“Use of Nonparametric Statistics Methods for an Estimation of Liquidity Risk of Banking System”

AUTHORS	Hanna T. Karcheva

ARTICLE INFO	Hanna T. Karcheva (2006). Use of Nonparametric Statistics Methods for an Estimation of Liquidity Risk of Banking System. *Banks and Bank Systems*, *1*(4)
RELEASED ON	Thursday, 21 December 2006
JOURNAL	"Banks and Bank Systems"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES

0

NUMBER OF FIGURES

0

NUMBER OF TABLES

0

USE OF NONPARAMETRIC STATISTICS METHODS FOR AN ESTIMATION OF LIQUIDITY RISK OF BANKING SYSTEM

Hanna T. Karcheva*

Abstract

Using nonparametric statistics methods is a perspective trend concerning complex assessment of liquidity risk and banks' financial solvency. Methodological basis of the model proposed is the concept of dynamic normal. In the paper this value is denominated as "dynamic parameter of liquidity", because it is not a necessary feature to exercise control of bank activity. To build the model of dynamic parameter of liquidity of banking system of Ukraine 8 parameters were chosen. The results confirm that dynamic normal along with gap-analysis, liquidity normals and coefficient analysis is a necessary component of system of estimating bank's liquidity risk and solvency.

Key words: banking system, liquidity risk, solvency, correlations.
JEL classifications: G21, C14.

Using mathematical techniques to assess liquidity risk allows obtaining generalized (integral) assessment of liquidity risk, in terms of considering bank as complex dynamic system [1].

Using nonparametric statistics methods is a perspective trend concerning complex assessment of liquidity risk and banks' financial solvency [2]. Methodological basis of the model proposed is a work comprising description of normative model of system analysis of financial statements [3]. At the heart of this model is the concept of dynamic normal which represents total of measures normalized according to rates of growth. Ordered series of measures offers an opportunity to demonstrate the dynamics of parameters in their mutual interaction and correlation, i.e. allows estimating bank's financial position, its liquidity rate, which is impossible to be accurately estimated by using some individual measure.

Ordinal scale is used to build dynamic normal. This ordinal scale makes it possible to determine that the measure possesses, in a greater or lesser degree, the liquidity compared with other measures.

To estimate liquidity risk two types of vector assessment are proposed [2]:

$u_t^1(t)$ – evaluation vector, which is calculated according to linear dynamic normal;

$u_t^2(t)$ – evaluation vector, which is calculated according to nonlinear dynamic normal on the basis of normative and actual matrices of correlations.

To calculate dynamic index we use vector $U^2(t)$ which is based on matrix analyses and includes next steps.

From our point of view it's not completely correct to use concept of dynamic normal of liquidity, because usually normals are established by National Bank in order to limit risks in banks' activity. Dynamic normal proposed is an estimated value, which is calculated on the basis of dynamics of measures characterizing individual aspects of banks' operations. It would be more correct to denominate this value "dynamic parameter of liquidity", because this value is not necessary to exercise control of bank activity.

Definition of dynamic parameter of liquidity includes several stages.

* National Bank of Ukraine, Ukraine.

1. Determination of set of parameters, on which basis dynamic parameter of liquidity will be formed. This stage is extremely important for constructing the model, because accuracy of estimating liquidity risk depends on the degree to which individual liquidity indicators chosen are sensitive. Shaping of the set of parameters must be based on system approach, to take into account the level of assets liquidity, liabilities stability and bank credibility. It has been proved that trace amount of parameters does not allow accurate generalized estimation, and insignificant changes in dynamics of individual measures can lead to substantial alterations. On the contrary, a good deal of parameters leads to loss of estimate sensitivity to changes in their dynamics, that is, substantial changes do not lead to respective changes in dynamic parameter. Use of ordinal scales testifies viability of their use in adjustment as many as 6 and not above 25 parameters [2].
2. Interpretation of measures relative to each other, establishing dynamic correlations between parameters. The accuracy of liquidity risk estimation depends on correctness of determining correlations between parameters. At this stage, maintenance of economic feasibility of comparison of each pair of parameters is a sine qua non condition. As a result of analysis of dynamic correlations between parameters, matrix of normative correlations of parameters is obtained. Every element p_{ij} of matrix of normative correlations *P* is determined as follows:

$$p_{ij} = \begin{cases} 1, \text{ if } i\text{-th parameter should grow more rapidly than } j\text{-th parameter;} \\ -1, \text{ if } i\text{-th parameter should grow more slowly than } j\text{-th parameter;} \\ 0, \text{ if normative correlation between parameters is not revealed.} \end{cases}$$

3. Forming matrix of actual correlations of parameters growth rates $M^F(t) = \{m_{ij}^F(t)\}_{kxk}$ for each time moment:

$$m_{ij}^F(t) = \begin{cases} 1, \text{if } I_i(t) > I_j(t) \text{ and } m_{ij}^A \text{ is not equal to } 0, \\ -1, \text{if } I_i(t) < I_j(t) \text{ and } m_{ij}^A \text{ is not equal to } 0, \\ 0 \text{ if } I_i(t) = I_j(t) \text{ and } m_{ij}^A = 0, \end{cases}$$

where: $I_i(t)$ is growth rate of i-th parameter at time t;

$I_j(t)$ – growth rate of j-th parameter at time t;

m_{ij}^A – element of matrix of actual correlations of parameters growth rates, existing at the intersection of i-th row and j-th column.

4. Forming coincidence matrix of actual and normative correlations of parameters growth rates

$M^C(t) = \{m_{ij}^C(t)\}_{kxk}$:

$$m_{ij}^C(t) = \begin{cases} 1, \text{if } m_{ij}^A(t) = m_{ij}^F(t) \text{ and } m_{ij}^A \text{ is not equal to } 0, \\ -1, \text{if } m_{ij}^A(t) \neq m_{ij}^F(t) \text{ and } m_{ij}^A \text{ is not equal to } 0, \\ 0, \text{if } m_{ij}^A = 0. \end{cases}$$

5. We estimate dynamic parameter of liquidity as a ratio of coincidences of normative and actual correlations to the quantity of normative correlations in absolute magnitude $U^2(t)$:

$$u_t^2(t) = \sum_{Ij} m_{ij}^C(t) / \sum_{ij} \left| m_{ij}^A(t) \right| \text{ for all 2, 3, …, } T \quad (1)$$

Dynamic parameter takes the value from -1 to 1. If at some time moment t estimate of u_t^2 will take the value 1, it is obvious that all normative correlations of parameters are actually executed. On the contrary, if $u_t^2 = -1$, then it means that actual order of parameters is in complete contrast to the normative one.

Vector $u_t^2(t)$ is the measure of closeness of actual and normative adjustment of liquidity parameters and bank's solvency, and it quantitatively characterizes liquidity risk. Negative values $u_t^2(t)$ in some accounting periods can be explained by limitation of financial resources for maintenance of parameters dynamics at the desired level.

The main features of high liquidity risk are sharp decrease of dynamic parameter of liquidity $u_t^2(t)$ under simultaneous change of its sign and/or maintaining the negative values of dynamic normal during long period. Decrease of dynamic normal values, as it comes from principles and methods of its composition, must be accompanied by increase of liquidity risk and bank's solvency.

Sharp increase in dynamic parameter values under simultaneous change of its sign from "-" to "+" raises a question concerning examination with the aim to conduct an assessment of bank liquidity.

If dynamic parameter $u_t^2(t)$ equals zero, it speaks about threshold level of liquidity, which requires enhanced monitoring with the aim to exclude crisis of liquidity.

It is worthwhile to say that dynamic parameter of liquidity, which is based on the assessment of closeness of values of actual and normative matrices of parameters growth rates correlations, possesses important features such as consistency (the estimation reflects parameters in their interrelation and in time), complexity (for construction of dynamic parameter measures reflecting the most important aspects of banks' liquidity and solvency are used). Also this dynamic parameter of liquidity is susceptible to consequences of management decisions taken and to liquidity risks growth, and every management decision is reflected in parameters dynamics.

Let's consider definition of dynamic parameter of liquidity and solvency for banking system of Ukraine in 2004 and 2005.

To build the model of dynamic parameter of liquidity of banking system of Ukraine 8 parameters are chosen (Table 1). The choice of these parameters is determined by their important role in estimating liquidity risk and solvency.

Each of these parameters is numerator or denominator of correlations which are the base of building of dynamic parameter of liquidity.

For 8 parameters selected normative matrix of correlations between individual parameters (P) is determined. By reference to requirements of liquidity risk minimization, if i-th parameter must grow at a faster pace than j-th parameter, then respective element of matrix equals +1 and -1 otherwise. Hence, to exclude liquidity risk the growth rates of highly liquid assets must be higher, than those of assets as a whole, therefore $p_{21} = +1$. Proceeding from requirements of solvency risk minimization assets must grow more slowly than capital, therefore $p_{16} = -1$. If there is no relation between parameters, respective element of matrix equals 0. Normative matrix of correlations between parameters determined for liquidity risk and solvency estimate is presented in Table 2.

Table 1

Dynamics of individual parameters of banking system[1] (mln. hryvnas)

№	Title	01.01.2004	01.01.2005	01.01.2006	Growth rates	
					2004	2005
1	Assets (A)	105539	141497	223024	1,34	1,58
2	Highly liquid assets (cash funds and bank metals, funds at request of NBU and other banks) (HA)	17692	26405	38502	1,49	1,46
3	Government securities (GS)	4816	2703	6487	0,56	2,40
4	Troubled loans (TL)	2500	3145	3379	1,26	1,07
5	Non-working assets (NA)	9508	12534	15808	1,32	1,26
6	Balance capital (BC)	12882	18421	25451	1,43	1,38
7	Current liabilities (CL)	31110	40246	59187	1,29	1,47
8	Household deposits (HD)	32113	41207	72542	1,28	1,76

Table 2

Matrix of normative correlations between parameters for liquidity risk and solvency estimate

№	Title	A	HA	GS	TL	NA	BC	CL	HD
1	Assets (A)	0	-1	-1	1	1	-1	0	0
2	Highly liquid assets (cash funds and bank metals, funds at request of NBU and other banks) (HA)	1	0	0	1	0	0	1	1
3	Government securities (GS)	1	0	0	1	0	0	0	0
4	Troubled loans (TL)	-1	-1	-1	0	0	-1	0	0
5	Non-working assets (NA)	-1	0	0	0	0	-1	0	0
6	Balance capital (BC)	1	0	0	1	1	0	1	1
7	Current liabilities (CL)	0	-1	0	0	0	-1	0	0
8	Household deposits (HD)	0	-1	0	0	0	-1	0	0
	Total	5	4	2	4	2	5	2	2

On the basis of parameters' growth rates values (Table 1) we construct matrix of actual correlations of parameters growth rates $m_{ij}^{F}(t)$, which are used for estimating liquidity risk and solvency of banking system of Ukraine in 2004 and 2005 (Tables 3, 4).

Table 3

Matrix of actual correlations of parameters growth rates in 2004

№	Title	A	HA	GS	TL	NA	BC	CL	HD
1	Assets (A)	0	-1	1	1	1	-1	0	0
2	Highly liquid assets (cash funds and bank metals, funds at request of NBU and other banks) (HA)	1	0	0	1	0	0	1	1
3	Government securities (GS)	-1	0	0	-1	0	0	0	0
4	Troubled loans (TL)	-1	-1	1	0	0	-1	0	0
5	Non-working assets (NA)	-1	0	0	0	0	-1	0	0
6	Balance capital (BC)	1	0	0	1	1	0	1	1
7	Current liabilities (CL)	0	-1	0	0	0	-1	0	0
8	Household deposits (HD)	0	-1	0	0	0	-1	0	0

[1] Computed according to data of official web site of National Bank of Ukraine www.bank.gov.ua

Table 4

Matrix of actual correlations of parameters growth rates in 2005

№	Title	A	HA	GS	TL	NA	BC	CL	HD
1	Assets (A)	0	1	-1	1	1	1	0	0
2	Highly liquid assets (cash funds and bank metals, funds at request of NBU and other banks) (HA)	-1	0	0	1	0	0	-1	-1
3	Government securities (GS)	1	0	0	1	0	0	0	0
4	Troubled loans (TL)	-1	-1	-1	0	0	-1	0	0
5	Non-working assets (NA)	-1	0	0	0	0	-1	0	0
6	Balance capital (BC)	-1	0	0	1	1	0	-1	-1
7	Current liabilities (CL)	0	1	0	0	0	1	0	0
8	Household deposits (HD)	0	1	0	0	0	1	0	0

At the next stage we construct coincidence matrix $m_{ij}^{C}(t)$ of actual correlations of matrix $m_{ij}^{F}(t)$ and normative correlations of matrix P. On the basis of coincidence matrix $m_{ij}^{C}(t)$ and matrix of normative correlations we calculate generalized dynamic parameter of liquidity $u_t^2(t)$ by formula (1) as a ratio of coincidences number (Tables 5, 6) to total amount of values modulo on normative matrix (Table 2).

Table 5

Coincidence matrix of normative and actual correlations between parameters in 2004

№	Title	A	HA	GS	TL	NA	BC	CL	HD
1	Assets (A)	0	1	-1	1	1	1	0	0
2	Highly liquid assets (cash funds and bank metals, funds at request of NBU and other banks) (HA)	1	0	0	1	0	0	1	1
3	Government securities (GS)	-1	0	0	-1	0	0	0	0
4	Troubled loans (TL)	1	1	-1	0	0	1	0	0
5	Non-working assets (NA)	1	0	0	0	0	1	0	0
6	Balance capital (BC)	1	0	0	1	1	0	1	1
7	Current liabilities (CL)	0	1	0	0	0	1	0	0
8	Household deposits (HD)	0	1	0	0	0	1	0	0
	Total	3	4	-2	2	2	5	2	2

Table 6

Coincidence matrix of normative and actual correlations between parameters in 2005

№	Title	A	HA	GS	TL	NA	BC	CL	HD
1	Assets (A)	0	-1	1	1	1	-1	0	0
2	Highly liquid assets (cash funds and bank metals, funds at request of NBU and other banks) (HA)	-1	0	0	1	0	0	-1	-1
3	Government securities (GS)	1	0	0	1	0	0	0	0
4	Troubled loans (TL)	1	1	1	0	0	1	0	0
5	Non-working assets (NA)	1	0	0		0	-1	0	0
6	Balance capital (BC)	-1	0	0	1	1	0	-1	-1
7	Current liabilities (CL)	0	-1	0	0	0	-1	0	0
8	Household deposits (HD)	0	-1	0	0	0	-1	0	0
	Total	1	-2	2	4	2	-3	-2	-2

Despite financial instability at the end of 2004 the level of liquidity and solvency of Ukraine's banking system was sufficiently high due to priority rates of capital growth (1,43) and highly liquid funds (1,46) compared with scope of active operations (1,34). There existed 18 out of 26 coincidences of normative and actual correlations of parameters which are used to estimate liquidity risk. Dynamic parameter of liquidity $u_t^2(t)$ of Ukraine's banking system amounted 69,2%.

$$u_t^2(t)_{2004} = (18:26)\times 100\% = 69.2\%. \quad (2)$$

Note that in 2004 there also existed positive trend concerning decrease of gaps between assets and liabilities concerning terms. Negative gap till 1 month decreased from -15,2% to -11,8%. Liquidity reserve made it possible to somewhat mitigate the outcomes of financial crisis in December 2004.

In 2005 dynamic parameter of liquidity took on a zero value, i.e. banking system had threshold liquidity level, and when the situation does not change and negative trend of decrease of generalized parameter of liquidity remains then dynamic parameter will take a negative value. This will testify the increased liquidity risk in banking system. Decrease in dynamic parameter of liquidity has occurred as a result of gap between capital growth rates (1,38), highly liquid assets (1,46) and assets growth rates in general (1,58).

Despite the fact that in 2005 gaps between assets and liabilities concerning terms decreased and value of liquidity normals compared with those in 2004 hadn't change, liquidity risk and solvency must be under regular monitoring.

Therefore, dynamic parameter of liquidity is an integral factor allowing estimate of bank liquidity. Dynamic normal along with gap-analysis, liquidity normals and coefficient analysis is a necessary component of system of estimating bank's liquidity risk and solvency. Note that both low as well as high values of bank liquidity are negative for financial stability of bank. Thus liquidity deficit limits banks' performance, increases risks of loss of solvency and decreases profitability of banking activity, because in such a situation banks are forced to maintain loss-making liquidity sizes in low-profit assets in order to be solvent. High liquidity reserve of banks tells about their inability to manage their own resources effectively which negatively affects the level of net interest margin and other indicators of banks performance and makes banks susceptible to risk of change in interest rates.

References

1. Буздалин А.В. Факторы оптимальной ликвидности // Банковское дело. – 2005. – № 1 – С. 2-7.
2. В. Недаровский. Ликвидность и платежеспособность кредитной организации в ординальном измерении // Банковские технологи. – 2001. – № 6. – С. 29-41.
3. Погостинская Н.Н., Погостинский Ю.А. Системный анализ финансовой отчетности. СПб.: Изд-во Михайлова В.А., 1999.
4. www.bank.gov.ua