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The Possibilities of Application of the Parametric and Nonparametric VaR Daily Returns Estimation – Regional Perspective

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The subject of this research is to test the performances of the parametric and nonparametric VaR models in the markets of the countries of the Southeast European region. The research objective is to provide concrete results regarding the possibilities of application of aforementioned VaR models in the observed markets. The research hypothesis is that the application of both parametric and nonparametric VaR models can provide optimal results regarding investment optimization. The methodology used in this research includes the application of MANOVA analysis, discriminant analysis, and Roy's test in the case of selected regional countries. The research results indicate the significance of the analysed VaR models application in the analysed markets and expand the potential for further research in the subject field. The results obtained in the research (rolling windows 100 and 300 days) implicate that statistically significant differences exists in the application of both parametric and nonparametric VaR models. Also, these results have significant international importance having in mind that there are very few studies in this area with the focus on the markets of the Southeast European region, especially with so wide and systemic approach as in this research. Having this fact in mind, the results obtained in this research significantly expand both academic and practical knowledge about possibilities and limitations of different Value at Risk models in everyday business practice.

Keywords: *Value at Risk, Parametric VaR, Nonparametric VaR, Return Estimation, Transitional Markets.*

Introduction

One of the key challenges of the contemporary concept regarding the investment processes is to obtain and maintain the balance between expected and actual investment returns. Many research papers have been investigating and discussing these issues, with more or less success. As Value at Risk, currently a standard measure of market risk, started to be frequently applied in the investment processes, there has been debate about the accuracy of various VaR calculation methodologies (Berkowitz & O'Brien, 2002; Bali *et al.*, 2009; Hong & Liu, 2009; Engle & Manganeli, 2004; Giot & Laurent, 2003; Glassserman *et al.*, 2000; Jin & Zhang, 2006; Yu *et al.*, 2015; Chernozhukov & Umantsev, 2001; Brooks *et al.*, 2005). VaR models were used as well in a significant number of studies addressing transitional markets in the context of the prediction of investment returns with a special focus on the possibilities for risk minimization (Soydemir, 2000), (Beirne *et al.*, 2010), (Chambet & Gibson, 2008).

Since the outbreak of the global economic crisis, a significant change in the approaches and perception regarding the nature of this relationship has occurred. First of all, in mathematical terms, the function of investment returns has started to behave differently – it changed from sinusoidal to T-distribution, which resulted in a need for extensive redefinition of concepts of investment risks/returns management. As a result of changed market conditions, developed and transitional markets have clearly differentiated as two distinctive groups of markets and their differences became even greater with the outbreak of global economic crisis. There have been a considerable number of studies with a focus on developed markets, but relatively few with a focus on transitional markets.

In order to test the possibilities of application of various VaR models (both parametric and nonparametric) in the transitional markets, the research presented in this paper includes the markets of developing countries of the Southeast European region: Republic of Croatia, Slovenia and Hungary. In the previous research paper published in 2014, a research with a focus on the market of the Republic of Serbia was conducted (Djakovic *et al.*, 2014). The results obtained indicated the need for expanding the scope of the research on similar regional transitional markets, taking into account the peculiarities and similarities/differences among these markets. The main objective of the research is to provide concrete results tested in practice regarding the possibilities of various VaR models application in the analysed transitional markets. Given this, the purpose of the research implies the need for empirically verified findings regarding the success of the analysed models application in the observed markets, in order to create real preconditions for further optimization of the effects from investment activities. The research results in this paper represent original, empirically verified and tested findings about the possibilities of application of the specific VaR models in the analysed markets, and it has a manifold significance. In case of the academic community, the results obtained during the research provide reliable and quality information about the possibilities of application of models for investment risk/returns estimation in the observed regional markets. MANOVA analysis, discriminant analysis, and Roy's test are used as the important methodology tools, especially regarding the acceptance/rejection of the stated hypothesis. The obtained results will benefit the professional community through actual application of models tested on specific markets.

The research results are derived from the previous author’s studies in this area, in which the existence of statistically significant difference among tested EVT, HS VaR and D VaR was tested relative to the success rate of the investment risk prediction in the markets of the Republic of Serbia, Croatia, Slovenia and Hungary.

Also, the previous author’s studies of the domestic market represented a solid starting point and an adequate basis for extending the focus of research conducted in this paper.

The tested hypothesis is that the application of both parametric and nonparametric VaR models can provide optimal results regarding investment optimization, thus tested VaR models in analysed markets can yield adequate results in terms of quantification risk from investment activities.

The scientific contribution of the research presented in this paper is manifold. First of all, the results indicate the possibilities of application of tested models in the aforementioned regional markets. Secondly, it enabled testing of similarities and differences among analysed markets through the prism of estimating effects from investment activities, and these findings represent the scientific basis for further research of the behaviour of tested markets. Also, bearing in mind the fact that a relatively small number of studies so far have been conducted with the focus on these markets, this research objectively represents a significant step forward in analysing the specific markets.

In the introduction, the subject, objective and hypothesis of the research are defined. In the second part of the paper, the review of the relevant recent literature is presented and compared. The used methodology is presented in the following section. The next section discusses the results of the research, followed by the conclusion and a reference list.

Literature Review

In this part of the paper will be presented and compared general literature review concerning topics of the conducted research.

The application of both parametric and nonparametric VaR models is particularly significant bearing in mind the possibility of adequate risk quantification, especially in the investment processes. The extreme events put a special emphasis on the need for specific VaR models application, in regard to the dynamic nature of the observed markets and with a special focus on volatile, low propulsive and undeveloped transitional markets.

Kuester *et al.* (2006), recognizing the importance of risk prediction, have compared the out-of-sample performance of the existing models with a couple of contemporary VaR estimation models in univariate context. The authors came to the conclusion that the conditional VaR models provide higher volatility levels compared to unconditional VaR models. The possible outcome of these circumstances involves a potential difficulty in allocating capital for investment purposes. The research results indicate that acceptable predictions of investment returns are obtained only with the application of conditionally heteroskedastic models.

Kim *et al.* (2015) analysed the adequacy of the VaR estimation, that is, the performances of the tested models for the Korean financial market in the period 2003-2012. This research is significant because it stresses the tested VaR models application specificities with special attention of providing the adequate VaR estimation. Also, it is significant to observe how the extreme events occurrence affects the VaR estimation in case of S&P 500, KOSPI 200, KOSPI 200 futures, and the VKOSPI volatility index.

Basak & Shapiro (2001) analyse the application of VaR models during the creation and management of an investment portfolio with a special focus on the possibility of minimizing the market risk in the investment processes. The authors focused on the transitional markets, taking into consideration the high risk level associated with these markets, with an objective to minimize the limitations of VaR models application.

Longin (2000) investigated the application of parametric models for VaR calculation as well as the application of Extreme Value Theory (EVT), especially regarding the necessity of their application in the optimal investment decision making processes, with special focus on adequate market positioning. The research was conducted with an objective to obtain empirical results regarding the performances of standardized VaR models application. The significance of this research lies in the fact that tested markets have been observed both in the environment characterized by extreme events, as well as in the relatively stable environment.

Wong *et al.* (2016) investigated the risk estimation for multiple period VaR for the major market indices in Asia, Europe and North America. Findings of the research implied that quantile regression approach is less likely to underestimate the VaR. The appropriate VaR risk estimation understands the necessity of macroeconomic variables and conditional kurtosis analyses in function of enabling prediction of stock returns.

Ferraty *et al.* (2016) estimated two risk measures, the value at risk (VaR) and the expected shortfall, with a focus on the S&P 500 time series. Martins-Filho *et al.* (2016) proposed specific nonparametric estimators for conditional value-at-risk (CVaR) and conditional expected shortfall (CES) in the connection with conditional distributions of a series of returns on a financial asset.

It is very interesting to point out that comparing the results from Kim *et al.* (2015), Wong *et al.* (2016), Ferraty *et al.* (2016) and Martins-Filho *et al.* (2016), it can be concluded that introduction and implementation of different value at risk models at different markets can provide optimal results in sense of portfolio (investment) optimisation, regardless the fact that different market conditions in period after the crisis produced specific returns distribution. In that sense, implementation and testing of possibilities of application of the parametric and nonparametric VaR daily returns estimation with focus on regional perspective is important both for academic and practical purposes, having in mind that research conducted in this article will significantly expand the knowledge and practical place of VaR models at different markets.

But also, it is important to emphasize that there are some differences in the results between the observed studies. These differences are derived, first of all, due to different behaviour in the tails of the expected returns. Different markets produce some differences in that area, which evidently have impact on estimation results. Wong *et al.* (2016) in their research are aware of need for conditional kurtosis analyses in function of enabling prediction of stock returns, and Ferraty *et al.* (2016) are at the similar track in their research on the S&P 500 time series.

Gencay & Selcuk (2004) analysed in their research daily investment returns in the tested transitional markets. The authors tested the successful application of VaR models including both parametric and nonparametric models. Besides Brazil and Turkey research results, tail estimates at 0.999 percentile along with 95 % confidence intervals imply that is possible to achieve over 10 % loses in one day. The conclusion of the empirical research is that in the given conditions the extreme value theory yields optimal results. These results are in high correlation with the results that later obtained Wong *et al.* (2016) in their research, especially having in mind the wide scope of the observed markets.

Vlaar (2000) conducted a research about the dynamic nature of the investment processes in the context of successful application, i.e. VaR models performances. The research tested the applicability of parametric and nonparametric models in the given context. The findings of the research indicate the necessary preconditions that are to be fulfilled in order to maximize the positive effects regarding the application of the selected model.

Aniunas *et al.* (2009) analysed the types of risk in the foreign exchange market and the level of risk associated with both the long and short position. The authors put special emphasis on risk estimation and risk management regarding making optimal investment decisions. The focus of the research was on the possibilities of risk management with the application of VaR models. Research results showed that the average deviation percentage was about 1% and that critical margin of 5 % was not over-passed for any time period. Also, the findings indicate that VaR models can be regarded as one of the most advanced tools when estimating the level of acceptable risk.

Christoffersen *et al*. (2001), bearing in mind the large scope of VaR models, as well as the complexity of selecting the appropriate one, focused on obtaining quantitative and qualitative findings regarding the possibilities of their adequate application. Given this, a framework was constructed in order to enable comparing and testing of various models, and selecting the optimal model in the given investment environment.

The aforementioned empirical research in the subject field indicate the current level of importance and relevance of the application of both parametric and nonparametric VaR models, especially in the context of making optimal investment decisions. The research conducted in this paper represents a step forward in the light of establishing adequate basis for an improvement in investment processes, as well as the possibility of risk reduction, especially in the transitional markets that have many distinctive features.

Methodology

In order to conduct a representative research, a sample used represents the daily historical stock index values in regional transitional markets, specifically: CROBEX, SBITOP and BUX, for the period of 01.01.2006-31.12.2012. Historical data span is chosen because it adequately represents the period prior to the global economic crisis and especially during the manifestations of the effects induced by the crisis. This approach enables the high representativeness of the research sample, regarding both the quantitative and the qualitative scope of used data.

The VaR models used in the research include both parametric (Extreme Value Theory – EVT and Delta Normal VaR – D VaR) and nonparametric VaR models (Historical Simulation – HS VaR), tested with a confidence level of 95 % for 100 and 300 days (rolling windows). In accordance with the established research objective, the authors have chosen a comprehensive approach to test the VaR models application in the observed markets, so both parametric and nonparametric VaR calculations models were tested in the research paper. Namely, the research methodology understands daily risk estimation of the both parametric and nonparametric VaR models performances in the observed period. The chosen rolling windows of 100 and 300 days for VaR models calculation represent in best manner the specificities of the observed markets.

In the research by Ottenwaelter (2008), the estimation of risk using VaR models is described by the changes in portfolio values (ΔP) during the time horizon and regarding the potential loss (100-α) observing the portfolio change (ΔP):

$$P(\Delta P < VaR) = 1 - \alpha \tag{1}$$

VaR could be considered as a percentage of (100-α) sample distribution on daily basis associated with different confidence levels. Delta normal VaR (D VaR) can be calculated as follows:

$$VaR(p^*) = Z_{1-p^*}\sigma_P \tag{2}$$

where

Z_{1-p} – value of the theoretical distribution

σ_P – standard deviation (Kondapaneni, 2005)

Extreme Value Theory (EVT) examines the random variable as follows:

$M_n = \max\{X_1, X_2, ..., X_n\}$

$m_n = \min\{X_1, X_2, ..., X_n\}$

when $n \to \infty$, $X_1, X_2, ..., X_n$ - random values with given probability distributions.

If for the random value Mn is valid:

$$P\left\{\frac{M_n - b_n}{a_n} \le x\right\} \to G(x), n \to \infty \quad (3)$$

where

G (x) - non degenerate distribution function,

$a_n > 0$, b_n ($n \in N$) - real numbers.

G(x) determines the marginal distribution of linearly normalized maxima M_n, while a_n and b_n are stipulating constants (Jockovic, 2009).

Results and Discussion

The following section includes the results obtained with the application of parametric (EVT and D VaR) and nonparametric (HS VaR) VaR models, i.e. with the application of MANOVA analysis, discriminant analysis, and Roy's test, with the confidence level of 95 % for 100 and 300 days.

By analysing CROBEX stock index with the application of above mentioned VaR models, the following results were obtained.

Table 1

The Difference Significance Among Tested Var Models in The Estimation of the Effects From Investment Activities for CROBEX (95 %, 100 Days) for the Period 2007–2012

Analysis	N	F	P
MANOVA	6	4.893	0.000
Discriminant	6	4.893	0.000

Legend: n – years (features), F – the values of Fisher distribution, p – significance level

Source: the author's calculations (Djakovic, 2013)

Table 2

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for CROBEX (95 %, 100 Days) Per Years

Year	χ	R	F	p	d. coeff
2007	0.101	0.102	3.942	0.020	0.025
2008	0.038	0.038	0.557	0.573	0.013
2009	0.060	0.060	1.351	0.260	0.001
2010	0.122	0.123	5.826	0.003	0.013
2011	0.056	0.057	1.209	0.299	0.029
2012	0.046	0.046	0.806	0.447	0.020

Legend: χ – Pearson's contingency coefficient, R – multiple correlation coefficient, F – the values of Fisher distribution, p – significance level, d. coeff – discrimination coefficient

Source: the author's calculations (Djakovic, 2013)

MANOVA and discriminant analysis indicate the existence of statistically significant difference among tested VaR calculation models in the analysed market of the Republic of Croatia. It is especially important to point out that the difference was not observed in 2008, 2009, 2011 and 2012.

Table 3

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for SBITOP (95 %, 100 Days) in the Period 2007–2012

Analysis	n	F
MANOVA	6	1.970
Discriminant	6	1.970

Legend: n – years (features), F – the values of Fisher distribution

Source: the author's calculations (Djakovic, 2013)

Table 4

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for SBITOP (95 %, 100 Days) Per Years

Year	χ	R	F	P	d. coeff
2007	0.079	0.080	2.412	0.091	0.011
2008	0.0033	0.034	0.424	0.655	0.004
2009	0.100	0.100	3.813	0.023	0.009
2010	0.047	0.047	0.841	0.432	0.004
2011	0.050	0.050	0.957	0.385	0.003
2012	0.062	0.062	1.448	0.236	0.004

Legend: χ – Pearson's contingency coefficient, R – multiple correlation coefficient, F – the values of Fisher distribution, p – significance level, d. coeff – discrimination coefficient

Source: the author's calculations (Djakovic, 2013)

MANOVA and discriminant analysis indicate the existence of statistically significant difference among tested VaR calculation models in the analysed market of the Republic of Slovenia. It is especially important to point out that the difference was not observed in 2008, 2010, 2011 and 2012.

Table 5

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for BUX (95%, 100 Days) in the Period 2007–2012

Analysis	n	F	p
MANOVA	6	2.334	0.006
Discriminant	6	2.335	0.006

Source: the author's calculations (Djakovic, 2013)

Table 6

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for BUX (95%, 100 Days) Per Years

Year	χ	R	F	P	d. coeff
2007	0.099	0.100	3.790	0.023	0.013
2008	0.051	0.051	0.967	0.381	0.007
2009	0.085	0.085	2.744	0.065	0.003
2010	0.067	0.067	1.693	0.185	0.001
2011	0.012	0.012	0.057	0.945	0.013
2012	0.083	0.084	2.657	0.071	0.003

Legend: χ – Pearson's contingency coefficient, R – multiple correlation coefficient, F – the values of Fisher distribution, p – significance level, d. coeff – discrimination coefficient
Source: the author's calculations (Djakovic, 2013)

MANOVA and discriminant analysis indicate the existence of statistically significant difference among tested VaR calculation models in the analysed market of the Republic of Hungary. It is especially important to point out that the difference was not observed in 2008, 2010 and 2011.

The following section includes the results obtained for the rolling window of 300 days, with the note that the period of four years is covered (2008–2012) as a result of the applied research methodology.

Table 7

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for CROBEX (95 %, 300 Days) in the Period 2008–2012

Analysis	n	F	p
MANOVA	5	2.752	0.003
Discriminant	5	2.764	0.002

Legend: n – years (features), F – the values of Fisher distribution, p – significance level
Source: the author's calculations (Djakovic, 2013)

Table 8

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for CROBEX (95 %, 300 Days) Per Years

Year	χ	R	F	P	d. coeff
2008	0.042	0.042	0.663	0.516	0.002
2009	0.020	0.020	0.144	0.866	0.002
2010	0.089	0.089	3.028	0.049	0.010
2011	0.129	0.130	6.444	0.002	0.023
2012	0.033	0.033	0.405	0.667	0.003

Legend: χ – Pearson's contingency coefficient, R – multiple correlation coefficient, F – the values of Fisher distribution, p – significance level, d. coeff – discrimination coefficient
Source: the author's calculations (Djakovic, 2013)

MANOVA and discriminant analysis indicate the existence of statistically significant difference among tested VaR calculation models in the analysed market of the Republic of Croatia. It is especially important to point out that the difference was not observed in 2008, 2009 and 2012.

Table 9

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities For SBITOP (95 %, 300 Days) in the Period 2008–2012

Analysis	n	F	p
MANOVA	5	0.007	1.000
Discriminant	2	1.671	0.155

Legend: n – years (features), F – the values of Fisher distribution, p – significance level
Source: the author's calculations (Djakovic, 2013)

Table 10

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for SBITOP (95 %, 300 Days) Per Years

Year	χ	R	F	p
2008	0.028	0.028	0.290	0.749
2009	0.000	0.000	0.000	1.000
2010	0.087	0.088	2.911	0.055
2011	0.070	0.070	1.873	0.155
2012	0.066	0.067	1.681	0.187

Legend: χ – Pearson's contingency coefficient, R – multiple correlation coefficient, F – the values of Fisher distribution, p – significance level
Source: the author's calculations (Djakovic, 2013)

MANOVA and discriminant analysis do not indicate the existence of statistically significant difference among tested VaR calculation models in the analysed market of the Republic of Slovenia. The results obtained with the application of Roy's test indicate the existence of difference in 2010.

Table 11

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for BUX (95 %, 300 Days) in the Period 2008–2012

Analysis	n	F	p
MANOVA	5	2.760	0.003
Discriminant	5	2.758	0.003

Legend: n – years (features), F – the values of Fisher distribution, p – significance level
Source: the author's calculations (Djakovic, 2013)

Table 12

The Difference Significance Among Tested Var Models in the Estimation of the Effects from Investment Activities for BUX (95 %, 300 Days) Per Years

Year	χ	R	F	p	d. coeff
2008	0.074	0.074	2.095	0.124	0.004
2009	0.085	0.085	2.758	0.064	0.019
2010	0.083	0.084	2.664	0.071	0.005
2011	0.097	0.098	3.634	0.027	0.011
2012	0.073	0.073	2.011	0.135	0.003

Legend: χ – Pearson's contingency coefficient, R – multiple correlation coefficient, F – the values of Fisher distribution, p – significance level, d. coeff – discrimination coefficient
Source: the author's calculations (Djakovic, 2013)

MANOVA and discriminant analysis indicate the existence of statistically significant difference among tested VaR calculation models in the analysed market of the Republic of Hungary. It is especially important to point out that the difference was not observed in 2008 and 2012.

Conclusions

The research results confirm the formulated hypothesis that the results of various VaR models application in the markets of Southeast Europe region countries are significant (CROBEX, SBITOB and BUX), i.e. that the application of these models can yield adequate results in the area of optimization and quantification of the effects from investment activities. In other words, the research created the conditions for significant improvement in the estimation of the effects from investment activities in selected markets in Southeast Europe, since the tested VaR models application can have a substantial impact on the minimization of risks associated with the investment returns. Also, the possibility of quantification of the effects from investment activities, especially regarding turbulent business environment characterized by crisis events, represents a significant step toward a comprehensive and systematic description and analysis of investment processes.

Bearing in mind the results obtained in the research (rolling windows 100 and 300 days), it is evident that there are statistically significant differences in the application of various VaR models. For the period 2007–2012 and rolling window 100, MANOVA and discriminant analysis indicate the existence of statistically significant difference among tested parametric VaR models, that is, the Extreme Value Theory (EVT) and Delta Normal VaR – D VaR) and nonparametric VaR models (Historical Simulation – HS VaR) in the analysed markets of the Republic of Croatia, Republic of Slovenia and the Republic of Hungary. For the period 2007-2012 and rolling window 300, the existence of statistically significant difference among tested parametric VaR models is confirmed in the analysed markets of the Republic of Croatia and the Republic of Hungary, while it is not confirmed in the analysed market of the Republic of Slovenia.

Comparing the results obtained in this research with the similar studies for other markets (especially for developed markets) it can be concluded that the results are pretty similar, hence it is proven for all of these markets that application of different Value at Risk models for different markets provide solid results in sense of returns estimations. This is very important fact, both in academic and practical way. In academic sense it is proven that Value at Risk models have significant potential in processes of returns estimation regardless what market is in focus, and in practical way these information is important for investors in investment decisions processes. Introducing specific, transitional markets in focus of this research, the basis for different Value at Risk models implementation is significantly expanded.

At the same time, this was also main limitation of this research, having in mind the fact that these markets are highly volatile, specific, with incomplete and poorly implemented regulation. Also, one of the limitations was in providing solid and reliable data about these markets.

In this regard, it is necessary to conclude that, in the tested markets of the countries of the Southeast European region, the application of both parametric as well as the nonparametric VaR models is required. These facts can be significant as a basis for further research in the subject field, aimed at the understanding of specific characteristics of application of the tested models in various markets that are in different conjuncture stages. Having this in mind, focus in future studies will be on further understanding the specificities of application of the tested models in observed markets in different markets conditions, with the goal to provide solid basis for improving and adjustment of different Value at Risk models to actual market conditions. In the light of obtained research results, a dilemma regarding the rolling windows optimization arises, which could be considered as a potential direction for further research.

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