable: D(NPL)

Excluded	Chi-sq	df	Prob.
D(EXR)	0.393363	2	0.8215
D(IRL)	2.662595	2	0.2641
D(IRD)	1.588132	2	0.4520
D(LOGLOANS)	1.456825	2	0.4827
D(LOGDEPOSITS)	0.337695	2	0.8446
All	10.68877	10	0.3823

The probability of NPL exogeneity is 38 %. Despite this fact, NPL variable is not excluded from the model as there is probably another cointegration equation for it which is not included to the model due to its insignificance. Other validation test indicated that residuals of each variable are white noise and normally distributed. Moreover, model is stationary which is confirmed by a unit-root test. Vector error correction models require k-r unit roots, where k – number of variables in the model, and r – number of cointegration equations [5, p. 20]. Thus, model has 5 unit roots.

The forecast quality is verified by estimating mean absolute percentage error (MAPE). Simulated and actual behavior of total loans variable, which serves as a proxy for the state of financial system, and its mean absolute percentage error can be seen in figure 1. Mean absolute percentage error of 1.27 % confirms the adequacy of the model.

Estimation of cause and effect relationships requires the analysis of variance decomposition. Variance decomposition, which is also known as forecast error variance, is used to estimate the weight of variables in specific shocks in individual variables [5, p. 17]. Analysis of variance decomposition function is important to determine the most dangerous risks for financial system in dynamics.

Figure 2 shows variance decomposition of total loans in financial system. Initially, 85 % of shock in total loans is explained by its variance and 15 % due to changes is exchange rate. This indicates the significance and danger of exchange rate risk for financial system. At the 20-month time period the weight of exchange rate increases to 25 %, 12 % of shock is explained by interest rate on loans, 3 % by total deposits, and more than 1 % by interest rate on deposits and fraction of non-performing loans individually. This indicates the significance of each variable in variance decomposition of total loans. Moreover, analysis of variance decomposition functions of other variables indicates the significance of each variable in the model which confirms the hypothesis of strong endogenous cause and effect relationships between variables.

In all cases the impact of NPL is insignificant, which indicates the inconsiderable effect of credit risk, but other endogenous variables explain shocks in NPL, thus, fraction of non-performing loans is not excluded from the model.

Impulse response function is used in particular research not only as a model validation tool but also for the quantitative estimation of shocks which occur in endogenous variables and are represented as

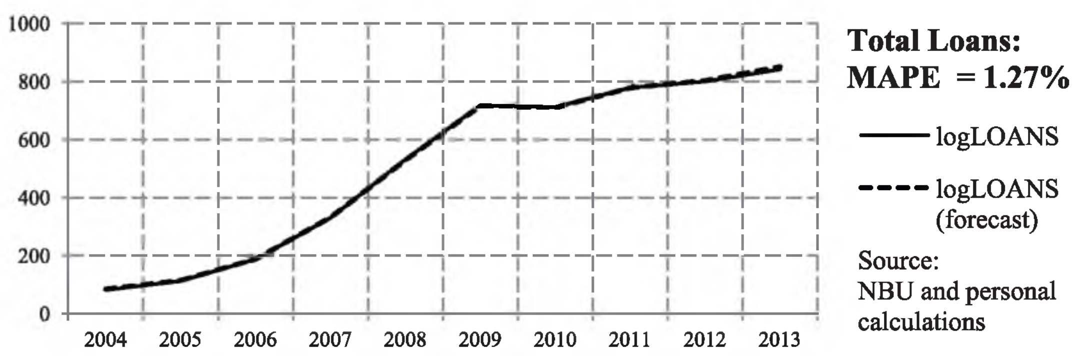
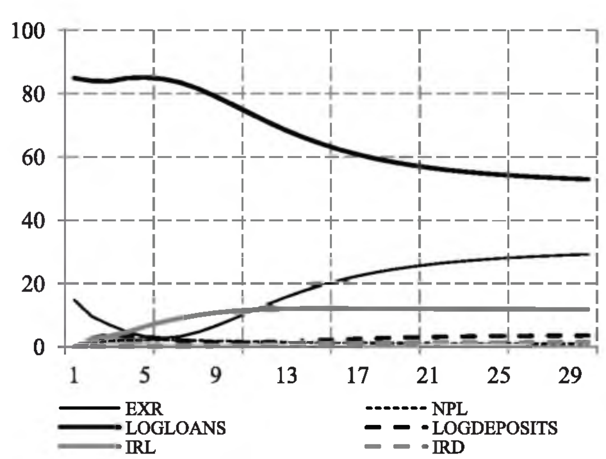


Fig. 1. Actual and simulated behavior of total loans, thou UAH. MAPE, %



X\Lag	1	10	20	30	40
EXR	14.8	8.87	25.3	29.2	30.6
NPL	0.34	1.78	1.13	0.98	0.92
LOAN	84.8	76.3	57.4	52.9	51.2
DEP	0	1.3	2.95	3.55	3.73
IRL	0	11.4	12	11.9	11.9
IRD	0	0.41	1.25	1.48	1.57

Fig. 2. Variance decomposition of total loans, %

financial risk realization. This helps to conduct stress-testing of the system [1, p. 5]. A shock in *i*-th variable is affecting *i*-th and is transmitted to all other endogenous variables though the dynamic lag structure. Traditionally, impulse response function provides the estimation of the effect of one-unit shock in residuals of variable [5, p. 18]. For the research purposes, shocks are modeled as separate matrixes which include one column and 6 rows for each variable depending on the ordering in the model. In order to test the realistic scenarios of possible future crises in Ukraine due to the realization of different financial risks shocks are set to have values which are determined by the empirical analysis of fractional growth rates of time series variables during the financial crisis in 2008

The most dangerous shock in the system is exchange rate risk realization which is confirmed by variance decomposition analysis. Matrix $\mathbf{A}_i$ represents shock in EXR which is set to be 0.3 UAH/USD, where *i* – is the number of scenarios used for stress-test. This shock was chosen due to the empirical analysis of exchange rate growth rate during the financial crisis in 2008. $\mathbf{A}_1$ represents a single shock in EXR, $\mathbf{A}_2$ and $\mathbf{A}_3$ represent additional shocks in other variables which are defined as an instant reaction of government and central bank to exchange rate realization.

$$\mathbf{A}_1 = \begin{pmatrix} 0.3 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{pmatrix}; \quad \mathbf{A}_2 = \begin{pmatrix} 0.3 \\ -1 \\ 1.5 \\ 0 \\ 0 \\ 0 \end{pmatrix}; \quad \mathbf{A}_3 = \begin{pmatrix} 0.3 \\ 1.5 \\ 1 \\ 0 \\ 0 \\ 0 \end{pmatrix}.$$

Policy of government and central bank directly or indirectly influences interest rates in financial system, thus, this variables can be used as a proxy for different policy scenarios. The first scenario does not include any monetary policy. The second scenario includes shocks in interest rates on loans and deposits which are set to be (1.5) and (1) p.p. respectively. This scenario is a common reaction of financial system management as the devaluation of national currency causes deposit outflow, thus, in order to overcome shock IRD increases. Moreover, currency devaluation causes the increase of nonperforming loans, thus, the price of loans increases. The third scenario provides (-1) and (1.5) p.p. reduction in interest rates on loans and deposits respectively. In this case, IRL decreases by 1 p.p. which is based on the hypothesis that lower interest rates on loans cause higher value of total loans which in turn causes higher value of deposits within the financial system. The response of total loans variable to each scenario is presented in figure 3.

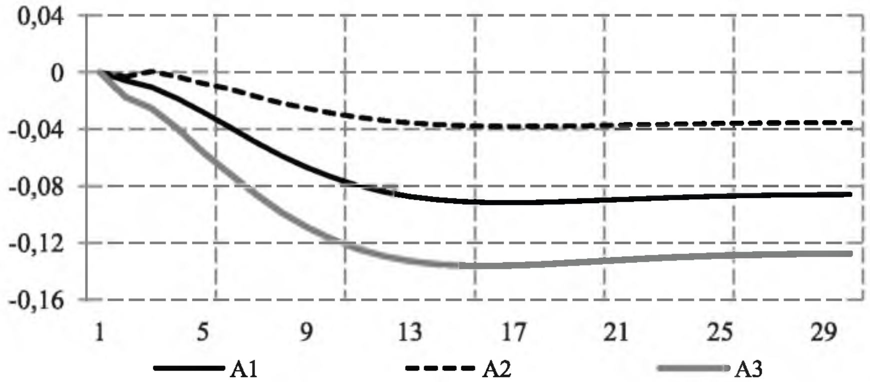


Fig. 3. Response of total loans to shocks in exchange rate and interest rates

The instant change of exchange rate in 0.30 UAH/USD (3.75 % increase) in one-year period causes 10% reduction of total loans. The first monetary policy, which is based on increased interest rates, aggravates the effect of exchange rate shock (14 % decrease of total loans in one-year period). The third policy, which provides increased IRD and decreased IRL, causes only 4 % decline of loans.

The second stress-test provides a shock of deposit outflow which is defined as the liquidity risk realization. Deposit outflow is believed to be the strongest factor of financial crisis in Ukraine in 2008. Empirical analysis of deposit growth rates in 2008 indicated the decrease of total deposits by 5.5 %. The first scenario in stress-test represents a single shock in total deposits. The second scenario provides the increase of interest rate on loans in order to keep profitability of financial institutions. The third scenario includes, in addition to deposit outflow, an instant increase of interest rate on deposits by 1.5 p.p. and decrease of exchange rate by 0.10 UAH/USD. The IRD increase is supposed to make deposit offers from financial institutions more attractive. The decrease of exchange rate is supposed to stimulate people exchange foreign currency to national currency and deposit money. Results are presented in figure 4.

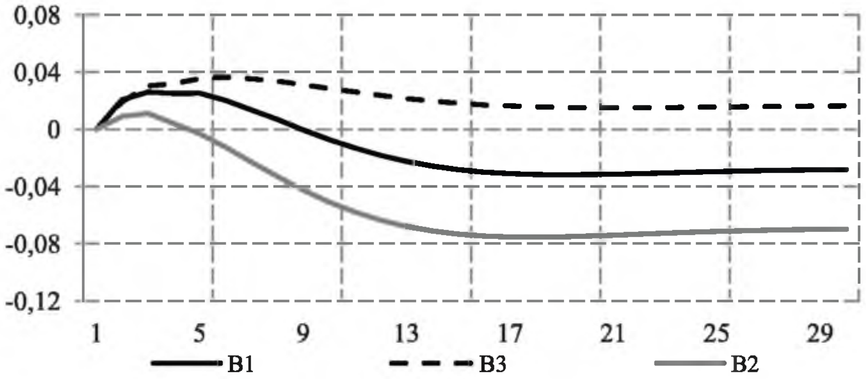


Fig. 4. Response of total loans to shocks in total deposits, interest rates, and exchange rate

In two-year period the liquidity risk realization causes the reduction of total loans by 4 %. Second scenario test indicated that the policy of IRL increase is inefficient. Third policy test confirms the positive impact of IRD increase and ERX decrease. Results of all scenario tests for the short-run are unexpected as total loans are increasing. The analysis of impulse response functions of the rest of variables indicated a rapid increase in total deposits and interest rate on deposits which can theoretically in short-run cause the increase in total loans.

Conclusions. This paper examined the impact of financial risks on the stability of financial system of Ukraine. The state of the system is represented by a proxy variable of total loans in the economy. Variance decomposition analysis indicated a significant impact of exchange rate, interest rate on loans, and deposit outflow in future forecast errors of total loans in economy which confirms the instability to exchange rate, interest and liquidity risks. The weight of non-performing loans in variance of total loans is small. This indicates that financial system is more stable to credit risk.

Two stress-tests were conducted in order to quantitatively estimate the impact of exchange rate shock and deposit outflow shock which are believed to be the main causing factors of financial crisis in Ukraine in 2008. Moreover, in order to overcome shocks and prevent future crises, different monetary policies were tested. The most efficient policy which stabilizes the system after the exchange rate risk realization is decreasing a spread of interest rates by lowering interest rates on loans. Liquidity shock can be eliminated by increasing interest rates on deposits and decreasing exchange rate.

Results of this research provide important information for developing better specified models which include exogenous factors for accurate estimation of financial risk impact on the financial system of Ukraine.

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ОЦІНКА СТАБІЛЬНОСТІ ФІНАНСОВОЇ СИСТЕМИ НА ПРИКЛАДІ УКРАЇНИ

У цій статті наведено результати оцінки впливу фінансових ризиків на стійкість фінансової системи України в рамках моделювання векторної авторегресії. За допомогою аналізу декомпозиції дисперсії показника обсягу кредитів в економіці, що обрано як проксі-змінна для репрезентації стану фінансової системи, виокремлено фактори ризиків. Крім того, в роботі проведено кількісну оцінку ризику ліквідності та валютного ризику, запропоновано заходи для їх нівелювання та забезпечення стійкості фінансової системи України.

Ключові слова: фінансова система, фінансова стабільність, фінансові ризики, векторна модель корекції помилки, стрес-тест.

Матеріал надійшов 14.02.2014

УДК 339.1:330.341

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LOGIT-MODEL OF MANAGEMENT INNOVATION PROCESSES

The article presents the results of research in the development of innovation in enterprises, proposed logit-model of the innovation process, which is based on that knowledge, are generated at all stages, considered a commodity, because intellectual property, allows implementing them not only to compensate their production costs, but also to develop further

Keywords: innovation, innovation process, innovation capacity, economic modeling, intellectual capacity, knowledge.

Statement of the problem. The need for new theoretical and practical approaches for management of innovation processes of enterprises, as well as the formation and development of the technological competitiveness of enterprises has increased interest in the improvement of expertise in the field of innovation management.

Questions to build an economic model, and their use is quite relevant in today`s market conditions. Due with disabilities use optimization methods, more attention is paid to the logit modeling to analyze problems and make effective decisions in the management of innovation processes.

Analysis of recent research. Ukraine`s European choice and its corresponding integration into high-tech competitive environment necessitated the formation of an innovative model of development, in which the role of the main source of long-term economic growth play scientific achievements and their technological application that allows to increase the competitiveness of the economy, to ensure the economic security of the state and its paramount importance in European Union provided a stable and rapid economic growth. At the same time innovative model of development should be considered as a tool for developing the foundations of innovation and the information society in Ukraine [2, p. 108].

The question of Ukraine`s transition to an innovative model of development has attracted increasing attention from scientists, politicians, business