Methods of risk modeling in economic activities

Simona Valeria Toma, Ioana-Veronica Alexa, Costel Nistor
Dunărea de Jos University of Galati, Galati, Romania

Abstract - **Any model of analysis, measurement and economic risk assessment should help identify the economic exposure to economic risks and to establish the financial impact related to these exposures. Since businesses are constantly changing their strategies, range of product and distribution channels, the management of economic organizations should be also interested inforecast results under different scenarios. In the end, the aim of this article is to present several methods, models which should provide information that enable the management to compare the company /business situation with other companies or to identify dequate ways of managing the identified risk.**
Keywords: risk management, risk assessment, risk methods and models

I. INTRODUCTION

Risk modeling is fundamental in economic activities because it offers and selects the appropriate policies and efficient techniques for risk management and because the risks and threats change over time, it is necessary for organizations to periodically reassess risks and reconsider whether the policies, decisions and control chosen are appropriate and effective.

All risks identified in economic processes and activities as well as in their future product should be evaluated by a review process taking into account the experience and data from previous activities of the organization. There are various methods and models for qualitative and quantitative risk estimation. Generally, they are based on estimating the probability of risks and their impact identify acceptable levels of risk for the organization and means of establishing the moments where risk levels agreed are exceeded. Quantification is required for both risk assessment and the interactions between them, and to estimate the potential impact on the organization.

II. TOP-DOWN VERSUS BOTTOM-UP MODELS

In general risk models are sorted by top-down models approach (top-down) and bottom-up models (bottom-up), both based on data recorded in history. Bottom-up models are based on an analysis of "loss" events of individual processes, while top-down models require the calculation of capital expenditures in the company and then allocate business lines, often using an intermediate means such as " score or expenses grid approaches. "In addressing the "bottom-up", the risk is calculated individually for each instrument (usually for corporations and capital market instruments) and in the case of the 'top-down', the risk is calculated based on aggregated data (usually retail segment).

Haubenstock and Hardin argue that bottom-up approach is preferred due to the degree of subjectivity in the allocation process and the lack of good business risk agent [1]. A limitation of top-down approach is that it does not clearly indicate how to manage and control the model results, and this is why bottom-up approach tends to be more widespread.

Allen and Bali argue that most of bottom-up models that are designed to measure economic risk from a cost perspective can provide erroneous results [2].

For example, if a company introduces risk management controls, overall costs will increase causing the bottom-up models to generate higher risk estimates but when management controls are effective, economic risk should decrease. Moreover, bottom-up models often suffer from over-disaggregation in that they split production processes into individual steps that could obscure the big picture.

Finally, bottom-up models are based on subjective data provided by employees who are under supervision and thus are not motivated to be quite honest. They also noted that while bottom-up models may be appropriate in diagnosing and designing risk management controls, top-down models are suitable for estimating economic capital requirements. Currie supports the use of both models to calculate capital requirements for financial risk [3].

III. PROCESS , FACTORS AND ACTUARIAL APPROACHES

Smithson classifies risk models into three approaches: (i) the process approach, (ii) factors approach and (iii) the actuarial approach. Process approach focuses on individual processes that make up economic activities, which means that models under this approach are necessarily bottom-up models [4].

Processes are decomposed into components (for example, a foreign exchange transaction is decomposed into processes ranging from initial discovery to final approval of the transaction price).

Each component is examined to identify the economic risk associated with it and by aggregating the economic risk inherent in individual components; it can result in a measure of economic risk for the entire process. This approach includes the techniques described in Table I.

The second approach refers to factors and attempts to identify significant determinants of the risk, either at the institution level or at lower levels (individual business profiles or processes). Thus, the economic risk is estimated as follows:

$$OR = \alpha + \sum_{i=1}^{m} \beta_i F_i + \varepsilon$$

Where F_i is the risk factor i. Factor approach covers the methods described in Table II.

TABLE I Methods of process approach

Method	**Description**
Causal networks	Historical data are used to get statistics about the behavior of components in the past, making it possible to identify problem areas. It is then possible to use scenario analysis and simulations to predict how processes will work in the future
Reliability Analysis and Statistical Quality Control	This technique is similar to causal networks, and is widely used in the evaluation of production
Connectivity analysis	We emphasize here the connection between components and processes. A connectivity matrix is used to estimate potential losses resulting from a process. For the entire institution, the failure of a component spreads throughout the process and throughout the institution.

TABLE II Methods to the factors approach

Method	**Description**
Risk indicators	A regression-based method is used to identify risk factors such as volume operations, audit rating, rotation of employees, age and quality of the systems and investment in new technologies. Once an equation has been estimated, it can be used to calculate the estimated losses
CAPM similar models (Capital Asset Pricing Model)	Better known as *price arbitrage models* or economic value models, they are used to give a measure of the volatility of earnings (earnings economic risk) related to economic risk factors. Model result is extremely important and common in financial theory and practice. This relationship shows the connection between risky financial asset return and return a fully diversified portfolio through risk indicators beta (β).
Predictive Models	In this case we use discriminatory analysis and similar methods to identify the factors leading to economic losses

The third approach is the actuarial one whose objective is the distribution losses associated with economic risk. This approach covers the following methods: (i) the empirical method of distribution losses, (ii parametric approach of explicit distributions, and (iii) EVT.

The empirical distribution method involves collecting data on losses and plotting a histogram. Since individual companies have their own data on high –frequency low-severity losses but not many cases of high severity low-frequency losses, the histogram is performed using internal and external data by bringing to scale.

The problem with this method is that after using external data, it is possible for the empirical histogram to have fewer data points, especially in the distribution *tail*. The solution to this problem can be found in the distribution explicit parametric approach which is used to smooth the distribution by choosing explicit forms of distribution.

It was suggested that it would be useful to specify a frequency distribution for different distribution losses and another for loss severity. Smithson argues that this approach has two advantages: (i) provides more flexibility and more control [4], and (ii) leads to an increased number of data points that can be used. For frequency, it is normally used Poisson distribution and for severity different distributions, including the lognormal and Weibull distribution, are used

After both distributions were parameterized using historical data, it is possible to combine the two distributions, using a process called convolution to achieve loss distribution.

EVT (extreme value theory) is used to describe the distribution of extreme values in repetitive processes and show that for a large class of distributions, losses above a certain sufficiently high threshold follow the same distribution (a generalization of the Pareto distribution) [5] .

An advantage of EVT is that it can be used to predict the likelihood of events that never occurred, which can be done by extrapolating the stochastic behavior of past events.

This, according to Cruz, is very useful in measuring the economic risk when large loss experience is limited or absent (which is very difficult to predict, but there is a low possibility of achievement) [6].

This does not seem to be supported by Embrechts, Kaufmann, and Samorodnitsk who argue that EVT cannot predict exceptional economic losses. The conclusion is that EVT is "a miraculous tool that can produce automatic estimates", but is the best tool that can analyze current data. Thus, EVT provides a very powerful statistical tool when there are sufficient normal data and few extreme events, in the sense that allows extrapolation from normal to extreme [5].

Neslehova, Embrechts and Chavez-Demoulin argue that "what makes EVT is to make the best use of what data you have available about a particular phenomenon" [7]. They warn, however, that EVT should not be used "blindly", as it is the risk not to choose the "right" threshold (i.e., not too low and not too high) and bring to attention EVT data requirements (almost) independent and identically distributed (IID), an assumption that may be too restrictive for practical applications. Similarly, Coles states that "in addition to objections on the general principle of extrapolation, there is no serious competitor model against that provided by the theory of extreme values" [8].

Another advantage of EVT, according to Moscadelli, is that it has a solid foundation in the mathematical theory of extreme behavior, which makes it (as indicated by other applications) a scientifically satisfactory approach to large and very large losses [9]. EVT provides an important set of methods for quantification of the limits between different classes of losses (is foreseen, unforeseen and catastrophic losses), and provides a scientific language to translate management indications to the limits in figures.

Hubner et al. are critics to the use of EVT for this purpose referring to "the myth that EVT can make an important contribution to exceptional economic risk assessment ". While EVT has been successful in describing extremes of physical processes where a t heory provides clues to the inherent distribution and observations are IID, Hubner et al. argue that any attempt to apply EVT to a small set of unrelated economic losses from different companies around the globe is "a triumph of magical thinking over reason" [10].

IV. ASSESSMENT OF THE LIKELIHOOD OF A LOSS EVENT

Sometimes the economic literature describing approaches to risk assessment of the probability of a loss event, which is another way of talking about models. These approaches form the basis of advanced measurement approach to measuring economic risk as indicated by Basel II Agreement. To begin with, there is a historical analysis approach, which is based on the assumption that the driving force behind the loss events does not change over time. Measurement in this case is based on internal and external data loss. Advantages of this approach are that: it catches idiosyncratic characteristics of a controllable risk of a company and provides (using external data) a larger sample to capture catastrophic risk. The disadvantages of this approach are that: focuses on the past, and there is limited data problem.

The second approach is subjective assessment of risk, which is a combination of interviews, scoring grids, self-assessments and workshops. The advantages of this approach lie in that it involves management, involves a wide range of experience / expertise, and looks more at the future than a historical approach. The disadvantages of this approach come from the fact that the data generated are exposed to individual or collective judgment errors as well as inconsistencies.

A third approach is causal and the factors causing high risk events to be explained are identified. It is based on a model in which an event is explained by a number of independent factors (explicit variables). This approach is suitable for relatively rare causally related events but for which other approaches are not suitable. The disadvantage of this approach is that it can only be used to estimate the frequency, not the severity

V. EXPECTED AND UNEXPECTED LOSSES

It is given n which is the frequency of exposure, p the probability of a loss event, E is the exposure severity, and r is the rate of loss when an event occurs. Thus, the estimated number of losses is $N = np$, the estimated severity is $S = Er$ and estimated total loss is NS.

For these measurements, Peccia defines economic risk as the sudden total loss of trust and confidence, which is related to the standard deviation of the total loss distribution [11]. Unexpected loss is the potential loss of all losses contained in the distribution of total losses at a given confidence level. For a co nfidence level of 99%, there is a probability of 0.99 that all losses are lower than those expected plus incidental ones or a 0.01 probability that all losses are greater than that sum. To reach unexpected losses, distribution losses should be constructed, which requires Monte Carlo simulations to combined frequency with severity distribution into a loss distribution.

Unexpected losses can be expressed as a multiple of expected losses that (according to the nomenclature), are called gamma. Gamma is an easy way to represent different levels of risk. For example, losses from credit card fraud can have a g amma value of 5, while unauthorized transactions may have a value of 100. Gamma is actually the loss not provided at expected losses. A related concept is the *vega*, which defines the loss rate for each business line / event type combination in normal circumstances.

The beta index is measuring the loss rate for each business profile, divided by the number of types of events. For example, retail banking beta is 12%, resulting in a vega of 12/7 = 1.7%.

The loss distribution can be achieved using simulated extreme values (EVS), which is described by Pezier (2003) (in a skeptical manner) as follows: the starting point is a large database of economic risk loss containing many types loss events. This database is then "purified" by eliminating events that do not apply to the company concerned (eg unauthorized transactions in a company that is not trading). Severity of remaining events is then brought to the relative scale of the firm/company, for example, using the number of transactions as a measure unit. The next step is to bring to scale the number of loss events per year for that company. For example, if N loss events remain in the reviewed database and are distributed to Y years according to total adjusted capital banks *C* (the capital corresponding to the target company relevant activities) and whether the firm's capital account is c , the estimated number of loss events in one year is E (n) = Nc / CY. Randomly choosing *n* loss events in addition to N events from the database where *n* is a random variable (which can follow the Poisson distribution) with the average E (*n*), the sum of all *n* losses result in finding the economic losses for the target company in a year. This exercise is repeated 10,000 times to produce a histogram of losses by 10 or more events beyond 99.9 percent.

After this description, Pezier is very critical in relation to this procedure, not only because of the difficulty in transposing relevant data to a specific firm. The main problem, he argues, is the confusion that can be made in the observation of rare loss events with an extreme loss model [12]. The extreme tail (99.9 percent of a distribution of economic losses) is dominated by the loss of low probability but extreme severity. The largest industry databases contain only a few examples of exceptional losses and thus lead to unreliable probability estimates. Pezier describes EVS as a b lind approach, giving as an example the difficulty to extrapolate what happened to the Titanic (a rare combination of events) to a modern cruise ship.

VI. CALCULATION OF CAPITAL EXPENDITURE

In general, capital expenditures (i.e. regulatory capital or regulatory capital requirements) are calculated from the total loss distribution using the concept of VAR. Cruz identifies two significant differences between market and economic VAR models. The first difference comes from the fact that, when EVT is applied to economic losses events, it can be made the normality assumption underlying the market VAR models (at least when using the parametric approach to calculate VAR) [13].

The second difference is that, unlike market prices which follow a stochastic continuous process, economic losses follow a discrete stochastic process.

Frachot, Moudouolaud and Roncalli argue that the definition of capital spending is ambiguous, thus suggesting three alternative definitions. The first definition is that 99.9 percent of the total loss distribution, is the probability of loss sustaining higher economic value at risk (OpVAR) is 0.1% or Pr (L> OpVAR) = 0.001 [14].

Such regulatory capital should cover both expected and unexpected losses.

The second definition takes into account only unexpected losses, which is OpVAR given in equation (6.3) except for expected loss which gives Pr (L> OpVAR + EL) = 0.001, where EL is the predicted loss.

Basel II Agreeement seems to accept this definition as long as the bank can demonstrate that it is prepared for expected/predicted losses. One of the quantitative standards is that users AMA should calculate the regulatory capital as the sum of expected and unexpected losses only if it c an demonstrate that expected losses are adequately captured in internal practice, in which case regulatory capital must provide only unexpected losses.

The third definition considers only losses above a cer tain limit, by the formula:

$$\Pr\left(\sum_{i=0}^{N} JL_i > \text{OpVAR}\right) = 0.001$$

where N is the number of loss events, L is the amount lost and J has a value of 1 if Li> H and 0 in other cases, where H is the threshold. This is probably the least acceptable definition of capital expenditures.

The use of the concept of value at risk to measure capital expenditures for the economic risk has not escaped criticism. For example, Hubner et al. argues against the use of "VAR figures" to measure economic risk, stating that although VAR models have been developed for economic risk, questions still remain as to the interpretation of these results [10].

Another problem is that the VAR figure gives an indication on the amount of risk but not on its form (for example, if legal or technological).

Moreover, some doubts were expressed in using the percentage 99.9. For example, Alexander argues that the total loss distribution parameters cannot be estimated precisely because the economic loss data are incomplete, unreliable and / or subjective. Alexander argues that people who prepare regulations should very seriously wonder if it is possible to measure capital expenditures based on a percentage of 99.9 [15].

VII. LEVER METHOD

Lever abbreviation refers to losses estimated by risk validated experts, as a method for estimating economic losses. This method is used as an alternative to statistical models where no adequate data are available. The method consists of constructing a combination of subjective probabilities expressed by experts to reach a rational consensus.

The combination of subjective assessments is based on expertise and testing using the so-called germ questions whose answers are known by analysts but not by experts.

Evaluation of subjective probability is obtained by using questionnaires covering a r ange of variables and germ variables, for which experts must give *quintile answers*. The difference between the target variables and germ variables is that the former are variables of interest and the latter are known. Bakker presents a cas e study using the Lever method to assess economic risk faced by a bank. He has the following recommendations in using Lever method:

- The survey should be done in such a way that it contains questions for no ambiguous answers
- Experts should be more at ease in expressing their estimated numbers

- Before using the Lever method , research should be undertaken on the correlation of economic risks
- Experts should not be able to distinguish between the germ and target questions [16].

VIII. CONCLUSIONS

One of the goals of this article is approval of the concepts, methods, techniques and solutions by analyzing the opinions of specialists in risk and presentation of some methods or models of risk management important to the economic activity.

To achieve this goal we put emphasis on how science works written in recent decades about risk issues highlight the interdependence between: organization (acting to achieve results sufficient to cover expenses and profit), the financial system (which, in case of risk and instability, assigns, in certain circumstances, cash funds to ensure business continuity), the state (through subsidies, and also taxes and fees) and l ast but not least consumers (representing t he customers of the organization).

With the growing risks from day to day, with the increasingly complex society, there is a need to address this topic in detail through risk identification, risk analysis, organization management and their response to risk.

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