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EMA VERSUS SMA USAGE TO FORECAST STOCK MARKETS: THE CASE OF S&P 500 AND OMX BALTIC BENCHMARK

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Abstract. The academic literature is showing a growing interest in such trading rules as Moving Average. The majority of researches were made using simple moving average. Although semi-professional traders use the technical analysis methods to predict the future stock prices, to identify the stock trend changes, OMX Baltic Benchmark Index was never tested. Previous researches on the S&P 500 Index using the most widely used method of technical analysis – Moving Averages are more or less appellative. Technical analysis is opponent to classical economic theory but investors use it widely all over the world. Technical Analysis methods can be less or more effective than it was thought until nowadays. This paper compares 2 trading rules of technical analysis – exponential smoothing method and simple moving average rule. Both methods were applied to US index S&P 500 and OMX Baltic Benchmark Index and the results were compared using systematic error (mean square error, the mean absolute deviation, mean forecast error, the mean absolute percentage error) and tracking signal evaluation, bias distribution estimation and appropriate Constanta level finding for each market forecast: the case of Standard and Poor's 500 and OMX Baltic Benchmark Index.

Keywords: technical Analysis, Simple Moving Average, Exponential Moving Average, bias, S&P 500, OMX Baltic Benchmark, forecast, stock.

EKSPONENTINIO IR PAPRASTO SLANKIOJO VIDURKIO NAUDOJIMO LYGINIMAS PROGNOZUOJANT AKCIJŲ RINKAS: S&P 500 IR OMX BALTIC BENCHMARK ATVEJIS

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Santrauka. Straipsnyje nagrinėjamos plačiai investuotojų bendruomenės taikomos prekybos taisyklės – paprastas dviejų dienų slankusis vidurkis ir eksponentinis vidurkis. Užsienio moksliniuose darbuose vis daugiau dėmesio skiriama šiai temai, tačiau Lietuvoje niekuomet nebuvo tiriamos galimybės prognozuoti Baltijos šalių akcijų rinkų indeksus taikant šiuos metodus. Atliekant tyrimus, buvo naudojami S&P 500 indekso ir OMX Baltic Benchmark indekso duomenys. Abu metodai buvo lyginami tarpusavyje taikant bendrą paklaidų sistemų metodiką. Buvo tikrinamas prognozės tikslumo lygmuo įvertinant vidutines kvadratines paklaidas, vidutines absoliučiąsias paklaidas, vidutines prognozavimo paklaidas, vidutines absoliučiąsias paklaidas ir sekimo signalą kaip prognozės naujų duomenų adekvatumo įvertinimą. Atlikus tyrimus, paaiškėjo metodas, kuris turi būti taikomas prognozuojant ateities indekso vertes, ir šio metodo tinkamumas kiekvienai iš pasirinktų rinkų – Lietuvos ir JAV.

Reikšminiai žodžiai: techninė analizė, paprastas slankusis vidurkis, eksponentinis slankusis vidurkis, paklaida, S&P 500, OMX Baltic Benchmark, prognozė, akcija.

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1. Introduction

At the period of economic instability financial market players suffer large losses. Everyone expects the financial markets, especially stock markets, to rise. Financial crisis of 2009 showed the investors' belief that the stock value will raise and never fall led to the bear market cycle.

Nowadays econometric science permits to apply its rules for the stock market forecast process, so investors can predict stock prices, the direction of the index trend, etc. but not all methods are efficient. One of the methods widely used by investors is technical analysis which uses the historical prices of a financial instrument to indicate the future behaviour of prices. Technical analysis consists of a number of specific methods and is opposite to fundamental analysis principles. The moving average method is generally used over several last decades. The specific moving averages like simple moving average, exponential moving average, etc. can provide different results predicting the stock market prices. It is necessary to find out which method is more accurate and more efficient. Previous researches show that indexes of Baltic States stock exchange were never tested although traders in Estonia, Latvia and Lithuania use different software based on technical analysis methods to predict the future stock prices. So it is necessary to make suggestions for those traders who prefer to trade not only in US markets but in Baltic markets too. The main research paper target is to compare Technical Analysis rules – Simple Moving Average and Exponential Moving Average application possibilities to forecast different stock markets: S&P 500 and OMX Baltic Benchmark Index. The main method to compare forecast rules is systematic error evaluation system which helps to estimate bias and to decide whether method is appropriate to forecast the stock market. The results can influence present investment forecast techniques and help to find out which method usage is more appropriate for each stock market.

2. Literature review on technical analysis issue

The moving average method is one of the most widely used methods of technical analysis (TA). Technical analysis can be described as the various stock market forces interactions and their impact on share prices survey. Technical factors related to stock market conditions are focused on price changes, market volume, the demand and the supply of the stocks (Norvaišienė 2005). Growing stock market and rising activity of the investors attract more increasing attention (Dudzevičiūtė 2004). Technical analysis involves making investment decisions which are based on past price movements and this method is very popular with the investment community (Taylor, Allen 1992). Edwards and Magee (1992) imply that moving averages can be classified as simple moving average (SMA), weighted moving average (WMA) or exponential Moving Average (EMA) and linear moving average (LMA). They concluded, that SMA can work properly as well but more complicated MA is more useful using computer to make the forecast. Exponential smoothing method (EMA) is relatively easy to use and requires a small number of historical data. When the smoothing constant is chosen then only two items of data are required to calculate forecasts. Marshall *et al.* (2007) and academia concluded that the return in stock markets can be predicted but the traders cannot profit from this forecast of return. Hartmann *et al.* (2008) imply that investors are able to forecast stock market and the return in real time. Technical Analysis supporters use gathered historical data and on these bases make charts (Weller *et al.* 2009). Girdzijauskas *et al.* (2009) have found out that the exponential growth models are more suitable for the modelling processes in the near future. Plummer (1989) states, that technical analysis rules have been used in financial markets for over a century. Early studies (Alexander 1964; Fama, Blume 1966) tested some TA strategies using equity index data. They concluded that although these simple trading rules have predictive power they were unable to generate positive profits. The survey by Taylor and Allen (1992) made among market participants showed that 90% of respondents place some weight to TA. The survey made by Mizrach and Weerts (2007) shows that 52% of semi-professional traders use simple moving rules and 56% prefer chart patterns. The main point of TA is the historical data. This data testing attempts to establish specific rules such as simple moving average, exponential moving average and so on. It helps to minimize risk of losses and to maximise profits (Pring 1991). TA includes different versions and levels of sophistication. The MA method is easy to use and apply in investment decision-making or empirical tests. In TA theory prices gradually adjust to new information (BenZion *et al.* 2003). TA methods are used widespread although they are contradictory to classical economy theories. Classical economy theory implies that TA has no basics. Brock *et al.* (1992) reviewed the literature on Technical Analysis issue and concluded that is has no statistical validity. Although Brock *et al.* (1992) study demonstrates that no statistical rules can be applied for stock markets, Myers (1989), Edwards and Magee (1992), Pring (1993) made findings that trends in prices tend to persist and market action is repetitive. Caginalp, Balenovich (2003) research paper on a theoretical foundation for technical analysis issue raised main problems: can patterns be detected in a market through statistical and computer testing, and if so, do they have predictive value. On the contrary, Neftci (1991) research shows that trading rules of TA can be formalised as nonlinear predictors. Eventually, Clyde, Osler (1997) provide a theoretical foundation for TA as a method for making nonlinear forecasting. In 1998 Gençay research results indicate strong evidence of nonlinear predictability in the strong market returns by using the buy-sell signals of the MA rules. Most studies find that TA does not add any value in the US equity markets. Our previous study (Dzikevicius, Saranda, Kravcionok 2010) implies that SMA usage in the US equity market is not efficient too. Most academic authors have found that momentum is an enduring anomaly which has led "pervasive" as Fama and French (2008) describe. Jarrett *et al.* (2008) on the contrary use ARIMA model to predict stock returns and found that some markets have a similar behaviour. Aniūnas *et al.* (2009) made literature review and claim that TA researches improve this methodology and include new trends of the markets all the time. Our previous results (Dzikevicius, Saranda, Kravcionok 2010) of testing SMA imply that this method of forecasting is not accurate and can not predict the right future stock prices, so more accurate methods should be found.

3. Data, trading rules specifications and methodology

This paper is focused on the one of technical analysis indicators - exponential moving average rule and the possibility to use this method for prices and market cycles forecast was tested. The methodology disassociates from particular buy-and-sell strategies and specific rules applications.

We source data for the 2 different markets. In this research we use daily data and our sample includes stock market close prices of 2 indexes: S&P 500 Index (US) and OMX Baltic Benchmark (Baltic States). Information on local daily prices was found on the stock market's respective websites. We source data for different periods because we have tested all indexes since they had appeared until the 22nd of May, 2009 because these indicate the first daily data which is available. The data is for the 03/01/1950-22/05/2009 period for S&P 500 Index and 01/01/2000-22/05/2009 period for OMX Baltic Benchmark Index. The study is conducted in two stages: appropriate EMA method application for S&P 500 and OMX Baltic Benchmark stock markets, EMA and 2-days SMA comparison in these markets.

The purpose of the first stage was to find out the appropriate value of Constanta α to apply EMA rule for two different stock markets. Exponential moving average presents the method of TA when the weighted average of the time series values is applied. The model for exponential smoothing is:

$$F_{t+1} = \alpha Y_t + (1-\alpha) F_t \,, \tag{1}$$

where F_{t+1} is times series forecast value for the period $t+1$, α – smoothing Constanta ($0 < \alpha < 1$). α value will be identified by evaluating systematic errors for each α level ($\alpha = 0.1, 0.2, .., 0.9$). When the appropriate level is found, α value will be evaluated with 0.01 accuracy level.
Mean Square Error (MSE) is calculated in this way:

$$MSE = \frac{\sum (F_t - Y_t)^2}{n} \,. \tag{2}$$

Forasmuch as any error is being raised with the square, so this way highlights the significant error values. This feature is quite significant because forecasting methods with approximations of bias are frequently more suitable than the method which gives not only negligible errors but also significant.

The Mean Absolute Deviation (MAD) is similar to standard deviation but the formula of estimation is less difficult to apply for time series:

$$MAD = \frac{\sum |F_t - Y_t|}{n} \,. \tag{3}$$

The usage is advisable when the forecast bias must be estimated using the same evaluation units as forecast factor is evaluated.

Very often it is very important to estimate whether the forecast method has a systematic error, 'id est' the present forecast value is always major (or minor) than time series value. In this case the mean forecast error (MFE) is being used:

$$MFE = \sum (F_t - Y_t) \,. \tag{4}$$

If the systematic bias does not exist the MFE value will be equal to zero. If the forecast value is signally negative the forecast method overestimates trend series. If the systematic bias is signally positive the forecast method generates major values than time series.

The Mean Absolute Percentage Error (MAPE) is useful when assessing the forecast error an important factor is the estimated value.

$$MAPE = \frac{1}{n} \sum \left| \frac{F_t - Y_t}{Y_t} \right| . \tag{5}$$

MAPE estimates the size of bias comparing with time series values. This fact is very important when the times series value is quite large.

$$TS = \frac{\sum (F_t - Y_t)}{MAD} \,. \tag{6}$$

Tracking signal is the method to control the forecast accuracy. New data is compared with forecast time series and adequacy is evaluated.

After α level is found for each stock market, EMA is compared with 2-days SMA. This method is applied for these times series which have no well-defined trend, cyclical or seasonal component.

$$MA = \frac{\sum_{t=1}^{n} Y_t}{n}, \quad (7)$$

where $\sum_{t=1}^{n} Y_t$ is the sum of the prices for the time period n. This method is used to forecast new prices in the stock market. All systematic bias evaluation methods are applied for the second stage of the research. The second stage of this study determines statistical estimates for absolute error for time series comparing real and predicted prices.

The Gumbel distribution is used for absolute error level explanation. It is defined as:

$$f(x) = \frac{1}{\beta} e^{\left(-\frac{x-\mu}{\beta}\right)} e^{-e^{\left(-\frac{x-\mu}{\beta}\right)}}. \quad (8)$$

The Gumbel distribution is appropriate to be used for index time series because it might be adjusted to estimating return and its level. It can explain the minimum and maximum values of return and in our case it is the absolute error level.

4. EMA method relevance to market forecast

EMA method was applied for time series of S&P 500 and OMX Baltic Benchmark. In this study the research purpose is to find out whether this TA trading rule is appropriate for market forecast. The main rule to determine the right α level is to evaluate bias (MSE, MAD, MFE, MAPE, and Tracking Signal). The lowest bias value provided the right α level. So, it is 0.97 for S&P 500 market and 0.99 for OMX Baltic Benchmark market. The correlation analysis research implies that the higher α level provides the forecast time series with the lower error level (Table 1). Data in the Table 1 shows that correlation ratio in both markets is quite similar and the difference is not very huge. In all cases the lower bias value means the higher α level. In other words, the bigger weight should be adjusted to Yt – the real data for the time period t. So the smaller weight is adjusted to forecasted value Ft for the same period. Then the absolute error Ft–Yt between Ft+1 and Yt+1 is the lowest. In S&P 500 market, all correlation trends have the same trend equation type – logarithmic. OMX Baltic Benchmark correlation trends indicate different types of trend equation: logarithmic, exponential and power. The forecast accuracy depends on the methods the trader or investor chooses. In our case, different α level is chosen to secure the most accurate way of forecast index values. The accuracy of forecasted times series can be displayed using Gumbel distribution. It will be displayed in the next section of this study.

5. Comparison of exponential smoothing method and simple moving average method

EMA method can be compared with 2-days SMA method because both of them include times series for the same period. As the smoothing method was described, it includes two items of data. Exponential moving average uses the forecast for time period t which is equal to the real historical price Y_{t-1}. So it means that instead of data F_t, time series of Y_{t-1} can be used. The equation also involves Y_t historical prices. SMA method also involves data for the time period Y_t and Y_{t+1}. The equation 7 can be defined as the average of past prices Y_t and Y_{t+1} to make forecast for time period t+1. So both methods can use the same data for forecast making. It means that these methods can be compared using the same methodology (systematic error evaluation, tracking signal adequacy estimation.)

In this study we compare EMA and 2-days SMA for both indexes: S&P 500 and OMX Baltic Benchmark using the bias data (Table 1) and descriptive statistics of absolute error.

Table 1. α level correlation ratio with bias and its trend equation

Type of bias	OMX Baltic Benchmark (α = 0.99)		S&P 500 (α = 0.97)	
	Correlation ratio	Trend	Correlation ratio	Trend
MSE	−0.7583	$y = 10.611x^{-1.06}$	−0.7892	$y = -57.1\ln(x) + 39.918$
MAD	−0.8469	$y = 1.8712x^{-0.58}$	−0.8608	$y = -1.363\ln(x) + 2.7266$
MFE	0.8384	$y = -0.4707x^2 + 0.2736x + 0.3096$	0.8303	$y = -0.1899\ln(x) - 0.0345$
MAPE	−0.8436	$y = 0.0064x^{-0.567}$	−0.8708	$y = -0.0004\ln(x) - 0.006$
Tracking Signal	−0.9773	$y = -22.38\ln(x) + 39.467$	−0.9192	$y = -423.6\ln(x) + 278.02$

Table 2. α = 0.97 EMA (S&P 500) and α = 0.99 EMA (OMX) comparison with 2-days SMA

The type of bias	MSE	MAD	MFE	MAPE	Tracking signal
S&P 500					
α = 0.97 EMA	48.6651	2.9103	−0.0602	0.0065	308.9345
2-days SMA	57.8677	3.2769	−0.0880	0.0076	401.3157
OMX Baltic Benchmark					
α = 0.99 EMA	11.4806	1.9515	−0.0313	0.0067	38.7844
2-days SMA	16.4379	2.3721	−0.0431	0.0081	43.9261

Table 3. EMA and 2-days SMA absolute errors descriptive statistics

TA rule	S&P 500		OMX Baltic Benchmark	
Statistic estimation	EMA (α = 0.97)	2-days SMA	EMA (α = 0.99)	2-days SMA
Mean	0.00	−0.03	0.04	−0.01
Standard Error	0.08	0.09	0.10	0.12
Standard Deviation	10.07	10.52	4.92	5.81
Sample Variance	101.33	110.61	24.16	33.76
Kurtosis	4042.10	3403.33	667.16	393.54
Skewness	45.98	40.55	19.19	9.77
Minimum	−103.74	−98.78	-24.41	−104.20
Maximum	887.05	887.67	174.93	175.91
Count	14943	14943	2415	2415

As it is seen (Table 2), S&P 500 case needs EMA usage. In all cases (MSE, MAD, MFE, MAPE and Tracking Signal) EMA method is superior to 2-days SMA, because the bias values are lower, so it means that forecast results are closer to index real values. OMX Baltic Benchmark Index testing provides the same results. So the usage of EMA is preferred. It should be noted that the forecast for OMX Baltic Benchmark is more accurate that for S&P 500 and the new forecast data is more adequate to the real appeared data.

The descriptive statistics helps to evaluate the forecast statistically (Table 3). This data once again confirms the EMA method as the more accurate. So this stage of study confirms our suggestion to use EMA method rather than SMA method which is widely used.

The distribution of absolute error values for each case can show the probability for a level of error. It is useful because each trader's gain is to minimize losses and so he can choose the method which can predict without big losses (in our case it is EMA). Table 4 presents the changes from positive value of absolute error Ft-Yt to negative value and vice versa for the recent period of time.

As it is shown in the table below, the probability that absolute error value will be converted from positive value of absolute error Ft-Yt to negative value and vice versa

Table 4. The probability of F_t-Y_t value change for the recent period of time

Days	S&P 500		OMX Baltic Benchmark	
n	**EMA**	**2 SMA**	**EMA**	**2 SMA**
1	80.2%	73.6%	78.7%	73.0%
2	9.4%	9.6%	7.8%	8.2%
3	4.8%	6.0%	4.5%	5.4%
4	2.6%	3.9%	3.7%	3.9%
5	1.4%	2.7%	2.1%	2.8%
>5	1.56%	4.2%	3.2%	6.7%

after one day is the highest using all methods for both markets.

Surprisingly EMA method takes the highest probability pro rata 80.2% for S&P 500 and 78.7% for OMX Baltic Benchmark. So these results imply that EMA method is more suitable for volatile stock market conditions. It should be noted that the formula we used does not include the length (number of days) for the forecast. So the forecast made using EMA should evaluate the number of days and probably it will provide more accurate results.

The comparison also involves the distribution of percentage bias $(F_t\text{-}Y_t)/Y_t$ for each method in both markets. It shows the accuracy of EMA and SMA and it lets to decide finally which method should be used to make forecast. Fig. 1 presents the comparison of EMA and SMA percentage bias for S&P 500 index. As it is seen, in both cases of S&P 500 the distribution surrounds ordinate axes. So the forecast values of both methods are quite close to the real stock prices. The first which is necessary to determine is the number of "correct" values with the percentage bias of 0.00%. For 2 days SMA this number is 771. So these values were forecasted exactly. For EMA the number of right predictions is 965 and it is more accurate than 2 days SMA for 25%.

The range of percentage bias for 2 SMA method is 39.81% while for EMA it is 36.28%. The minimum values in both cases – 2 days SMA and EMA – are quite the same pro rata –10.66% and – 10.34%.

So the deviation of unevaluated forecast values is the same. The maximum percentage bias for 2 days SMA usage is approximately 10 % higher than EMA is. Only 154 forecasted values have the percentage bias of |3.50%|.

So the affirmation that the distribution surrounds ordinate axes can be confirmed in S&P 500 market for 2 SMA by data of 6752 values with the percentage bias (0.10% – 3.50%) and 7265 values with the percentage bias (–3.50 – 0.10%).

The EMA usage provides symmetrical percentage bias distribution considering the ordinate axes (0.00%). The percentage bias of mentioned periods is 6933 and 6932 respectively. Comparing 2 days SMA and EMA for S&P 500 it should be noted that the first method is linked to underestimate values when EMA overestimates values. So the conclusion that EMA is more appropriate method to forecast S&P 500 Index values can be made.

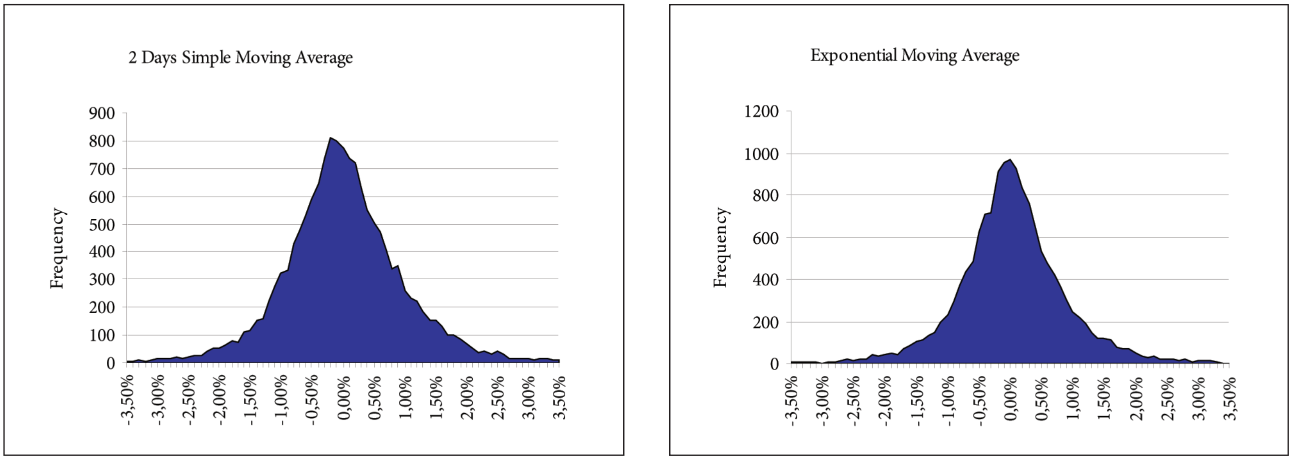

Fig. 1. The comparison of EMA and SMA usage percentage bias of S&P 500 market

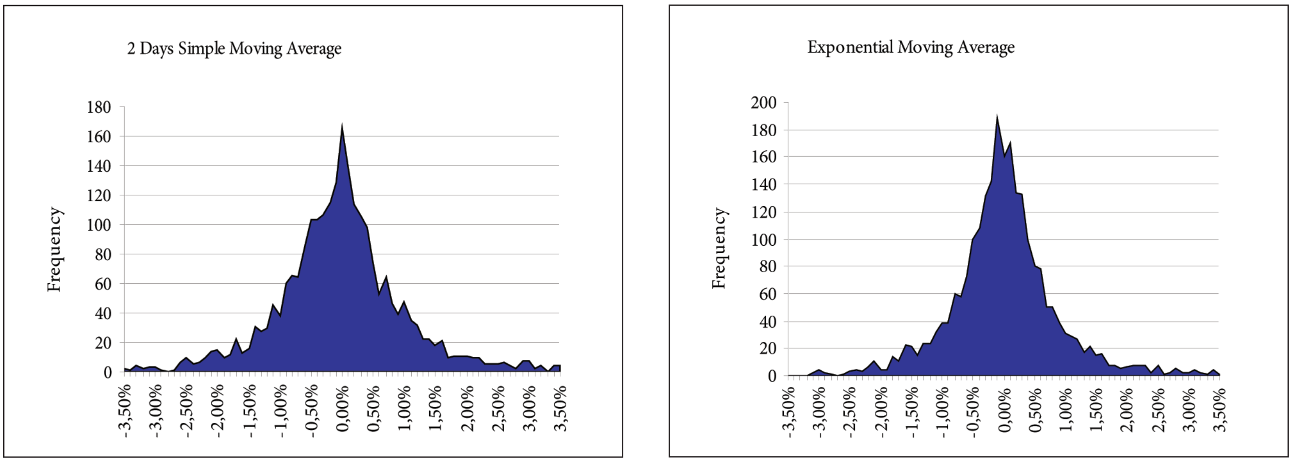

Fig. 2. The comparison of EMA and SMA usage percentage bias of OMX Baltic Benchmark market

The distribution of EMA and 2 days SMA for OMX Baltic Benchmark Index (Fig. 2) shows the same results as in S&P 500 Index case. For 2 days SMA the number of "correct" forecast values is 165. For EMA the number of right predictions is 160 and it is very similar to 2 days SMA results. The range of percentage bias for 2 SMA method is 20.72% while for EMA it is 17.69%. The minimum value for 2 days SMA and EMA –7.96% and –8.40% for EMA. The maximum percentage bias for 2 days SMA usage is approximately 17% higher than EMA is. Only 48 out of 2 days SMA forecasted values have the percentage bias of |3.50 %|. So the affirmation in OMX Baltic Benchmark market that the distribution surrounds ordinate axes can be confirmed.

As distinct for S&P 500 case, both methods – 2 days SMA and EMA can be used to predict Baltic States stock markets but exponential moving average method is preferable because of its lower range of percentage bias.

The finding that exponential smoothing method is superior to simple moving average can be made. The accuracy of exponential moving average is higher because the bias level is lower and the frequency to make a forecast with the higher bias level is higher using 2 days simple moving average.

This study implies test result for S&P 500 index and OMX Baltic Benchmark index which was never tested by Lithuanian authors and other academia. Results of both indexes show that the next stage of our research should include the number of the days and hypothesis testing which will show the adequacy of the research.

6. Conclusions

This study is the first academia research of technical analysis usage to predict the values for OMX Baltic Benchmark Index and comparing it with S&P 500 Index of US using exponential smoothing method. A significant part of semi-professional traders use technical analysis as a method to forecast stock prices but no researches in the Baltic States confirmed or refused the statistical validity of this method usage evaluating systematic errors too.

EMA method is relevant to forecast index values. The research claims that for each index an appropriate Constanta level should be found. So, it is 0.97 for S&P 500 market and 0.99 for OMX Baltic Benchmark market. The correlation analysis showed that the higher α level is relevant to the lower bias level and the forecast becomes more accurate.

The comparison of EMA and SMA methods was made using systematic error evaluation. The better results came from EMA method. The Mean absolute error level is very low and it means that EMA method is adequate to predict to some degree. Tracking signal showed that EMA method can forecast involving new data series with fewer losses. The enlarged Y_t weight from 0.1 to 0.9 for S&P 500 makes the absolute error value lower:

– MSE – 4;
– MAD and MAPE – 2;
– MFE – 9 times.

For OMX Baltic Benchmark these changes are the following:

– MSE – 12;
– MAD and MAPE – 4;
– MFE – 8 times.

So the highest α level reduces the probability of a higher bias level for traders.

The suggestion to use EMA method instead of SMA method was confirmed once again by descriptive statistics in each case. If the standard deviation reflects the risk of the index, it means that EMA method is less risky to use for estimating absolute error level.

The evaluation of the probability that absolute error value will be converted from positive value of absolute error Ft-Yt to negative value and vice versa after one day determined that EMA method should involve the length of period – a number of days. This case will be researched in our next study.

The comparison also involved the distribution of percentage bias (Ft-Yt)/Yt for each method in both markets. It seems that EMA method is more suitable to predict S&P 500 values rather than short moving average is. The distribution of EMA percentage bias is symmetric to ordinate axis and provides more correct result with the bias level 0.00 % - 965. In both cases the distribution of percentage bias surrounds ordinate axes and it mostly fluctuates from -3.50 % to 3.50 %.

The distribution of EMA and 2 days SMA percentage bias for OMX Baltic Benchmark Index shows the same results as in S&P 500 Index case but the research also shows that short moving average trading rule can be used too.

Summarizing the study, exponential smoothing method is appropriate to indicate the future values of S&P 500 and OMX Baltic Benchmark indexes.

It should be noted that during the research it provided the closest forecast values to the real index values because the higher weight is ensured to real historical prices of the previous day.

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