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Foreshock volatility based metal hedging strategy

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Abstract
The latest capital market crises are not the first and the last we will experience. These events of the previous decades led investors to diversify their portfolios with precious metals. As a result, the prices for raw materials, auxiliary materials, and operating materials have risen very strongly. As a result, companies are required to apply various hedging strategies to hedge production costs. This paper presents a hedging strategy based on volatility, which allows hedging against falling commodity prices. This paper deals with developing a new volatility-based hedging strategy for metals. The focus is on hedging against falling prices. The newly developed Foreshock-Vola-based strategy outperformed the 200-day MA strategy. It must be noted that this is the first study on the presented model due to the newly developed methodology. In this respect, it is recommended for further contributions that the investigation period be divided into individual years, and thus, the respective under - or outperformance of the vola-based hedging strategy compared to the 200-day MA be investigated separately.

Keywords
Finance, hedging strategies, 200-day moving average, precious metals

Introduction

The latest capital market crises are not the first and the last we will experience. At the turn of the millennium, the global capital markets were already affected, and the dot-com bubble caused the entire economy to collapse. The next financial crisis in 2008, the euro crisis that developed from it, and the subsequent sovereign debt crisis all had essential effects on companies' business models (Gavurova et al. 2020). However, innovative firms having flexible management strategy (Kliuchnikava, 2022; Civelek et al., 2023a; Simionescu et al., 2021) and some firms having flexible structure, such as small and medium-sized enterprises could give quick reactions against negative outcomes of crises (Krajcik et al., 2023). On the other hand, some opposing views declare smaller firms' more intensive perceptions of issues and risks (Ključnikov et al., 2022a; Ključnikov et al., 2022b; Civelek et al., 2023b).

Moreover, these crises, and also the Covid-19 pandemic and the Ukrainian war, negatively affected many businesses in various industries (Iwu et al., 2023), such as tourism (Lincényi & Bulanda, 2023; Shpak et al., 2023; Gavurova et al. 2023) and services (Azman et al., 2023). Especially the manufacturing companies, which have to use raw materials, have had to accept the difficulties in the production processes due to the Corona pandemic and the Ukraine crisis (Skare et al., 2023a,b). These events of the last decades led investors to diversify their portfolios with precious metals (Baur and McDermott, 2010; Creti et al., 2013; Bredin et al., 2015; Mensi et al., 2014; Hiller et al., 2006; El Hedi Arouri et al., 2015). As a result, the prices for raw materials, auxiliary materials, and operating materials have risen very strongly. All the more, therefore, all companies are required to apply various hedging strategies to hedge production costs (Simionescu et al. 2020). This paper presents a hedging strategy based on volatility, which allows hedging against falling commodity prices. Thus, this paper is primarily addressed to mines, commodity producers, and refiners of metals and commodities, as well as stockholders, who are particularly affected by falling market prices.

The principle of hedging is always preferable to speculation and forms one of the central assumptions of the analyses to be performed. Based on this assumption, the currently pursued hedging strategy is always defined as the reference value. Thus, any hedging results will, depending on the reference value (the currently pursued hedging strategy), also indirectly reflect the success or failure and thus the advantageousness of a new versus the presently used hedging strategy. The findings are also tested statistically for their stability.

Existing literature provides extensive insight into the precious metals hedging potential. For example, Bhatia et al. (2020), Jiang et al. (2019), and Lahiani et al. (2021) in their studies provide evidence that precious metals serve as hedging assets against stock markets. Rehman et al. (2018) and Salisu et al. (2021) looked at oil price risk and found that precious metals have hedging capabilities. Hassan et al. (2021) and Rehman (2020) found that this is also the case for cryptocurrency markets. Peng (2020) found the same for the bond market, Bedoui et al. (2020), Nguyen et al. (2020) and Pierdzioch et al. (2016) for exchange rates, Cheng et al. (2022) for geopolitical risk and Sikiru and Salisu (2022) for uncertainty due to epidemics and pandemics.

The primary objective of the financial and statistical analyses is to obtain information that will enable a basis for developing recommendations for strategic hedging measures for decreasing prices. Consequently, the prices of aluminium, zinc, nickel, lead, tin, and copper are considered. In the analysis, the return ratios, i.e., the respective changes in the figures from period to period, are always included in the calculation. In addition, the daily-end data were considered. In the case of the missing values, the values of the respective previous days were used.

Material and Methods

Within the scope of the analyses, the metals aluminium, zinc, nickel, lead, tin, and copper are analyzed from January 02, 2008, to March 15, 2023. The analyses are based on the LME 3-month Officials. In case of missing values, the data will be derived from the cash settlement of the individual metals. If these data are unavailable, the last known historical price is used. Two different hedging strategies are compared. First, a new trend change strategy we developed based on the volatility of the metals' returns is examined. The 200-day moving average is calculated as the reference strategy. Both hedging strategies are used in the case of hedging against falling prices. The consideration takes place for the entire investigation period and amounts to 15 years. The strategies are compared with each other concerning their overall performance. This is calculated, in which, with a signal to the Hedgen in each case, a three-month sale is immediately accomplished. We use 60 days, meaning the price in 60 days is subtracted from the price on the day of the hedge signal. This means that we get either a positive or a negative performance. As mentioned above, these values are then all added together to get the strategy's overall performance at the respective metal in the period under consideration. The two strategies are compared inductively only, as entirely different approaches with mismatched data sets are being compared here.

200-day moving average (200-day MA)

The hedging points of the 200-day moving average (200-day MA) hedging strategy (based on rolling long-term averages) are related to the points of contact or crossover of the metal prices with long-term moving average prices, which are used as a reference value. A simple system of moving averages was tested. Instead of referencing industrial costs, a hedge (long) is built when the slope of the 200-day average level changes from negative to positive (and vice versa). This is considered below as an indicator of a change in the (price) trend regime; 200-day averages are used for all metals.

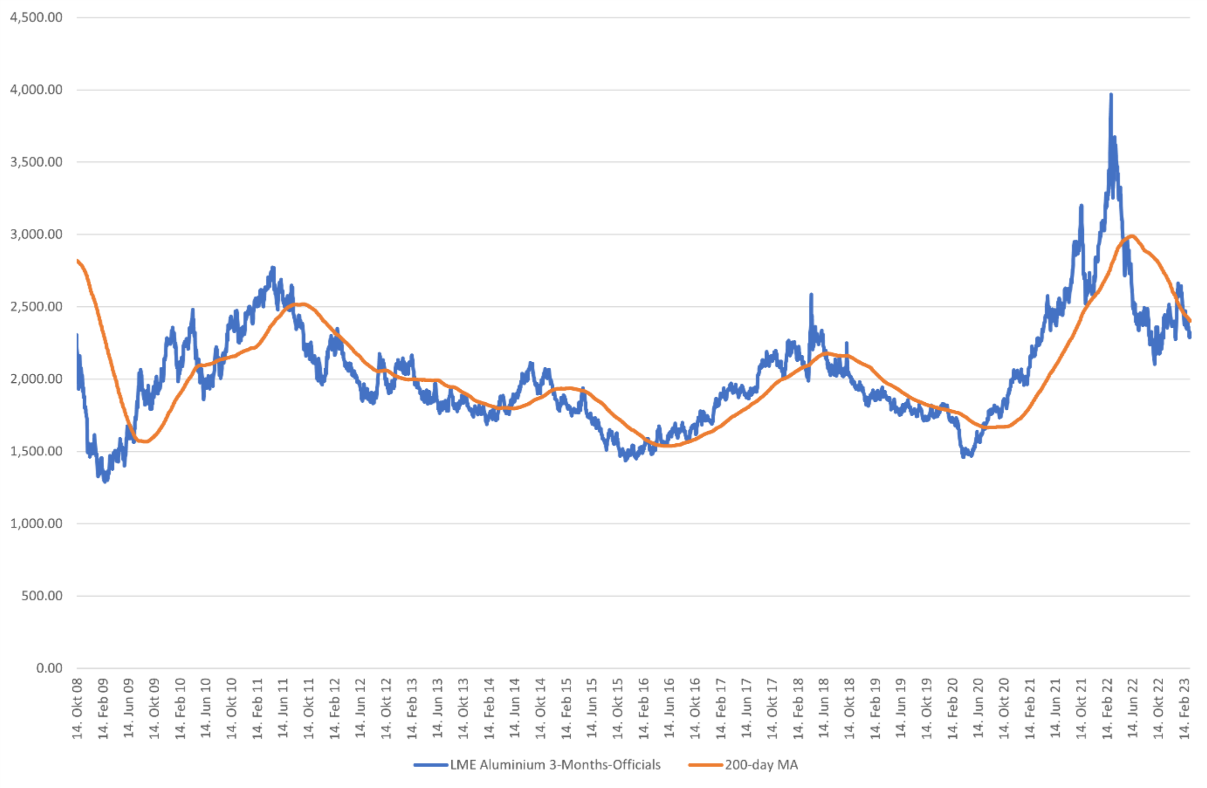

Fig. 1. LME Aluminium 3-Months-Officials and 200-day MA

In financial analysis, the 200-day MA, the most popular moving average rule (Brock, 1992), is a technical indicator utilized to analyze market trends and stock prices. Essentially, this indicator is derived by calculating the average closing price of a security over the last 200 trading days and then plotting it on a chart. By utilizing the 200-day MA, investors and traders can identify long-term trends in the market. In particular, when a security's current price is trading above the 200-day MA, this is typically interpreted as an uptrend, indicative of bullish sentiment. Conversely, if the current price of a security is trading below the 200-day MA, this generally is interpreted as a downtrend, which is indicative of bearish sentiment. Given its ability to provide a broad overview of the long-term trend of a security or the overall market, the 200-day MA is widely used among investors and traders (Zohuri et al., 2022).

The objective of the new volatility-based hedging strategy is to identify trend reversal signals using a volatility switch, which is a volatility of returns-based indicator, to integrate short-term market anomalies into the hedge. This concerns anomalies not mapped by the fundamentally oriented 200-day MA strategy. The vola switch is a condensed indicator, which should allow the detection of a trend change earlier than the developed and tested 200-day MA strategy. Analogous to the findings from geology, the assumption is made that every trend change is accompanied by increasing fluctuation in prices and, consequently, in the volatilities of the returns of prices.

The calculation of the returns of the prices of selected metals is done as a continuous daily return and is formed by a natural logarithm of the quotient of the current price P_t and the price of the previous day P_{t-1}.

$$Return_t = \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{1}$$

The calculation of the price volatility is based on the standard deviation of the prices over 20 days. This period was chosen because it corresponds to a trading month on the one hand and allows corresponding signals to be detected earlier than the 200-day MA strategy. Shorter time intervals provide corresponding signals even faster, but these are unstable and, therefore, not sufficiently reliable. At the same time, the goal of a forecast of the trend signals is pursued, with which it is necessary to let the 20-day period end with the previous day for the respective current trading day. The functional calculation context can be represented as follows:

$$s_{t,20-days} = \sqrt{\frac{1}{20} * \sum_{t=-1}^{-21} (\bar{r} - r_t)^2} \quad (2)$$

The hedge band is the functional mapping of the vola switch, which signals a trend change. The hedge band follows the functionality of the Bollinger bands or the 200-day MA line. The objective is to receive a corresponding trend change signal when the price line of the respective metal is crossed.

A reliable prediction of the future in the form of a forecast is only possible in corresponding intervals and with a probability of less than 100%. It should be noted at this point that the forecasts are based on average expectations, which means that the actual values on the market can also be above or below these forecasts.

The use of an interval in the context of the determination of a hedge band uses the quantiles of the returns. The 10% quantile is used for the lower interval limit, and the 90% quantile for the upper interval limit. The quantiles refer to a time interval of 20 days ending one day before the current observation time.

Both the upper and lower hedge bands are calculated based on the quantiles and the mean of the metal prices in the last twenty days before the time of hedge band determination. In each case, the average prices are adjusted between 1% and 45% quantile of returns for the lower band and between 99% and 55% quantile of returns for the upper band.

$$Hedge\ band_{lower} = quantile_{r_t}^{10\%} * \frac{1}{20} * \sum_{t=-1}^{-21} P_t \quad (3)$$

$$\boldsymbol{Hedge\ band_{upper} = quantile_{r_t}^{90\%} * \frac{1}{20} * \sum_{t=-1}^{-21} P_t} \quad (4)$$

The hedge band centre is determined as the average of the lower and upper hedge bands. The intersection points of the hedge band centre with the metal price determine the trend change signals. If the hedge band intersects the price from top to bottom, there is a signal for a rising trend. In the opposite case, if the hedge band crosses the metal market price from the bottom to the top, there is a signal for a falling trend. The trend remains until a new signal is detected. A trend-up signal can be followed by a trend-down signal as well as a trend-up signal.

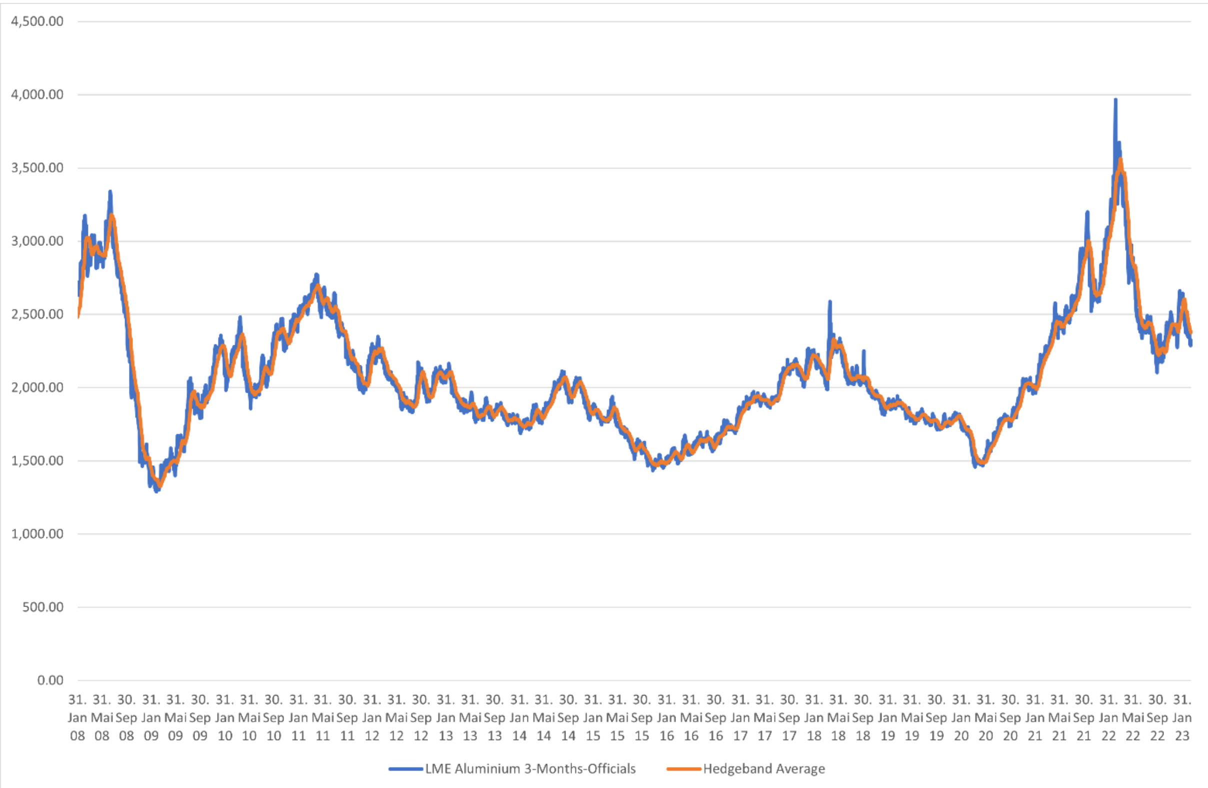

Fig. 2. LME Aluminium 3-Months-Officials and Hedge Band Average

The newly developed key figure Foreshock-Vola is intended to check the strength and relevance of the trend change signals and additionally adjust them. For this purpose, the Foreshock-Vola uses the volatility of the returns.

The natural logarithm of the quotient of the volatility of the previous day and the average of the volatilities of the last 20 days before the valuation date are calculated.

$$\boldsymbol{Foreshock - Vola_t = ln\left(\frac{\sqrt{\frac{1}{20} * \sum_{t=-1}^{-21}(\bar{r}-r_t)^2}}{\frac{1}{20}\sum_{t=-1}^{21} s_{t,20-days}}\right)} \tag{5}$$

Analogous to the procedure with the hedge bands, the Foreshock-Vola is also provided with an upper and a lower band. The idea is to implement more sensitivity in the trend change signals, in which fewer short changes of the up and down signals take place. The bands are flexibly drawn around the Foreshock-Vola. Only when the respective band is crossed will the Up or Down signal start. In our analysis, we use a 60-day period before the day of the trend change signal calculation.

$$Foreshock - Vola\ band_{lower} = quantile^{z\%}_{(Foreshock-Vola_{t=-61};Foreshock-Vola_{t=-1})} \tag{6}$$

$$\boldsymbol{Foreshock - Vola\ band_{upper} = quantile^{y\%}_{(Foreshock-Vola_{t=-61};Foreshock-Vola_{t=-1})}} \tag{7}$$

This is followed by the determination of the parameter z from 1% to 45% quantile of Foreshock-Vola Values for the lower band and the parameter y from 99% to 55% quantile of Foreshock-Vola Values for the upper band of the Magnitude-Vola in a simulation. These are used to adjust the trend change signals.

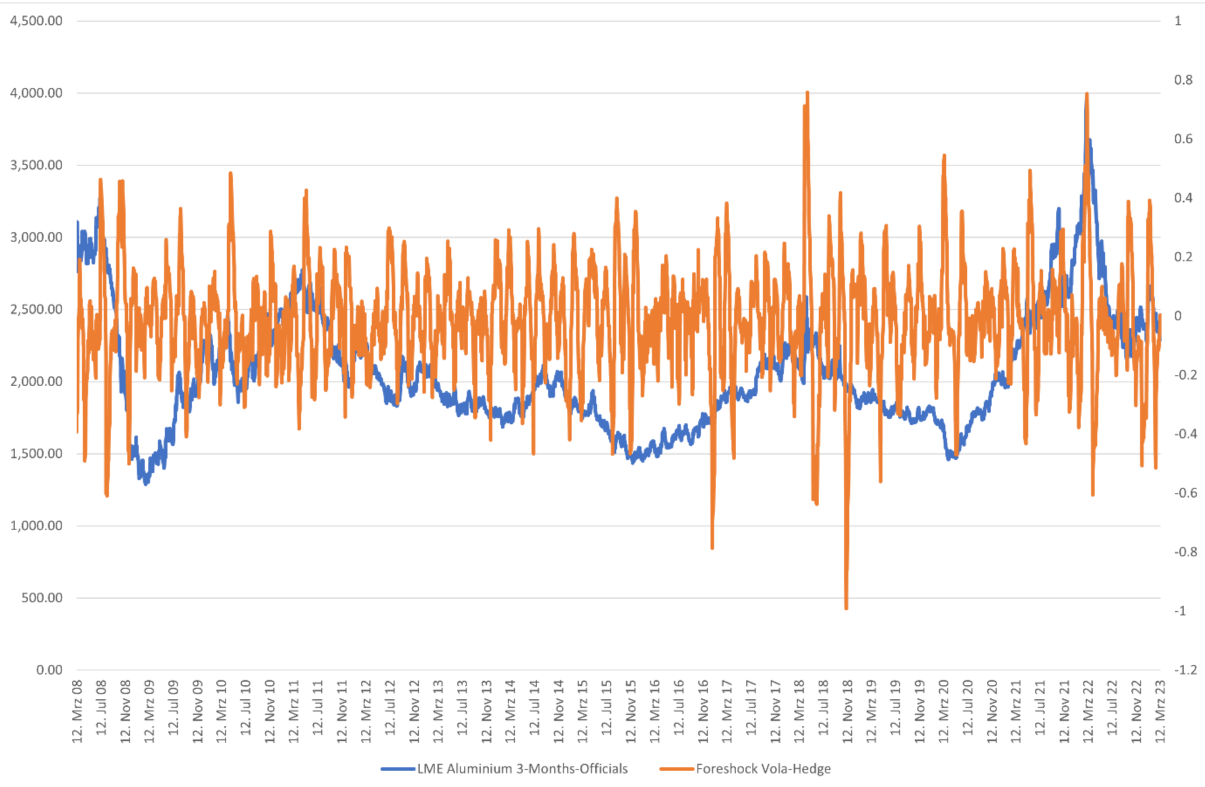

Fig. 3. LME Aluminium 3-Month-Officials and Foreshock Vola with 5% quantile of returns for the lower band and 95% quantile of returns for the upper band

Analogous to the procedure with the 200-day MA, the metal price is immediately sold for three months in case of a trend-down signal. This gives the performance of the strategy.

Results

In the statistical analyses of the Vola-Based Hedge strategy, its statistical significance is tested against the results of the 200-day MA strategy as part of the performance comparison. It is important to note that the period under review only starts from October 15, 2008, as the 200-day MA initially requires a 200-day lead time. When calculating the performance of the Vola-Based strategy for the individual metals, individual settings of the quartiles are taken into account in that the lower band quartile assumes values of 0.01 to 0.45, and the upper band quartile assumes values of 0.99 to 0.55. A simulation is then used to calculate all combinations of these quartiles and determine the performance.

The results show that individual combinations of the upper and lower band quartiles lead to the best performance of the Foreshock-Vola performance in each case. These combinations are listed in the following table.

Tab. 1 Lower and upper band quantiles of metals

	Aluminium	Zinc	Nickel	Lead	Tin	Copper
lower band quartile	1%	4%	11%	1%	1%	6%
upper band quartile	94%	99%	84%	99%	86%	93%

The generated performances in USD are shown in comparison to the 200-day MA in the following table. It can be seen that at the respective optima for the Foreshock-Vola base hedge strategy, it consistently outperforms the 200-day MA strategy using the assumptions and data. This can be seen in the following table.

Tab. 2 Hedge Performance for Foreshock-Vola

	Aluminium	Zinc	Nickel	Lead	Tin	Copper
Hedge-Performance 200-DMA	$ 164,321.00	$ 92,937.00	$ 947,988.00	$ 7,915.50	$ 1,654,588.00	$ 470,015.00
Hedge-Performance Foreshock-Vola (Max)	$ 230,478.50	$ 293,420.50	$ 1,805,881.00	$ 195,175.50	$ 2,746,962.00	$ 699,702.50
Hedge-Performance Foreshock-Vola (Average)	$ 38,183.47	$ 92,700.27	$ 685,137.60	$ 45,950.45	$ 971,992.18	$ 202,060.82
Hedge-Performance Foreshock-Vola (Median)	$ 30,969.00	$ 115,562.00	$ 766,686.00	$ 46,602.00	$ 1,189,714.50	$ 168,442.50

The following figure shows the performance of the Foreshock-Vola-based strategy by considering the individual combinations of the upper and lower band quartiles for all metals. It can be seen that not every quartile combination performs positively but can also lose money.

An adjustment must be made within the inductive evaluations since the Foreshock Vola-based strategy is only conditionally comparable with the 200-day MA strategy because the hedge signals can turn out differently. Thus it can happen that on one day, the 200-day MA strategy delivers a hedge signal, whereas the Foreshock Vola-based strategy does not enter a hedge. In case of a hedge signal, the metal is sold for three months, with which a hedge against falling prices should be achieved. There are two possibilities. On the one hand, the strategy generates positive performance.

On the other hand, the strategy generates negative performance. In the case of no hedge, we assume the performance value is zero. With this adjustment, generating a continuous time series of performance values is possible depending on the respective date. These are now compared with each other by a two-sample t-test for differences. The H_0 hypothesis is:

H_0: There is no difference between the 200-day MA and the Foreshock Vola bases strategy.

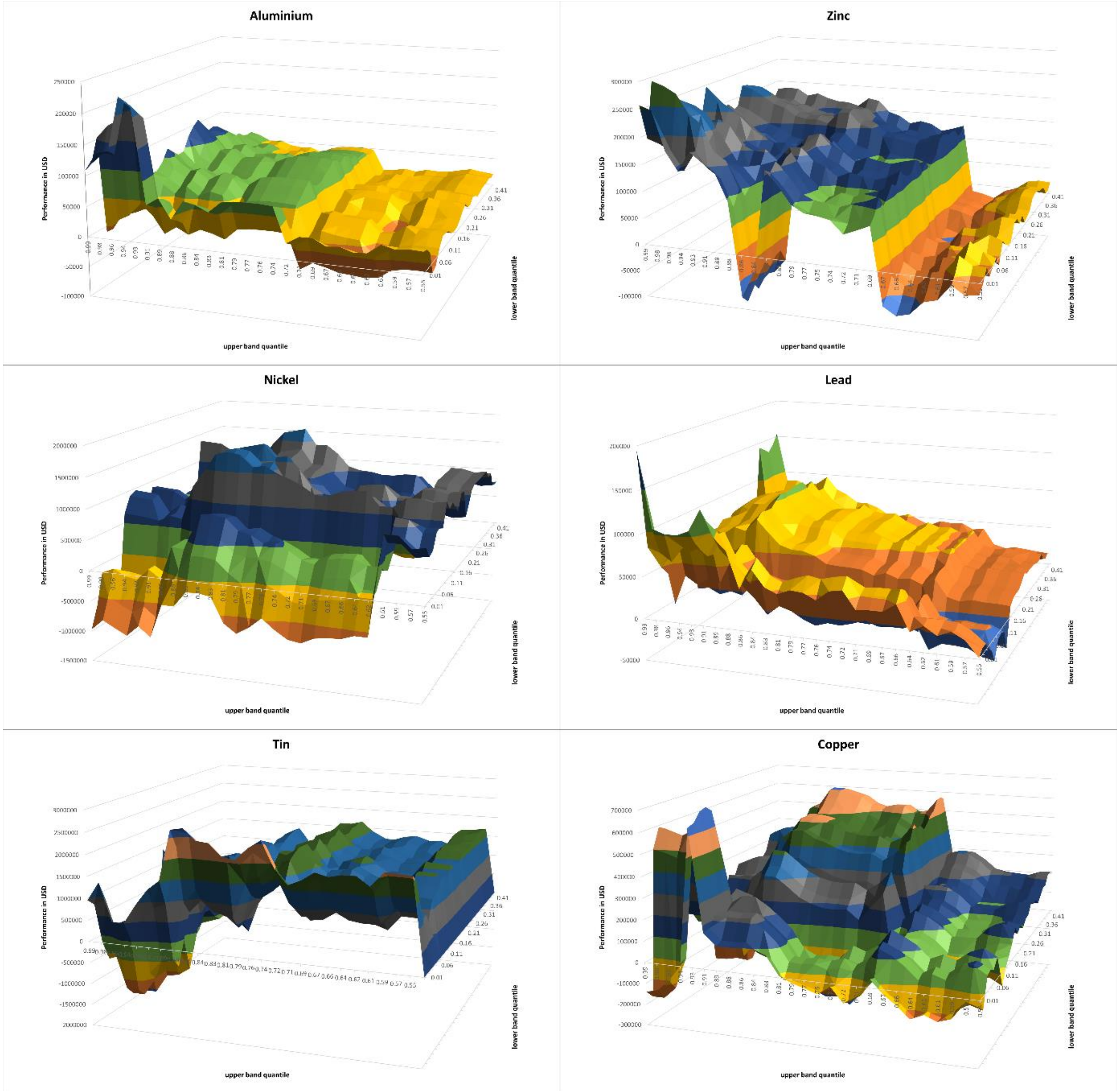

Fig. 4. Performance of Foreshock-Vola strategy visualized

Tab. 3 Paired Samples Statistics & Paired Samples Test

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Hedge-Performance 200-DMA Aluminium	45.081	3645	335.2626	5.5531
	Performance Foreshock Vola Aluminium	47.670	3645	369.7186	6.1238
Pair 2	Hedge-Performance 200-DMA Zinc	25.497	3645	434.5245	7.1972
	Performance Foreshock Vola Zinc	80.499	3645	450.9501	7.4693
Pair 3	Hedge-Performance 200-DMA Nickel	260.08	3645	3798.175	62.911
	Performance Foreshock Vola Nickel	343.45	3645	4141.104	68.591
Pair 4	Hedge-Performance 200-DMA Lead	2.172	3645	295.5254	4.8949
	Performance Foreshock Vola Lead	44.568	3645	296.0410	4.9035
Pair 5	Hedge-Performance 200-DMA Tin	453.93	3645	3894.837	64.512
	Performance Foreshock Vola Tin	694.35	3645	4516.563	74.810

Pair 6	Hedge-Performance 200-DMA Cooper	128.948	3645	1232.2038	20.4096
	Performance Foreshock Vola Cooper	164.008	3645	1253.8460	20.7680

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Performance Foreshock Vola Aluminium - Hedge-Performance 200-DMA Aluminium	2.5886	185.5759	3.0738	-3.4379	8.6151	0.842	3644	0.400
Pair 2	Performance Foreshock Vola Zinc - Hedge-Performance 200-DMA Zinc	55.0023	194.9846	3.2296	48.6703	61.3344	17.031	3644	0.000
Pair 3	Performance Foreshock Vola Nickel - Hedge-Performance 200-DMA Nickel	83.368	2077.350	34.408	15.907	150.830	2.423	3644	0.015
Pair 4	Performance Foreshock Vola Lead - Hedge-Performance 200-DMA Lead	42.3967	194.7013	3.2249	36.0739	48.7196	13.147	3644	0.000
Pair 5	Performance Foreshock Vola Tin - Hedge-Performance 200-DMA Tin	240.418	2655.660	43.987	154.177	326.660	5.466	3644	0.000
Pair 6	Performance Foreshock Vola Cooper - Hedge-Performance 200-DMA Cooper	35.0599	490.6876	8.1275	19.1251	50.9948	4.314	3644	0.000

The results should be interpreted with caution concerning the performance of the two strategies listed above since implementing zero values in the data set affects the average performance. However, the absolute performance is the same. It can be shown that using the optimal quantile combination of the upper and lower bands, the newly developed Foreshock Vola-based hedge significantly outperforms the 200-day MA hedge strategy. This is true for all metals except for aluminium, with significance at 5% only for zinc and 1% for all other metals. Thus, the H0 hypothesis can be rejected for all metals except for aluminium.

Conclusions

This paper dealt with the development of a new volatility-based hedging strategy for metals. The focus was on hedging against falling prices. As a result, the newly developed Foreshock Vola-based strategy outperformed the 200-day MA strategy. Concerning the findings, it must be noted that this is the first study on the presented model due to the newly developed methodology. In this respect, it is recommended for further contributions that the investigation period be divided into individual years, and thus, the respective under- or outperformance of the vola-based hedging strategy compared to the 200-day MA be investigated separately. Moreover, a forecast figure for the subsequent period can also be determined concerning the quartiles to be selected for the lower and upper hedging bands. In this way, the performance can be compared with alternative hedging strategies and examined for their outperformance.

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