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RISK AND UNCERTAINTY IN THE CHOICE OF AN OPTIMAL PORTFOLIO ON THE ROMANIAN CAPITAL MARKET[1]

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Abstract: *The financial system represents one of the most important components of a country's economy, with a well defined function in the capital resources mobilization from those who own them (the investors) towards those who need them (the beneficiaries - public or private entities).*

The modern financial theory has formalized a complex objective – the optimization of the correlation between return and risk – in order to determine the portfolio's strategy (which weight of the total available amount should be invested in each asset).

Value at Risk (VaR) is considered to be one of the most important measures of market risk and it has been widely used for financial management by institutions including banks, regulators and portfolio managers.

In the Markowitz model it is suggested that the process of portfolio selection should be approached from the angle of the probable estimations of the future returns of the bonds. The analysis of these estimations in order to determine a set of efficient portfolios and the selections made from this set of portfolios which correspond to the investor's preferences represent the value of his theory. The Sharpe model starts from the Markowitz theory with the intention to simplify the method of bond selection in the portfolio.

Through the comparison of the achieved results from the application of these two models on a national portfolio constituted from three stocks quoted on the Bucharest Stock Exchange Market, it can be concluded that the model developed by Markowitz leads to the best results, optimizing the financial placing decision from the angle of the efficiency criteria return-risk.

Moreover it is also taken into consideration the correlation between these aspects and the area intensely linked with them represented by e-business.

Key words: *portfolio, financial bonds, optimality, VaR, return, risk, model testing, Markowitz, Sharpe, market indexes*

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1. Introduction

Modern portfolio theory relies on the study developed by Markowitz (1952). Rubinstein (2002) appreciated that Markowitz's research represents the first mathematical formalization of the diversification concept of investments, emphasizing the fact that even though diversification reduces risk, it can not eliminate it completely. So, through diversification risk can be reduced without having any effects on the portfolio expected return. Thus, investing in different classes of financial securities and in different industrial sectors enables investors to improve the performance of their portfolios (Aloui, 2010)

The financial system represents one of the most important components of a country's economy, with a well defined function in the capital resources mobilization from those who own them (the investors) towards those who need them (the beneficiaries - public or private entities). The risk and return criterions represent the foundation of the financial investments made by asset owners, the well known portfolio management models being the ones that establish the principles of the investment behavior.

Due to the fact in the last years there has been noticed a growing inclination to adopt financial trading automated systems, the context of this paper sets out to present an electronic trading model, as well as other aspects linked with the modern portfolio model analysis. The modern portfolio theory is based on two categories of models: normative models and positivists models. The normative model category includes the basic modern portfolio theory models: the Markowitz Model and the Single Index Model of William Sharpe. Despite their apparent perfection, these models have continuously been reformulated, new hypotheses being added, or the ones that have been rejected by the market corrected.

The conclusions of this paper highlight the essence of the issues approached, being pointed out that the models approached and tested in this paper are efficient and viable on the Romanian Capital Market.

2. Value at Risk (VaR)

Value at Risk (VaR) is considered to be one of the most important measures of market risk and it has been widely used for financial management by institutions including banks, regulators and portfolio managers. Since the risk management group J.P. Morgan developed the RiskMetrics model for VaR measurement in 1994, this model has become a benchmark for measuring market risk (So,Yu, 2006). A crucial factor for the accuracy of the VaR estimates relies on the underlying measure of volatility (Moosa, Bollen, 2002). Therefore, the problem that arises in the estimated VaR is finding a suitable performance measure that has the capacity to evaluate the performance of the estimates correctly.

The Basel Committee on Banking Supervision (1996) at the Bank for International Settlements imposed banks and other authorized financial institutions to communicate at the beginning of each day the daily estimated risk to the closest monetary authority using one or more models of Value at Risk (VaR). These models have become a very popular tool for measuring the market risk of a portfolio of financial assets. By definition VaR represents an estimate of the maximum potential loss in the value of a portfolio of financial assets with a given probability over a certain time horizon, or, in other words, it represents the decline in the market value of an asset or a portfolio of financial assets that can be expected within a given time horizon with a given probability. In order to define the concept of VaR of a portfolio of securities, we must first define the daily returns of the portfolio (Moosa, Bollen, 2002):

$$r_t = \ln(p_t) - \ln(p_{t-1}) \quad (1)$$

where r_t represents the continuously compounded return of the portfolio at time t, p_t represents the price of the portfolio at time t. So:

$$r_t = \ln\left(\frac{p_t}{p_{t-1}}\right) \quad (2)$$

$$e^{r_t} = \frac{p_t}{p_{t-1}} \quad (3)$$

$$p_t = p_{t-1} e^{r_t} \quad (4)$$

Let r_t^c be the critical portfolio return such that the observed return on day t is less than or equal to the critical level with a given probability. Thus, for a probability of 1% we have:

$$P(r_t \le r_t^c) = 0.01 \quad (5)$$

The critical portfolio value p_t^c that corresponds to a probability of 1% implies the fact that the observed return on day t will be less than or equal to r_t^c and it can be obtained by combining equations (4) and (5). Therefore:

$$p_t^c = p_{t-1} e^{r_t^c} \quad (6)$$

For a portfolio whose market price is p_t, the VaR represents the loss in the value of the portfolio with a 1% probability. Thus:

$$VaR_t = p_t - p_t^c$$

By combining equations (5) and (6) we obtain:

$$VaR_t = p_t - p_{t-1} e^{r_t^c} \quad (7)$$

We know that $e^x \approx 1 + x$, when x is very small, so equation (7) can be written as:

$$VaR_t \approx p_t - p_{t-1}(1 + r_t^c) \quad (8)$$

An important hypothesis of the VaR model is the fact that the portfolio returns are normally distributed, therefore the critical return for a 1% probability will be:

$$r_t^c = -2.326\sigma_t \quad (9)$$

So the value at risk can be calculated as:

$$VaR_t = p_t - p_{t-1}(1 - 2.326\sigma_t) \quad (10)$$

where σ_t represents the volatility of the portfolio on trading day t.[2]

[2] The volatility of the portfolio can be measured using the variance of the portfolio or the portfolio standard deviation.

3. Optimal portfolio selection models on the Romanian Capital Market

3.1. Financial electronic trading model

Suppose there are M agents, N financial risky assets and a market that works like a double-auction automated system. Agents, trading to reach their own target portfolio, enter the market sequentially. At each time step k within a trading day t is randomly extracted, with replacement, one agent to enter the market.

The agent will enter the market, and he will post his orders, if P is greater than a random number drawn from a uniform distribution over the $[0,1]$ interval. The probability P is an increasing function of the total imbalance between the target and the current portfolio.

The activation function P reflects the urgency of trading for the candidate agent. Agents will be more impatient to trade the more distant their current wealth allocation will be from their target portfolio. Correspondingly, the filtering device P will make the effective probability of entering the market dependent on portfolio's imbalance.

When a trader enters the market he faces an exchange book with orders to buy and to sell. Agents will be able to trade immediately at the current quotes placing market orders, or submit limit orders that will be stored in the exchange book and that will be executed if matching orders will arrive before the end of the trading day.

At each moment in time during the day, the exchange book, divided in a buy side and a sell side, shows all the orders that have been issued up to that time and that have not found a matching order. For each order, the order size, the limit price, and the posting time are reported.

The limit price is the maximum price that an agent is willing to pay to purchase the registered quantity in the case of a buy order, and the minimum price that an agent is willing to accept to sell the submitted quantity in the case of a sell order. At the end of the trading day all orders will be canceled.

Agents will trade on this market to rebalance their portfolio. That is, at each moment in time they will trade to adjust their portfolio according to their optimal target allocation.

3.2. The Harry Markowitz Model

Markowitz's paper "Portfolio Selection" published in 1952 is considered to be the beginning of a new type of research and analysis in the investment field. In this paper investors were presumed to have risk aversion, meaning that they preferred to take the smallest risk possible for a given level of expected return. Moreover, an investor that held a bond portfolio was not so preoccupied with the bond's risk, but for the risk of the portfolio itself. According to this quantification of the risk, the construction of risk-return based models was possible and their goal was to give the potential investor the optimal portfolio bond choice and guarantee him the biggest return according to his willingness to take risks.

In order to determine the risk-return outline the investor had to design the minimum variance curve of all the placement possibilities at a given expected return rate. Being given the expected return, standard deviation and covariance for all the risky bond combinations the minimum variance portfolio was obtained.

Testing the Markowitz Model on the Romanian Capital Market

Starting from the fundamental hypotheses of the Markowitz Model we have made an attempt to determine the minimum variance portfolio on the Romanian Capital Market, using two stocks from the financial investment sector: SIF Banat-Crisana S.A.(SIF1) and SIF Oltenia S.A.(SIF5) and one stock from the pharmaceutical sector Zentiva S.A.(SCD).

With these stocks we have computed a data base that contains the closing prices of the transactions made in the following period: 01/05/2001-10/20/2008 (1790 observations). This data base leaded to the calculation of the daily bond returns with the formula:

$$R_i = \frac{p_{t+1}}{p_t} - 1$$

(dividends were not taken into consideration).

These historical series conducted to the calculation of the daily expected average returns (like a mean of the daily values), variance and standard deviation.

In order to determine the minimum variance portfolio we have started with the following bond weights in the portfolio: 33% SIF1, 33% SIF5 and 34% SCD with the purpose to minimize the portfolio standard deviation, this type of scenario being characteristic for the investors that have a strong risk aversion.

Using the "Microsoft Excel Solver" we have optimized the financial results taking into consideration the following restrictions: an asset portfolio is considered to be efficient if it offers the smallest risk for a given expected return, the sum of the bond weights has to be equal to 1 and short selling is not allowed, meaning that all bond weights have to be ≥ 0 .

Thus, we have obtained the portfolio with the absolute minimum variance of 0.11% which gives the bond combination that offers the smallest risk of 3.32% for an expected return of 0.08%. We have concluded that the following bond weights in the portfolio are optimal: 27.66% SIF1, 35.28% SIF5 and 37.06% SCD.

3.3. The Single Index Model (Sharpe)

In 1963, William Sharpe has tried to bring changes to the fundamental portfolio selection model. These changes implicated not only the reduction of the information level needed to set up the portfolio selection model, but also supplemental information regarding diversification as a method to reduce risk.

Sharpe included the market fluctuations in the return and risk of each bond calculations, considering a linear dependency between the bond return and the market index return.

So, this model measures the "surprise" return correlated with the "surprise" market index return and the expected gain under the materialization of the firm specific risks, which can be eliminated through diversification. An important implication is that the need to estimate a huge number of covariances is eliminated.

Testing the Single Index Model on the Romanian Capital Market

The development of this model has had as a starting point the previous stocks in order to ensure data comparability. We have considered the mean market return given by the evolution of the BET index as the macroeconomic factor of the model.

With the help of "Eviews" we have estimated with the Ordinary Least Squares Method the regression equations for each bond with the purpose to determine the volatility coefficient. The results obtained lead to the following observations:

- There is a significant linear dependency between the stocks quoted on the Bucharest Stock Exchange Market and the market return because the slopes of the regression lines are > *0*, and the stocks are little volatile because their volatility coefficients have values < *1*;
- According to the values of the determination report: *58.57% of the variance of the SIF1 return, 57.87% of the variance of the SIF5 return and 45.08 of the variance of the SCD return* is explained by the movements in the market return;
- For a 5% significance level according to the *Fisher-Snedecor Test* from Eviews we have tested if the three regression models are correctly specified. According to the test's probability (*<5%*) the models are correctly specified and their coefficients differ significantly from 0;
- The *Durbin-Watson Statistic* computed for the regression models that there is no first order autocorrelation present.

We have calculated the systematic and non-systematic risk of the portfolio. The market linked risk (systematic risk) refers to factors such as inflation, recession or interest rates, which affect al businesses alike and their effects can not be eliminated. The company risk (non-systematic risk) is caused by the success or failure of the marketing programs, the win or loss of major contracts, and other events that take place in a company. Due to the fact that these events have a random nature they can be eliminated through diversification. The results computed for these two indicators lead to the conclusion that the non-systematic risk is the one that has greater significance in the total portfolio risk so it can be eliminated in case the diversification decision is taken.

In order to determine the minimum variance portfolio we started from the scenario used for the Markowitz Model. The portfolio optimization was done again with the help of "Microsoft Excel Solver" being taken into consideration one additional restriction in comparison to the previous model: the portfolio volatility coefficient equals the multiplication between the portfolio bond weights and their volatility coefficient.

We computed the minimum variance portfolio of 0.94% which gives the bond combination that offers the smallest risk of 9.68% for a given return of 0.09%. Thus the optimal bond combination is: 33.08% SIF1, 32.91% SIF5 and 34.02% SCD.

4. Conclusions

On the speed century's background when people show great interest for technological development, information, e-resources and their efficient usage, the optimization of the financial decisions represents a priority.

This paper sets out to "walk through" the modern methods of portfolio construction on the Romanian Capital Market describing in the beginning a financial electronic trading model that gives investors with limited resources the possibility to interact without having them resort to financial intermediaries.

The next step in our paper was to test the two normative portfolio management models that are believed to be the core of today's financial theory.

Through the comparison of the results obtained we have concluded that the model Markowitz developed lead to the best results, optimizing the financial placement decision from the risk-return efficiency criterion point of view.

Thus, the minimum variance portfolio is the one given by the Markowitz model: 27.66% SIF1, 35.28% SIF5 and 37.06% SCD with a variance of 0.11%, 3.32% risk and 0.08% expected return.

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