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The Effectiveness of the GlueVaR Risk Measure on the Metals Market – the Application of Omega Performance Measure

Abstract: Decision-making process is an individual matter for each investor and the strategy they choose, reflects the level of accepted risk. Nevertheless, any investor wants to minimize huge losses while maximizing profits. As far as the measure of risk is concerned, literature is full of examples of tools which help to evaluate the risk. However, the level of the risk usually differs, depending on circumstances. In this paper we present two non-classical risk measures: Omega performance risk measure and GlueVaR risk measure. Both of them require a threshold to be set, which reflects the starting point for the investment to be considered as a loss. The effectiveness of the Omega and GlueVaR risk measures is compared using the example of metals market investments.

Keywords: Omega risk measure, GlueVaR, effectiveness, risk, metals market

JEL: G01, G11, G31

1. Introduction

Risk analysis is the subject of discussion in many areas, both scientific and business alike. On one hand, some theoretical tools quantifying risk are proposed and on the other hand there is a need for application of these measures in practice. The aim of such application is the limitation of risk down to a level which is acceptable to an investor. But the term "acceptable level" is very subjective, therefore the risk measure should take into account an individual attitude toward risk and risky behaviors.

In this paper we focus on one of the innovative approaches to risk measurement, namely the GlueVaR measure. It is based on two commonly used measures: Value-at-Risk and Conditional Value-at-Risk and its ingenuity lies in the fact that it is a coherent risk measure, which takes into account investor's attitude toward risk. The evaluation of investment's activities is carried out using performances measure called Omega. This tool allows for a specification of the convergence of investor's activities with his expectations, taking into account a specific threshold which divides the set of potential outcomes into two groups: the area of profits and the area of losses. One can recognise the validity of combining these two statistical tools with each other. The theoretical part of the paper is presented practically, using the example of actual investments on the non-ferrous metals market.

2. Risk and risk measurement

Risk is observed in many areas of human life and is usually defined in negative terms. From the financial point of view, risk refers to the difference between real and expected outcome of an investment and this difference is associated with loss. Each investor defines risk personally, depending on his individual preferences. Therefore, it is really difficult to find a general, acceptable level of risk which would depend on an undertaken investment. Risk is related to unexpected and unpredictable events which may result in huge loses. Such risk is defined in the literature as extreme risk (Jajuga, 2009: 38–40). There are tools which are practically used in the analysis of extreme risk (i.e. the Extreme Value Theory). However, in order to look at risk from the quantitative point of view, the measure of risk must be defined. If $\mathbb{X}$ is defined as the set of all random variables for a given probability space $(\Omega, \mathcal{A}, P)$, then a risk measure ρ is defined as a mapping from $\mathbb{X}$ to $\mathbb{R}$. Therefore, $\rho(X)$ is a real value for each $X \in \mathbb{X}$. But not every mapping is a risk measure. To meet the requirements of a proper risk measure, Artzner et al. (1999: 208–210) proposed a set of four axioms defining so called coherent risk measure: positive homogeneity, monotonicity, translation invariance and subadditivity. The last property seems to be the most important, especially if portfolio investments are of interest. Subadditivity means that the risk of portfolio cannot be greater than the sum of its individual risks. Taking into account the definition of subadditivity, we can easily find the relation to diversification, where the cumulated risks of individual investments cannot be greater than the total risk of the portfolio consisting of these investments.

There are a lot of investment risk measures used in practice, but two most popular are VaR and CVaR (also called the Expected Shortfall). One can find comprehensive descriptions of both these measures in the literature, therefore only short definitions are presented herein. Value-at-Risk at the significance level α is defined as an α-quantile of probability distribution of random variable X, whereas the Conditional Value-at-Risk is the expected value beyond VaR. The advantage of both these measures is that they present the level of risk as a real value (under some specific conditions: significance level and investment's horizon). The drawback is that the VaR measure is not a coherent risk measure, therefore the inference based on its results, especially in terms of portfolio investments, may lead to wrong decisions. Among these two risk measures, only CVaR is coherent.

3. GlueVaR risk measure

As mentioned above, both VaR and CVaR may be used in risk assessment at a given significance level. The significance (or tolerance) level might also be interpreted in terms of investor's attitude toward risk. If investor is less conservative, the tolerance level is higher. In contrast, if investor is more conservative, the level of significance is lower. The need for the investor's preferences in calculating risk to be taken into account, requires that a proper risk measure meets additional conditions. In 2014 Belles-Sampera et al. (2014: 121–134) proposed the new class of risk measures called the GlueVaR. The measures belonging to the family of GlueVaR risk measures are defined as linear combinations of VaR and CVaR, but at two different significance levels. Additionally, GlueVaR is a coherent risk measure and distortion risk measure, and if this second class is of interest, the measure might be expressed using Choquet integral (Belles-Sampera et al., 2016: 102–103). Generally speaking, at the very beginning an individual investor:

1) has to establish significance levels for less conservative (α_1) and more conservative (α_2) attitudes towards risk (additional assumption: $0 < \alpha_1 \leq \alpha_2 < 1$),
2) has to establish weights w_1 and w_2 for each of the significance levels.

The significance level refers to the probability of occurrence of an extreme event which might be more or less acceptable by an investor. On the other hand, every investor looks at such event in a different way, therefore he or she can assign a weight for such event in a final calculation of GlueVaR risk measure. From the mathematical point of view the formula for GlueVaR is as follows (Belles-Sampera et al., 2016: 103):

$$GlueVaR_{\alpha_1,\alpha_2}^{w_1,w_2}(X) = w_1 CVaR_{\alpha_2} + w_2 CVaR_{\alpha_1} + (1 - w_1 - w_2) VaR_{\alpha_1} \quad (1)$$

As we can see in the formula (1) the information about? VaR and CVaR is also requested. It is easy to define special cases of the GlueVaR risk measure as follows:

1) $GlueVaR_{\alpha_1,\alpha_2}^{w_1=0,w_2=0}(X) = VaR_{\alpha_1}$,

2) $GlueVaR_{\alpha_1,\alpha_2}^{w_1=1,w_2=0}(X) = CVaR_{\alpha_2}$,

3) $GlueVaR_{\alpha_1,\alpha_2}^{w_1=0,w_2=1}(X) = CVaR_{\alpha_1}$.

GlueVaR risk measure is subadditive and therefore might be used effectively in portfolio investments. Another advantage is that there are explicit mathematical formulas for calculating GlueVaR for the most popular probability distributions (e.i. normal or student distribution) (Belles-Sampera et al., 2014: 126).

Regardless of the risk measure, the effectiveness of investment activities based on information given by this measure is also an important issue. In the following section one of these measures – the Omega risk measure – is presented.

4. Effectiveness of investment – Omega performance measure

The main goal of every investment is the convergence of investor's expectations with real, unknown result of an investment. There are variety of criteria which help to assess the effectiveness of financial investment. If the risk measure is taken into account, the effectiveness measures are based on volatility, Value-at-Risk, lower partial moments or drawdown. The first group represents the oldest approach, where volatility is defined in terms of standard deviation. Within this group we can find the Sharpe Ratio or Adjusted Sharpe Ratio. Measures based on Value-at-Risk approach use VaR or CVaR for calculating the ratio of effectiveness, i.e. Excess Return on VaR or Conditional Sharpe Ratio. Within the group of lower partial moments risk measures we find such measures as Omega Performance Measure or Sortino Ratio. The last group is based on drawdown and describes the level of potential decline observed in the value of an asset, in relation to a fixed threshold in a given period of time (i.e. Calmar Ratio and Burke Ratio).

Selection of a particular tool for the assessment of the effectiveness of an investment also depends on some specific characteristics of the asset. If the asset return is of interest, one may analyze its probability distribution together with its parameters. In this paper we focus on the assessment of effectiveness using Omega performance measure.

Omega ratio has been proposed as a tool for effectiveness measurement by Keating and Shadwick in 2002 (Keating, Shadwick, 2002b: 59–84). The idea of Omega measure is that one may indicate a threshold dividing the set of investment outcomes into two groups: the area of profits and the area of losses. If quantile risk measure is taken into account, such threshold may be represented by VaR or CVaR. This enables the assessment of effectiveness using Omega performance measure.

Omega is an alternative tool for all measures based on normality. In the portfolio theory of Markowitz, two basic parameters are calculated: expected value and standard deviation. The first one represents expected return and the second one – risk. However, in practice, the normality assumption is usually rejected, therefore the ratio of investment effectiveness has to be modified. Omega ratio (and Omega function) uses entire distribution of return without focusing on specific parameters. Thus, there is no assumption about the distribution of returns. Omega is calculated using historical data from a given period of time. From the statistical point of view, the advantage of Omega is that it uses all moments of probability distribution function and therefore may be used if the high level of asymmetry and kurtosis is observed, even for asymmetric, bimodal and fat-tailed distribution (Keating, Shadwick, 2002b: 1–15). If all higher moments are statistically insignificant Omega gives the same information as classical measures. But if these moments are significant, the use of wrong measure may lead to a different assets' allocation in investment portfolio.

The mathematical formula for Omega function, for the continuous random variable X and for a given threshold τ, is as follows[1]:

$$\Omega(X) = \frac{\int_{\tau}^{+\infty}(1 - F(x))\,dx}{\int_{-\infty}^{\tau} F(x)\,dx}, \tag{2}$$

where $F(x)$ is the cumulative distribution function of X. If random variable X is discrete, the formula for Omega function is:

$$\Omega(X) = \frac{E(\max\{X - \tau, 0\})}{E(\max\{\tau - X, 0\})} = \frac{\sum_{x_i \geq \tau}(x_i - \tau)p_i}{\sum_{x_i < \tau}(\tau - x_i)p_i}, \tag{3}$$

where p_i is the probability function of X.

If the interval of $[a, b]$ describes the possible values of random variable, the properties of Omega function are as follows (Pichura, 2013: 91–92):

1) the function is continuous in $[a, b]$,
2) the function is decreasing in $[a, b]$,

[1] The formula (2) may be interpreter in financial terms as the price of European call option divided by the European put option (Kazemi, Schneeweis, Gupta, 2004: 17).

3) for $\tau \to a$: $\Omega(\tau) \to +\infty$, whereas for $\tau \to b$: $\Omega(\tau) \to 0$,
4) if $E(X) = \mu$, therefore $\Omega(\tau = \mu) = 1$.

In addition, Omega function is related to the stochastic dominance of first and second order and thus allows for comparison of different decision scenarios (Michalska, Dudzińska-Baryła, 2015: 72–73).

The assessment of effectiveness using Omega measure requires the identification of a threshold dividing the set of possible outcomes of investment into area of profits and losses. This threshold is determined subjectively by an investor. Following the formulas (2)–(3) we can easily define the results of an investment as:
1) profit: $E(X|X \geq \tau) - \tau$,
2) loss: $\tau - E(X|X < \tau)$.

Assuming the probability of random variable X above a given threshold τ as $P(X \geq \tau) = 1 - \mathrm{F}(\tau)$ and below this threshold as $P(X < \tau) = \mathrm{F}(\tau)$ the Omega ratio is defined as:

$$\Omega(X = \tau) = \frac{[E(X|X \geq \tau) - \tau][1 - F(\tau)]}{[\tau - E(X|X < \tau)]F(\tau)}. \tag{4}$$

The threshold mentioned above may represent risk-free return, the level of any macroeconomic index or any other value which defines the area of profits and losses for an investor. Taking into account the properties of Omega function and the fact that it is based on cumulative distribution function, an investor may select a threshold as the value of VaR or other quantile risk measure. The optimization criteria using Omega is the maximization criteria. The higher the value of Omega ratio, the more likely it is for the outcome of investment to be in the area of profits.

5. Empirical analysis

The level of development of the metals market is an important factor indicating the level of development of the economy as a whole. Metals are used in many various branches of industry, such as: the infrastructure, automotive industry, construction industry and many others. Metals are primarily used in production, constituting the main component of a wide range of final products. However, it is also worth looking at the investment side of things – there are many companies on the market whose activity depends on metals prices. For example, quotations of copper and quotations of share prices of one of the largest Polish company are associated with this metal, namely KGHM. Monitoring of price volatility in the underlying asset area can effectively predict price volatility in the area of related assets. Due to the significant impact of metal prices on many areas of the economy, we focused on the diverse level of volatility in their returns. We considered the extreme changes in the return of metals, and consequently, a high level of risk.

In the empirical part of this paper, we apply the investment effectiveness analysis in portfolio investments realized on the non-ferrous metals market. All metals (ALUMINIUM, COPPER, LEAD, NICKEL, TIN, ZINC) are quoted on the London Metal Exchange, and the log-returns of closing spot prices are analyzed. In addition, the quotation of LMX index is used. The data comes from the period of January 2010 – December 2015. On the basis of all metals present at the Exchange? we created 20 portfolios consisting of three assets each and as a risk measure we used the value of GlueVaR calculated for quantiles 0.95 and 0.99 of the log-return of LMX index. Descriptive statistics of returns are presented in Table 1.

Table 1. Descriptive statistics

Metal	Mean	Min	Max	Variance	Skewness	Kurtosis
ALUMINIUM	–0.000258	–0.067416	0.062022	0.000164	–0.153740	1.241540
COPPER	–0.000306	–0.066401	0.052029	0.000191	–0.318691	1.742108
LEAD	–0.000204	–0.081923	0.060501	0.000287	–0.228446	1.723853
NICKEL	–0.000514	–0.128365	0.061617	0.000328	–0.625204	3.059557
TIN	–0.000118	–0.115580	0.085265	0.000286	–0.413569	3.446167
ZINC	–0.000315	–0.080596	0.092983	0.000257	–0.177932	1.941752
LMX	–0.000299	–0.066486	0.057172	0.000178	–0.222396	2.314341

Source: own calculations

As presented in Table 1, all analyzed assets generated loses (in terms of expected value). The largest were observed for NICKEL (with the largest value of risk measured by the variance). All probability distributions of returns are left-skewed, with high level of kurtosis. Using tests of Kolmogoov-Smifnov and Shapiro-Wilk the assumption of normality has been rejected (Tab. 2).

Table 2. Normality tests

Metal	Kołmogorow-Smirnow			Shapiro-Wilk		
	K-S	df	p-value	S-W	df	p-value
ALUMINIUM	0.031	1512	0.002	0.991	1512	0.000
COPPER	0.047	1512	0.000	0.981	1512	0.000
LEAD	0.047	1512	0.000	0.982	1512	0.000
NICKEL	0.047	1512	0.000	0.973	1512	0.000
TIN	0.076	1512	0.000	0.959	1512	0.000
ZINC	0.052	1512	0.000	0.983	1512	0.000
LMX	0.047	1512	0.000	0.976	1512	0.000

Source: own calculations

Figure 1 shows the appropriate charts for the LMX index. It is easy to see some typical characteristics observed for financial time series, i.e. clustering of variance or periods of higher volatility. QQ-plots confirm that the distribution of log-return is heavy-tailed.

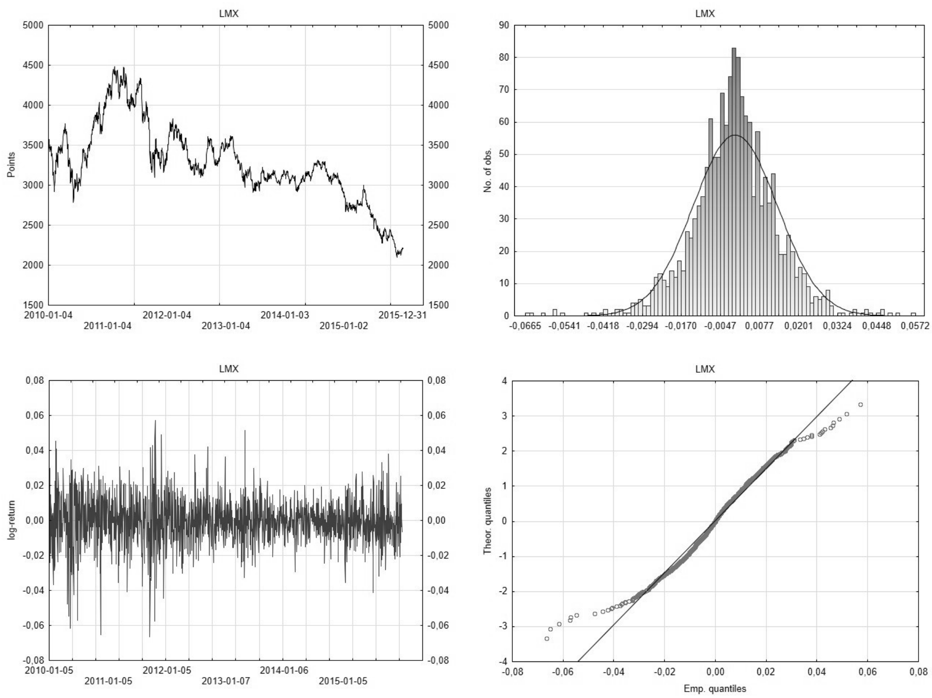


Figure 1. Quotation of LMX

Source: own calculations

From the summer period of 2011 the downward trend on metals market was observed. It was mainly caused by the slight slowdown of economic growth in the BRIC countries and by the crisis on financial markets in general, as well as by the crisis on the real-estate market in the USA. As we can see, the downward trend was observed until the end of 2015.

In the next part of the analysis we focus on portfolio optimization problem. Using log-returns of all metals we created 20 simulated portfolios consisting of three assets each. The components of portfolios are shown in Table 3.

Table 3. Components of portfolios

Portfolio	Components			Portfolio	Components		
P1	ALUMINIUM	COPPER	LEAD	**P11**	COPPER	LEAD	NICKEL
P2	ALUMINIUM	COPPER	NICKEL	**P12**	COPPER	LEAD	TIN
P3	ALUMINIUM	COPPER	TIN	**P13**	COPPER	LEAD	ZINC

Portfolio	Components			Portfolio	Components		
P4	ALUMINIUM	COPPER	ZINC	**P14**	COPPER	NICKEL	TIN
P5	ALUMINIUM	LEAD	NICKEL	**P15**	COPPER	NICKEL	ZINC
P6	ALUMINIUM	LEAD	TIN	**P16**	COPPER	TIN	ZINC
P7	ALUMINIUM	LEAD	ZINC	**P17**	LEAD	NICKEL	TIN
P8	ALUMINIUM	NICKEL	TIN	**P18**	LEAD	NICKEL	ZINC
P9	ALUMINIUM	NICKEL	ZINC	**P19**	LEAD	TIN	ZINC
P10	ALUMINIUM	TIN	ZINC	**P20**	NICKEL	TIN	ZINC

Source: own calculations

At the beginning we assumed equally-weighted portfolios and the relation between expected return and risk is presented in Figure 2. Only few portfolios are less risky than the LMX index. Minimizing risk measured by the variance of portfolio, the relation between expected return and risk is presented in Figure 3.

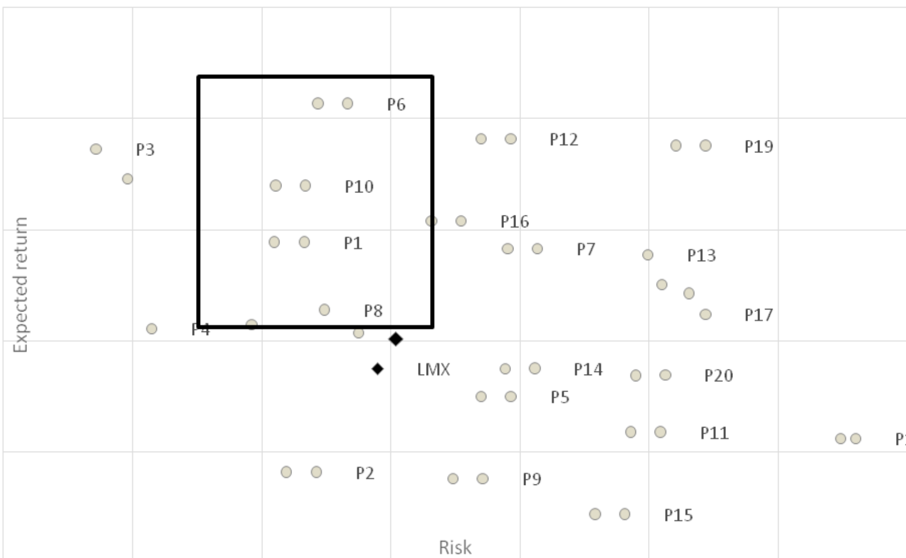


Figure 2. Equally-weighted portfolios: risk-return

Source: own calculations

Looking at the characteristics of investment portfolios and comparing them to those calculated for the LMX index, it is easy to see that the optimization procedure allowed for risk reduction (together with reduction of expected losses). If we look deeper into the components of each portfolio, we can find that the least? risky group of portfolios contains ALUMINIUM. Figure 4 shows the results of cluster analysis.

As shown in Figure 4, we can identify two separate groups of portfolios. The first group (marked by the gray frame) represents portfolios containing ALLU-

MINIUM, so these results are similar to those for optimal portfolios. It should be mentioned that both prices and log-returns of ALUMINIUM are less correlated with remaining metals, so it might be significant in terms of portfolio diversification.

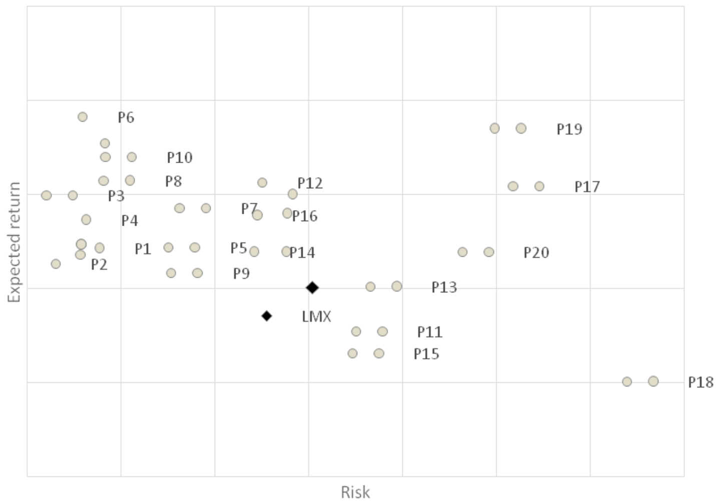


Figure 3. Optimal portfolios: risk-return

Source: own calculations

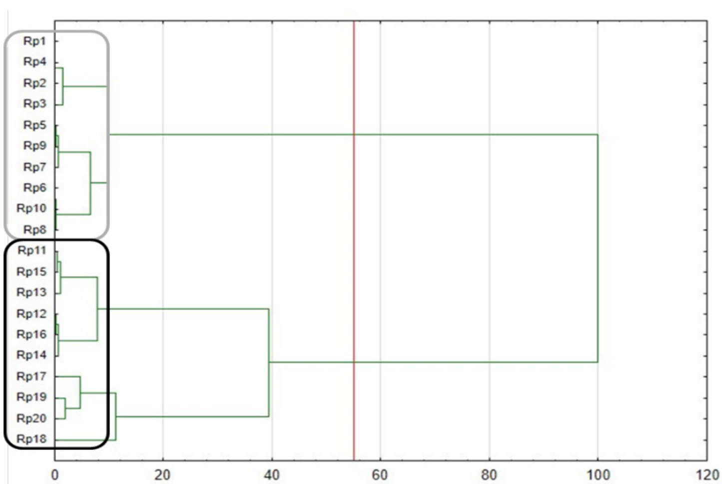


Figure 4. Dendrogram of optimal portfolios (distance: Euclidean squared, grouping method: Ward)

Source: own calculations

In the last stage of the analysis the assessment of portfolios' effectiveness was performed. We applied the Omega function to compare the results of undertaken investments. We decided to use this ratio of effectiveness as it allows for the selection of any threshold, according to investor's preferences. Figure 5 shows the Omega function for selected portfolios. Portfolio P3 is the minimum-variance portfolio, portfolio P19 is the maximum-expected return portfolio and portfolio P18 is the most risky and with the highest loss.

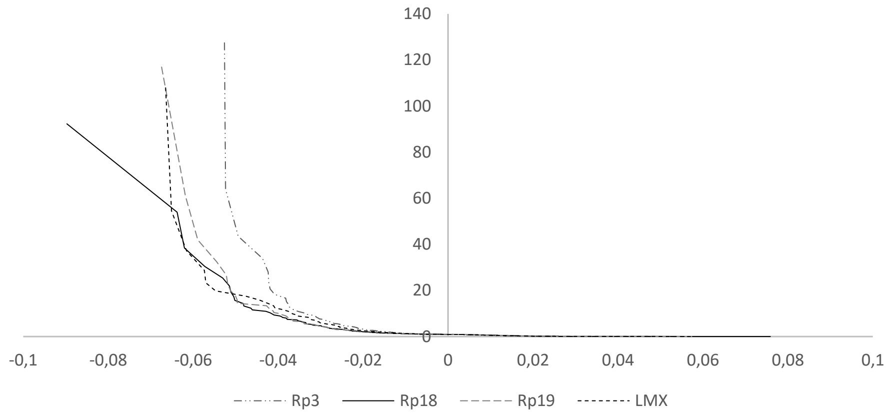


Figure 5. Omega functions for selected portfolios

Source: own calculations

Figure 5, presents the levels of return for which the investments in portfolios are more effective than in LMX index. The Omega function for portfolios dominates then the function for LMX index.

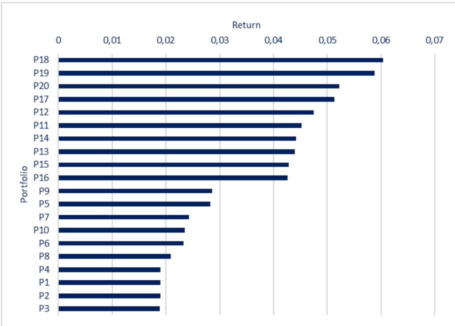
To select a threshold allowing for comparison of all portfolios, the GlueVaR risk measure for LMX index was calculated. The final values of the GlueVaR risk measure for given tolerance levels and for given weights are presented in Table 4.

Table 4. GlueVaR risk measure

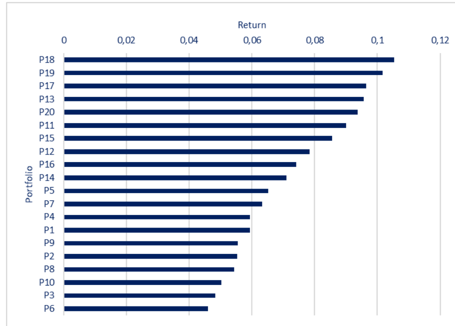
Weights								
w_1	100.00%	0.00%	0.00%	33.33%	0.00%	66.67%	66.67%	33.33%
w_2	0.00%	100.00%	0.00%	33.33%	66.67%	0.00%	33.33%	66.67%
$1-w_1-w_2$	0.00%	0.00%	100.00%	33.33%	33.33%	33.33%	0.00%	0.00%
				LMX_1	LMX_2	LMX_3	LMX_4	LMX_5
Risk measure	$CVaR_{0,99}$	$CVaR_{0,95}$	$VaR_{0,95}$	$GlueVaR_{0.95;0.99}^{w_1;w_2}$				
Value	0.041467	0.028355	0.020623	0.030148	0.025778	0.034519	0.037096	0.032726

Source: own calculations

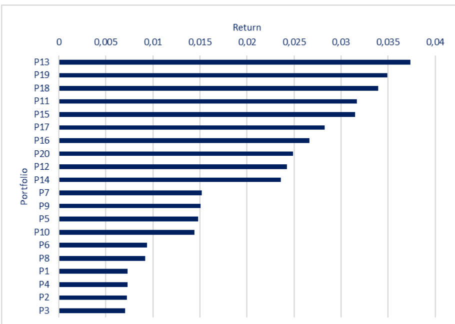
$\tau = GlueVaR(LMX_1) = 0.030148$



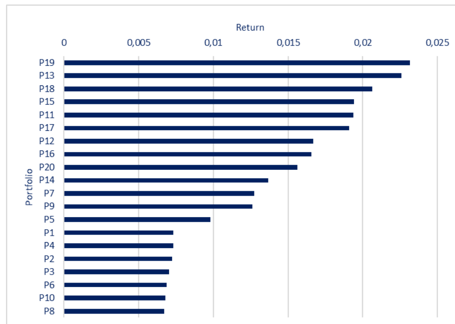
$\tau = GlueVaR(LMX_2) = 0.025778$



$\tau = GlueVaR(LMX_3) = 0.034519$



$\tau = GlueVaR(LMX_4) = 0.037096$



$\tau = GlueVaR(LMX_5) = 0.032726$

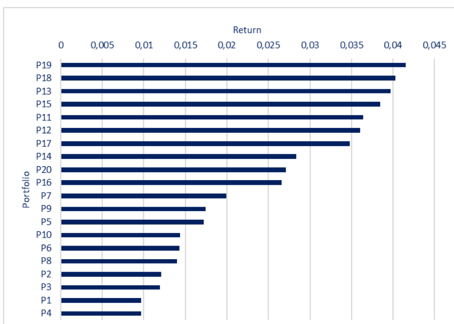


Figure 6. Portfolios' ranking using Omega measure

Source: own calculations

The level of risk depends on the probability of occurrence of an extreme event and on the weight given to this probability. The tolerance level might be fixed arbitrarily or using substantive expertise, market characteristics, etc. In the final part of the research, the Omega ratio for each portfolio was calculated. The value of the threshold is given by the value of the GlueVaR risk measure presented in Table 4. It should be mentioned that the more conservative investor's attitude toward risk ($w_1 \to 1$, $w_2 \to 0$), the higher the value of GlueVaR risk measure. And respectively, the less conservative investor's attitude toward risk ($w_1 \to 0$, $w_2 \to 1$) the lower the value of the GlueVaR risk measure. The results of portfolios' ranking are presented in Figure 6.

The results of assessment of effectiveness of portfolios' investments using GlueVaR risk measure of LMX index as a threshold show differences in rankings dependent on the value of GlueVaR. The higher values of Omega ratio were obtained if investments in ALUMINIUM were excluded from the portfolio (portfolios P11–P20). This might be caused by a slightly low correlation between ALUMINIUM and the other metals.

6. Conclusions

Risk analysis is a prerequisite for an effective investment decision-making process. There are many measures which help to quantify the risk, therefore it is not difficult to find the theoretical tool for measuring of risk. However, the point is, that this tool should take into account risk assessment from an individual investor's point of view. In this paper we focus on the new class of risk measures called the GlueVaR risk measures. In general, the GlueVaR might be expressed as a linear combination of widely used risk measures: VaR and CVaR. Its main advantage is that it takes into account two different tolerance levels, reflecting the probability of an extreme event occurrence. In addition, each investor looks at such event individually so the risk measure should consider that fact.

Another important issue related to the decision-making process is the effectiveness of an investment. In the classical approach we usually use standard deviation as a measure of risk. But considering some stylized facts observed in financial time series, such approach has to be modified. Each investor is able to point out the level of investment outcome which divides all possible unknown results into two groups defined as profits and losses. This approach is much more subjective, therefore the effectiveness measure should take this into account. An interesting tool for this seems to be the Omega ratio (related to the Omega function), calculated as a ratio of expected profits to expected losses, with respect to a fixed threshold. From statistical point of view, an important advantage of Omega is that it does not require any assumption about the probability distribution function of analyzed random variable. The measure uses all of the information about the random variable on the basis of the cumulative distribution function.

In this paper we also presented the practical use of risk measure GlueVaR and the Omega ratio on the example of investments in non-ferrous metals. We proposed 20 simulated portfolios, consisting of three assets each and we compared the results of investment for equally-weighted and minimum-variance portfolios. We noticed that if investments in ALUMNIUM are included in optimal portfolios, the level of risk and corresponding expected loss is lower. Then, all portfolios investments were compared, using as a threshold the value of GlueVaR calculated for LMX index. The GlueVaR risk measure has been calculated using confidence levels 95% and 99% and different weights related to each one. The results show that the presence of ALUMINIUM also plays an important role in this case. The portfolios, which take into account ALUMINIUM turned out to be relatively less effective for a given threshold point than the other portfolios. In summary, it can be said that the use of different levels of risk which reflect investor's attitude toward risk affects the efficiency of investment. It is worth emphasizing that the use of non-classical risk measures is reasonable primarily if the assumption of normality of returns is not met or if the series of data suffers from outliers. The classical risk measures such as VaR (especially if calculated under the assumption of normality) may lead to misleading conclusions.

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Efektywność miary GlueVaR w ocenie ryzyka na rynku metali – zastosowanie wskaźnika Omega

Streszczenie: Podejmowanie decyzji inwestycyjnych jest indywidualną kwestią każdego inwestora. Strategia, jaką przyjmuje, znajduje swoje odzwierciedlenie w poziomie akceptowalnego ryzyka. Niemniej jednak każdy z inwestorów dąży do minimalizacji dużych strat przy jednoczesnej maksymalizacji zysku. Istnieje wiele miar ryzyka, a każda z nich przekazuje inną informację. W artykule poddano ocenie efektywność dwóch nieklasycznych miar ryzyka: wskaźnika Omega oraz koherentnej miary GlueVaR. Cechą wspólną obu tych mierników jest konieczność ustalenia pewnego punktu progowego określającego, kiedy podjęta inwestycja rozumiana jest jako strata. Efektywność miar ryzyka przeanalizowano na przykładzie inwestycji podejmowanych na rynku metali.

Słowa kluczowe: miara Omega, GlueVaR, efektywność, ryzyko, rynek metali

JEL: G01, G11, G31

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