ESTIMATION OF Z-SCORE FOR UKRAINIAN BANKING SYSTEM

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Abstract. The article analyzes the problematic aspects of evaluating the financial stability of banking systems on the basis of the Z-score methodology. The econometric model estimation of Z-score for the Ukrainian banking system was constructed where the following indicators were chosen in role of explanatory variables: the share of foreign capital in bank system, inflation, change in nominal GDP and share of overdue loans in credit portfolio. We have conducted the analysis of the banking sector in Ukraine on the base of the constructed Z-score model and determined macroeconomic factors that have the most significant impact on the Z-score assessment and banking system stability. Drawbacks and limitations of the Z-score methodology usage in banking business are discussed.

Keywords: Z-score, banking system, stability of bank, risk measure, bank bankruptcy, Ukrainian banking system.

Introduction

The way how to measure bank risk and bank stability has always an important academic interest, especially in the post-crisis period. Traditionally, the most commonly used risk measures by financial institutions are VaR and ES. VaR was recommended by Basel II Accord as a standard risk measure for bank risk management. However, VaR is often criticized that it is not a coherent risk measure, as Value-at-risk is not sub-additive and cannot capture any loss beyond the VaR loss level (the so-called "tail risk"). ES has been developed to overcome VaR's shortcomings, and is recommended in Basel III. However, another weakness for both VaR and ES is that they measure mainly the risk of an individual institution, and cannot fully capture systemic risk. One of the most popular risk measures in the literature related to estimation of banking and financial stability on the macro and micro level is z-score, which evaluates a bank's probability of insolvency. Boyd and Graham *(1986)* in their studies proposed the z-score approach as a risk indicator, that can measure the probability that a bank will fail or go bankrupt. Subsequently, Boyd and Graham *(1988)* and Boyd et al. *(1993)* also used z-score methodology as a measure of the probability of bank bankruptcy, and investigate the risk effects of bank mergers with non-bank financial company.

Literature reviews and theoretical framework

Today we can come across many approaches in the scientific literature that help to analyze the stability of either banks or entire banking system. In the literature, one of the most

spread and popular approaches to analyze the probability of bank bankruptcy is using Z-score methodology. Among these different measures, the Z-score is the most widely used in the empirical banking literature as a tool that can estimate a bank's probability of insolvency. Besides, it is one of the indicators used by the World Bank in their Global Financial Development Database in order to measure financial institutions soundness. It should be noted that the coefficient of financial stability (as a ratio of equity to total assets) is a very simplistic approach to assessing the vulnerability of both a single bank and the system as a whole. In world practice, Bank Z-Score calculated according to A. Roy's *(1952)* methodology has found a much wider usage.

In its general form, the Z-score was initially only used for cross-sectional studies. Starting with work by Boyd et al. *(2006)*, the Z-score is now also commonly being implemented as a time-varying measure in panel studies. Lepetit and Strobel *(2013)* analyzed the different approaches used in the construction of time-varying Z-scores. Afterwards, Lepetit and Strobel *(2015)* gave a new probabilistic interpretation of Z-scores as an insolvency risk measure. In general, the usage of Z-score is so popular because it is negatively related to the probability of insolvency of banks. It means that the higher Z-score, the better financial situation of the bank. To estimate Z-score of the bank researchers mainly have to use a bank capital asset ratio and its return on assets. Return on assets (ROA) shows the percentage of profit a bank earns in relation to its overall resources, while Capital asset ratio answers the question whether the bank has enough money to support its assets.

Lepetit, L. and Strobel, F. *(2015)* analyzed the probabilistic foundation of the traditional link between Z-score measures and bank's probability of insolvency, providing an improved measure of that probability without imposing additional distributional assumptions. They admitted that traditional measure of the probability of insolvency therefore provides a less effective upper bound of the probability of insolvency but can, in fact, be meaningfully reinterpreted as a measure capturing the odds of insolvency instead. They obtained analogous refined probabilistic interpretations of the commonly-used simple and log-transformed Z-score measures.

Z-score determines the probability of default of a country's bank system. Z-score weighs the buffer of a country's banking system or more precisely - capitalization plus returns with the volatility of returns. It is estimated according to the following formula:

$$Z_{score} = \frac{\mu(ROA) + \dfrac{\text{equity}}{\text{assets}}}{sd(ROA)} \tag{1}$$

where $\mu(ROA)$ - expected value of ROA, $sd(ROA)$ - standard deviation of ROA. ROA, equity, and assets are country-level aggregate figures.

The bigger value of the Z-score, the longer is the distance to capital exhaustion and a lower probability of insolvency of the bank. Subsequently, the higher the value of the indicator Z, the more stable is the bank. In literature connected with analysis of banks on the baser of Z-Score approach, when calculating the indicator in the formula (1), the average value of the return on assets E (ROA) is very often substituted by its current value. In this case, index Z is interpreted as "distance to default". It shows on how many standard deviations we have to reduce the current value of profitability so that the losses of an object (bank, banking group or banking system as a whole) that were formed as a result of negative factors could exceed its equity *(Beck, Jonghe, 2013; Berger, Klapper, Turk-Ariss, 2008)*.

Analysis of Ukrainian banking sector using the Z-score model

In this article, we have analyzed the stability of the Ukrainian banking system from 2001 to 2017 on the basis of the Z-score approach. For this purpose, the statistical data of the National Bank of Ukraine was used concerning the financial results of Ukrainian banks and their financial statements for the analyzed period. To obtain an assessment of the Z-score of the Ukrainian banking system, we used an approach in which the average ROA is substituted by its current value at the end of the period:

$$Z_{score} = \frac{ROA + \dfrac{equity}{assets}}{sd(ROA)}.$$

Return on Assets (ROA) data and the ratio of equity to total assets of the banking system for the analyzed period were obtained from the official website of the National Bank of Ukraine (table 1).

Table 1

Z-score of Ukrainian banking system

Years	Z score	ROA (%)	$\dfrac{equity}{assets}$
2001	5,40	0,1	0,123
2002	6,72	0,7	0.147
2003	7,40	0,8	0.129
2004	8,42	1,07	0.137
2005	6,65	1,31	0.119
2006	6,75	1,6	0.125
2007	4,92	1,5	0.116
2008	5,14	1	0.129
2009	2,94	-4,4	0.138
2010	4,22	-1,45	0.155
2011	3,91	-0,76	0.147
2012	5,83	0,45	0.151
2013	5,80	0,12	0.151
2014	4,84	-4,07	0.112
2015	3,41	-5,46	0.077
2016	2,31	-12,6	0.096
2017	2,90	-1,94	0.084

Source: formed by authors on the base of *(Official site of National bank of Ukraine)*

From figure 1, constructed on the basis World Bank data for the period from 1996 to 2015 and our own calculation, and where the value of Bank Z-score of Ukrainian and other countries' banking sectors are shown, it is easy to see that Ukraine's banking system has actually experienced two major financial crises, namely 2008-2009 and 2015-2016.
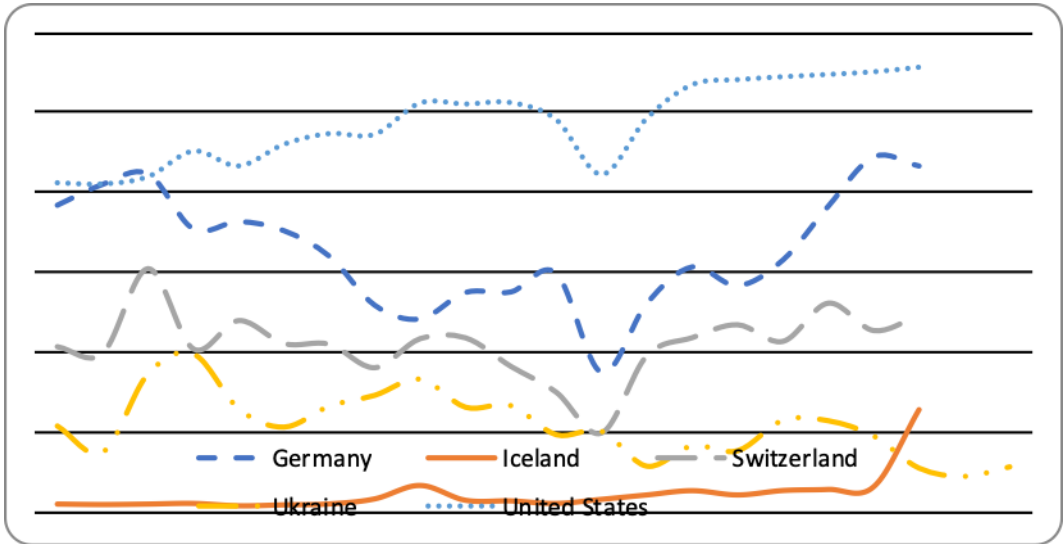
Fig. 1. Z-score of Ukrainian and banking systems of other countries
Source: formed by authors on the base of *(Official site of National bank of Ukraine and Datamarket website)*

The global financial crisis of 2008-2009 became a real test for the banking systems of almost all countries of the world. Thus, the Z-score of the US banking system, which experienced the hardest hit by this crisis, dropped by almost 20% in 2008 (table 2). A similar situation was observed in other developed countries, which economies, however, managed to cope with the problems in the banking sector quickly enough. For example, in the United States, after the turning point in 2014 the economy began to grow rapidly, creating jobs at its most rapid pace since 1999. One of the most important results of the 2008 crisis is the awareness of regulators at the national and international levels that banks should be prepared for a crisis for at least the next three to five years, regardless of macroeconomic forecast. This approach is clearly tracked in the new standards of the Basel Committee, especially those relating to liquidity and capital adequacy ratios, and which follow the concept of "getting ready for a crisis at any time".

In 2016 Ukraine's banking system restored the historical maximum for losses, having received a negative result − 159 billions UAH. January 1, 2017 in Ukraine the total loss of working banks amounted to 158 482 billion UAH, insolvent banks − 1 661 billion UAH. Therefore, it is entirely natural that its minimal Z-score the Ukrainian banking system reached in 2016, when there was a real bank-drop in Ukraine during 2014-2917 − out of 180 operating banks at the beginning of 2014 only 83 survived until the end of 2017. The most successful in terms of sustainability for Ukrainian banks was 2004, when Z-score was equal to 8.42.

After the record losses in 2016, the Ukrainian banking system partly stabilized in 2017. Due to a significant sum of deductions to reserves, the Ukrainian banking sector finished 2017 with losses of 24.4 billion UAH, mainly due to four large banks, especially Privatbank. However, the National Bank noted the revival of the Ukrainian banking sector and the restoration of lending in 2017. The number of banks showing profitable business was

increasing. The number of loss-making banks for the past year decreased to 18 out of 33 in 2016.

Table 2

Comparison of Z-score for different banking systems

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
China	25,06	23,28	25,54	24,86	25,69	25,82	29,46	28,62
United States	21,2	24,64	26,69	26,99	27,17	27,31	27,47	27,75
Austria	20,72	25,45	22,76	21,6	23,05	22,45	21,66	24,37
Germany	8,75	13,07	15,33	14,16	15,76	19,11	22,18	21,61
Spain	19,58	20,31	19,91	17,24	16,27	19,71	20,13	19,86
France	8,31	12,77	13,41	12,19	13,62	15,55	16,94	18,93
Australia	13,92	15,08	15,57	14,62	14,1	13,78	14,66	14,78
Slovak Republic	11,16	11,63	12,17	12,94	13,8	13,8	14,2	13,5
Switzerland	5,05	9,85	10,96	11,76	10,73	13,1	11,4	12,33
Brazil	15,07	14,55	13,08	12,46	11,16	10,76	12,22	11,54
Italy	14,52	14,98	16,28	12,02	13,63	11	10,02	11,22
Euro area	8,31	10,49	10,14	8,85	10,12	8,78	11	10,31
Poland	7,18	7,22	7,74	7,68	8,61	8,4	8,57	8,3
Turkey	7,86	9,39	9,41	8,12	9,2	7,66	7,83	7,23
Uzbekistan	9,34	8,94	7,26	6,67	6,56	6,37	6,85	6,62
Moldova	8,01	6,73	7,15	7,68	6,49	5,94	5,05	6,47
Latvia	4,14	2,63	3,42	5,05	5,68	5,98	5,98	6,15
Czech Republic	4,83	5,23	5,3	5,17	5,87	5,63	6,02	6,02
Russian Federation	6,83	5,35	6,3	6,46	5,9	5,88	4,28	4,34
Ukraine	5,14	2,94	4,22	3,91	5,83	5,8	4,84	2,82

Source: formed by authors on the base of *(Official site of National bank of Ukraine and Datamarket website)*

Thus, the net increase of bank loans during the past year was 42%. In addition, the state-owned "PrivatBank" became the leader in lending, while the consumer lending sector showed the highest growth rates. At the same time, since the second half of the year, lending of business in Ukraine grew. In 2017, hryvnia corporate loans grew significantly in foreign

and state banks by 17.5% and 12.8% respectively. According to the results of the second half of the year, the share of non-performing loans in the banking system of Ukraine decreased to 54.5%. In 2018, the National Bank expects the continued rapid growth of consumer lending, as well as the revival of hryvnia lending business. According to the results of 2017, deposits of the population in the hryvnia rose by 22.4%, in the currency - the volumes did not change. At the same time, the leader in attracting hryvnia funds of the population was "Privatbank", and in currency − "Oshchadbank".

To determine the macroeconomic factors that have the most significant impact on the Z-score assessment of the banking system of Ukraine, an appropriate linear regression model was constructed. It was found that the best approximation of the Z-score is achieved if the share of foreign capital in the banking system (F_capital), inflation (Infl), the change in nominal GDP in the dollar equivalent (Ch_GDP) and the share of overdue debt in the loan portfolio of Ukrainian Banks (Overdue_loans) were used as explanatory variables (table 3).

Table 3

Variables of regression model

Variable	Calculation
Z score	Z score of the Ukranian bank system obtained from (1).
F_capital	The share of foreign capital in bank system ,%.
Infl	Inflation rate in Ukraine,%.
Ch_GDP	Change in nominal GDP in US dollars, %.
Overdue_loans	Share of Overdue Loans in credit portfolio,%.

Source: formed by authors

The values of the model variables for the period from 2003 to 2017 and their descriptive statistics are presented in tables 4 and 5. The average value of the Z-score of the Ukrainian banking sector is 4.98, which is significantly smaller in comparison to this indicator for the highly developed countries. The average in the world for 2015 was 13.13 index points. The highest value was in Bhutan: 53.63 index points and the lowest value was in Togo: 1.4 index points.

Finally, the Z-score assessment model of the Ukrainian banking system will acquire the following form:

$$Z_{score} = \text{-}0,14629 \cdot \text{F\_capital} \text{-} 0,02056 \cdot \text{Infl} + 0,01996 \cdot \text{Ch\_GDP} +$$
$$+ 0,00996 \cdot \text{Overdue\_loans} + 12,37821 + \varepsilon$$

(2)

The coefficient of determination for the constructed regression model is 0.887, which indicates a rather high level of correlation between explanatory and explanatory variables. It can be argued that 88.7% of all deviations of the dependent variable are due to the built-in regression equation (2). The explanatory variables F capital, Infl and CH_GDP were statistically significant. According to the obtained model (2) the growth of the share of foreign capital and the level of inflation in the country leads to a decrease of the Z-score for the Ukrainian banking system. Instead, an increase of the GDP growth rate in dollar terms leads to an increase of the Z-score.

Table 4

Values of regression model variables

	Z-score	The share of foreign capital in bank system ,%. **F_capital**	Inflation, %. **Infl**	Change in nominal GDP in US dollars, %. **Ch_GDP**	Share of Overdue Loans in credit portfolio,%. **Over_loans**
2003	7,4	19	108,2	18,3	1,9
2004	8,42	19	112,3	29,4	1,55
2005	6,65	23	110,3	32,8	2,36
2006	6,75	35	111,6	25,1	1,89
2007	4,92	36,7	116,6	32,5	1,30
2008	5,14	35,8	122,3	26,1	2,30
2009	2,94	40,6	112,3	-34,9	9,40
2010	4,22	41,9	109,1	16,4	11,20
2011	3,91	39,5	104,6	19,6	9,60
2012	5,83	39	99,8	7,7	8,90
2013	5,8	34	100,5	4,3	7,70
2014	4,84	32,5	124,9	-28,1	13,50
2015	2,82	43,3	143,3	-31,3	22,10
2016	2,3	54,7	112,4	2,9	30,47
2017	2,9	56	113,7	20,2	55,90

Source: formed by authors

Table 5

Descriptive statistics

Variable	**Mean**	**Minimum**	**Maximum**	**Std.Dev.**
Z-score	4,98	2,3	8,42	1,83
F_capital	36,7	19	56	10,81
Infl	113,46	99,8	143,3	10,71
Ch_GDP	9,4	-34,9	32,8	23,07
Over_loans	12	1,3	55,9	14,70

Source: formed by authors

The results of estimating the regression parameters in the package Statistics are presented in Tables 6 and 7.

Table 6

Regression parameters

Coeficient		St. error	p-value
C	12,37821	2,611456	0,000792
F_capital	-0,14629	0,029487	0,000569
Infl	-0,02056	0,020564	0,034106
Ch_GDP	0,01996	0,009766	0,048167
Overdue_loans	0,00996	0,021482	0,652791

Source: formed by authors

Table 7

Regression summary

R	0,9421
R^2	0,8876
Adjusted R^2	0,8427
Std. Error of estimate	0,72753
p<0,00010	

Source: formed by authors

However, Z-score methodology as a measure of financial stability of the banking institution has several drawbacks and limitations. The limitations of the Z-score model are based on the fact that its formula contains financial ratios which mainly depend on the individual financial and accounting statements of the banks. Unfortunately, it is a well-known fact that financial and accounting statement manipulation is a current worldwide issue that can falsify bank's stability in order to avoid a state of disbelief among potential clients. That would result in a strong negative impact on the bank's business. Another drawback of this model is the time horizon taken into account for predicting an episode of financial instability, namely up to five years, which is insufficient for the bank to operate consistent changes on its strategy *(Badea, Matei, 2016)*.

One of the most important constraints is that Z-score is based exclusively on accounting and financial reporting. The correctness of such an approach depends directly on the precise functioning of the bank accounting and auditing systems. If the financial institutions can somehow smooth out the reporting in desired for them form, then the Z-score will be an overestimated assessment of the financial institution's sustainability. In addition, Z-score evaluates each institution in particular, without taking into account the risk of the bankruptcy impact of one of the financial institutions on the other and on the financial system as a whole.

Conclusions and suggestions

The article conducts the analysis of banking systems stability for different countries on the basis of Z-score methodology. Very high volatility of Z-score was noted even for the banking sectors of the developed countries. Taking into account the latest financial crisis in Ukraine, we aim through this paper to analyze the main determinants and driven factors for financial stability of a commercial bank and a co-operative bank.

The proposed econometric model of the Z-score estimation contains the following explanatory variables: the share of foreign capital in the banking system (F_capital), the inflation rate (Infl), the change in the nominal GDP equivalent in dollar (Ch_GDP) and the share of overdue debts in the loan portfolio of Ukrainian banks (Overdue_loans). Moreover, the growth of the share of foreign capital and the level of inflation in Ukraine leads to a decrease in the Z-score of the Ukrainian banking system. Instead, an increase in the GDP growth rate in dollar terms leads to an increase in Z-score. Z-score presents several advantages, but at the same time disadvantages. The main plus of this risk measure is represented by the easy computation for a financial institution, bank or entire banking system. On the other hand, the main disadvantage of this approach is represented by the fact that it does not count the correlation between financial institutions (contagion relation).

The prospect of further research is that the proposed Z-score evaluation model can be used to construct stress scenarios to determine the sensitivity of the Ukrainian banking system towards changes in macroeconomic factors and external shocks.

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