Artificial Systems and Models for Risk Covering Operations

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Abstract

Mainly, this paper focuses on the roles of artificial intelligence based systems and especially on risk-covering operations. In this context, the paper comes with theoretical explanations on real-life based examples and applications. From a general perspective, the paper enriches its value with a wide discussion on the related subject. The paper aims to revise the volatilities' estimation models and the correlations between the various time series and also by presenting the Risk Metrics methodology, as explained is a case study. The advantages that the VaR estimation offers, consist of its ability to quantitatively and numerically express the risk level of a portfolio, at a certain moment in time and also the risk of on open position (in titles, in FX, commodities or granted loans), belonging to an economic agent or even individual; hence, its role in a more efficient capital allocation, in the assumed risk delimitation, and also as a performance measurement instrument. In this paper and the study case that completes our work, we aim to prove how we can prevent considerable losses and even bankruptcies if VaR is known and applied accordingly. For this reason, the universities in Romania should include or increase their curricula with the study of the VaR model as an artificial intelligence tool. The simplicity of the presented case study, most probably, is the strongest argument of the current work because it can be understood also by the readers that are not necessarily very experienced in the risk management field.

Keywords: VaR, volatility, artificial systems and econometrics models.

1. Introduction

Value at Risk, also known as VaR by all the risk management specialists, is a financial technique, a mathematical model able to offer, in any moment, an exact quantitative aspect of the exposure to the market risk. For working with the VaR tool, the user needs to have a cognitive focus to a high interdisciplinary knowledge achieved during his/her student years, such as mathematics, economics, computer science, psychology and soft skills combined with a core foundation of an artificial intelligence, like mathematical and econometrics modeling. Between 1994-1996 J. P. Morgan created and improved this methodology for financial risk analysis and evaluation. This method is recognized even today as being the most efficient method used in the market risk management, being, in fact, an interaction between human thinking and artificial systems and models. The analysis of the VaR framework methodology in this paper is begun by defining the notion and presenting its advantages and limits.

Further on, in this paper, we will specify the various VaR calculation and simulation modalities for the portfolios with exposures to the market risk. Here, we will exemplify the most used methods of risk management and of VaR estimation for a portfolio comprising financial assets in foreign currencies.

2. Acknowledging the subject

Our paper will demonstrate that the exposure to complex financial operations attracts risks that may occur as a result of some speculative positions deliberately taken by a bank (by its own account trading), or may derive from the market creator activities for the clients (dealing operations). The modification financial market conditions may affect the bank through the three main interdependent, yet separately managed transmission channels. These are: the variation of the evolution trend and of the interest rate levels, the variation of the foreign currency exchange rate, the variation of the local currency value (of various assets and liabilities expressed in a foreign currency) and, consequently, the variation of the financial assets rate that may affect the market value of the titles portfolio and the value of the titles issued by the bank (bonds or shares).

As laypersons, we may be intrigued by the complexity of the VaR model. But, if we understand how our own intelligence works, we can use this knowledge to make the mathematical models better and we can make them to support us, even to protect our financial investments. Moreover, by transforming the behavior of the computers and mathematical models more similar to humans' behavior, we learn more about how our own cognition works.

All these market risk types of exposures will be empirically explained in the following pages for useful purposes.

The Interest Rate Risk is in relation with the position associated with the fixed revenue titles and with their derivates, as Ross, Westerfield, & Jordan (2010) considered. The risk factors that are in the direct relation with the interest rate are estimated in all the currencies for which the bank has sensitive positions to the interest rate, within the balance sheet and also outside of it. The risk factors refer to the sensitivity of the portfolio accepted by the market, where the short and long position on various instruments may be compensated. It is known that the bank has a "long position" when the assets with fixed interest rate are bigger than the liabilities with fixed interest rate. This position is favorable to the bank during the decreasing periods of interest rate, as it benefits from the fixed level of interest rates for the assets (that are bigger), while the interest rated is decreasing. The position of the bank is "short" when the assets with fixed interest rate are smaller than the liabilities of the same type, to the benefit of the bank, in the period of interest rate increase, as the level of the interest rate stays fixed at a lower level compared with the market trend.

The objective of any bank, concerning the prevention of the risk associated with the variation of the interest rate, is to achieve the largest possible margin between the average level of the passive interests and one of the active interests, at the same time maintaining this margin for as long as possible, meaning, in conditions of minimum volatility of the market. This goal could be achieved by artificial intelligence models as VaR and simulations.

The foreign currency risk or the risk of the currency rate is determined by the probability that a variation of the currency rate on the market, to lead to a net profit diminishing for the bank or to negative influences upon the banking interest margin. Several studies (Ionescu, 2003 and Roxin, 1997) underline the idea that the risk impacts, the banking operations using foreign currency. Banking operations performed in their name of the banks or at the clients' orders, the exposure being directly proportional to the difference between the assets and liabilities in foreign currency from the same maturity category, and has three components. The first component is the exposure, due to transactions developed with assets and liabilities that are sensitive to risks. The second is represented by the exposure associated with the operations of conversion from one foreign currency to another. And, the last one is the economic exposure that undertakes the influence of the foreign currency rates fluctuations upon the bank's value and is calculated as the discounted value of all the incomes obtained by the bank, in all its operating foreign currencies. We can easily understand that without support of the macroeconomics

models and artificial intelligence simulations applied on the various portfolios of assets and liabilities, this task could be almost impossible to be achieved, only by human intelligence.

The risk of shares represents the probability that a bank registers losses or does not achieve the estimated incomes, following the unexpected modifications of the owned financial assets prices on the market. This risk category refers to having certain positions in the trade register, positions that are related to the shares or instruments having a similar behavior and their derivates (e.g. Futures and Swaps). Also, the risk related to shares is calculated for the specific risk that is associated with the ownership of a title and also, for the position on the market, as a whole. For the derivates, the risk is evaluated by converting the derivate into a notional position of shares on the initial instrument. The equilibrium prices are the ones that settle the market which is based on the rate between the demand and supply. When this report is unbalanced, the prices of the financial assets record significant variations that express the volatility of the price. For a complex and diversified portfolio of financial assets, the effect of the title-variation may be compensated, at least partially, by reverse variations of other ownerships, fact that, at the level of an entire bank that professionally manages the assets and liabilities, may not only lead to avoiding deficits, but also has to lead to profit making.

We may, thus, state that the sources of risk on the market are the price variations of the financial portfolio, of the own capital instruments, of the interests spread and of the foreign currencies exchange rates. This is why; its major components are the risk related to the shares position, the risk related to the goods, the risk of the interest rate and the foreign currency exchange rate risk. Each risk component includes a certain aspect regarding the general risk on the market and an aspect regarding the specific risk, both having their origins in the portfolio structure that is specific to the bank. Besides the standard instruments, the market risk is applied to the various derivate instruments such as the options, the derivates on shares or the foreign currency ones and also the derivates on the interest rate. Thus, the role of the artificial systems and models for risk covering operations becomes not only very important, but even indispensable.

As Hastie et al. (2009) demonstrated, the role of the artificial systems is to discover patterns in big data sets, involving models at the intersection of artificial intelligence, mathematics, machine learning, statistics, econometrics and database systems. Acting this way, the artificial models for risk covering operations accomplish new steps towards the "knowledge discovery in databases" process Fayyad et al. (1996). The overall goal of the artificial models is to extract information from a data set and transform it into an understandable structure for users. Aside from the analysis step, Han and Kamber (2001) show us that data mining concepts and techniques involve database and data management aspects, data pre-processing, interestingness metrics, complexity considerations, post-processing of discovered structures, visualization, and online updating.

3. The impact of the major players upon the market and the ways to determine its volatility by artificial systems and calculation models

The presence of the big institutional investors, such as the pension funds, the insurance companies or the investment funds, had also a certain impact upon the structure of the market and upon the market risk.

The institutional investors adjust their own investment portfolios having a stable liquidity and that are traded at a wide range, by means of high-value transactions, as on markets with increasing prices, the high-value acquisitions tend to increase the prices even more. On the contrary, the markets with descending trends become more tensed when massive stock unit packages of institutional dimension are sold. Eventually, this leads to enlarging the spread of the prices variation and, implicitly, to a greater market risk.

The exposure to the market risk, determined by the growth of the number of banks, is due to the diversification trend of their activity, from its traditional function of intermediation to activities of market creating and of own name trading activities by which the banks are saving "risk capital" for activities that involve deliberately risk taking. In this case, this risk should be well managed and a better management is possible by the use of new IT&C intelligent tools.

After the market risk sources are acknowledged, we must analyze the ways and means of contamination with these risk factors, namely the variation of the evolution trend and of the interest rates level, the variation of the foreign exchange rates and consequently of the value of the external assets and liabilities, in local currency, and also the variation of the financial assets price that impacts the market value of the commercial title portfolio and also of the bank issued ones (shares, bonds).

The evaluation of the impact upon the activity or measuring the risk on the market consists of determining the volatility of the results or of the market values (implied volatility, calculated with a formula similar to the Engel curve equation (eq. 1) :

$$\sigma_t^2 = \gamma \cdot V + \sum_{i=1}^{n} \alpha_i r_{t-i}^2),$$

The evaluation could be done using one or some of the following methods:

- the method of the percentage variation of the price of the fixed assets, that, through its value, indicates the volatility;
- the method of the standard variation or of the standard main square deviation, that highlights a standard modification more or less, around the average price variation of the financial asset;
- the method of the correlations, that relies on a set of indicators calculated by extrapolating an already known historical trend;
- the method of the simulations, that consists in fixing a maximum accepted level for the losses and simulating all the possible situations for the existing portfolio, with considering the various volatility degrees;
- the method of the scenarios consists in choosing certain scenarios that are very likely to be achieved, out of the already performed simulations, calculating a volatility for all the scenarios and optimum value for a certain scenario.

A simplistic approach when evaluating the market risk deals with every market where the bank is exposed as a separate entity and does not consider the relations that may exist among different markets. Consequently, every risk is individually assessed. A more comprehensive approach concerns the evaluation of the risk from a consolidated perspective that considers the existing relation among the markets and the fact that the fluctuation on one market may have an impact on various others. For example, the fluctuation of the foreign exchange rate may also affect the price of the bonds issued in a certain currency.

Considering the on-growing interference of the banks in the investment and trading activities, but also the increased volatility of the market, the precise and on time evaluation of the market risk has become necessary. At the same time, it is mandatory to evaluate the ricks attributed to the investment portfolios with a stable liquidity, of the trading portfolios, and also of the positions that are whether in the balance sheet or outside of it.

The capacity to systematically evaluate the risk and to efficiently manage the open net position is crucial. The methods vary from the calculation of the open net position (the sensitivity of the factor "market") to the value at risk calculation and to other more complex risk-

estimations. Once the term transactions which are not yet settled, are taken into account, a projected position is determined and its accounting value is converted into the market value, then it is given to a common nominator which represents the equivalent position of the "cash" market. This methodology belongs to the static type of market-risk evaluation instruments, known as standard instruments or instruments based on tables. This estimation offers a simple value at risk as one single factor, the correlation between the positions is not considered. Based on the open net position, we can estimate the potential income or the capital at risk, by multiplying the open net position (the sensitivity of the risk factor on the market) with the volatility price. It is assumed that the randomness of the variance process changes alongside the variance, as opposed to the square root of the variance taken from the Heston model. The basic Heston model assumes that the price of the asset is determined by a stochastic process, as Wilmott (2006) demonstrated. The model specifies that the instantaneous interest rate follows the stochastic differential equation, modifying the random market risk factor with 3 parameters. In finance, Vasicek (1977) elaborated a mathematical model describing the evolution of the interest rates. This is a type of one-factor short rate model describing the interest rate movements driven by only one source of the market risk. The model can be used in the expertise of the interest rate derivatives and it has also been adapted for the credit markets, although it has the disadvantage of allowing negative interest rates. In order to clarify any misunderstanding regarding the value of the inferred correlation, Damghani (2013) introduced a statistical test which uses the measured correlations in different moments of the financial industry. With all those aforementioned models, an issue that the analysts and the supervision entities often face is that the banks deliberately avoid or postpone admitting the existence of deficits. This type of practice is carried out in order to transfer the low-quality investment assets from one institution to another (or to the permanent investment category that is "kept for the tenor"). The transfer between institutions can be done by simultaneous purchase and sales or by swapping the assets with the other banks or the non-banking financial institutions. For example, the bonds-swapping consists in the simultaneous sale and purchase of a title, for an over-evaluated price compared to the market price that is depreciated. The IAS 39 accounting standard closed this gate as the title has yet to be presented at its fair value (if it is not kept for tenor). The less developed infrastructure on the secondary market could, at the same time, increase the risk and complicate its evaluation even more. For example, in certain markets, the settlement is done few days or few weeks after the transaction is completed. This extended settlement period involves an exact evaluation of the partner's risk – namely, the risk that, within the settlement period, the payment related to the position to be completed and the partner not to have made the delivery. In certain countries, the financial instruments markets are not liquid, and thus potentially generating a volatility of the initial price that is much higher and implicitly, generating a higher risk exposure.

All this show us that the risk relies on events likely to happen and it is obvious that no human evaluation without an adequate intelligent instrument or model (but, used always by human-mind) can illustrate the multiple faceted nature of the market risk. Even the most uncomplicated aspects of the market risk management may present a problem in real life situations – particularly when the bank does not have an adequate system of molding the investment portfolio.

4. How to cover the risk of the open positions through mathematical simulation

All these extended developments of the mathematical and econometrics models, together with derivate instruments that we have been mentioned before, allow their users to cover the risk of the open positions in more complex ways. As the liquidity of the market is a crucial precondition for using such instruments this expanded the researchers' preoccupation for the evaluation and the efficiency of the risk covering operations, with a number of sophisticated methods, such as mathematical simulation. Our current work also channels the attention upon

these preoccupations, thus we will perform an empirical analysis of the most used methods of evaluation and measurement of the exposures of the Romanian banks to the market risk, as Treapăt and Anghel (2016) argue in a recent research.

4.1. The value at risk (VAR)

Most of the banks highly exposed to the market risk which play crucial roles, have implemented complex risk indicators and instruments for evaluating the impact of the risk upon the activity, tools that can be applied on different markets. Although the specific arrangements may differ, these internal evaluation models are usually framing into a common conceptual scenery. Typically, these models are evaluating the aggregated exposure to the market risk of a bank and, taking in consideration the probability level, they estimate the amount that the bank would lose if it owned certain assets for a certain period of time. Such models relying on VAR cover a series of market risks; the bank may "adjust" the structure of its portfolio by choosing from a series of options in order to diversify its portfolio, to reduce the risk it is exposed to and/or the associated capital requirements. The data that is the input in the VAR-based model contains information about the positions and the prices of the bank, the volatility and their risk factors, such as the term of the assets. The data must be comprehensive enough in order to illustrate all the risks that are incidental to the balance sheet positions of the bank and to the positions outside the balance sheet of the bank. All the risks covered by the model must include all the positions related to the interest, foreign currency rates, shares, commodities, and to the options in the portfolio of the bank. The evaluation parameters include the duration of the ownership, the historical time span considered for the observation, the prices of the risk factors, and the trust interval that enables a cautious judgment for an optimal protection level (meaning, that it identifies the maximum acceptable losses). The time span considered for the observation will be chosen by the bank with the purpose that it can illustrate relevant market conditions for its risk management strategy. Usually, the internal models combine the potential modification of the value of each position that would result from the variations that are specific to the basic risk factors, with the probability that these variations occur. The value modifications are accumulated at the level of the segments in the trade registry and/or for all the activities and markets. The VAR value can be calculated by using one of the methods presented below:

1. The method of the historical simulation which calculates the hypothetic modification of the value of the current portfolio, and it is based on the historic variations of the risk factors (at a level of trust of 99%, we could consider the lowest value out of 100 daily observations and to apply this profitability to the current portfolio, thus determining the maximum loss for the following variations).
2. The delta-normal method or the method of the variance/covariance is the most widely used method by the portfolio managers. Through this method it is assumed that the distribution of the assets profitability is normal and that the daily profitability is successively independent (meaning it is not influenced by the profitability previous of the previous days). For calculating the potential modification of the current portfolio value, we have to calculate the average and the standard deviation of the assets profitability. This mathematical operation is done in order to obtain a combination between the risk factors sensitivities and the individual positions within the covariance matrix, representing the risk factors volatilities and the correlations among the asset.
3. The Monte Carlo simulation method builds up the distribution of the current portfolio, using an enlarged sample of price scenarios randomly combined, whose probabilities are, usually, based on the previous experience. This method is more flexible than the other two methods and does not rely on hypotheses about the normality of the profitability, but the scenarios number rapidly increases alongside the complexity of the portfolio and the related risk factors.

The Basel Committee established certain quality standards for the internal models, when they are used in the context of capital adequacy. If the recent volatility of prices was elevated, the qualitative standards contain a trust interval with a single limit, of 99%, an ownership period of 10 trading days, and a historical observation time span of minimum 1 year. Yet, a shorter observation time span will generate a higher value in contrast to the time horizon that is covering a larger period, but is usually less volatile. The VAR numbers must be cumulated by summing them up, on risk categories factors, while considering the crossed correlations in every category. The standard, regarding the capital for the market risk as established by The Basel Committee, requires that the VAR to be calculated on a daily bases and, also, the capital requirements related to the market risk to be daily accomplished. The capital requirements are expressed in values: the maximum between the previous day VAR and the average of the daily VAR indicators, alongside the previous 60 days in line. Afterwards, this is multiplied with an additional multiplying factor "k" (that has a minimum value of 3.0), designated by the national supervising authorities and related with the quality of the bank's risk management system.

The supervising entities will increase "k" with a factor between 0.0 and 1.0; according to how many times the projected VAR was exceeded as resulted of the reverse testing of the internal model. This "plus" factor is connected with the "ex-after" application of the internal model. This measure will probably introduce and stipulate the banks to fix and use, on a regular basis, "a routine and exact program" of stress tests for identifying the events or influences that may have a negative impact upon the position of the capital of the bank.

4.2. The stress test

The aim of the stress test is to identify the events and influences that may generate a loss – namely, the ones that have a negative impact upon the position of the capital of the bank. The stress tests must have both a qualitative and a qualitative nature. The quantitative criteria must identify possible stress scenarios that might occur within the market environment; scenarios that are specific for the banks. The qualitative criteria must focus on two key aspects of the stress test: the evaluation of the capacity of the bank to absorb big losses, and on the identification the measures that the bank can adopt in order to reduce the risk and to preserve the capital.

Following the conducted researches, we have discovered that it is almost impossible to elaborate a standard scenario for the stress test, able to have a consistent impact upon all banks, because the environment could be influenced, practically, by an infinite set of variables. Consequently, the methodology we propose for stress testing involves a series of stages, such as:

1. Reviewing information about the biggest losses that were effectively registered on a certain time span, in comparison with the losses levels as estimated by the internal system for the risk assessment of the bank. This step of the methodology offers information about the "top" losses degrees while covered by a certain VAR estimation.
2. The simulation of the extreme stress scenarios, including also a test of the current portfolio compared the previous periods of time that presented significant turbulences. This type of test must include both the price variations and the big decreases in the level of liquidity; facts that are usually associated with these events.
3. The sensitivity degree evaluation of the bank exposure to the market risk, towards the modification of the estimations about the volatilities and correlations. In other words, the current position of the banks must be compared with the extreme values of the variations for volatilities and correlations within the historical time span.
4. Performing the specific test scenarios, that illustrates the trading portfolio's features of one bank, in the most adverse conditions.

The results of the stress tests must be periodically reviewed by the committee that manages the risk and by the superior management and must be reflected as the upcoming modifications, regarding the policies for specific risk management and the exposure limits. If the

stress tests indicate a certain vulnerability, the bank must immediately take the necessary measures concerning the situations and the risks that generate the respective vulnerability. The stress test scenarios and the testing results are, usually, subject to a supervisory attention (Central Bank). Normally, the complexity of the stress tests reflects the complexity of the exposures to the market risk and to the respective market environments of one bank. Based on a relatively simple analysis, we could evaluate the impact upon the capital of the banks if the expected volatility of the market price would materialize.

The estimations which were generated this way can be used also as instruments for the evaluation of the portfolios and, also, as management instruments. For example, these estimations can be compared with the gained profit or the registered losses, during the period of observation. The comparison of the effective impact upon the profits towards the reported profits enables us, in addition, to evaluate the quality of the market risk management.

By its nature, the market risk demands a constant managerial attention and an adequate analysis. In our opinion, the prudent managers must be aware of the exact way in which the exposures of the bank to the market risk are correlating with its capital.

4.3 Mark to Market

This activity refers to (re)evaluating portfolios of a bank for reflecting the variation of the assets prices, which is due to the fluctuations of the price on the market. This policy requires that the asset to be (re)evaluated at its market value according to the 39thAccounting International Standard. The volume and the nature of the activities a bank engages in determine, in general, the prudent frequency of the evaluation. It is considered prudent for a bank to (re)evaluate the positions of the investment portfolio having a stable liquidity, at least monthly. As the assets in the trading portfolio are being continuously sold and purchased, the positions related to the trading portfolio of a bank must be evaluated and marked to the market at least once a day.

Other aspects that should be approached by the policies concerning the marking to market are: the responsibility of the evaluation and the method used for determining the new (market) price of the asset. The policy regarding the risk management must stipulate that the prices are determined (also the marking to the market) by employees that are independent from the respective dealer, trader or its managers. The market risk management policy must, also, include the requirements concerning the stop-loss sale and the consultation that are related to a predetermined limit for the exposure to the loss (risk budget). The stop-loss exposure limit must be determined concerning the bank capital structure, the incomes trends, and, also, concerning the overall risk profile. When the losses for the positions of a bank reach an unacceptable level, the positions should be automatically closed or consultations must be initiated in order to set or reconfirm the strategy for stopping the losses. The consultations must held by specialists in the risk management or belonging to the committee for administrating the assets and liabilities.

The advanced IT technology, available in the recent years, was compulsory for developing plenty of new instruments. The technology improved the quality and the access to information, and thus increased the efficiency and the liquidity of the interfacing secondary markets. As Gheorhiu (2016) highlights,"…in 2016, the World Bank has placed Romania 37th out of 189 economies analyzed in terms of ease of doing business... Internet services in Romania exceed those from many developed countries. In the latest five years, only Bucharest has attracted more than 170 start-ups and means a rapid growth of big software companies and IT services. The presence of global technology corporations such as Intel, Motorola, Microsoft, Oracle, Sun Microsystems, Boeing, Nokia and others, helped the growth of the IT industry, through software development activities and R&D own centers in Romania. At the present moment, Romania is the third leading country (after India and China) among software exporters and the most important competitive advantage in software development consists of its highly qualified, cost-effective human resources. IT workforce is a driving force of Romania".

The model and the analytical techniques, providing pertinent and exact information and which are consistent at an internal level, offer the necessary technical support for developing the transactions and the decision making acts. Moreover, the complex IT programs allowed processing and evaluating the risk transactions simultaneously, offering the necessary information for the management and employees, thus understating the exact nature of the risk and the value of the open positions, in real time.

The technological capacity, artificial intelligence and skilled young specialists, enabled the banks to engage themselves in trading, meaning that they can assume positions for financial instruments, including positions for derivative products outside balance-sheet instruments. The banks assume such positions to benefiting, on a short term, from the current or anticipated differences between the purchasing and sale prices or from other price or interest rate variations.

5. How to use standard deviation models for a better management of the interest rate, FX risk and price variation for the financial assets

The concern of the interest margins, regarding their stability and preservation, becomes understandable, because, as we know from past experiences that from 2003-2008, some banks had margins between 12% and 18% attributed to the interests in national currencies and margins between 7% and 8% attributed to the loans granted in foreign currencies.

Of course, the margins decreased nowadays, but still they are high. Thus, we have encountered the situation when the weight of the incomes from interests is between 60-70% from the total incomes achieved by some banks or even more for the banks that do not have such a wide range of products and services to bring commissions or other non-interest incomes. A different situation, regarding the margin between the asset and liabilities interests concerns, was acknowledged starting with the 4^{th} quarter of 2008 and properly felt during 2009, following, on the one hand, the financing severe price increase of the sources, and on the other, the blocking of the real estate market. This fact determined a dramatic decrease concerning the demand of loans for immovable assets or the mortgage loans, but also of the consumption loans. From the analyses performed at certain commercial banks in Romania, we acknowledged that, by the end of the second semester of 2009, the in the same loans categories the average balances were between approximately 30-40% which did not impact by the crisis. These values resulted from the average balances of the I^{st}, II^{nd}, and III^{rd} quarters of 2008.

The sensitivity to the variation of the interest on the market is illustrated by the margin variation, under the influence of, at least, two categories of factors. Internal factors, respectively, the ones that are related to the balance sheet structure, the assets quality, the account receivable eligibility, the maturities management, etc. And external factors related, mainly, to the general economic conditions, the political and social stability, etc. If the former are related to the internal organization and the professionalism of the bank employees, being up to them the degree of the influence these factors, the latter are related to the general micro-climate of the market.

The effects of the unforeseen modifications of the interest rates have an impact upon the balance sheet elements with fixed interest rate that cannot be aligned to the market and their dimension gives, in fact, the exposure to risk or the so-called position of the bank to the margin variation that can be long, short or neutral. The bank finds itself in a long position where the fixed interest assets are bigger than the fixed interest liabilities. This position is favorable for the bank in the periods of interests decrease as it benefits from the fix level of the interests for assets (that are bigger) in period in which the interest of such assets are decreasing.

The position of the bank is short when the fixed interest assets are smaller than the liabilities of this kind. The periods of interest rate increase are to the benefit of the bank, as the level of the interest calculated for the resources remains fixed at an inferior level, compared with the trend on the market.

The neuter position is ideal, and appears in the case of equality between the fixed interest assets and liabilities, but it does not secure 100% the bank and does not enables the possibility to the treasurers to speculate the variation of the interest rate. Another modality to manage the interest rate variation risk is the management of the gap. The interest rate variation risk relies on anticipating the trends and immunizing the bank by periodically modifying the assets and liabilities (adequacy).

Taking in consideration the classic approach, without artificial intelligence is more difficult, the gap management involves a recurrent calculation (usually, monthly or quarterly) of the indicator. The calculation is based on the data in the balance sheet or other verification reports, anticipating the evolution of the interest rate level on the market and, correspondingly, adapting the structure of the assets and liabilities elements according to the sensitivity degree (fixed or variable assets).

The assets and liabilities, sensitive to the interest rate, are grouped in tenor intervals (up to 1 month, 3-6 months, 6-12 months and over 12 months), according to the time left until the moment of the interest rate rehabilitation and/or until the tenor. According to this method, we can evaluate by simulations the influence of the interest rate modification (in general, with 1%) of the net interest incomes of the bank. This influence is quantities on various time horizons.

The grouped gaps management is the second method, supported by artificial intelligence. This method is based on grouping the assets and liabilities in sensitive and non-sensitive according to the variation of the interest rate, within a matrix in which the tenors are intersected with every element that is a subject of the analysis. The dynamic management of the gaps is based on the forecast regarding the modification in time of the interest, recalculating the portfolio for every dynamic work hypothesis using some IT programs.

We found that the artificial intelligence models and the simulation methods permit the analysis of the influences that the uncertain sources have upon some parameters of the interest rate risk, foreign currency risk (FX), and price variation for the financial assets. The unforeseen modifications of the prices on the market for the owned financial assets represent the most dangerous enemy of the investors. The equilibrium prices are the ones to adjust the market based on the request and demand ratio. When this ratio is unbalanced, the prices of the financial assets record significant variations that express the volatility of the price. For a proper management of the prices volatility, we have to analyze the factors that generate and augment this instability and to search for remedies to place these variations within an acceptability range, beyond which the exposure at risk must be necessarily covered by specific methods.

This is why, for a complex and diverse portfolio of financial assets, we could rely on artificial intelligence. Our opinion is that only by artificial intelligence simulation techniques the effect of financial titles variations may be, at least, compensated with the reverse variations of other owned elements. At the level of a bank that manages plenty of assets and liabilities, the artificial models for standard estimation of the deviation is the only intelligent way to avoid losses. Among the prevention and management measures, in what the price variation risk for the financial assets is concerned, the most commonly used technique is the one of grouping the volatilities. This technique relies on obtaining statistical information about the previous standard deviation, that by extrapolation – based on a model and simulation techniques – calculates the present and the anticipated standard deviation. The registered values for the volatilities are grouped, thus succeeding in making pertinent analyses regarding the prices modification in one way or reversely.

6. Discussions based on a case study

In the prospective time, not using the artificial intelligence tools as artificial systems and models for risk covering operations, in financial competitions between major players, may trigger major effects upon the investments performance and even bankruptcies. In order to

demonstrate the practical utility of applying the artificial systems in the daily activities of the companies and persons that temporarily have certain liquidities (investors), we will use a calculation example supported by artificial intelligence for the titles portfolio with "n" financial assets, called optimal or immune to the market risk in certain limits, that field specialists described in the recent research works (Treapăt and Anghel, 2016, p.154-155). A particular situation from the issues presented above in this paper is due to the fact that many banks build portfolios from the financial assets that exist on the market and also offer the possibility for the clients to create deposits by investing in such portfolios. In the structure of some portfolios of this kind, there are mainly bonds issued by the state, but also other kinds of financial assets. As any investor in this type of portfolios is permanently exposed to the market risks, it is useful to follow an indicator that, by a single value, calculates the total inducted risk of this type of portfolio without spreading it at the level of the risks created by every asset in particular. A response to such a necessity is represented by the value at risk (VaR), an intelligent estimation method that helps investors to choose in an argumentatively way from a series of options for diversifying its portfolios and increase their options.

In order to mold the phenomenon, some Romanian authors (Arsene and Marin, 2007) considered a portfolio consisting of "n" financial assets, according to the description above, at the present moment "t".

If we note with (1), the value of the asset "i" at the moment "t", and we will admit that the number of assets "i" included in the portfolio is "ni", then, the value of the portfolio at the moment "t" will be calculated with the following formula (2):

$$Si(t),\ i= 1,2,3,\ldots,\ N \quad (1)$$

$$\prod(t) = \sum_{i=1}^{N} ni(t)\ Si(t) \quad (2)$$

Legend:

- *Si(t)* – the value of the asset "i" at the moment "i";
- *ni* – the number of assets purchased by the bank, at the value that was taken into consideration in the present formula;
- $\prod(t)$ – the value of the built portfolio;
- *V* – VaR ;
- *R* – the number of necessary simulations for determining the VaR.

The value of the portfolio at the moment "t" will change in time, both due to the modifications in the structure of the portfolio (the numbers ni(t)), and also to the modification of the values of the components Si(t). Consequently, we can speak about a future value of the portfolio "$\prod(t + \Delta t)$" after "Δt" time units.

We call the value at risk (VaR) that corresponds to a certain period of time "Δt" and to a level of trust of "p" percents, the number "V" bellow which the value of the portfolio at one point "$t + \Delta t$" will not decrease, with a level of trust of "p%", namely: (3)

$$\text{probability}\ [\ \prod(t + \Delta t) \geq V] = p \quad \text{(eq.3)}$$

For the case of the banks, it is recommended that, for calculating the value at risk, to use the following values: $\Delta t = 10$ days and $p = 99\%$. Then, we can express more eloquently that, for a surety degree of 99% in the following 10 days, the value of the owned portfolio will not decrease under "V" monetary units. Of course, the values in view for "Δt" and "p" can be modified as the user of the model wishes, following its own interest.

We would also like to mention that the relation for defining the value at risk can be written in equivalent, as follows:

$$\text{probability}\left[\prod(t+\Delta t)-\prod(t)<V\right]=1-p \quad \text{(eq.4)}$$

A high number (K) of simulations are to be done for the evolution of the financial assets prices that are included in the structure of the portfolio. For every simulation, the future value of the portfolio will be calculated $[\prod (t + \Delta t)]$. Taking in consideration the above mentioned calculation, we will keep in mind K(1-p) unfavorable values and, consequently, the K(1- p)+1 value, in an increasing order, will be VaR. If we have an available data base, containing the daily movements of prices for the assets in the portfolio (and, of course, every bank has such statistics), it can be used as a simulation fund. This type of calculation called historical simulation has the advantage that the method relies on a distribution of probabilities that really existed.

7. Conclusions

By the extended theoretical approach and case study presented in this paper, we can demonstrate not only the scientific validity of the artificial intelligence methods, but also its practical utility for the investors. In the current paper, we presented various methods for risk estimation, thus enabling a better understanding of the great diversity of situations that might occur in practice. This paper offers the readers the possibility to choose consciously the proper method for their exposures. We consider that the usage of a single model could cancel the flexibility necessary for adjusting every exposed-to-risks entity to the real features of the portfolio held at a certain moment in time, "t". Following the researches we accomplished our work hypothesis because it is almost impossible to elaborate a standard scenario for the stress test, in such a manner that it will have a consistent impact upon all of us.

This is why, the approach that we suggest for the stress test involves a series of stages that allow revising the information about the greatest real losses, simulating the extreme stress scenarios, assessing the sensitivity degree of the exposure, and also, rolling the test scenarios that illustrates the transitioning features of the portfolio in the most adverse/difficult situations. But, this could be achieved only by using the intelligent models. If we ask ourselves "why?", then the answer could be that, slowly the human thinking has been proving its huge potential to the academic, scientific, and business community. Actually, there are scientific opinions (Vătămănescu et al., 2016, p.19) that a new relation was built between human and knowledge.

If we try to express some future thoughts, we believe that studying the artificial models profoundly in universities and not only using them in financial institutions, we should be able to mold and stimulate aspects of cognition. This way, we learn how to create artificial information systems that mimic econometric systems, as well as how to use theoretical insights for a better understanding of the cognitive processing in the human brain.

Acknowledgment

As previously stated, creating this paper was one of the targeted objective of an on-going wider research, initially presented by Treapăt and Anghel (2016) at Strategica International Academic Conference, the 4th edition, in Bucharest. This objective is now completed with a new

research conducted towards a new direction, namely how much the financial techniques, mathematical and econometrics models support us, humans, to deal with the estimation models volatilities and with correlations between the various series of data. Having this new approach of our research, we strive to demonstrate that interactions between the human thinking, the artificial systems, and the intelligent tools, help us to gain, at least, a partial control over the imminent hazard of a risky investment.

References

Arsene, C., Marin, D. (2007).*Modelarea deciziei financiare [*Modelling the Financial Decision*]*. Bucharest: A.S.E. Publishing House.

Bartov, E., Bodnar, G.M. & Kaul, A. (1996). Exchange Rate Variability and the Riskiness of U.S. Multinational Firms: Evidence from the breakdown of the Bretton Woods System. *Journal of Financial Economics, 42*(1), pp.105-132.

Basno, C. & Dardac, N., (2002). Management bancar [Banking Management]. Bucuresti, Economica Printing House.

Bernstein, J. (2000). Piața contractelor futures. [The Market of the Futures Contracts]. Bucuresti, Herma Printing House.

Bodnar, G. M., Hayt, G. S., Marston, R. C. & Smithson, C. W. (1995). Wharton Survey of Derivatives Usage by U.S.Non-Financial Firms. *Financial Management*, *24*(2), pp. 104-114.

Caracota, C.R. & Enusi, M. (2005). Gestionarea riscului valutar [The Management of the Foreign Exchange Risk].Bucuresti, Tribuna Economica Magazine (7).

Choi, J. J., & Prasad, A. M. (1995). Exchange Risk Sensitivity and its Determinants: A Firm and Industry Analysis of U.S. Multinationals. *Financial Management, 24*(3), pp.77-88.

Ciurlău, L. (2006). Managementul riscului valutar prin intermediul tehnicilor de hedging [The Management of the Foreign Exchange Risk by Hedging Techniques]. *Finante-Provocările viitorului [Finance-The Challenges of the Future] Magazine, 5*, pp. 235-240.

Copeland, L. (2000). Exchange Rates and International Finance. *Prentice Hall*.

Dhanani, A. (2000). Risky Business. *Financial Management*, pp. 30-31.

Fayyad, U.*,* Piatetsky-Shapiro, G.*, Smyth, P. (1996).* "From Data Mining to Knowledge Discovery in Databases"*,* Retrieved October 2016*.*

Gheorghiu, A. (2016). "Technology Entrepreneurship in Romania - a Great Opportunity for the Future Years". Strategica International Academic Conference, 4-th. edition, Bucharest, pp.395-405.

Goldberg, S.R. & Tritschler, C.A. (1995). Financial Reporting for Foreign Exchange Derivatives. *Accounting Horizons, 9*(2), pp. 1-15.

Han, J.*, Kamber, M. (2001). Data mining: concepts and techniques.* Morgan Kaufmann*. p. 5.* ISBN 978-1-55860-489-6.

Hastie, T.*,* Tibshirani, R.*, Friedman, J. (2009).* "The Elements of Statistical Learning: Data Mining, Inference, and Prediction". Retrieved 2012-08-07

Hull, J. (2000). Options, Futures and Other Derivatives, Mc Graw Hill.

Ionescu, C. (2003*). Managementul riscului [Risk Management].* Cluj-Napoca: Dacia Publishing House, p.17.

Mahdavi Damghani B. (2013). The Non-Misleading Value of Inferred Correlation: An Introduction to the Cointelation Model. *Wilmott Magazine*, (67), pp.50-58.

Makar, S. D. & Huffman, S. P. (1997). Foreign Currency Risk Management Practices in U.S. Multinationals. Journal of Applied Business Research, 13(2), pp. 73- 86.

Mathur, I. (1982).Managing Foreign Exchange Risk Profitably. Columbia Journal of World Business, 17(4), pp. 23-30.

Niţu I. (2000). *Managementul riscului bancar [The Banking Risk Management]*. Bucharest: Expert Printing House.

Phillips, A. L. (1995). Derivatives Practices and Instruments Survey. *Financial Management Journal,* 24(2), 115.

Ross, Westerfield, & Jordan (2010). *Fundamentals of Corporate Finance*. McGraw Hill. p. 746.

Roxin, L. (1997). *Gestiunea riscurilor bancare [Banking Risk Management]*. Bucharest: Didactică şi Pedagogică R.A.Publishing House, p.194.

Sarno, L. & Taylor, M. (2002). *The Economics of Exchange Rates*. Cambridge: University Press Publishing House.

Steiner, R. (1998). *Mastering Financial Calculations. A step by step guide to the mathematics of financial market instruments*. New Jersey: Prentice Hall.

Treapăt, L-M., Anghel, L-C.(2016). Managing the Market Risk in Banks. *Strategica International Academic Conference, 4-th. edition*, Bucharest, pp.147-156.

The National Academies Press (1991). Artificial Intelligence in Mathematical Modeling. Retrieved from: https://www.nap.edu/read/1909/chapter/6, p.31.

Vasicek, O. (1977). An equilibrium characterization of the term structure, *J.Financial Economics*, 5: 177–188

Vătămănescu, E.M., Gorgos, E.A., Andrei, A.G. Alexandru, V.A. (2016). The Technological Advent and Dynamics of the Network Society. The Middle-Aged Approach. *BRAIN-Broad Research in Artificial Intelligence and Neuroscience Journal, 7*(3), 16-30.

Wilmott, P. (2006). Paul Wilmott on quantitative finance (2nd ed), p. 861.