DEVELOPING ENTERPRISE FINANCIAL SUSTAINABILITY AND BANKRUPTCY FORECASTING MODEL IN SPECIFIC ECONOMIC-MATHEMATICAL ENVIRONMENT USING SIMULATION METHOD

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Abstract: *The possibility of developing a specific economic-mathematical model of financial stability and prediction for simulation in the simulated mode is justified by optimal choice of multivariate model. The software package developed by us allows simulations mode based on a general model to develop a number of concrete models of the enterprise and optimal options. Using simulator's techniques and technology is described below.*

Keywords: *Simulator, Financial Sustainability, Model development*

ITHEA Keywords: *I.6.7 Simulation Support Systems*

Introduction

There are many publications dedicated to financial sustainability and bankruptcy forecasting of enterprises. In the advanced countries of the world are developed and used different economic- mathematical models, such as: Altman models, Olsen, Lisa, Dzivjevski and others. The long-term statistical data of bankrupt and financially sustainable enterprises of this country and the sector are based on the determination of the values of the coefficients in any model. Countries, which are moving on a market economy, like Georgia, many statistical data of enterprises bankruptcy does not exist, so the rates statistical methods is not possible, and using models without modifying them in developing and post-Soviet countries invariably serious reduced to problems linked.

Simulation modeling is the most rational way to solve the problem. The purpose of simulation of financial stability and bankruptcy prediction of any simulator and the enterprise is:

- On the basis of a general model that can be considered as a standard model, a particular economic mathematical model of the financial sustainability assessment of the enterprise can be used in the actual activity of the problematic area;
- In the process of teaching: first – getting knowledge using simultaneous modeling, second - simulation of typical situations and decision-making skills, and third - identification and evaluation of received knowledge;
- In the course of scientific research, getting the factors involved in financial sustainability of a particular enterprise or enterprise group.

Setting the task

Financial analyst has three main tasks:

- Assess the financial position of an enterprise based on actual data;
- Prognosis of financial sustainability according to actual data;
- In case of unwanted forecast results, elaborate the plan's plan during which future financial sustainability will be ensured;
- Establish organizational and technical measures based on the results of the forecast and control its implementation.

Specialist in the preparation of the financial analysis has the same tasks, the only difference is that he should acquire financial mathematical methods and models used in the analysis, using a mathematical model capable of modeling - simulation, identify the model of which the characteristics of what can be achieved to the desired values financially stable situation.

The aim of the research was to use the mathematical models used in technology and other areas of the economy (securities market and other) used to assess the financial sustainability of the enterprise without any statistical data:

1. Based on modeling, hypotheses about the structure and content of an integrated indicator of the financial condition of the enterprise. Ie Let's justify the possibility of assessing the financial position of an enterprise with selected economic indicators;
2. The probability of reliability / insecurity of the combination of each indicator and indices shall be calculated by considering the possible financial conditions of an enterprise;
3. Compute the share of each of the indicators and indicators in the financial position of the enterprise;
4. Implementation of the impact of the share of each indicator and the combination of indicators on the expected financial condition of the enterprise;
5. Based on modeling, the financial development strategies of the enterprise should be shown;
6. Calculate the risk of financially unsustainable enterprise of the enterprise and develop ways to prevent it;
7. Based on modeling, the optimum option for the development of the enterprise was chosen and this option should be used to monitor the financial stability of the enterprise;
8. Based on the actual data, the financial stability of the enterprise will be assessed and the bankruptcy assessment forecasts of the enterprise will be implemented.

Our goal is to provide the basis for the financial mathematical model of financial sustainability of the enterprise to achieve the tasks that are listed on the bankruptcy of enterprises which are the basis of the existing models.

Our method requires that achievement of the goals listed here must be achieved only in terms of logical (economic content) connections between economic indicators simulation mode.

We analyzed the mathematical models and algorithms used in the assessment of the financial sustainability of the enterprise - the 14 models: Altman (4 model), Altman-Sabato, Fulmer, Sprengite, Dzivjevsk, Olson, Conan-Goldend, Taffler, Lego, Lisa, Chester models.

Besides the selected indicators based on the economic essence in any model, it is important to determine the values of the $\mathbf{b_i}$-coefficients of this model, which is carried out by the processing of statistical data.

In developing and post-Soviet countries (such as Georgia) there is no long-term statistics on bankruptcy of enterprises, so the next issue on the agenda - designed for such method, which would allow the financial sustainability of the economic mathematical model based on the determined risk of bankruptcy and is not used for the statistical data.

Problem solving method

We have two ways of realizing this task:

First - In economic mathematical model, logical connections between selected economic indicators should be considered. Assess the financial sustainability of the enterprise by comparing logical connections, factual values of the normative values of experts evaluated by the expert (experts);

Second - To develop a specific economic mathematical model of financial sustainability assessment and forecasting for a specific enterprise. Found. The models of P_i and P_{i+1} are different from the values of the coefficients.

Today we have a program that is the second approach to developing economic mathematical model of financial sustainability and forecasting of enterprises.

The second, the essence of the approach chosen by the economic mathematical model of financial sustainability and forecasting of enterprises is the following:

The $\mathrm{m_i} \in \mathrm{M}$ model is chosen from selected models range and by $S_j$enterprise's actual data model's arguments (values) average will be counted.

The first step of solving problem

The first step is realizing with a simulation model. Simulation object is a selected model.

The task is set, when in equation $Z = f_i \emptyset k_t$ model's arguments (values) $\mathrm{f_i} = \mathrm{Const}$, should be found such values of k_i, when: first – Z shows enterprise financial sustainability, or second – Z's different values are counted for different values when Z is changing with Δ step.

So many of the Z's options are different, which are different from the values of the modes in the model. Assessment of the results of any variant is automatically carried out by the rules adopted in the selected model, or in general

$Z = \sum_{i=1}^{n} b_i x_i \to max;\ Z = \sum_{i=1}^{n} b_i x_i \to min$

$b_{i,min} \le b_i \le b_{i,max}$

$b_{i,min} = 0{,}001;$

x_i*- i argument's actual data's average*

Second: The optimum option will be chosen from the variants. The selection criterion is the minimum margin of bankruptcy forecasts. The economic mathematical model of the financial sustainability assessment of the obtained S_j enterprise is different from the sampling $m_i \in M$ model with the values of the coefficients;

Third: Correction of the model adopted according to the actual data of S_j.

The second step of solving problem

First, in the equation $Z = f_i \emptyset k_t$ by using simulation model were found values of input coefficients and many variations of Z, from which was chosen one and tested on actual data. Let's set the task. We have b_i=const, we have to find all x_i arguments' (variables) values. We have to find for t_i, i=1,n year such values, when Z show us stability of the enterprise's financial stability, or get Z's different values for changing model's variables by Δ step. Generally,

$Z = \sum_{i=1}^{n} b_i x_i \to max;\ Z = \sum_{i=1}^{n} b_i x_i \to min$

$x_{i,min} \le x_i \le x_{i,max}$

$x_{i,min}$ - minimal value of actual values;

$x_{i,max}$ - maximal value of actual values;

b_i – values, found with using coefficients' simulation model

For any $m_i \in M$ model plan's many variances is calculated for t_i ,$i = 1, n$ year. Then, the optimal one is chosen from calculated majority of variances, where criteria of optimization is equal to minimum margin of bankruptcy forecasts.

This model is taken to guide the financial stability of the given enterprise and as a model of the bankruptcy forecasts.

Both tasks are the task of optimization. For the 14 reviewed models only two of them (Fulmer, Olson) are not linear optimization, and the rest twelve - linear optimization.

The first task - based on the sample model S_j - the development of economic mathematical model of financial sustainability of the enterprise is simulated by the method /Figure 1/

Developing enterprise financial sustainability and forecasting special model

Development of the economic-mathematical model of the financial sustainability assessment of the enterprise (simplified model of the concrete enterprise and selection of the coefficients of this model) is implemented by the software package FINSIM1_PRO2019[89]. Program's interface is multilingual. One can work with it in Georgian, English and other languages [1,2].

For S_i enterprise, specifically JSC "Telasi", compilaiton of financial stability's assessment and bankruptcy forecast of economic-mathematical model is carrying out by a user, who has got appropriate permissions. The user is allowed to edit data, work with the system in training mode and, what's more important, create specific model for certain enterprise and save calculated results in database. Work with FINSIM1_PRO2019 is carried out in the following sequence:

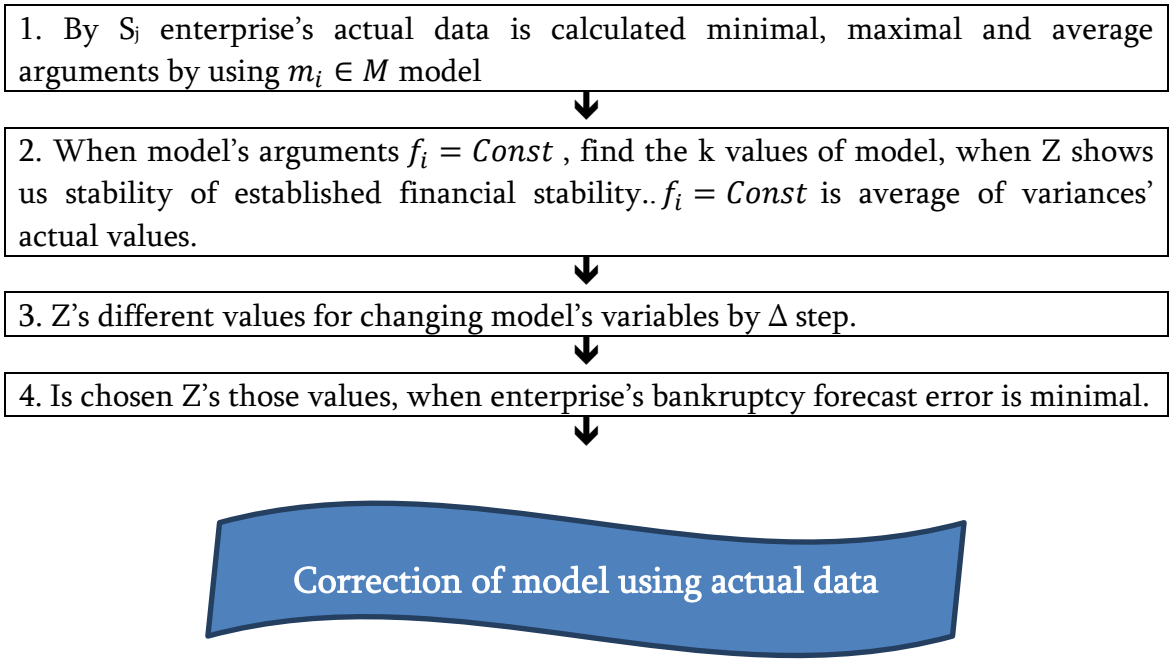


Figure. 1. The stages of developing an economic mathematical model of the financial sustainability assessment and forecasting of the enterprise

1. After choosing interface language and writing ID number and password the next window will pop out /Figure 2/

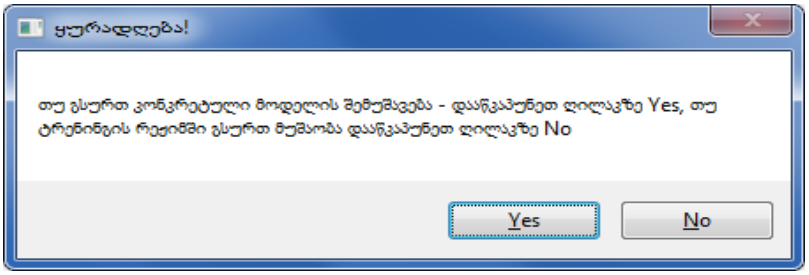
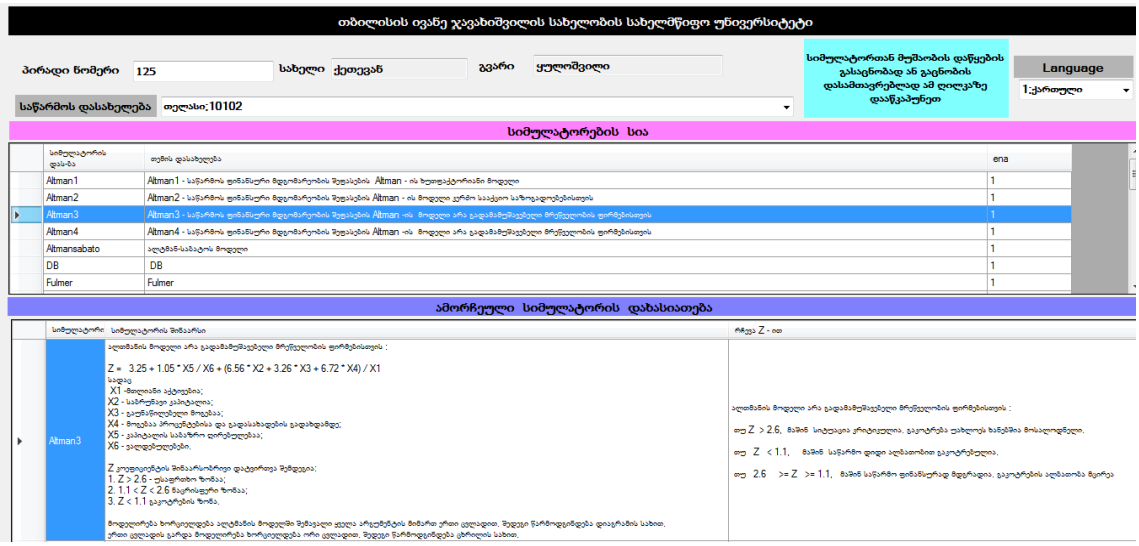


Figure 2. Model development message

2. After pressing "Yes" button, enterprise's name will automatically appear and list of ethernon models of financial sustainability assessment and forecasting of enterprise will roll out, based on which enterprise's concrete economic-mathematical model must be developed. If we change enterprise, which was

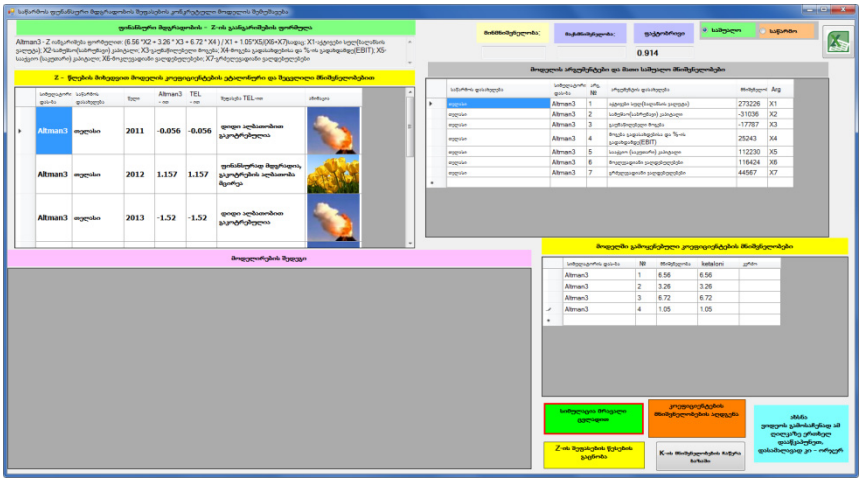
chosen by system, after it list of ethernon models of financial sustainability assessment and forecasting of enterprise will roll out. In both cases we can choose preferred model from the list of models, particularly Altman's model for non-manufacturing enterprises with a conditional name Altman3 /Pic. 3/. In the same window, click on "Click on this button to get started working with the simulator" to start watching the video about how to get started with the simulator.



Pic. 3. Window after user's identification and choosing enterprise and model

First step of specific model developing: In pic.3 in the table "Description of selected simulator" after marking row Altman3 a window /Pic. 4/ will appear. The values of the coefficients used in the table "model" column "K etalon" are recorded in the sampled model by us - the values of the coefficients used in the Altman model, namely: b1 = 6,56; b2 = 3,26; b3 = 6,72; b4 = 1,05. The same values are repeated in the column "value". In the table "The model arguments and their average values" the names of the arguments in the Altman's model are written and their average values are calculated, in the field "Z financial sustainability's calculation formula" Z's calculating formula with selected model is shown, in field "actual" Z's average actual value, which is calculated from Z's average values, is shown, and in the table "Z-year-by-year model coefficients of

phonetic and altered values" is calculated according to the values used in the Altman sampling model of the Z values - column "Altman3" and coefficients, changed by us, - (column "value", table "coefficients, used in the model") Z's values from the column "TEL". According to Z's value, enterprise sustainability's rates are visualized by text and pictures. On the first step of modeling our coefficients aren't changed, so Altman3 and TEL values are equal.



Pic.4. Model developing first step's window

Second step of specific model developing: The determination of the values of the b_i-coefficients in the model is performed on the second and third steps of the development of a specific model. In the second step, the $b_i \in B$ will be selected from the multiplicity of the coefficients, during which the value of Z is accepted within the permissible limits.

Any sample model consists of N number coefficient, so before the start of the second step of the modeling it is necessary to select the coefficient that significantly affects on Z's importance. For this purpose it is necessary to examine the value of Z in the value of the output of any coefficient of the $\forall b_i$ component in the model. The argument of the $\forall b_i$ significance Δ is the change in b.

In order to determine any $\forall b_i$ portion of the model in the value of Z, press the "weight calculator" button. The message "If the value of the coefficient is

increased, write down the number of cycles in the whole number, and if the value of the coefficient is reduced - write the decimal or integer minus sign" will appear.

The number of cycles is calculated when writing a negative number N=b_i/n, where n<0.

The calculation revealed that the values of the B3 coefficient 22.72-38.22 in the values of Z are derived from the values of Z, whereas the production is stable and in the 38.72-47.22 range - the unstable situation. The probability of bankruptcy is small but not excluded.

With the change of the importance of the b_i-coefficient in terms of the role, it has been calculated for years with the desired value of Z. The calculations are as follows:

In the table "The values of the coefficients used in the table" column "value" click the highest-weight coefficient - the value of the b4 coefficient in our case. The message will appear /Figure 5/

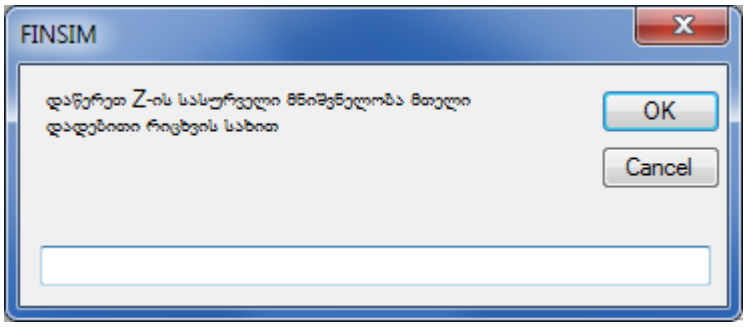


Figure 5. Z's value pointing window

After writing Z value and pressing OK button the values of the Z will be calculated according to the system by years, their assessment will be presented, and the results will be reflected in the table " /Figure 6/.

Third step of specific model developing According to the values of the coefficients selected on the second step of the modeling: first - With a certain set of Z changes, many variables of Z are calculated. second - the variants of the b_i-coefficients will be selected from the variants which the value of Z is the adequate factor of the enterprise. For this purpose:

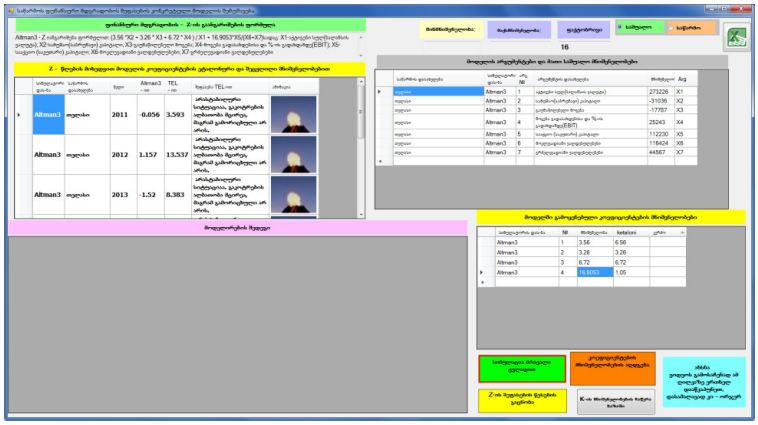
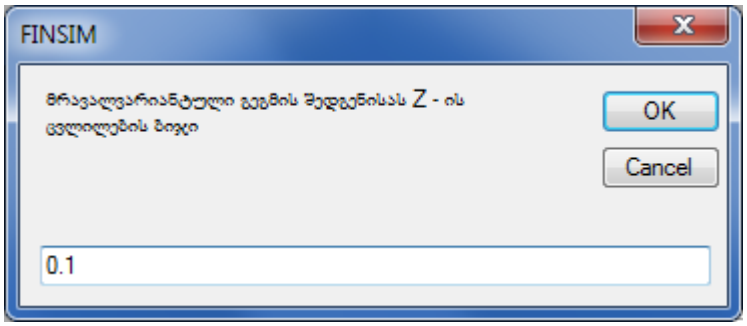


Figure 6. Z's calculated values by changing b_4 coefficient and pointing Z=16 by years

Click the button "Simulate multiple variables". The window will change the Z to change the step. For example, write 0.1 /Pic. 7/



Pic. 7. Set step of changing of Z coefficient

After pressing OK: First – model arguments' average values are calculated; second - system will set as default model coefficient's minimal value as 0,001, and maximal values – values, which were got on the second step of calculations, in particular: b_1=3,56; b_2=3,26; b_3=6,72; b_4=16,9053. third – Z's actual, minimal and maximal values are calculated. We will get, Z_{actual} =0,004, Z_{min} = -616, Z_{max} =12,406. fourth – Z's many variants are calculated. Calculation results will appear in the table "Results of modeling" /Figure 8/;

Variants differ by coeeficients' values. For each variant, the value of Z is calculated and evaluated enterprise's financial stability according to the Altman model.

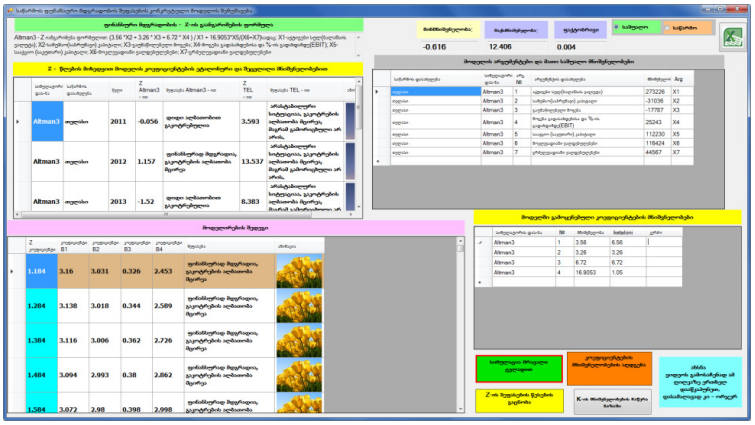


Figure 8. Result of modeling with many variables

In the table "modeling results" Z's values, calculated by arguments' average values, JSC "Telasi" is stable in range 1.184-2.584. Each variant's b_i coefficient value is assigned to a certain set of values.

Fourth step of specific model developing: Our goal is to select from range of variants that one, which is based on the factual data according to the fact that the value of the Z is adequately reflected in the financial position of the enterprise. In order to achieve this goal it is enough to indicate the result in the table "modeling result". After selecting the row selected result will appear in the table "Coefficient values changed by Z years" /Figure 9/. We can print this table by pressing button  after what our table will be exported in Excel /Table 1/.

The table 3.1 shows the estimates obtained by the selected coefficients according to years.

Table 1 shows that from 7 cases in 5 of them, the TEL1 and Altman3 calculations do not match. The enterprise is bankrupt by Altman3, in fact the enterprise is financially stable, the probability of bankruptcy is small. Stable, it seems, the TEL1 calculations make an adequate picture of reality. We can express the opinion that the model of the financial position and bankruptcy forecasts of JSC "Telasi", which we received, is a reflection of the TEL1 reality. At any time we can adjust the TEL1 coefficients.

Table 1. Evaluation of the finerness obtained by the equations of the coefficients and the values obtained by modeling

Simulator's name	Name of Enterprise	Year	Z by Altman3	Rate Altman3	Z by TEL	Rate by TEL
Altman3	Telasi	2011	-0.056	Very likely is bankrupt	2.83	The unstable situation. The probability of bankruptcy is small but not excluded.
Altman3	Telasi	2012	1.157	Financially sustainable, the probability of bankruptcy is small	10.552	The unstable situation. The probability of bankruptcy is small but not excluded.
Altman3	Telasi	2013	-1.52	Very likely is bankrupt	5.999	The unstable situation. The probability of bankruptcy is small but not excluded.
Altman3	Telasi	2014	1.081	Very likely is bankrupt	10.333	The unstable situation. The probability of bankruptcy is small but not excluded.
Altman3	Telasi	2015	-0.388	Very likely is bankrupt	9.021	The unstable situation. The probability of bankruptcy is small but not excluded.
Altman3	Telasi	2016	1.395	Financially sustainable, the probability of bankruptcy is small	14.846	The unstable situation. The probability of bankruptcy is small but not excluded.
Altman3	Telasi	2017	0.914	Very likely is bankrupt	12.378	The unstable situation. The probability of bankruptcy is small but not excluded.

In Figure 10 the table with coefficients, which were got after selection of variant, is shown

Fix calculation results – inserting data in database is implemented by pressing button „Insert K values in database"

Based on actual data, TEL1 can provide a report for any t year on the financial sustainability of an enterprise with actual data. For this:

- After completing multivariate calculation field "Enterprise" will be automatically checked and the window for writing year will pop out. The same result will be achieved after checking field "Enterprise";
- Write a year and click "Financial sustainability evaluation" button. The result of calculation will be opened in Excel as a table;
- To get a report according to all the years on the enterprise database, the "Year" field should be empty. By clicking on the " Financial sustainability evaluation " button, the report will be appeared for every year.

According to years of different models, the report of assessing the financial sustainability of the enterprise after the completion of the program.

FINSIM1_PRO2019 is written on VB.NET, database is organized on SQL Server.

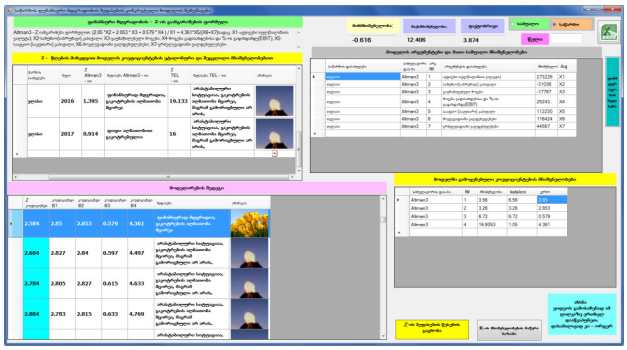


Figure 9. Variant selection

მოდელში გამოყენებული კოეფიციენტების მნიშვნელობები

სიმულატორის დას-ბა	№	მნიშვნელობა	ketaloni	კერძო
Altman3	1	3.56	6.56	2.85
Altman3	2	3.26	3.26	2.853
Altman3	3	6.72	6.72	0.579
Altman3	4	16.9053	1.05	4.361

Figure 10. Coefficients, got after selecting variant

Conclusion

1. Enterprise's bankrupt and financial sustainability forecast in any existing economic-mathematical model uses country and industry's long-term statistical data. In countries with the transition to the market econom, such as Georgia, long-term statistical data of bankruptcy does not exist, so the determination of coefficients is not possible by using stastistic methods, and the use of existing models does not make the desired result.
2. It is justified that the rational way of solving the problem is simulation modeling.
3. Our simulator FINSIM_PRO2019 allows:
   - On the basis of a general model that can be considered as a reference model, a particular economic mathematical model of the financial sustainability assessment of the enterprise can be utilized in the actual activity of the problematic area;
   - To be used by different countries with a single legal space, including Georgia, to prepare specialists in different universities;
   - Specialists employed in management area: economists, financers and others.

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