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Technology of Predictive Analysis of Entity's Financial Stability Based on Linear Constrains

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Abstract: ***This paper describes the technology for the predictive analysis of a business entity's financial stability through the contemporary concept of equilibrium stability of a system. Analyzing the capability of business transactions to restore the financial equilibrium in the forecast period (where such financial equilibrium is disturbed as of the end of the reference period) is the most important part of the predictive analysis. In this paper, the author explains the structure, content of, and algorithms for this part of the predictive analysis of financial stability. The author has developed the general linear inequality to set the limits for the values of future business transactions that restore the financial equilibrium of a business entity***

Index Terms: ***canonical criterion function for financial condition, financial equilibrium, financial equilibrium stability, matrices of the effect of business transactions on the asset and liability sides of the balance sheet model, vector of business transactions***

I. INTRODUCTION

This paper deals with the rationale behind the new paradigm for analysing the financial stability of a business entity through the concept of its equilibrium stability [13], and the methods for analysing financial stability within the new paradigm [14].

II. METHODS AND MATERIALS

A. GENERAL DESCRIPTION

This paper reviews the methods for the predictive analysis of financial stability in terms of an aggregated balance sheet model of the financial condition [12]:

$$FS_t = \left\{ \bar{a}_t = \begin{pmatrix} F_t \\ E_t^{ST} \\ E_t^{AR} \\ E_t^{CASH} \end{pmatrix}, \bar{p}_t = \begin{pmatrix} K_t^C \\ K_t^{LTL} \\ K_t^{STL} \\ K_t^{AP} \end{pmatrix} \right\} \qquad (1)$$

where F_t - non-current assets together with long-term receivables;

E_t^{ST} - stocks (together with the balance VAT on assets acquired, which is not claimed as VAT credit);

E_t^{AR} - short-term financial investments (other than cash equivalents) and short-term receivables,

Other than contributions owed by the members (founding members) to the authorized capital (other current assets shall be classified either as stocks or as debts, depending on their role in the circular flow);

E_t^{CASH} - cash and cash equivalents;

K_t^C - net assets;

K_t^{LTL} - log-term liabilities;

K_t^{STL} - short-term loans;

K_t^{AR} - accounts payable, estimated short-term liabilities and other short-term liabilities (other than deferred income reported as net assets);

$$\bar{a}_t = \begin{pmatrix} a_{1t} \\ a_{2t} \\ a_{3t} \\ a_{4t} \end{pmatrix} = \begin{pmatrix} F_t \\ E_t^{ST} \\ E_t^{AR} \\ E_t^{CASH} \end{pmatrix}$$

- vector of the asset side of the balance sheet model FS_t, which at the given degree of aggregation includes four items of the asset side of the analytical balance sheet at a given point of time t;

$$\bar{p}_t = \begin{pmatrix} p_{1t} \\ p_{2t} \\ p_{3t} \\ p_{4t} \end{pmatrix} = \begin{pmatrix} K_t^C \\ K_t^{LTL} \\ K_t^{STL} \\ K_t^{AP} \end{pmatrix}$$

- vector of the liability side of the balance sheet model FS_t, which at the given degree of aggregation includes four items of the liability side of the analytical balance sheet at a given point of time t.

The canonical criterion function for the financial equilibrium of model (1) is described by the following formula [14] (a dot product of the canonical function coefficient vectors and the asset and liability vectors of balance sheet model (1) is used to formulate the criterion function):

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$$f_{CR}(FS_t)=\sum_{i=1}^{4}\lambda_i a_{it}+\sum_{j=1}^{4}\mu_j p_{jt}=(\lambda_1;\lambda_2;\lambda_3;\lambda_4)\cdot\begin{pmatrix}F_t\\ E_t^{ST}\\ E_t^{AR}\\ E_t^{CASH}\end{pmatrix}+(\mu_1;\mu_2;\mu_3;\mu_4)\cdot\begin{pmatrix}K_t^{C}\\ K_t^{LTL}\\ K_t^{STL}\\ K_t^{AP}\end{pmatrix}=$$
$$=(\bar{\lambda},\bar{a}_t)+(\bar{\mu},\bar{p}_t)$$
, (2)

where $\bar{\lambda}=(\lambda_1;\lambda_2;\lambda_3;\lambda_4)$ - the vector of the coefficients of the asset items of the balance sheet model $\bar{a}_t=\begin{pmatrix}a_{1t}\\ a_{2t}\\ a_{3t}\\ a_{4t}\end{pmatrix}=\begin{pmatrix}F_t\\ E_t^{ST}\\ E_t^{AR}\\ E_t^{CASH}\end{pmatrix}$ in the criterion function for the financial equilibrium (2);

$\bar{\mu}=(\mu_1;\mu_2;\mu_3;\mu_4)$ - the vector of the coefficients of the liability items of the balance sheet model $\bar{p}_t=\begin{pmatrix}p_{1t}\\ p_{2t}\\ p_{3t}\\ p_{4t}\end{pmatrix}=\begin{pmatrix}K_t^{C}\\ K_t^{LTL}\\ K_t^{STL}\\ K_t^{AP}\end{pmatrix}$ in the criterion function for the financial equilibrium (2).

If at the end of the reference period, the financial equilibrium of a business entity is disturbed ($f_{CR}(FS_t)<0$), possible business transactions shall be reviewed to re-stablish the equilibrium in the forecast period, which immediately follows the reference one.

The algorithm for estimating the value of business transactions aimed to restore the entity’s financial equilibrium requires that the canonical criterion function for the financial condition (2) is used. Using the coefficients of the canonical criterion function, an inequality can be formulated so as to include the values of business transactions aimed to restore the entity’s financial equilibrium [1, 7, 9, 15, 25].

To formulate such inequality, matrices of the effect of business transactions on the asset and liability sides of the balance sheet model of financial condition are also taken into account [12, 17, 19, 21, 22]. Such matrices couple the vectors of the asset and liability sides of the balance sheet model for two successive points of time (hereinafter, the same notations are used as in the description of the canonical criterion function (2)):

$$\begin{cases}\bar{a}_{t+\Delta t}=\bar{a}_t+A\bar{x}_{[t,t+\Delta t]}\\ \bar{p}_{t+\Delta t}=\bar{p}_t+P\bar{x}_{[t,t+\Delta t]}\end{cases},\qquad(3)$$

where

$$\bar{x}_{[t,t+\Delta t]}=\begin{pmatrix}x_{1[t,t+\Delta t]}\\ \vdots\\ x_{k[t,t+\Delta t]}\\ \vdots\\ x_{l[t,t+\Delta t]}\end{pmatrix}$$

- the vector of the business transactions [12] implemented by the business entity in the period of time $[t,t+\Delta t]$ immediately following the reference period. Item $x_{k[t,t+\Delta t]}$ of the business transactions vector represents the value of the k group of homogeneous transactions implemented by the business entity in a given period of time $[t,t+\Delta t]$;

$A=(\alpha_{ik})$

- matrix of the effect of business transactions on the asset side of the balance sheet model [12], where α_{ik} represents the effect of the k group of homogeneous transactions on the i item of the vector of the asset side of the balance sheet model: the effect is positive if $\alpha_{ik}>0$, the effect is negative if $\alpha_{ik}<0$, the effect is zero if $\alpha_{ik}=0$; matrix A comprises four lines that correspond to the items of the vector of the asset side of the balance sheet model, the number of columns is equal to the number of groups of homogeneous business transactions;

$P=(\pi_{jk})$

- matrix of the effect of business transactions on the liability side of the balance sheet model [12], where π_{jk} represents the effect of the k group of homogeneous transactions on the j item of the vector of the liability side of the balance sheet model. Item values of matrix P are determined in the same manner as item values of matrix A.

The value of the criterion function at a given point of time $(t+\Delta t)$ can be calculated using the equations of the balance sheet model flow (3) (hereinafter, the canonical criterion function is used in proving the equation):

$$f_{CR}(FS_{t+\Delta t})=(\bar{\lambda},\bar{a}_{t+\Delta t})+(\bar{\mu},\bar{p}_{t+\Delta t})=(\bar{\lambda},\bar{a}_t+A\bar{x}_{[t,t+\Delta t]})+(\bar{\mu},\bar{p}_t+P\bar{x}_{[t,t+\Delta t]})=$$
$$=(\bar{\lambda},\bar{a}_t)+(\bar{\lambda}A,\bar{x}_{[t,t+\Delta t]})+(\bar{\mu},\bar{p}_t)+(\bar{\mu}P,\bar{x}_{[t,t+\Delta t]})=$$
$$=[(\bar{\lambda},\bar{a}_t)+(\bar{\mu},\bar{p}_t)]+(\bar{\lambda}A+\bar{\mu}P,\bar{x}_{[t,t+\Delta t]})=f_{CR}(FS_t)+(\bar{\lambda}A+\bar{\mu}P,\bar{x}_{[t,t+\Delta t]})\qquad(4)$$

The two consecutive points of time are understood as the end of the reference period (t), at which the financial nonequilibrium is observed, and a point of time $(t+\Delta t)$ in the period immediately following the reference one, at which the financial equilibrium must be restored following the implementation of the forecasted business transactions:

$$\begin{cases}f_{CR}(FS_t)<0\\ f_{CR}(FS_{t+\Delta t})\geq 0\end{cases}\qquad(5)$$

If the requirement of non-negativity of the criterion function at a given point of time $(t+\Delta t)$ (condition for the financial equilibrium at some point in the forecast period) is applied to expression (4):

$$f_{CR}(FS_t)+(\bar{\lambda}A+\bar{\mu}P,\bar{x}_{[t,t+\Delta t]})\geq 0,\qquad(6)$$

then

$$(\bar{\lambda}A+\bar{\mu}P,\bar{x}_{[t,t+\Delta t]})\geq -f_{CR}(FS_t) \quad (7)$$

Business transactions that restore the equilibrium after it is disturbed at the end of the review period should be implemented within the specified maximum recovery period. If the condition is met, the financial equilibrium in the review period is recognized as stable, otherwise - as unstable [2, 5, 11, 23].

Inequality (7) limits the values of the future business transactions that restore the financial equilibrium of a business entity, but it does not, however, stringently predetermine these values, since the scope of the estimated future operations can vary, and different combinations of such business transactions are possible. For the purpose of the proposed method, the predictive analysis of the equilibrium restoration in terms of the transaction values is reduced to finding the solutions to this inequality (7). In the general case, this inequality may have infinitely many solutions. Moreover, many of such soultions may fail to conform to the business entity's conditions. Therefore, inequality (7) should be supplemented by other inequalities or equations to limit or bind the values of the business transactions based on any additional information about the current and forecasted business conditions or based on the set values for a number of parameters that reflect the entity's objectives. Ideally, such set of constraints should consist of inequalities and equations in the number at least equal to the number of unknown business transaction values. In reality, such ratio cannot always be achieved, which is another reason for using scenario-based predictive analysis with regard to the restoration of financial equilibrium [3, 4, 6, 12, 20].

B. ALGORITHM

To evaluate business transactions that restore the equilibrium, i.e. to find solutions to the linear inequalities, including inequality (7), the findings of the theory of systems of linear inequalities must be applied [14, 18, 24, 26]. The method of predictive analysis of the possible restoration of the financial equilibrium cannot be recognized as truly complete due to the requirement to consider whether it is possible to apply the contemporary mathematical methods for solving systems of linear inequalities to the set of constraints represented by linear inequalities and equations in relation to the values of the future business transactions. However, an algorithm must be provided for setting up linear inequalities that limit the values of the future business transactions aimed to restore the financial equilibrium. Such algorithm can be helpful in conducting a predictive analysis of future business transactions, i.e. for the purpose of comparison between different combinations of business transactions from the point of view of their efficiency in restoring the financial equilibrium. This algorithm results in the computation of coefficients of the linear inequalities for the values of business transactions that restore or maintain the financial equilibrium (or impair the equilibrium within the financial safety margin), and in the development of various combinations of linear inequalities depending on the criterion function selected. This algorithm requires the following preliminary procedures [8, 10, 13, 16] to be carried out:

- Select and compile a list of business transactions that restore financial equilibrium in the forecast period;
- Set up matrices for the effect of business transactions on the asset and liability items of the balance sheet model of financial condition;
- Select and put down canonical criterion functions for the financial equilibrium of a business entity;
- Set up a balance sheet model of the financial condition and calculate the values of the selected criterion functions for the financial conditions as of the end of the review period.

III. RESULTS

Computation of coefficients of the linear inequalities for the values of business transactions that restore or maintain the financial equilibrium and development of various combinations of linear inequalities depending on the criterion function selected.

Since the vectors of the coefficients $\bar{\lambda}$ and $\bar{\mu}$ in the canonical criterion function depend on the type of the function, then for the criterion function f_{CRi} having the i number in the list of the criterion functions selected, linear inequality (7) for the values of business transactions that restore financial equilibrium is as follows:

$$(\bar{\lambda}(f_{CRi})A+\bar{\mu}(f_{CRi})P,\bar{x}_{[t,t+\Delta t]})\geq -f_{CRi}(FS_t), \quad (42)$$

where $\bar{\lambda}(f_{CRi})$ - the vector of the coefficients of the asset items of the balance sheet model (1) in the canonical function f_{CRi};

$\bar{\mu}(f_{CRi})$ - the vector of the coefficients of the liability items of the balance sheet model (1) in the canonical function f_{CRi}.

The value of $\bar{\lambda}(f_{CRi})A+\bar{\mu}(f_{CRi})P$ reflecting the dot product on the left side of inequality (42) is the vector of the coefficients multiplied by the values of the business transactions concerned. The coefficient multiplied by the value of the x_k business transaction is

$$(\bar{\lambda}(f_{CRi}),A_k)+(\bar{\mu}(f_{CRi}),P_k), \quad (43)$$

where A_k - the k column of matrix A of the effect of business transactions on the asset side of the balance sheet model (1);

P_k - the k column of matrix P of the effect of business transactions on the liability side of the balance sheet model (1).

For each of the six canonical criterion functions selected (12), (16), (20), (24), (28), (32), twenty coefficients on the left side of inequality (42) are calculated according to the formula (43) using the values of the vector items (13), (14), (17), (18), (21), (22), (25), (26), (29), (30), (33), (34) and matrices (9), (10).

The algorithm for the computation of coefficients on the left side of inequality (42) is shown below for the first of the six selected criterion functions.

For the remaining five criterion functions, the vector of the coefficients on the left side of inequality (42) should be determined in the same manner. In the algorithm for the computation of coefficients through the example of the first coefficient on the left side of inequality (42) for the first criterion function, the values $(\bar{\lambda}(f_{CRi}),A_k)$ and $(\bar{\mu}(f_{CRi}),P_k)$ are calculated first and and only then their sum is found $(\bar{\lambda}(f_{CRi}),A_k)+(\bar{\mu}(f_{CRi}),P_k)$. For the remaining nineteen coefficients, only the sums $(\bar{\lambda}(f_{CRi}),A_k)+(\bar{\mu}(f_{CRi}),P_k)$ are shown (calculated in the same manner).

1) Computation of the linear inequality coefficients for the criterion function f_{CR1} (working capital to stocks ratio):

$$(\bar{\lambda}(f_{CR1}),A_1)=(-1;-1;0;0)\cdot\begin{pmatrix}0\\0\\1{,}2\\0\end{pmatrix}=(-1)\cdot 0+(-1)\cdot 0+0\cdot 1{,}2+0\cdot 0=0$$
(44)

$$(\bar{\mu}(f_{CR1}),P_1)=(1;0;0;0)\cdot\begin{pmatrix}1\\0\\0\\0{,}2\end{pmatrix}=1\cdot 1+0\cdot 0+0\cdot 0+0\cdot 0{,}2=1$$
(45)

$$(\bar{\lambda}(f_{CR1}),A_1)+(\bar{\mu}(f_{CR1}),P_1)=0+1=1$$
(46)

$$(\bar{\lambda}(f_{CR1}),A_2)+(\bar{\mu}(f_{CR1}),P_2)=1+(-1)=0$$
(47)

$$(\bar{\lambda}(f_{CR1}),A_3)+(\bar{\mu}(f_{CR1}),P_3)=0+(-1)=-1$$
(48)

$$(\bar{\lambda}(f_{CR1}),A_4)+(\bar{\mu}(f_{CR1}),P_4)=(-1{,}2)+0=-1{,}2$$
(49)

$$(\bar{\lambda}(f_{CR1}),A_5)+(\bar{\mu}(f_{CR1}),P_5)=(-1{,}3)+0=-1{,}3 \quad (50)$$

$$(\bar{\lambda}(f_{CR1}),A_6)+(\bar{\mu}(f_{CR1}),P_6)=0+0=0 \quad (51)$$

$$(\bar{\lambda}(f_{CR1}),A_7)+(\bar{\mu}(f_{CR1}),P_7)=0+(-1)=-1 \quad (52)$$

$$(\bar{\lambda}(f_{CR1}),A_8)+(\bar{\mu}(f_{CR1}),P_8)=0+(-1)=-1 \quad (53)$$

$$(\bar{\lambda}(f_{CR1}),A_9)+(\bar{\mu}(f_{CR1}),P_9)=0+0=0 \quad (54)$$

$$(\bar{\lambda}(f_{CR1}),A_{10})+(\bar{\mu}(f_{CR1}),P_{10})=0+0=0 \quad (55)$$

$$(\bar{\lambda}(f_{CR1}),A_{11})+(\bar{\mu}(f_{CR1}),P_{11})=1+0=1 \quad (56)$$

$$(\bar{\lambda}(f_{CR1}),A_{12})+(\bar{\mu}(f_{CR1}),P_{12})=-1{,}2+0=-1{,}2 \quad (57)$$

$$(\bar{\lambda}(f_{CR1}),A_{13})+(\bar{\mu}(f_{CR1}),P_{13})=0+1=1 \quad (58)$$

$$(\bar{\lambda}(f_{CR1}),A_{14})+(\bar{\mu}(f_{CR1}),P_{14})=1+(-1)=0 \quad (59)$$

$$(\bar{\lambda}(f_{CR1}),A_{15})+(\bar{\mu}(f_{CR1}),P_{15})=0+1=1 \quad (60)$$

$$(\bar{\lambda}(f_{CR1}),A_{16})+(\bar{\mu}(f_{CR1}),P_{16})=0+0=0 \quad (61)$$

$$(\bar{\lambda}(f_{CR1}),A_{17})+(\bar{\mu}(f_{CR1}),P_{17})=0+0=0 \quad (62)$$

$$(\bar{\lambda}(f_{CR1}),A_{18})+(\bar{\mu}(f_{CR1}),P_{18})=0+0=0 \quad (63)$$

$$(\bar{\lambda}(f_{CR1}),A_{19})+(\bar{\mu}(f_{CR1}),P_{19})=0+0=0 \quad (64)$$

$$(\bar{\lambda}(f_{CR1}),A_{20})+(\bar{\mu}(f_{CR1}),P_{20})=0+(-1)=-1$$
(65)

Twenty calculated values (46) - (65) make up the vector of the coefficients on the left side of inequality (42), which is set up using the criterial function f_{CR1}. The vector of the coefficients is as follows:

$$\bar{\lambda}(f_{CR1})A+\bar{\mu}(f_{CR1})P=(1;0;-1;-1{,}2;-1{,}3;0;-1;-1;0;0;1;-1{,}2;1;0;1;0;0;0;0;-1) \quad (66)$$

By replacing the left side of inequality (42) by vector (66) and the right side of inequality (42) by value (36) of the criterion function f_{CR1} as of the end of the review period, and by skipping any terms with zero coefficients, the linear inequality can be obtained to limit the values of the business transactions aimed to restore the financial equilibrium identified through the function f_{CR1} :

$$x_1-x_3-1{,}2x_4-1{,}3x_5-x_7-x_8+x_{11}-1{,}2x_{12}+x_{13}+x_{15}-x_{20}\geq 3000 \quad (67)$$

The development of methods for solving inequality (67) and similar inequalities for any other criterion functions is a separate important task of the financial stability analysis, to solve which the contemporary mathematical theory of linear inequalities [1 – 11; 15 - 22] must be used (the author believes that the solution to this task, which is clearly beyond the scope of this paper, is the next step in developing the method for analyzing the financial stability of a business entity within the new analysis paradigm).

To solve inequality (67), additional conditions and relations between the values of business transactions must be introduced as represented by equations and inequalities, e.g. the following ones (subject to possible extension):

a) the condition of non-negativity of the values of all business transactions planned:

$$\forall i(x_i\geq 0) \;;$$
(68)

b) the income tax equation (set up at a 20% tax rate and simplified for the purposes hereof, but subject to itemization if the list of business transactions is extended):

$$x_3 = 0{,}2(x_1 - x_2 - x_7 - x_8 + x_{13} - x_{14}) \quad ; \quad (69)$$

c) the equation for the relation between the cost of sales and revenue at a given sales gross profit margin r^N:

$$x_2 = (1 - r^N)x_1 \quad ; \quad (70)$$

d) dividend distributions limited by the net profit value for the review period (calculated at a 20% tax rate):

$$0{,}8(x_1 - x_2 - x_7 - x_8 + x_{13} - x_{14}) \geq x_{20} \quad (71)$$

2) Computation of the linear inequality coefficients for the criterion function f_{CR2} (long-term sources to stocks ratio):

The vector of the coefficients on the left side of inequality (42), made up using the criterion function f_{CR2} in the same manner as in the above algorithm of (44) – (65) shown for the criterion function f_{CR1}, is as follows:

$$\bar{\lambda}(f_{CR2})A + \bar{\mu}(f_{CR2})P = (1;0;-1;-1{,}2;-1{,}3;0;0;-1;0;0;1;-1{,}2;1;0;1;1;-1;0;0;-1) \quad (72)$$

By replacing the left side of inequality (42) by vector (72) and the right side of inequality (42) by value (37) of the criterion function f_{CK2} as of the end of the review period, and by skipping any terms with zero coefficients, the linear inequality can be obtained to limit the values of the business transactions aimed to restore the financial equilibrium identified through the function f_{CR2}:

$$x_1 - x_3 - 1{,}2x_4 - 1{,}3x_5 - x_8 + x_{11} - 1{,}2x_{12} + x_{13} + x_{15} + x_{16} - x_{17} - x_{20} \geq 1000 \quad (73)$$

To solve inequality (73), additional conditions and relations between the values of business transactions can be introduced as represented by equations and inequalities similar to (68) – (71).

3) Computation of the linear inequality coefficients for the criterion function f_{CR3} (main sources to stocks ratio):

The vector of the coefficients on the left side of inequality (42), made up using the criterion function f_{CR3} in the same manner as the above algorithm of (44) – (65) shown for the criterion function f_{CR1}, is as follows:

$$\bar{\lambda}(f_{CR3})A + \bar{\mu}(f_{CR3})P = (1;0;-1;-1{,}2;-1{,}3;0;0;0;0;0;1;-1{,}2;1;0;1;1;-1;1;-1;-1) \quad (74)$$

By replacing the left side of inequality (42) by vector (74) and the right side of inequality (42) by value (38) of the criterion function f_{CK3} as of the end of the review period, and by skipping any terms with zero coefficients, two versions of the linear inequality are obtained to limit the values of the business transactions allowing deterioration of the financial equilibrium identified through the function f_{CR3} to the critical financial condition threshold or maintaining the financial equilibrium as of the end of the review period. In this case, the linear inequality does not represent the condition for restoring the financial equilibrium but the condition for the allowable deterioration thereof (financial safety margin) or the condition for maintaining the previous degree of financial equilibrium.

The first version of the linear inequality represents soft limits for the values of business transaction that allow approaching the margins of the critical financial condition:

$$x_1 - x_3 - 1{,}2x_4 - 1{,}3x_5 + x_{11} - 1{,}2x_{12} + x_{13} + x_{15} + x_{16} - x_{17} + x_{18} - x_{19} - x_{20} \geq -1400 \quad (75)$$

The second version of the linear inequality represents the requirement for non-deterioration of the financial situation as of the end of the review period and excludes approaching the margins of the critical financial condition:

$$x_1 - x_3 - 1{,}2x_4 - 1{,}3x_5 + x_{11} - 1{,}2x_{12} + x_{13} + x_{15} + x_{16} - x_{17} + x_{18} - x_{19} - x_{20} \geq 0 \quad (76)$$

To solve inequality (75) or (76), the same additional conditions and relations between the values of business transactions can be introduced as represented by equations and inequalities similar to (68) – (71).

4) Computation of the linear inequality coefficients for the criterion function f_{CR4} (cash ratio):

The vector of the coefficients on the left side of inequality (42), made up using the criterion function f_{CR4} in the same manner as in the above algorithm of (44) – (65) shown for the criterion function f_{CR1}, is as follows:

$$\bar{\lambda}(f_{CR4})A + \bar{\mu}(f_{CR4})P = $$
$$= (-0{,}04;0;-0{,}2;-0{,}24;-0{,}26;0;0;-0{,}2;1;-0{,}8;0{,}2;-0{,}24;-0{,}04;0;0;1;-1;0{,}8;-0{,}8;-0{,}2) \quad (77)$$

By replacing the left side of inequality (42) by vector (77) and the right side of inequality (42) by value (39) of the criterion function f_{CR4} as of the end of the review period, and by skipping any terms with zero coefficients, two versions of the linear inequality are obtained to limit the values of the business transactions allowing deterioration of the cash ratio identified using the function f_{CR4} to the minimum threshold (for the cash ratio, the minimum equilibrium value is zero) or maintaining the cash ratio as of the end of the review period. In this case, the linear inequality does not represent the condition for restoring the financial equilibrium but the condition for the allowable deterioration thereof (financial safety margin) or the condition for maintaining the previous degree of financial equilibrium.

The first version of the linear inequality represents soft limits for the values of business transaction that allow approaching the allowed minimum cash ratio:

$$-0{,}04x_1 - 0{,}2x_3 - 0{,}24x_4 - 0{,}26x_5 - 0{,}2x_8 + x_9 - 0{,}8x_{10} + 0{,}2x_{11} -$$
$$-0{,}24x_{12} - 0{,}04x_{13} + x_{16} - x_{17} + 0{,}8x_{18} - 0{,}8x_{19} - 0{,}2x_{20} \geq -400 \quad (78)$$

The second version of the linear inequality represents the requirement for non-deterioration of the financial situation as of the end of the review period and excludes approaching the minimum cash ratio:

$$-0{,}04x_1 - 0{,}2x_3 - 0{,}24x_4 - 0{,}26x_5 - 0{,}2x_8 + x_9 - 0{,}8x_{10} + 0{,}2x_{11} -$$
$$-0{,}24x_{12} - 0{,}04x_{13} + x_{16} - x_{17} + 0{,}8x_{18} - 0{,}8x_{19} - 0{,}2x_{20} \geq 0 \quad (79)$$

To solve inequality (78) or (79), the same additional conditions and relations between the values of business transactions can be introduced as represented by equations and inequalities similar to (68) – (71).

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5) Computation of the linear inequality coefficients for the criterion function f_{CR5} (quick ratio):

The vector of the coefficients on the left side of inequality (42), made up using the criterion function f_{CR5} in the same manner as in the above algorithm of (44) – (65) shown for the criterion function f_{CR1}, is as follows:

$$\bar{\lambda}(f_{CR5})A+\bar{\mu}(f_{CR5})P=(1;0;-1;-1{,}2;-1{,}3;0;0;-1;0;0;1;-1{,}2;1;0;1;1;-1;0;0;-1)$$
(80)

By replacing the left side of inequality (42) by vector (80) and the right side of inequality (42) by value (40) of the criterion function f_{CR5} as of the end of the review period, and by skipping any terms with zero coefficients, the linear inequality can be obtained to limit the values of the business transactions aimed to restore the financial equilibrium identified through the function f_{CR5}:

$$x_1-x_3-1{,}2x_4-1{,}3x_5-x_8+x_{11}-1{,}2x_{12}+x_{13}+x_{15}+x_{16}-x_{17}-x_{20}\geq 1000$$
(81)

To solve inequality (81), the same additional conditions and relations between the values of business transactions can be introduced as represented by equations and inequalities similar to (68) – (71).

Inequality (81) set up using the criterion function f_{CR5} is the same as inequality (73) set up using the criterion function f_{CR2}, assuming that the criterion functions f_{CR2} and f_{CR5} are equivalent in terms of reflecting financial equilibrium of a business entity and the conditions of its restoration. Moreover, based on the balance sheet model (1) it can be proved that the values of the criterion functions f_{CR2} and f_{CR5} are always equal for each and every financial condition since these expressions are identical. The criterion functions f_{CR2} and f_{CR5} can be interpreted as different ways to compute the same criterion of financial equilibrium based on the balance sheet model data (1).

6) Computation of the linear inequality coefficients for the criterion function f_{CR6} (current ratio):

The vector of the coefficients on the left side of inequality (42), made up using the criterion function f_{CR6} in the same manner as in the above algorithm of (44) – (65) shown for the criterion function f_{CR1}, is as follows:

$$\bar{\lambda}(f_{CR6})A+\bar{\mu}(f_{CR6})P=(0{,}8;-1;-2;-1{,}2;-1{,}3;1;0;-2;0;1;1;-2{,}2;0{,}8;0;1;1;-1;-1;1;-2)$$
(82)

By replacing the left side of inequality (42) by vector (82) and the right side of inequality (42) by value (41) of the criterion function f_{CR6} as of the end of the review period, and by skipping any terms with zero coefficients, two versions of the linear inequality are obtained to limit the values of the business transactions allowing deterioration of the current ratio identified using the function f_{CR6} to the minimum threshold (for the current ratio, the minimum equilibrium value is zero) or maintaining the current ratio as of the end of the review period. In this case, the linear inequality does not represent the condition for restoring the financial equilibrium but the condition for the allowable deterioration thereof (financial safety margin) or the condition for maintaining the previous degree of financial equilibrium.

The first version of the linear inequality represents soft limits for the values of business transaction that allow approaching the allowed minimum current ratio:

$$\begin{aligned}&0{,}8x_1-x_2-2x_3-1{,}2x_4-1{,}3x_5+x_6-2x_8+x_{10}+x_{11}-\\&-2{,}2x_{12}+0{,}8x_{13}+x_{15}+x_{16}-x_{17}-x_{18}+x_{19}-2x_{20}\geq -2000\end{aligned} \quad (83)$$

The second version of the linear inequality represents the requirement for non-deterioration of the financial situation as of the end of the review period and excludes approaching the minimum current ratio:

$$\begin{aligned}&0{,}8x_1-x_2-2x_3-1{,}2x_4-1{,}3x_5+x_6-2x_8+x_{10}+x_{11}-\\&-2{,}2x_{12}+0{,}8x_{13}+x_{15}+x_{16}-x_{17}-x_{18}+x_{19}-2x_{20}\geq 0\end{aligned} \quad (84)$$

To solve inequality (83) or (84), the same additional conditions and relations between the values of business transactions can be introduced as represented by equations and inequalities similar to (68) – (71).

IV. DISCUSSION

The applicability of linear inequalities (67), (73), (75), (76), (78), (79), (81), (83), (84) to the scenario-based predictive analysis of financial equilibrium of a business entity is reviewed through the example of inequality (81). Suppose the criterion function selected for the financial equilibrium is that for the quick ratio, i.e. f_{CR5}, the canonical form of which is shown as formula (28), and the criterion function is negative ($f_{CR5}(FS_t)<0$), i.e. financial nonequilibrium is observed. Suppose the forecasted business transactions are represented by the vector $\bar{x}=\begin{pmatrix}x_1\\ \vdots\\ x_k\\ \vdots\\ x_{20}\end{pmatrix}$ comprising the 20 items listed above.

Assume that the financial budgeting procedures result in the development of a set of n scenarios of combinations of future business transactions:

$$S=\{\bar{x}_1,\ldots,\bar{x}_i,\ldots,\bar{x}_n\}, \quad (85)$$

where $\bar{x}_i=\begin{pmatrix}x_{i,1}\\ \vdots\\ x_{i,k}\\ \vdots\\ x_{i,20}\end{pmatrix}$ - the i scenario that includes estimated values of the twenty future business transactions;

$x_{i,k}$ - the estimated value of the k future business transaction included in the i scenario.

Then, using inequality (81), a set of allowable scenarios numbered $i_1,\ldots,i_m$ that restore financial equilibrium can be established as follows:

$$VS = \{\overline{x}_{i_1}, ..., \overline{x}_{i_m}\}, \quad (86)$$

A scenario is considered admissible if the requirements of inequality (81) are met:

$$(\exists \overline{x}_i \in S(x_{i,1} - x_{i,3} - 1{,}2x_{i,4} - 1{,}3x_{i,5} - x_{i,8} + x_{i,11} - 1{,}2x_{i,12} + x_{i,13} + x_{i,15} + x_{i,16} - x_{i,17} - x_{i,20} \geq 1000)) \Rightarrow$$
$$\Rightarrow (\overline{x}_i \in VS)$$

(87)

If any scenario within the S set fails to meet the requirements of inequality (81), such scenario is considered inadmissible in terms of its capability to restore the financial equilibrium:

$$(\exists \overline{x}_i \in S(x_{i,1} - x_{i,3} - 1{,}2x_{i,4} - 1{,}3x_{i,5} - x_{i,8} + x_{i,11} - 1{,}2x_{i,12} + x_{i,13} + x_{i,15} + x_{i,16} - x_{i,17} - x_{i,20} < 1000)) \Rightarrow$$
$$\Rightarrow (\overline{x}_i \notin VS)$$

(88)

Thus, inequality (81) allows to select admissible scenarios from the developed set of scenarios of future business transactions, that would restore the financial equilibrium with regard to the given criterion function for financial equilibrium (28).

V. CONCLUSION

This paper describes the technology for the predictive analysis of the financial stability of a business entity through the concept of its equilibrium stability. Within this concept, financial stability of a business entity is understood as a reference margin of the entity's financial condition reflecting, whether the financial equilibrium is maintained, deteriorated or restored in the reference and forecast periods. The financial equilibrium in this concept is determined based on the values of the criterion functions for the financial condition, i.e. financial equilibrium indicators that depend on the item values of the balance sheet models describing the entity's financial condition.

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