PARTICULARS OF TREATMENT OF EXTREMELY ASYMMETRIC RISK

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Abstract. *The Society perceives the dangers as threats, challenges and risks. Risk is defined as direct and assumed threat. Most of all, the highest risks in modern society are likely asymmetric.*

They include the whole sphere of human activity and they are accompanying man in almost everything he does. As long as the world is diversifying and is ranking, the more numerous and more acute become asymmetric threats. Because asymmetry is difference, meaning the possibility to act differently and to react differently, in order to capture, destroy, win strategic initiative and freedom of action and, therefore, to defeat. We present a series of theoretical issues related to risk analysis and risk analysis techniques: scenario technique and probability-impact matrix technique. In the second part of the paper an analysis of critical infrastructure and types of asymmetric risks are presented. The third part of the paper presents a study of portfolio risk using GARCH models (1.1), considering the daily returns of RASDAQ-C and BET indexes and the RON / USD exchange rate, and also an analyses of the achieved results will be considered.

Keywords: dangers, threats, vulnerabilities, risks, critical infrastructures, risk evaluation, extreme risk, asymmetric risk

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The risk analysis processes are divided into two main categories: qualitative risk analysis and quantitative risk analysis.

Qualitative risk analysis results are not very accurate, having rather a guidance manner than a precise one. If these results are not very good, risk management offers also a quantitative analysis which presents results in the figures following the calculations.

1. Risk analysis techniques

Scenario technique

This technique means adding a group of informed people, specialists, whom are required to apply their knowledge and imagination to describe one or more possible ways of running an event in a particular case. This type of activity takes place at all times by anyone who wants to plan an activity.

There are many ways to generate scenarios, but two are the most representative: generation scenarios in perspective and generation scenarios from perspective.

Generating scenarios in perspective involves taking as a starting point the present reality and based on it future situations are imagined. This type of scenario can answer the question: *What if*?

Generating scenarios from perspective involves the way you can reach a future situation in terms of present reality. This type of scenario answers the question: *How can it end up in X situation*?

Probability-impact matrix technique

The risk involves two basic issues: the probability and the impact.

Table 1 presents a matrix that combines the following elements:

✓ Probability - on three levels: high probability, average probability, less likely;

✓ Impact - on three levels: a big impact, a medium impact, a low impact.

The result of combining these elements consists of a matrix with 3 rows and 3 columns. The intersection of each row with each column represents a certain level of risk. If such a matrix is given three types of risks can be identified: high risk, medium risk, low risk.

Table 1. Probablity-Impact matrix

PROBABILITY				
	High	Low Risk	Medium Risk	High Risk
	Average	Low Risk	Medium Risk	Medium Risk
	Low	Low Risk	Low Risk	Low Risk
		High	Medium	Low
		IMPACT		

Of course, this matrix may also be carried on multiple rows and columns to better highlight the level of risk. For example, we consider a matrix with five rows and five columns, corresponding to the following categories of probability and effects:

- probability expressed in five percentage ranges between 0 and 99.99%. It does not consider 100% probability events, because certainty does not require risk analysis: between 0% and 19.99%; between 20% and 39.99%; between 40% and 59.99%; between 60% and 79.99%; between 80% and 99.99%.
- the impact value is expressed on a scale from 0 to 4, corresponding to five levels of severity: 0 - occurrence of an event with zero impact has no implications for risk analysis, or if they are not noticeable consequences; 1 - an event with impact of low degree; 2 - the impact of grade 2 refers to notable consequences that may affect a project or an activity; 3 - the consequences of an impact grade 3 are serious enough and must be analyzed in detail; 4 - grade 4 is the corresponding impact of a disaster.

Based on this gradation of risk components, the probability-impact matrix represented in Table 2 includes the following risk categories: *very low risk* - the probability of such an event is almost zero; *low risk* - this risk category is an event with medium probability and low impact, or an event with low probability and medium impact; *medium risk* - requires an event with a probability above average, even very high, but has a small effect, or, conversely, a low probability event but with an impact above average, very high; *high risk* - appears when an event has a probability of occurrence of 40% and its impact is above level 3; *high* *risk* - refers to a situation with very likely events which may have a major impact, that is above 3.

Table 2. Probability-impact matrix 5 levels of risk

PROBABILITY	80.00%-99.99%	Medium Risk	Medium Risk	Hiigh Risk	Very High Risk	Very High Risk
	60.00%-79.99%	Medium Risk	Medium Risk	Hiigh Risk	Hiigh Risk	Very High Risk
	40.00%-59.99%	Low Risk	Low Risk	Medium Risk	Hiigh Risk	Hiigh Risk
	20.00%-39.99%	Very Low Risk	Low Risk	Low Risk	Medium Risk	Medium Risk
	0.00%-19.99%	Very Low Risk	Very Low Risk	Low Risk	Medium Risk	Medium Risk
		0	1	2	3	4
				IMPACT		

The probability-impact matrix is a very useful risk management tool. This technique is often used in practice, easily manageable, and because it helps the management to assess risk events in order to determine those events requiring special attention.

2. Analysis of Critical Infrastructures

Modeling asymmetric risk of extreme events is essential in the efficient damage assessment and prioritization of government interventions. Actual techniques seek new solutions of analytical and numerical treatment of asymmetric distributions with thick ends.

To define new solutions, it assumes the need for a synergistic but flexible response, providing increased capacity to cover immediate exposure to asymmetric attacks, based on the functionality of markets and transfer of innovative solutions supported alternative.

Classical mathematical approach to model extreme risks is based on the probability theory and mathematical statistics. The potential extreme risk value presents a highly asymmetric distribution, with thick ends, difficult to analyze even knowing the behavior of similar developments. In asymmetric extreme events, the appearing probability is very limited, but with a catastrophic impact /loss.

An integrated model is describing the risks, their evolution and correlations between them, providing a perspective on how the risks interact. Complexities and multiple subjective elements of these models are a challenge to their application. For the integration into the dynamic financial analysis DFA of extreme asymmetric events, VaR and EVT concepts are analyzed in terms of how practical difficulties associated with valuation and filtering are.

If traditional VaR methods tend to ignore extreme events, and focuses on risk measures for the entire range of distribution, the objective is search for answers to ensure functionality in catastrophic risks, too. An answer to this problem is based on the use of robustness tests and scenario analysis. It can simulate dynamic changes under extreme future events.

These solutions are useful, but inevitably limited because you cannot explore all possible scenarios and, by definition, they do not provide indications of the behavior of all variants considered.

This specific issue of extreme risk management, which cannot predict fairly extreme values, distort the results. Researchers have proposed solving the problem by extreme value theory (EVT), a branch of statistics designed for optimal use of limited information about extreme distributions.

In EVT, the attention is focused on the POT (peaks-over-thresold) problem of peaks that exceed the critical value. If the end of the loss distribution refers to the risk of development, system, operational or insurance, the POT model is a simple but effective risk assessment at the ends of the distribution.

It proposes an original model in which POT methods can be embedded in a stochastic volatility to provide superior VaR estimates in a classical manner.

It also proposes a risk model based on the selection of particular probability distributions; distributions are considered from the empirical analysis of statistical data. In this case, EVT is a tool to provide the best possible estimator of the distribution end.

However, even in the absence of useful data, EVT provides a good guide to the type of distribution that should be selected so that extreme risks are assessed and operated correctly.

Techniques of active-passive type management (ALM) are representative of a wide variety of strategies used in the insurance sector and vary greatly in terms of complexity. Since each has certain advantages and disadvantages, practitioners were unable to determine whether it is preferable to use simple models or complex models.

Dangers, threats, vulnerabilities, risks

As social and economic activities grow, the critical infrastructures of the state and society, particularly those in industry and energy, become more vulnerable to various risks and threats.

While science and technology progress, the vulnerabilities are increasing and so is the possibility of the production of an attack or accident that may affect the population, material assets and the environment increase. The range of hazards and threats to ICEn and ICI is sufficiently diversified, the asymmetric incidence is increasing.

A classification[1] of hazards and threats, which can always be supplemented or modified, could be: ***natural*** dangers/threats: *symmetrical*, such as earthquakes, floods, landslides, drought, etc.; *asymmetrical*, for example, extreme weather, fall of meteorites and cosmic objects, global warming, etc.; ***human*** dangers/threats: *symmetrical*; *physical*, such as: chemical accident, conventional war, etc.; ***cyber***, for example, programming errors etc.; *asymmetrical*: *physical*, such as: terrorism and organized crime, design errors, operation and maintenance systems, etc.; cyber, for example, information warfare, network-based war.

3. Asymmetric risk typology

Asymmetric risks do not have the same configuration for everyone.

Therefore, they have to be observed and analyzed differently, depending on specific conditions, the policy options and the forces that are or could be engaged in confrontation. The world is diverse and, as such, the opportunities for action or response are different.

Asymmetric risks, in view of the United States, are largely different from those we are considering, for example, for Third World states. The difference in technology, civilization, specific conditions, and opportunities and, of course, the

[1] Radu Andriciuc, *Dangers and threats to critical infrastructure,* Psihomedia Publishing, Sibiu, 2008, p.59.

mentality is expressed primarily in the strategies of confrontation, in what we call strategic asymmetry. A specific threat (risk) relationship is made - asymmetric response, asymmetric attack-defense, which will probably dominate the typology of conflicts, at the beginning of the millennium.

The typology of the asymmetric nature threats (risks) requires a new evaluation of areas of strategic interest and philosophy of confrontation, since the world has changed radically and, in spite of economic globalization and information, it remains very different and contradictory.

4. Portfolio risk analysis using GARCH models

Often in practice, financial series are proving not to follow a normal distribution. So, series are leptokurtic, meaning that there is a big deviation of their extreme values from the average. In these situations, it is required to verify whether the normal Kurtosis index (one that shows how "bold extremities are" or how much the maximum and minimum values deviate from their mean) is 3, in the financial series the indicator has much higher values (we will see this in the proposed practical example). Also, financial series tend to be asymmetric. It implies that the skewness index (which captures the symmetry or asymmetry of a series) has non-zero values.

Financial series show two particularly important problems: serial correlation recovered in residue; heteroscedasticity - uneven evolution of dispersal of that series over the analyzed time period.

GARCH models are designed to model economic series which present the characteristics listed above. GARCH means: G - generalized, AR - autoregressive, C - conditional; H - heteroscedasticity.

The first model was developed by Robert Engle in 1982. It was an ARCH model. The model includes an equation for a medium and one for dispersion, respectively:

$$\begin{aligned} y_t &= \gamma x_t + \varepsilon_t \\ \sigma_t^2 &= \omega + \alpha \varepsilon_{t-1}^2 + \beta \sigma_{t-1}^2 \end{aligned} \qquad (1)$$

where:

y_t - dependent variable in the current period;

x_t - independent variable in the current period;

γ - is the coefficient which shows the influence of the independent variable on the dependent variable;

ε_t - the residuals in the current period;

σ_t^2 - dispersion of the dependent variable in the current period

ω - constant of the dispersion equation

α - ARCH coefficient

ε_{t-1} – the residuals of the previous period

σ_{t-1}^2 - dispersion of the dependent variable in the previous period

β - GARCH coefficient

The model described above is GARCH (1,1) where the first number shows that on the dispersion act residual terms of the previous period and the second number shows that the dispersion of the previous period has an influence on current dispersion. In fact, for very large series, GARCH (1,1) can be generalized to GARCH (p, q)1.

Because our application refers to a portfolio risk analysis, we will focus only on the dispersion equation. The model can be used successfully in studies of volatility. Unlike the method of least squares, the GARCH equation includes both error terms (often called "shocks") and heteroscedasticity. Also, the model is useful if the series are not normally distributed, but they rather have thickened extremities. No less important is that the confidence intervals can vary over time and therefore more accurate intervals can be obtained by dispersion residual returns modeling.

An interesting approach to GARCH models is the possible existence of a leverage effect. In fact, GARCH (1,1) is a symmetric model and implies that the residual terms have the same sign. In reality, the financial series often presents asymmetry. A very useful model in this case is EGARCH or otherwise called the exponential GARCH model introduced by Nelson (1991):

$$\log \sigma_t^2 = \omega + \log\left(\sigma_{t-1}^2\right) + \alpha \left|\frac{\varepsilon_{t-1}}{\sigma_{t-1}}\right| + \gamma \frac{\varepsilon_{t-1}}{\sigma_{t-1}} \qquad (2)$$

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[1] An interesting presentation of GARCH models is found in *The Econometrics of Financial Economics*, by John Campbell, Andrew Lo and Craig MacKinley, published in 1997, Princeton University Press, pp. 479-490.

The leverage effect can be tested by testing inequality $\gamma < 0$ and $\gamma \neq 0$. We observe that this model is similar to model GARCH (1,1). However, the log term turns this model into a non-linear one. The residual terms are also reported to dispersion, becoming standardized residues.

For the portfolio construction data from the 04.01.2005-22.12.2007 period were used, including a total of about 755 observations. We used in our analysis BET and RASDAQ-C indexes and the RON/USD exchange rate. Data on the evolution of the BET index were provided by BSE, data on the evolution of the RASDAQ-C were collected from the official site of the RASDAQ Stock Market, while the evolution source of the RON/USD exchange rate is the National Bank of Romania.

In our application, we assume that an investor is willing to invest a part of his wealth in the Romanian capital market. The investor has a significant tolerance to risk, yet wishing to diversify his investment. Suppose that this investor prefers the stock market investment. More precisely, assume that 50% of his capital is invested in the first category of Bucharest Stock Exchange (to simplify the simulation we take the market index BET as financial asset), 30% in RASDAQ OTC market (i.e. the RASDAQ-C index), while for better diversification and protection against risk is 20% invested in USD (i.e. the investor wants a significant degree of liquidity).

Our investor is interested in monitoring his investment and in this respect he wants to know how his portfolio risk evolved. Also, he would like to know which were the reasons leading to some peaks of volatility. Thus, he will choose the GARCH methodology to analyze volatility.

The first step will be testing the ARCH signature presence on portfolio. This will be achieved through correlogram of efficiencies radical. If the ARCH signature is present, we shall move to the conditional dispersion modeling. Thus, GARCH (1,1) will be compared with EGARCH (1,1). Finally, after choosing the most suitable model, we test the residual terms existence by means of radical standardized residual terms correlogram and by application of the ARCH LM test.

Based on primary data, daily returns were calculated (of the BET and RASDAQ-C indexes and of the exchange rate). Next, based on percentages above, the portfolio was composed and the daily returns of the portfolio were calculated. Later, the data were transferred in Eviews 7.0, where all the necessary tests were taken.

5. Results analysis

First we present a primary statistics of data. The following table considers the daily returns of RASDAQ-C and BET indexes and the RON / USD exchange rate. The last column includes a constructed portfolio.

Table 3. Descriptive statistics

	BET	RASDAQ-C	RON/USD	Portfolio
Mean	0.000382	8.73E-05	0.000596	0.000335
Std. Deviation	0.007931	0.005889	0.001671	0.004254
Skewness	0.293	0.325	4.808	0.139
Kurtosis	7.977	52.493	81.379	7.685

The table indicates that the stock market was the most risky (if we refer to BET index). The lowest risk was recorded in the currency market (which was expected, anyhow). Standard deviation of the portfolio was significantly reduced by balancing the portfolio with the USD, yet another clear evidence of diversification. Also it shows that the USD yield to a higher efficiency than that of BET index.

The table also indicates that all four series, including built portfolio, do not follow a normal distribution. This thing is highlighted by the values of Skewness and Kurtosis indicators.

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