EMPIRICAL STUDY REGARDING THE USAGE OF THE MONTE CARLO METHOD IN THE ANALYSIS OF GLOBAL RISK

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Abstract

Risk is a natural component of the social and economic life, which originates from multiple causes and takes on extremely various shapes. In parallel with the progress of the process of globalization, with the promotion of the new technologies, with the increase of competitiveness on the capital market, we witnessed an unprecedented diversification of the risk and uncertainty situations in the business world. At the same time, numerous specialists in the field of finances, financial analysis, management, and applied statistics, have become concerned with drawing integrated risk analysis, monitoring and eliminating models.

This paper aims at founding a mathematical model of analysis of the global risk of organizations, based on the study of the correlations established between a set of variables (economical-financial indicators) able to characterize the causes of the modifications occurred in the exploitation and financial activities of the organization, which may be perceived as symptoms of risks. This way, a useful instrument will be drawn for organizational management, for controlling risk dynamics, preventing and limiting the risk factors, and at the same time an indispensable instrument for the auditor, for obtaining audit proofs regarding the (non-)compliance with the principle of the continuity of the audited activities. The design of this model implies a study of the financial statements belonging to a sample made up of 80 enterprises quoted in the Stock Exchange of Bucharest. The model will be tested using a sensitivity analysis, through the Monte Carlo method. The methodology of the sensitivity analysis recommends formulating alternative scenarios, simulating the effects of the modification of certain critical variables in relation to the scenarios initially drawn, on the variation of the results of the company (global risk). In order to perform the regression analyses, the multiple correlations, and the simulation implied by the foundation of the model, the statistical instrument SPSS 15.0 and software Oracle Crystal Ball will be used.

Key words: global, sensitivity analysis, the Monte Carlo method

Globalization, the change of the consumers' behavior, the technological evolution, the variation of the prices of production factors, the political, legal, economic, and natural environment, as well as the economic-financial policies that a company applies, are the main factors that may generate the occurrence of associated risks (Albouy, M., 2003).

In financial theory, risk is translated through the uncertainty of achieving the forecasted values of specific variables (sales figure, profit, stock market price, etc.), measured by the dispersion of the values of these variables according to the average, as the expression of the non-conformity between the hypotheses achieved *ex-ante*, connected to the future, and what has actually been achieved, *ex-post*. Risk can manifest itself either negatively (as a possible loss), or positively, as an opportunity (Mironiuc, M., 2006).

At the company level, two categories of *variables* can be distinguished, which may determine the sensitivity of the indicators to the expected result: *the cost structure* and *the financial structure of the company*, as the factors that can cause the appearance of **economic** and **financial risk** (De La Bruslerie, H., 2006).

Economic or operational risk is determined by the inability of the company to correlate its level of activity to its cost structure, without influencing, however, the result it obtains. Therefore, any variation in the activity volume will influence the company's operating results, through changes at the level of the cost component, and in unfavorable situations, risk is manifested through a decrease of the operating results (Mironiuc, M., 2006).

Financial risk is based on the inability of the company to establish an optimal structure of its own capital. Therefore, the level of the borrowed capital, as well as the level of financial expenses determined by its achievement, influence the financial profitability ratio (financial expenses absorb some of the operating results and contribute to decreasing the net result), thus increasing financial risk (Mironiuc, M., 2006).

Global risk, quantified through the coefficient of the total lever, points out the *effects*

of the investment policy on the structure of the company, on the various cost components, which in their turn are reflected upon the variability of operating results. Also, global risk evaluates *the effects of the financial policy* on the variability of the net result, through the structure of the capital and of the cost of the borrowed capital.

MATERIAL AND METHOD

This article aims at setting the foundation of a mathematical model that would analyze the correlations established between a set of variables (economical-financial indicators) able to characterize the causes of the changes occurred in operating and funding activities of the company, which may be perceived as risk symptoms.

In our methodological approach, we suggest a series of work hypotheses that we wish to test, so as to prove, through their validation, the role of mathematical modeling in providing pertinent information regarding the quantification and management of operating, financial, and global risk, that are present in the company.

Hypothesis 1: Is there any significant connection between operational risk, expressed through the coefficient of the operational lever (an indicator of (the lack of) going concern), as a dependent variable, and a series of consecrated financial ratios – liquidity, assets structure, and activity ratios (independent variables)? What are the main factors that influence operational risk?

Hypothesis 2: Is there any significant connection between financial risk, expressed through the coefficient of the operational lever (an indicator of the financial policy), as a dependent variable, and a series of consecrated financial ratios – liquidity, indebtedness, or capital structure (independent variables)? What are the main factors that influence financial risk?

Hypothesis 3: Is there any significant connection between global risk, expressed through the coefficient of the total lever (an indicator of performing a profitable activity), as a dependent variable, and a series of consecrated financial ratios – liquidity, asset structure, activity, solvency, indebtedness, or capital structure (independent variables)? What are the main factors that influence global risk?

The analysis was performed on a sample made up of 80 companies quoted in the Bucharest Stock Exchange (BVB), as follows: 13% in the food industry, 16% in constructions, 21% in services, 11% in commerce, and 39% in non-food industry. The period analyzed is represented by the fiscal years 2007 and 2008. The independent and dependent variables that have provided the test basis for the work hypotheses can be synthesized as in *table 1*.

Table 1

Meaning of the analyzed variables

Analyzed variables	Computing method	Meaning
X_1 = *Floating assets ratio*	Floating assets/Total assets (A_{fl}/A_t)	The elasticity of the company to the market requirements
X_2 = *General liquidity ratio*	Floating assets/Current debt (A_{fl}/D_c)	The degree in which the debt that has to be paid within a year can be funded by floating assets (potential liquidity)
X_3 = *Turnover of the floating asses in the sales figure*	Sales figure/Floating assets (SF/A_{fl})	The intensity (efficiency) of the usage of floating assets through the sales effect
X_4 = *Turnover of the own capital in the sales figure*	Sales figure/Own capital (SF/C_{own})	The intensity (efficiency) of the usage of the own capital through the sales effect
X_5 = *General solvency ratio*	Total assets /Total debts (A_t/D_t)	The degree to which the total debt of the company can be covered by total assets
X_6 = *Global indebtedness ratio*	Total debt/ Own capital (D_t/C_{own})	The degree to which the total debt of the company contributes to its funding
X_7 = *Ratio of due date indebtedness*	Debts older than one year / Permanent capitals (D>1year/CPM)	The degree of dependency of the company on foreign resources whose due date is older than one year
X_8 = *Global financial autonomy ratio*	Own capital / Total assets (C_{own}/A_t)	The degree to which the company's funds come from its own resources
Y_1 = *Operational lever*	Relative variance of the operational result/ Relative variance of the sales figure (ΔRop/Rop)/(ΔSF/SF)	Sensitivity of the percentage variance of the operational result from to the variation by 1% of the sales figure
Y_2 = *Financial lever*	Relative variance of the net result/ Relative variance of the operational result ($\Delta_r R_{net}/R_{net}$)/($\Delta_r R_{op}/R_{op}$)	Sensitivity of the percentage variance of the net result to the variation by 1% of the operational result
Y_3 = *Total lever*	Relative variance of the net result / Relative variance of the sales figure ($\Delta_r R_{net}/R_{net}$)/(Δ_rSF/SF)	Sensitivity of the percentage variance of the net result to the variation by 1% of the sales figure

In order to prove the hypotheses, the work method used was the multiple regression analysis, employing the SPSS 15.0 statistical tool. The multiple regression analysis is a method of predicting the values of a dependent variable (Yi), starting from the values of several independent

variables (Jaba, E., 2005). The equations of the regression lines will be of the type: $\mathbf{Y_1} = \alpha_0 + \alpha_1 \cdot X_1 + \alpha_2 \cdot X_2 + \alpha_3 \cdot X_3 + \alpha_4 \cdot X_4$; $\mathbf{Y_2} = \beta_0 + \beta_1 \cdot X_5 + \beta_2 \cdot X_6 + \beta_3 \cdot X_7 + \beta_4 \cdot X_8$; $\mathbf{Y_3} = \gamma_0 + \gamma_1 \cdot X_1 + \gamma_2 \cdot X_2 + \gamma_3 \cdot X_3 + \gamma_4 \cdot X_4 + \gamma_5 \cdot X_5 + \gamma_6 \cdot X_6 + \gamma_7 \cdot X7 + \gamma 8 \cdot X8$, where α0..4, β0..4 and γ0..8 are the coefficients of the mathematical model, X1..8= independent variables of the model, and Y1..3= dependent variables.

Based on these coefficients, as well as on the model of the regression equation, it is possible to compute the values of *Operating risk*, of *Financial risk*, and of G*lobal risk*, based on the various scenarios, so that these values might be forecasted. The main disadvantage of making forecasts based on multiple regression models is that the probability of occurrence of a value of a dependent variable thus calculated is not known.

In order to eliminate these deficiencies, we will use the *Monte-Carlo method*, based on the *Oracle Crystal Ball* software product (Charnes, J., 2007). Therefore, using the 10,000 simulations made with this software, taking into account the averages of the independent variables, as well as the average standard deviations, it will be possible to obtain, with a confidence level of 95%, the statistical distributions of the *Operating risk*, of the *Financial risk*, and of the *Global risk*. The *Monte-Carlo* method determines the values of these dependent variables as statistical distributions, using a random number generator, evenly distributed in the [0;1] interval (Sugiyama, S., 2008).

Using the Monte-Carlo method, we will test the probability for a company to have an operating, financial, and global risk higher than the average computed for the entire analyzed sample.

RESULTS AND DISCUSSIONS

The main results obtained after processing the sample data present the values of the regression coefficients. Moreover, the SPSS 15.0 statistical tool allows computing descriptive statistics (the average values of each analyzed variable and the average standard deviations associated to these), as well as the *Pearson* correlation coefficients. The *Pearson* correlation coefficient is used to indicate the degree of linear reciprocal association between two variables, with values within the interval [-1; +1]. Therefore, the values that tend towards -1 indicate a significant relationship in the reverse direction, the values that tend towards + indicate a significant and direct relationship between the variables, and the coefficient values that tend towards 0 indicate the lack of correlations between the variables (Jaba, E., 2005).

Table 2

Descriptive statistics, regression and correlation coefficients

Variables	Average	Standard deviation	Pearson Correlation Coefficients			Regression coefficients				
			Y_1	Y_2	Y_3	α/β	Y_1	Y_2	γ	Y_3
X_1	0.38	0.24	0.10	-	-0.20	α_1	559.94	-	γ_1	-408.76
X_2	3.24	5.28	-0.07	-	-0.11	α_2	-8.08	-	γ_2	-12.44
X_3	2.43	1.97	0.09	-	-0.04	α_3	66.64	-	γ_3	-11.00
X_4	0.61	6.57	-0.04	-	-0.13	α_4	-13.03	-	γ_4	-27.52
X_5	14.90	41.22	-	-0.08	0.00	β_1	-	-0.01	γ_5	-0.42
X_6	-0.61	7.89	-	0.06	-0.07	β_2	-	0.02	γ_6	14.94
X_7	0.28	0.69	-	0.04	-0.01	β_3	-	0.16	γ_7	-28.18
X_8	0.49	0.54	-	0.01	0.03	β_4	-	0.16	γ_8	25.63
Y_1	-179.82	1163.85	1.00	0.05	-0.44	α_0	-518.46	-	-	-
Y_2	0.81	1.97	0.05	1.00	-0.06	β_0	-	0.76	-	-
Y_3	-22.75	571.19	-0.44	-0.06	1.00	-	-	-	γ_0	225.61

Table 2 presents a series of descriptive statistics at the level of the analyzed sample, and for each independent and dependent variable, the averages and the corresponding standard deviations are computed. These computing elements, together with the regression coefficients, will be used in making forecasts with the help of the Monte-Carlo method.

The *Regression coefficients* section of *table 2* presents the coefficients of the mathematical models suggested in the three work hypotheses. Therefore, in what concerns *hypothesis 1*, we can notice that the increase of the degree of investment of the company's resources in floating assets will lead to an increase in the operating risk, a situation caused first of all by the total production costs that will determine a decrease of the level of the

operating result. At the same time, an increased efficiency of the own capital through the effect of sales will trigger, on the one hand, both the increase of the sales figure and the decrease of certain production costs (as the used resources belong to the company), which will determine a higher operating result and a low operating risk. Therefore, an increase by one unit of the floating assets ratio in the total sales figure will trigger an increase by 559.94, respectively by 66.64 units in the operating risk, and the decrease by one unit in the turnover of the own capital in the total sales figure will lead to an increase by 13.03 units in the operating risk. According to the regression equation suggested in *hypothesis 1*, the mathematical model that will define the level of operating risk will be of the type: $CLE = -518.46 + 559.94 \cdot A_C/A_t - 8.08 \cdot A_c/D_c + 66.64 \cdot SF/A_c - 13.03 \cdot SF/C_{own}$.

In relation to *hypothesis 2*, a decrease of the degree to which the total debt of the company can be covered by its total assets (insolvency), correlated to an increase of the degree to which the level of current and long-term debt contribute to the formation of the company's own capital represent symptoms of financial risk and, implicitly, of the risk of bankruptcy on the long term. Therefore, the decrease by one unit of the solvency ratio will determine an increase by 0.01 units of financial risk, and the increase by one unit of the due date indebtedness ratio will lead to an increase by 0.16 units of financial risk. The mathematical model that will define the level of financial risk will be of the type: $CLF = 0.76 - 0.01 \cdot A_t/D_t + 0.02 \cdot D_t/C_{own} + 0.16 \cdot D_{>1year}/CP + 0.16 \cdot C_{own}/A_t$.

In what concerns *hypothesis 3* suggested in this article, we must also take into account the relation of computing global risk; therefore, global risk is the product between operating risk and financial risk. Based on this computing formula, as well as on the coefficients of the regression equation, we can state that an increase in the degree of investment of the company's resources (mainly its own resources) in floating assets, correlated with an increase of the floating assets and the turnover ratio of the own capital in the volume of the sales figure will determine a significant decrease of global risk. Moreover, a subunit report of the global debt ratio will lead to a decrease of global risk. Therefore, based on the coefficients of the mathematical model suggested in *hypothesis 3*, we can say with a confidence of 95% that, for an increase by one unit of the floating assets ratio and of the own capital turnover ratio in the total sales figure, global risk will diminish by 408.76, and respectively 27.52 units. At the same time, an increase by one unit of the global debt ratio, as well as a decrease by one unit of the due date debt ratio will involve an increase by 14.94, respectively 28.18 units of global risk. According to the regression equation suggested in *hypothesis 3*, the mathematical model that will define the level of operating risk will be of the type: $CLT = 225.61 - 408.76 \cdot A_C/A_t - 12.44 \cdot A_c/D_c - 11.00 \cdot CA/A_c - 27.52 \cdot SF/C_{own} - 0.42 \cdot A_t/D_t + 14{,}94 \cdot D_t/C_{own} - 28.18 \cdot D_{>1year}/CP + 25.63 \cdot C_{own}/A_t$.

Based on the averages of independent variables, of the average standard deviations, as well as on the regression coefficients presented in table 2, after performing the 10,000 simulations using the Crystal Ball software tool, we have obtained the probabilistic distributions of operating risk (Y_1), financial risk (Y_2), and global risk (Y_3), with a degree of confidence of 95%.

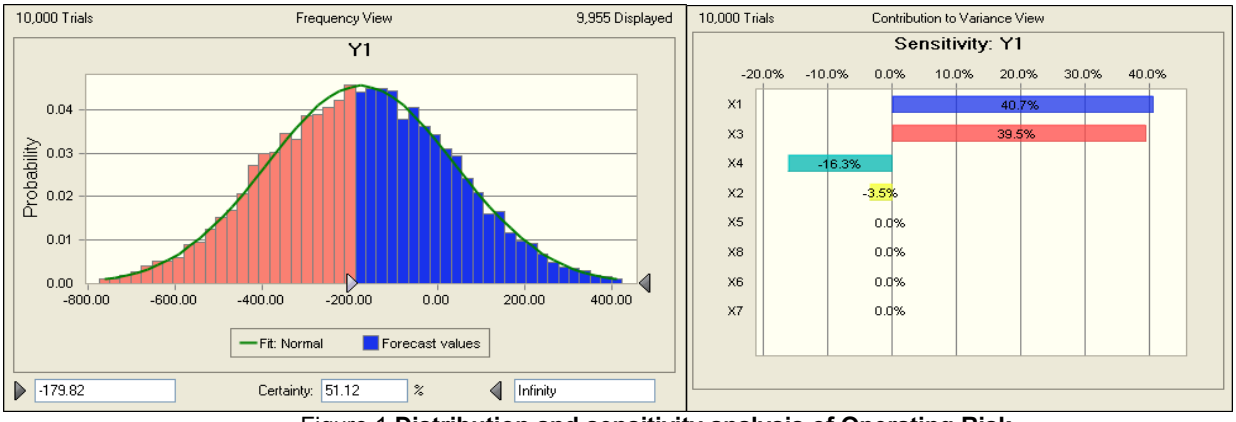

Figure 1 **Distribution and sensitivity analysis of Operating Risk**

Figure 1 presents the statistical distribution of operating risk, a distribution forecasted after performing the 10,000 simulations, as well as the sensitivity analysis that presents the influence of the independent variables suggested in the mathematical model in hypothesis 1 on *operating risk*. Therefore, we can state with a confidence of 95% that the probability to have an operating risk

higher than the current average value of the analyzed sample (-179.82), is 51.12%: for 10,000 companies, of which 5112 will have an operating risk above the current average level. At the same time, the forecasted evolution of operating risk will be directly and positively influenced by the *floating assets ratio* and *the floating assets turnover ratio in the sales* in proportion of 40.7%, respectively 39.5%. The average level of the forecasted operating risk will increase by 2.20%, reaching a level of –175.86.

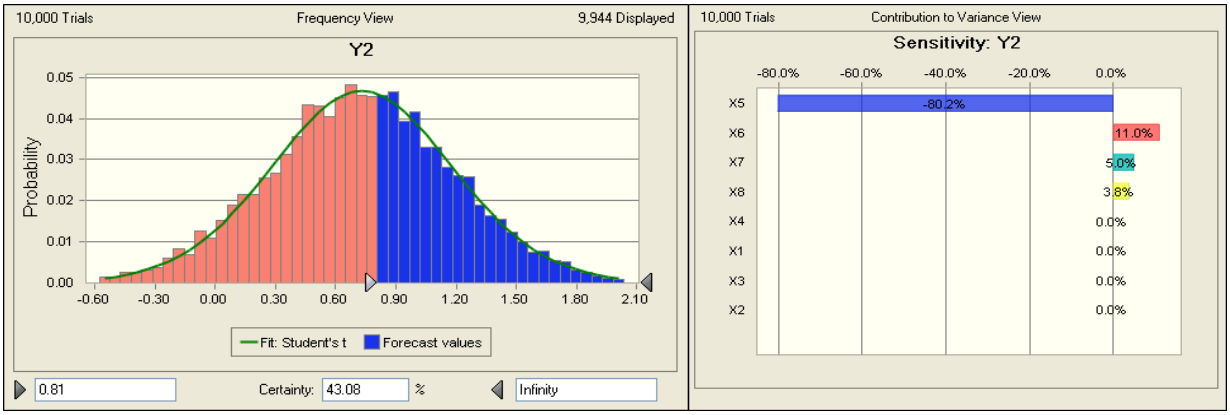

Figure 2 **Distribution and sensitivity analysis of Financial Risk**

Figure 2 presents the statistical distribution of financial risk, a distribution obtained after performing the 10,000 simulations, as well as the sensitivity analysis that presents the influence of the independent variables suggested in the mathematical model in hypothesis 2 on *financial risk*. Therefore, we can state with a confidence of 95% that the probability to have a financial risk higher than the current average value of the analyzed sample (0.81) is 43.08%: for 10,000 companies, of which 4308 will have a financial risk above the current average level. At the same time, the forecasted evolution of financial risk will be directly and negatively influenced by the *solvency ratio* in proportion of 80,2% (a decrease in solvency will determine an increase of financial risk on the long term). The average level of the forecasted financial risk will decrease by 9.87%, reaching a level of 0.73.

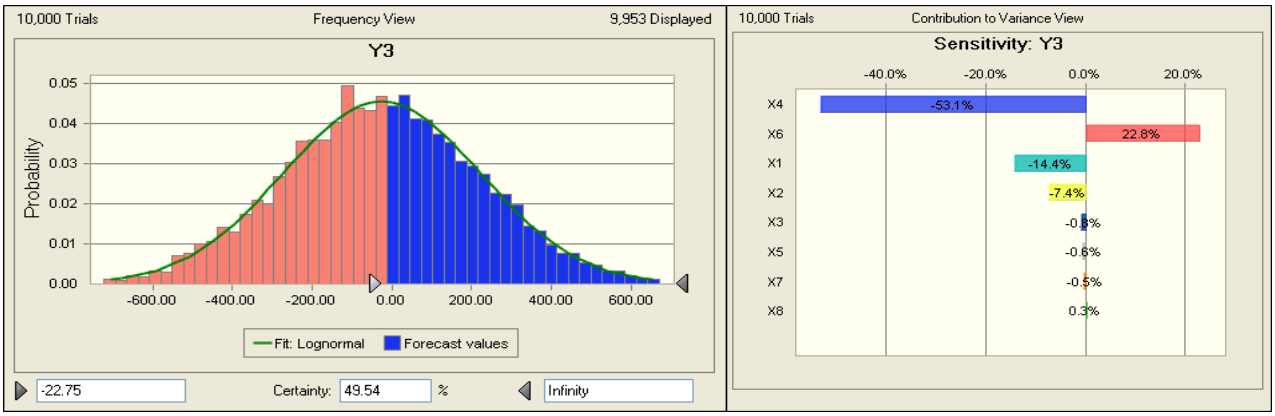

Figure 3 **Distribution and sensitivity analysis of Global Risk**

Figure 3 presents, with a confidence of 95%, the statistical distribution of global risk, a distribution obtained after performing the 10,000 simulations, as well as the sensitivity analysis that presents the influence of the independent variables suggested in the mathematical model in hypothesis 3 on *global risk*. Based on the same confidence level of 95%, we can state that the probability to have a global risk above the current average value of the analyzed sample (-22.75) is 49.54%: for 10,000 companies, of which 4954 will have a global risk above the current average level. In what concerns the forecasted evolution of global risk, it will be directly and negatively influenced by the *own capital turnover ratio in the sales figure* in proportion of 53.1% (a decrease in this ratio will determine the increase of global risk on the long term). Moreover, an increase of the *global debt ratio* will directly and positively influence the level of global risk in proportion of 22.8% (a high degree of indebtedness will have direct consequences upon the increase of global risk in the company).

CONCLUSIONS

The present business environment, as well as the new management strategies, aim at knowing and keeping under control all the risks that appear at the company level. The new tendencies in risk management place the accent on quantitative approaches and on mathematical representations of the influence of various factors on the occurrence and effects of economic, financial, and global risk. This article proves, based on empirical evidence, the fact that the classic approach of global risk, as a product between operating and financial risk, cannot fully meet the needs and requirements of the stakeholders and that the appearance and evolution of a category of risks must be regarded in the global context of the company's environment.

Therefore, it is necessary to establish and quantify the relations established between various financial ratios (solvency, indebtedness, asset structure, liquidity, and turnover) and global risk (inclusively for each component – operating and financial). Keeping global risk under control presupposes, on the one hand, its mathematical modeling, and on the other, using efficient statistical tools for making forecasts that are pertinent and useful for managers.

This study should be completed both through the increase of the working sample and through a reconfiguration of the mathematical models suggested (be they logarithmical, logical, or exponential), so as to capture the reality of the financial environment where the company performs its activity as faithfully as possible.

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