The best combination of indicators for the U.S. stock market

By

Fuwang He

A thesis submitted to the

Department of Computer Science

in conformity with the requirements for

the degree of Master of Science

Bishop's University

Canada

December 2023

Abstract

This study scrutinizes the predictive power of technical analysis indicators in U.S. stock market over 22 years. Through a comprehensive examination of 1,440 combinations of indicators, including Bollinger Bands (BB), Moving Averages (MA) and Relative Strength Index (RSI). The paper back tested the overall performance of various indicators in terms of total return, and also provided as detailed an analysis as possible on the specific performance of different indicators or combinations of indicators, such as average trading time, drawdown magnitude, and trading frequency. This allows readers to select indicators based on their own preferences, or to further refine their trading systems. This article also further investigates the potential applications of these indicators in deep learning models such as LSTM and GRU. This paper's experiments have helped streamline the number of technical analysis features applied in deep learning.

Keywords: technical analysis, U.S. stock market prediction, indicator performance, quantitative analysis, trading system, GRU deep learning model

Acknowledgement

I am filled with immense gratitude as I extend my sincere thanks to the Computer Science Department at Bishop's University, which has been the gateway to my master's degree journey. The resources, opportunities, and support provided by the department have been pivotal in my academic pursuits.

Special appreciation goes to Dr. Russell Bulter, whose unwavering support, patience, and invaluable guidance have been instrumental throughout this process. His involvement has been indispensable, and I am profoundly thankful for his mentorship.

I would also like to express my gratitude to all the faculty members in the Department of Computer Science, including Dr. Bentabet, Dr. Stefan Bruda, Dr. Lin Jensen, Dr. Madjid Allili and Dr. Mohammed Ayoub Alaoui Mhamdi. Their teachings have immensely enriched my knowledge and enhanced my experience, leaving a lasting impact on my academic journey.

My heartfelt thanks go to the Bishop's University Foundation and once again to Dr. Russell Bulter for granting me the scholarship. This financial assistance has significantly alleviated the monetary burden of my studies, allowing me to focus more intently on my academic endeavors.

I would be remiss if I did not express my gratitude towards ChatGPT, which has been a valuable tool in refining my thesis. The assistance I received in improving grammar and fluency has been crucial in completing my paper smoothly.

Contents

List of Figures

List of Tables

List of Indicators

1 Introduction

With the development of computer science, financial markets have gradually shifted from purely manual trading to automated trading. This is a market with great potential that has not been fully tapped yet. Whether it's high-performance distributed computing or deep learning for quantitative trading, these are currently hot research topics with surprising progress made each year. This article aims to use high-performance computing methods to comprehensively analyze the performance of most technical indicators available in the market, both for manual trading and for application in deep learning to predict stock prices.

Technical analysis is a highly respected method of evaluating securities within the financial market. Traditional techniques often incorporate chart patterns (Bulkowski, 2021), Japanese candlestick patterns (Heinz et al., 2021), trend analysis, support, and resistance analysis (Schannep, 2012). Additionally, emerging technologies like deep learning have started to make their mark on stock market predictions, further expanding the pool of analytical tools available (Hiransha et al., 2018).

With the advancement of neural networks, time series analysis has made significant strides, and numerous research papers have applied these methods to stock price prediction. For example, studies such as Yang Qing and (Wang Chenwei, 2019) have used LSTM models, and another study (Keshab, 2023) has employed GRU models for prediction, achieving noteworthy results. These studies are examples of how deep learning techniques are successfully applied in the analysis of financial markets.

To simplify the complex dynamics of stock prices and trends for traders, various indicators have been developed. Despite extensive research into these tools (Achelis, 2001) (Lee et al., 2019), there remains a significant gap in literature concerning the comprehensive examination of multiple indicator integration.

This study seeks to fill that gap by providing a detailed examination of both the standard and combined uses of various indicators, evaluating a total of 1,440 combinations within the U.S. stock market through an extensive back-testing period. The goal is to offer investors and trading strategy developers a substantial reference for constructing trading models, including those based on deep learning.

We also employ extensive use of multi-threaded computing and vector calculations as acceleration methods to compute all combinations of indicators for all stocks in a short period of time. The total volume of data used for back testing and deep learning reached approximately 13.5 million rows, with the number of feature dimensions for back testing indicators reaching 1450, which means the total volume of data is approximately a table with 13.5 million rows and 1450 columns.

The indicators evaluated in this analysis include:

- Accumulation/distribution index (ADI) (Haningsih et al., 2014),
- Average Directional Movement Index (ADX) (Szetela et al., 2020),
- Bollinger Bands (BB) (Day et al., 2022),
- Commodity Channel Index (CCI) (St Mt et al., 2019),
- Double exponential moving average (DEMA) (Chen et al., 2023),
- Detrended Price Oscillator (DPO) (Kulkarni & More, 2014),
- Exponential Moving Average (EMA) (Cai et al., 2021),
- Ease of Movement Value (EMV) (Chavarnakul & Enke, 2006),
- Keltner channel (KC) (Cohen, 2023),
- Stochastic Oscillator (KDJ) (Ni, Liao, & Huang, 2015),
- Moving Average (MA) (Dinesh, R, Anusha, & R, 2021),

- Moving average convergence divergence (MACD) (Putriningtiyas & Musadieq, 2017),
- Moving average envelope (MAE) (Ling, Abdul-Rahim, & Said, 2020),
- Money flow index (MFI) (Banik et al., 2022),
- Momentum (MOM) (Zakamulin & Giner, 2020),
- On-balance volume (OBV) (Tsang & Chong, 2009),
- Oscillator (technical analysis) (OSC) (Tsang & Chong, 2009),
- Parabolic SAR (PSAR) (Yazdi & Lashkari, 2012),
- Range Expansion Index (REX) (The Forex Geek, 2022),
- Rising Moving Average (RMA) (Stock Market Freedom, 2013),
- Relative Strength Index (RSI) (Göçken et al., 2016).,
- Triple exponential moving average (TEMA) (Peleg, Weiss, & Hoogi, 2023),
- Triple Exponential Moving Average Oscillator (TRIX) (Trading Technologies, 2023),
- Ultimate Oscillator (UO) (TradingSim, 2019),
- Vortex indicator (VI), (Botes & Siepman, 2010)
- Williams %R (W%R) (Groette, 2023)

2 Data and Methods

2.1 Data

For this study, I collected 11,573 US stocks. The data for US stocks was sourced from the Sina database. Guided by Charles Dow's principle, which emphasizes the importance of trading volume in technical analysis (Schannep, 2012), I ensured the robustness of my analysis by including only securities with a daily average trading volume exceeding 100,000. This method reduced the impact of minor transactions on the market, allowing the study to focus on larger transactions that more accurately reflect market trends. Additionally, in pursuit of higher returns, I imposed a constraint on the stock prices within the dataset: the average daily price of US stocks was limited to 5-30 US dollars. Moreover, I eliminated securities with single transaction returns significantly above the average return, as these could distort the results. After implementing these filtering criteria, the final dataset consisted of 2,330 US stocks.

To facilitate the demonstration of the indicator calculation methods, the well-known Apple stock was also used. However, due to the high stock prices, it was not considered in the actual calculations. The specific data range is as follows: Daily data of Apple Inc. stock from January 1, 2020, to December 31, 2022.

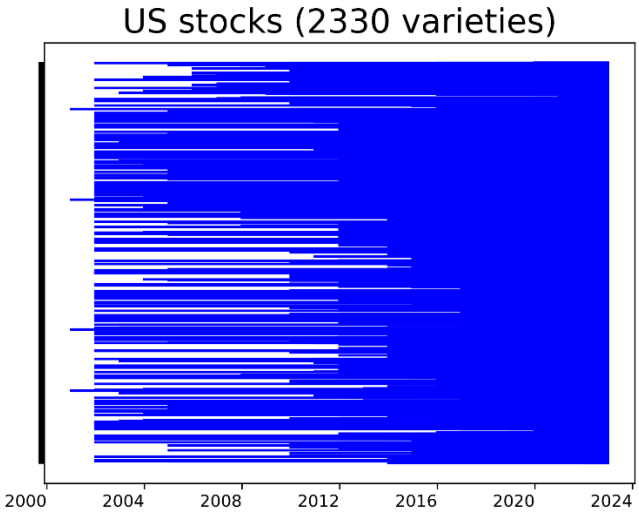

Figure 1.1 U.S. Stock Market dataset date range

2.2 Indicators

A total of 25 indicators were calculated and tested for this study, which I broadly classified into two categories. The first category comprises indicators that can function as standalone buy or sell signals, predominantly generated when the closing price crosses above or below a particular indicator, or when two signals from the same indicator intersect. The second category includes auxiliary indicators, which assist in determining the reliability of the signals generated by the first category of indicators.

Table 1.1 provides details of indicators. The first column lists the full names and abbreviations of different indicators. The second column identifies whether the indicator can function independently, corresponding to the first category mentioned earlier. The third column indicates whether the indicator can act as an auxiliary, corresponding to the second category of indicators previously described. The number in parentheses in the second and the third column represents the number of different methods in which each indicator can be used.

indicators	cross	auxiliary
Accumulation/distribution index (ADI)		aux
Average Directional Movement Index (ADX)		aux
Bollinger Bands (BB)	cross	aux
Commodity Channel Index (CCI)		aux
Double exponential moving average (DEMA)	cross (2)	aux (2)
Detrended Price Oscillator (DPO)	cros	
Exponential Moving Average (EMA)	cross (2)	aux
Ease of Movement Value (EMV)	cross	aux
Keltner channel (KC)	cross	aux
Stochastic Oscillator (KDJ)	cross	aux
Moving Average (MA)	cross (2)	aux
Moving average convergence divergence (MACD)	cross	aux
Moving average envelope (MAE)		aux
Money flow index (MFI)	cross	aux
Momentum (MOM)		aux
On-balance volume (OBV)		aux
Oscillator (technical analysis) (OSC)		aux
Parabolic SAR (PSAR)		aux
Range Expansion Index (REX)	cross	aux
Rising Moving Average (RMA)	cross	aux
Relative Strength Index (RSI)		aux
Triple exponential moving average (TEMA)	cross (2)	aux
Trix (technical analysis) (TRIX)	cross	
Ultimate Oscillator (UO)	cross	aux
Vortex indicator (VI)	cross	aux
Williams %R (W%R)		aux

Table 1.1 All indicators used in the paper.

The detailed calculation formulas for different indicators, as well as the periods and parameters used for these indicators in this study, are provided in appendix.

Table 1.2: Table 1.2 outlines these CROSS and AUX indicators in detail, with _L denoting long positions and _S indicating short positions.

long position		short position	
CROSS	AUX	CROSS	AUX
BB_L	ADI_L_aux	BB_S	ADI_S_aux
10DEMA_L	ADX_L_aux	10DEMA_S	ADX_S_aux
20DEMA_L	BB_L_aux	20DEMA_S	BB_S_aux
DPO_L	CCI_L_aux	DPO_S	CCI_S_aux
10EMA30_L	10DEMA_L_aux	10EMA30_S	10DEMA_S_aux
5EMA10_L	20DEMA_L_aux	5EMA10_S	20DEMA_S_aux
EMV_L	10EMA30_L_aux	EMV_S	10EMA30_S_aux

KC_L	EMV_L_aux	KC_S	EMV_S_aux
KDJ_L	KC_L_aux	KDJ_S	KC_S_aux
10MA30_L	KDJ_L_aux	10MA30_S	KDJ_S_aux
5MA10_L	10MA30_L_aux	5MA10_S	10MA30_S_aux
MACD_L	MACD_L_aux	MACD_S	MACD_S_aux
MFI_L	MAE_L_aux	MFI_S	MAE_S_aux
REX_L	MFI_L_aux	REX_S	MFI_S_aux
RMA_L	MOM_L_aux	RMA_S	MOM_S_aux
10TEMA20_L	OBV_L_aux	10TEMA20_S	OBV_S_aux
10TEMA30_L	OSC_L_aux	10TEMA30_S	OSC_S_aux
TRIX_L	PSAR_L_aux	TRIX_S	PSAR_S_aux
UO_L	REX_L_aux	UO_S	REX_S_aux
VI_L	RMA_L_aux	VI_S	RMA_S_aux
	RSI_L_aux		RSI_S_aux
	30TEMA_L_aux		30TEMA_S_aux
	UO_L_aux		UO_S_aux
	VI_L_aux		VI_S_aux
	WR_L_aux		WR_S_aux

Table 1.2 All indicators for both positions used in the paper.

Figure 2.1: Figure 2.1 provides a visual representation of how one particular indicator, the 5MA CROSS 10MA, can be used for long positions. It uses AAPL stock data from 2020 to 2022 for demonstration purposes. The figure comprises two subplots, with the upper subplot representing the candlestick chart, and the lower subplot depicting the volume chart. The x-axis represents dates.

In the first subplot, the blue line signifies the 5-day moving average (5MA), while the orange line illustrates the 10-day moving average (10MA). Green circles highlight buy points, which occur when the 5MA crosses above the 10MA. This is specifically at the closing price position, not at the CROSS point itself. The red circles mark sell points when the 5MA crosses below the 10MA.

Each completed trade is annotated with the individual trade's return, the time required for the trade (counting from the day after the purchase as day one), and the maximum drawdown (Mdd) within each trade. Mdd can represent either the realized loss, which occurs when the stock is closed or liquidated, or the maximum floating loss incurred during the holding period of the stock. All buy and sell points are assumed to be the closing prices on the day the CROSS occurs.

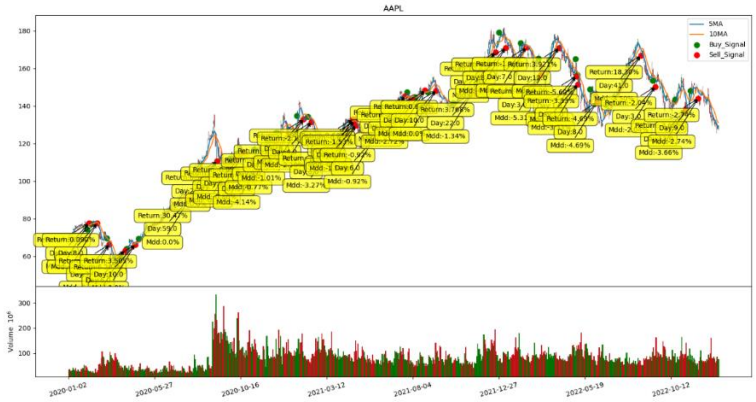

Figure 2.1 Example of determining buying and selling points with a single indicator.

2.3 Double indicators

In the realm of double indicators, each AUX indicator is paired with a CROSS indicator, yielding a total of 500 combinations for long positions. The same process is repeated for short positions, adding another 500 combinations. Hence, there are a total of 1000 combinations.

Table 1.3: Table 1.3 showcases the combinations. For instance, in the long position, the AUX indicator assists the 10MA crossing the 30MA. The combinations for short positions, with the AUX indicator assisting the BB indicator, are also displayed in the same table.

The indicators listed before the first "_L" are CROSS indicators, while those between the first "_L" and the second "_L" are AUX indicators. As a result, for the long position strategy, we have 520 indicators: 20 single indicators plus 500 double indicators. The short position strategy also comprises 520 indicators, totalling 1040 indicator combinations.

long position		short position	
10EMA30_L_10DEMA_L	10EMA30_L_MAE_L	BB_S_10DEMA_S	BB_S_MAE_S
10EMA30_L_10EMA30_	10EMA30_L_MFI_L	BB_S_10EMA30_S	BB_S_MFI_S
10EMA30_L_10MA30_L	10EMA30_L_MOM_L	BB_S_10MA30_S	BB_S_MOM_S
10EMA30_L_20DEMA_L	10EMA30_L_OBV_L	BB_S_20DEMA_S	BB_S_OBV_S
10EMA30_L_30TEMA_L	10EMA30_L_OSC_L	BB_S_30TEMA_S	BB_S_OSC_S
10EMA30_L_ADI_L	10EMA30_L_PSAR_	BB_S_ADI_S	BB_S_PSAR_S
10EMA30_L_ADX_L	10EMA30_L_REX_L	BB_S_ADX_S	BB_S_REX_S
10EMA30_L_BB_L	10EMA30_L_RMA_L	BB_S_BB_S	BB_S_RMA_S
10EMA30_L_CCI_L	10EMA30_L_RSI_L	BB_S_CCI_S	BB_S_RSI_S
10EMA30_L_EMV_L	10EMA30_L_UO_L	BB_S_EMV_S	BB_S_UO_S
10EMA30_L_KC_L	10EMA30_L_VI_L	BB_S_KC_S	BB_S_VI_S
10EMA30_L_KDJ_L	10EMA30_L_WR_L	BB_S_KDJ_S	BB_S_WR_S
10EMA30_L_MACD_L		BB_S_MACD_S	

Table 1.3 Example of combination of AUX and CROSS indicators.

Figure 2.2: Figure 2.2 displays the combined use of two indicators, the 5MA CROSS 10MA and MACD, for long positions. The first subplot is identical to that of Figure 2.1, but it also includes ExBP, represented by blue circles. ExBP represents buy points given by a single indicator, but are discarded buy points when considering dual indicators. This means they satisfy the buying rules of the first indicator, but when both indicators are observed simultaneously, at least one indicator does not meet the buying signal.

The second subplot of Figure 2.2 depicts the MACD values. Regions where the DIF (MACD line) is greater than the DEA (signal line) are highlighted in green, suggesting that long positions can be taken, or existing short positions should be closed. The areas where the DIF is less than the DEA are marked in red, indicating that short positions can be taken, or existing long positions should be closed.

In the first subplot, the buy and sell points for the 5MA CROSS 10MA indicator are adjusted according to MACD_AUX. When the second subplot is green, the first subplot triggers a bullish crossover, suggesting long positions. Conversely, if the second subplot is red, the first subplot triggers a bullish crossover, but long positions are not recommended. Additionally, the sell points (red circles) in the first subplot may deviate slightly from those in Figure 2.1. This deviation occurs because long positions must be closed if MACD_AUX shifts into the red region. Hence, the sell points (red circles) in the first subplot of Figure 2.2 may be triggered earlier or remain unchanged compared to those in Figure 2.1.

Figure 2.2 Visual example of determining buying and selling points with double indicators.

2.4 Evaluating Indicator Performance

To assess the performance of various indicators, we compare the cumulative returns, or TGR (Annual Compound Growth Rate).

Image 2.3: This image illustrates the calculation of TGR using a dataset of 22 U.S. stock indices from 2020 to 2022, with the 5MA CROSS 10MA strategy as the chosen indicator.

In the first subplot of Image 2.3, different colored dots represent the final returns generated by applying the 5MA CROSS 10MA strategy on these indices. Each dot represents a complete trade (measured at the closing position of each trade). These trades are then grouped by month, and the average return for each monthly group is calculated. The red triangle markers, located at the end of each month, represent the average returns for that month.

$$Return \in Returns_{2020-Jan}, 2020/01/01 < Return_{date} < 2020/01/31$$

$$Return_{2020-Jan_{avg}} = (\sum Return_{2020-Jan\_i})/n\ )$$

$$Return_{All_{avg}} = \{Return_{2020-Jan_{avg}}, Return_{2020-Feb_{avg}} \dots Return_{2022-Dec_{avg}}\}$$

$$TGR = \prod_{2020-Jan}^{2022-Dec} Return_{Month_{avg}}$$

$$CAGR = \sqrt[n]{TGR}\ (n = 22.29)$$

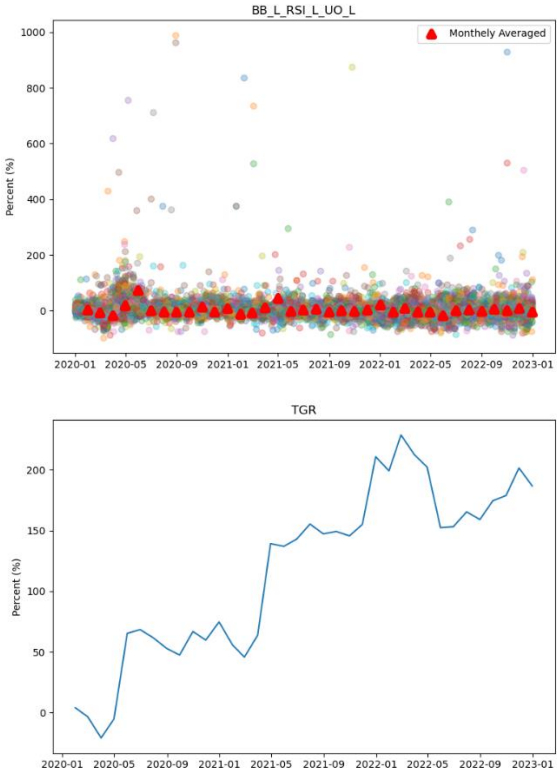

Figure 2.3 Visual illustration of TGR calculation

2.5 Triple indicators

Upon calculating the TGR, I evaluated the performance of different double indicators. Subsequently, I selected the top 5 AUX indicators for each CROSS indicator, which yielded the highest combined TGR.

Table 1.4: This table exhibits some of the results using the US stock dataset. For instance, for long positions and the 10EMA CROSS 30EMA indicator, the five best AUX indicators are MFI, BB, 10MA30, 10EMA30 (which is the indicator itself), and ADX.

long position		short position	
double indicators	TGR (%)	double indicators	TGR (%)
10EMA30_L_MFI_L	1387.84	10EMA30_S_10EMA30_S	1415.64
10EMA30_L_BB_L	762.70	10EMA30_S_ADX_S	1415.64
10EMA30_L_10MA30_L	672.82	10EMA30_S_OSC_S	1231.50
10EMA30_L_OSC_L	498.60	10EMA30_S_MACD_S	306.03
10EMA30_L_10EMA30_L	464.28	10EMA30_S_30TEMA_S	291.68
10DEMA_L_WR_L	83.50	10DEMA_S_REX_S	181.06
10DEMA_L_KC_L	66.74	10DEMA_S_RMA_S	160.62
10DEMA_L_MAE_L	58.71	10DEMA_S_MOM_S	155.71
10DEMA_L_CCI_L	45.64	10DEMA_S_10MA30_S	141.84
10DEMA_L_KDJ_L	37.46	10DEMA_S_PSAR_S	135.61

Table 1.4 Example of best double indicators based on TGR.

These AUX indicators were then combined in different ways, resulting in 10 unique double AUX combinations for this CROSS indicator. In total, for the 20 CROSS indicators, we obtained 200 indicator combinations. The same was done for short positions, yielding another 200 indicator combinations. Thus, for triple indicators, we obtained 400 indicator combinations.

Table 1.5: This table displays the indicator combinations from Table 1.4. The indicators listed before the first "_L" denote the CROSS indicators. The indicators between the first and second "_L" represent the first AUX indicators used, and those between the second and third "_L" represent the second AUX indicators used.

long position	short position
10EMA30_L_10MA30_L_10EMA30_L	10EMA30_S_10EMA30_S_30TEMA_S
10EMA30_L_10MA30_L_OSC_L	10EMA30_S_10EMA30_S_ADX_S
10EMA30_L_BB_L_10EMA30_L	10EMA30_S_10EMA30_S_MACD_S
10EMA30_L_BB_L_10MA30_L	10EMA30_S_10EMA30_S_OSC_S
10EMA30_L_BB_L_OSC_L	10EMA30_S_ADX_S_30TEMA_S
10EMA30_L_MFI_L_10EMA30_L	10EMA30_S_ADX_S_MACD_S
10EMA30_L_MFI_L_10MA30_L	10EMA30_S_ADX_S_OSC_S
10EMA30_L_MFI_L_BB_L	10EMA30_S_MACD_S_30TEMA_S
10EMA30_L_MFI_L_OSC_L	10EMA30_S_OSC_S_30TEMA_S
10EMA30_L_OSC_L_10EMA30_L	10EMA30_S_OSC_S_MACD_S
10DEMA_L_CCI_L_KDJ_L	10DEMA_S_10MA30_S_PSAR_S
10DEMA_L_KC_L_CCI_L	10DEMA_S_MOM_S_10MA30_S
10DEMA_L_KC_L_KDJ_L	10DEMA_S_MOM_S_PSAR_S
10DEMA_L_KC_L_MAE_L	10DEMA_S_REX_S_10MA30_S
10DEMA_L_MAE_L_CCI_L	10DEMA_S_REX_S_MOM_S
10DEMA_L_MAE_L_KDJ_L	10DEMA_S_REX_S_PSAR_S
10DEMA_L_WR_L_CCI_L	10DEMA_S_REX_S_RMA_S
10DEMA_L_WR_L_KC_L	10DEMA_S_RMA_S_10MA30_S
10DEMA_L_WR_L_KDJ_L	10DEMA_S_RMA_S_MOM_S
10DEMA_L_WR_L_MAE_L	10DEMA_S_RMA_S_PSAR_S

Table 1.5 Example of best triple indicators based on TGR.

Figure 2.4: Figure 2.4 showcases the concurrent application of three indicators, employing the same data as Figures 2.1 and 2.2. Its functioning is akin to the utilization of two indicators, as depicted in Figure 2.2. In Figure 2.4, Subplot 2 mirrors Subplot 2 in Figure 2.2, while Subplot 3 introduces the EMV indicator. In the same vein, the green region, represented by the EMV indicator, signals the area where long positions can be opened, and the red region indicates where long positions must be closed.

Subplot 1 presents a candlestick chart, MA (Moving Average), and buy/sell points. It builds upon Image 1.2 but further omits some buy points. The buying rule stipulates that purchases should only be made when both the MACD and EMV are in the green area concurrently, as depicted in Subplot 2 and Subplot 3, following the manifestation of a golden cross in MA. The selling rule is to sell either when there is a death cross in MA or when either the MACD or EMV indicator enters the red region.

In the image, the blue dots (ExBP: 1->2) symbolize the buy points discarded when transitioning from a single indicator to a double indicator. The orange dots (ExBP: 2->3) represent the buy points further discarded transitioning from double indicator to triple indicator.

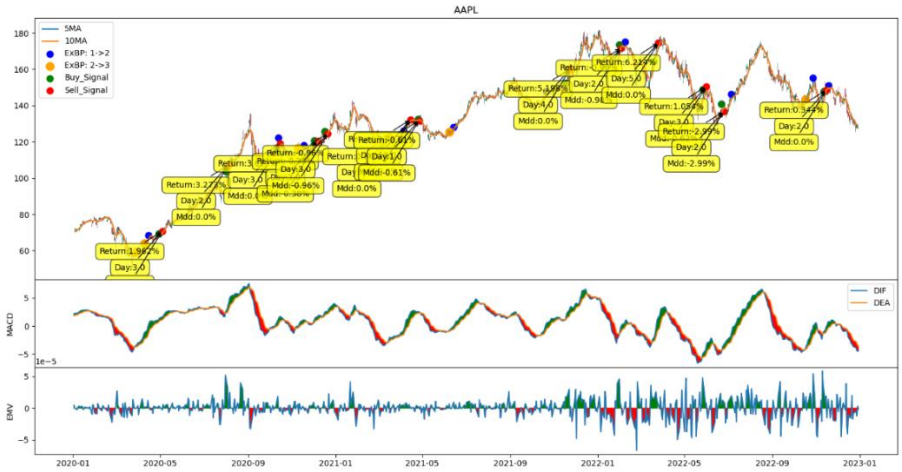

Figure 2.4 Visual example of determining buying and selling points with triple indicators. In total, we obtained 1440 different indicator strategies:

40 single indicators, 1000 double indicators, and 400 triple indicators.

2.6 Statistical Approaches

In addition to TGR, I have performed some statistical analyses on the double and triple indicators to facilitate a comprehensive evaluation of their performance.

Table 2.1 and Table 2.2: These tables provide some illustrative examples. To conserve memory resources, all calculations were executed using monthly averaged data, akin to the process in Figure 2.3. The "0+_m" signifies the number of months with positive monthly averaged returns, indicating the number of profitable months out of the total months. "RAR" signifies the ratio of the number of months with positive average returns to the number of months with negative average returns.

0+_cnt represents the number of trades with positive returns. all_cnt represents the total number of trades generated. PRT is the ratio of these two.

The "med (%)" represents the median of the monthly returns in percentage terms, where 0.5 signifies 0.5% rather than 50%. Similarly, "mdd (%)" symbolizes the median of the maximum drawdowns of individual months, also expressed in percentage terms. MAR is the ratio of these two.

"dur (days)" represents the median duration of individual trades from opening to closing, measured in days. It's worth noting that as all individual trades are averaged monthly, decimal values may appear in this column.

The calculation method for the TGR (Total Growth Rate), expressed as a percentage, is the same as the one depicted in Figure 2.3. CAGR is the annual average return rate calculated based on TGR and the total trading time, which is the square root of TGR at 22.29.

	0+_m	RAR	0+_cnt	all_cnt	PRT	med	mdd	MAR	std	dur	TGR	cagr
10DEMA_L_CCI_L_KC_L	172	1.61	138413	373167	0.37	0.31	-1.64	0.19	0.02	2.95	140.83	4.02
10DEMA_L_CCI_L_UO_L	173	1.63	140914	377012	0.37	0.32	-1.63	0.20	0.02	2.89	137.68	3.96
10DEMA_L_CCI_L_WR_L	177	1.74	130908	340950	0.38	0.28	-1.68	0.17	0.02	2.74	147.30	4.15
10DEMA_L_KC_L_UO_L	174	1.66	143356	418707	0.34	0.29	-1.68	0.17	0.02	3.27	130.93	3.83
10DEMA_L_MAE_L_CCI_L	179	1.79	123934	329954	0.38	0.32	-1.60	0.20	0.02	2.92	165.92	4.49
10DEMA_L_MAE_L_KC_L	177	1.74	125110	347365	0.36	0.32	-1.55	0.21	0.02	3.12	152.33	4.24
10DEMA_L_MAE_L_UO_L	174	1.66	126763	350874	0.36	0.34	-1.55	0.22	0.02	3.12	150.86	4.21

10DEMA_L_MAE_L_WR_L	177	1.74	122122	318205	0.38	0.32	-1.62	0.19	0.02	2.79	176.43	4.67
10DEMA_L_WR_L_KC_L	177	1.74	133818	354866	0.38	0.28	-1.68	0.17	0.02	2.78	132.85	3.86
10DEMA_L_WR_L_UO_L	176	1.71	135180	357261	0.38	0.28	-1.69	0.17	0.02	2.77	132.74	3.86

Table 2.1 Example of statistical results for double indicators.

	0+_m	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
10DEMA_L_10DEMA_L	166	1.47	155271	466322	0.33	0.26	-1.71	0.15	0.02	3.74	75.27	2.55
10DEMA_L_10EMA30_L	130	0.88	71431	211320	0.34	-0.05	-1.38	-0.03	0.01	2.81	-24.37	-1.25
10DEMA_L_10MA30_L	136	0.96	77103	222972	0.35	-0.01	-1.37	-0.01	0.01	2.68	-18.35	-0.91
10DEMA_L_20DEMA_L	154	1.23	96284	291308	0.33	0.09	-1.61	0.05	0.01	3.18	24.33	0.98
10DEMA_L_30TEMA_L	154	1.23	97961	292603	0.33	0.09	-1.67	0.05	0.02	3.38	6.19	0.27
10DEMA_L_ADI_L	157	1.29	84051	248188	0.34	0.17	-1.53	0.11	0.02	3.62	32.69	1.28
10DEMA_L_ADX_L	166	1.47	155271	466322	0.33	0.26	-1.71	0.15	0.02	3.74	75.27	2.55
10DEMA_L_BB_L	170	1.56	155575	450227	0.35	0.26	-1.62	0.16	0.02	3.14	86.47	2.83
10DEMA_L_CCI_L	174	1.66	141230	379285	0.37	0.31	-1.62	0.19	0.02	2.91	132.20	3.85
10DEMA_L_EMV_L	162	1.38	142118	365883	0.39	0.14	-1.31	0.11	0.01	2.36	19.31	0.80
10DEMA_L_KC_L	173	1.63	143332	422608	0.34	0.26	-1.69	0.15	0.02	3.33	121.91	3.64
10DEMA_L_KDJ_L	166	1.47	147289	442341	0.33	0.26	-1.75	0.15	0.02	3.73	94.36	3.03
10DEMA_L_MACD_L	148	1.13	68379	201484	0.34	0.08	-1.59	0.05	0.02	2.98	-2.28	-0.10
10DEMA_L_MAE_L	175	1.68	126762	354701	0.36	0.32	-1.54	0.21	0.02	3.19	144.30	4.09
10DEMA_L_MFI_L	172	1.61	150710	445365	0.34	0.25	-1.67	0.15	0.02	3.57	94.47	3.03
10DEMA_L_MOM_L	132	0.90	80844	231232	0.35	-0.05	-1.42	-0.03	0.01	2.63	-14.86	-0.72
10DEMA_L_OBV_L	167	1.49	156091	458429	0.34	0.14	-1.18	0.12	0.01	2.06	28.08	1.12
10DEMA_L_OSC_L	132	0.91	72962	215760	0.34	-0.03	-1.39	-0.02	0.01	2.82	-23.45	-1.19
10DEMA_L_PSAR_L	141	1.04	64712	187522	0.35	0.03	-1.47	0.02	0.01	2.93	-15.50	-0.75
10DEMA_L_REX_L	131	0.89	77514	228131	0.34	-0.06	-1.52	-0.04	0.01	2.87	-32.07	-1.72
10DEMA_L_RMA_L	131	0.89	81662	244510	0.33	-0.06	-1.48	-0.04	0.01	2.84	-32.13	-1.72
10DEMA_L_RSI_L	165	1.45	149756	445248	0.34	0.24	-1.68	0.14	0.02	3.53	98.15	3.12
10DEMA_L_UO_L	168	1.51	154259	456761	0.34	0.29	-1.71	0.17	0.02	3.55	103.72	3.24
10DEMA_L_VI_L	135	0.96	78484	230240	0.34	-0.02	-1.48	-0.01	0.01	2.83	-24.39	-1.25
10DEMA_L_WR_L	177	1.74	135189	358156	0.38	0.28	-1.70	0.17	0.02	2.77	129.79	3.80

Table 2.2 Example of statistical results for triple indicators.

3 Results

3.1 Detailed results

This section unpacks the specifics of the results in three primary ways. First, the TGR bar chart visually presents the cumulative returns of diverse indicator combinations. The data selection for presentation is as follows: for long positions, the top 5 indicators exhibiting the highest individual TGR performance are chosen; for double indicators, the top 10 indicators with superior TGR performance are selected; and for triple indicators, the top 10 indicators displaying the best TGR performance are chosen. The indicators utilized in the statistical results tables mirror those in the TGR bar chart.

Figure 3.1 features a bar chart of TGR, sorted first by the number of indicators, from least to most, and then by descending order of TGR. It's important to note that the unit here is "%", implying that 25000 represents a cumulative growth rate of 250 times.

Tables 3.1 to 3.3 showcase statistical results. Table 3.1 exhibits results for individual indicators, including the top 5 long positions, the bottom 5 long positions, the top 5 short positions, and the bottom 5 short positions. Table 3.2 reflects the results for two-indicator combinations, displaying the top 10 and bottom 10 for both long and short positions. Similarly, Table 3.3 illustrates the results for three-indicator combinations, including the top 10 and bottom 10 for both long and short positions.

Figures 3.2 to 3.7 delve deeper into the results. Figures 3.2 to 3.4 represent the top three long position TGR results for all indicators (including single, double, and triple indicators). Figures 3.5 to 3.7 depict the top three short position results.

Consider Figure 3.2 as an example, where the subplot arrangement is as follows: First row: Subplot 1 and Subplot 2. Second row: Subplot 3 and Subplot 4. Third row: Subplot 5 and Subplot 6.

In Subplot 1, the returns of all individual trades are displayed, with each point signifying a complete trade. The red dashed line marks the median of all returns, while the red solid line signifies the average monthly return. The calculation method for both lines is consistent with the statistical method outlined in the Statistical methods section.

Furthermore, in the graph, the red dashed line represents the median of all trades, the red solid line represents the average monthly return, and the blue solid line represents the average annual return.

In Subplots 1, 3, and 6, the units are multiplied by 100, implying that 400 represents 400%. The calculation of medians in Figures 3.2 to 3.7 differs from the statistical tables. It is directly derived from all individual trades, rather than using average monthly trade results. In Subplots 1 to 3, the positions of all points correspond to the completion time of the trades, while in Subplot 4, the points are positioned at the end of each month.

Subplot 2 and Subplot 3 maintain the same presentation format as Subplot 1 but with different data content. Subplot 2 reflects the number of days required for each individual trade, while Subplot 3 represents the Maximum Drawdown (MDD) of each individual trade. For detailed calculations, refer to the Statistical methods section.

Subplot 4 represents the number of trades generated each month. A notable trend is the increase in trade results in recent years, attributable partially to the growing amount of stock market data due to a rise in listed companies since 2000. For more details, refer to the Data section.

Subplot 5 illustrates the distribution of returns and Maximum Drawdown (MDD). Here, the quantity of returns has been normalized to demonstrate the MDD distribution. Furthermore, as most returns are within 200%, subplot 5 is split into two sections to separately showcase the distribution of significant returns.

Subplot 6 depicts the NAV (Net Asset Value) of the indicators employed in Figure 3.n. This figure also identifies the standard reference indices for the dataset, with the Dow Jones Industrial Average (.DJI) representing the U.S. market. The indices have been standardized based on the NAV of the indicators for ease of comparison. Moreover, subplot 6 emphasizes the three best-performing years (highlighted in yellow) and the three worst-performing years (highlighted in red) for the indicator. The final NAV is also outlined with a green border in the subplot.

The subsequent segment outlines the calculation method for NAV and Scaled_DJI or Scaled_000001.

$$TGR = TGR_{year-t_{Dec}}$$

$$NAV_t = (1 + TGR_t) * NAV_{t-1}$$

$$a = (NAV_{max} - NAV_{min})/(DJI_{max} - DJI_{min})$$

$$b = NAV_{min} - a * DJI_{min}$$

$$Scaled_{DJI} = DJI * a + b$$

3.2 How to use detailed results

Every trader has a different preference for risk, so a higher TGR does not necessarily mean better for every trader. In this case, traders can try to select the most suitable indicator combination for themselves through detailed information from different indicator combinations, and then further refine and optimize their trading system. For example, some traders are busy with their usual work and want as few trading times as possible, so they can choose indicator combinations that generate fewer trading times primarily based on the all_cnt column, or indicators with a larger duration in the dur column, and then make a selection based on other performances of the indicator. Similarly, if a trader wants to minimize risk, they can choose indicators with the largest possible PRT or RAR column, or the smallest possible mdd, and then combine that with other performances of the indicator.

For instance, in table 3.1, the BB_L indicator performs relatively well, generating positive returns in 40% of its trades, with an average gain of 1.68% per trade, an average drawdown of 5.11% during trading or at stop-loss, and an average duration of 17.64 trading days per trade. If you don't want to frequently check and choose stocks, then you can opt for VI_L, which has an average duration of 33.46 trading days per trade but a larger drawdown of 6.62%. If you want to combine these two types of indicators, you could choose 10MA30_L. Furthermore, if you feel uneasy about the trading signals from a single indicator, you could choose a combination of two or three indicators for trading.

However, it's important to note that trading is a complex matter. Although the focus of this article is technical analysis, it's also essential to have a general understanding of the overall market. The most obvious example is that during the 2008 financial crisis, going long on stocks was certainly not a good choice, as can be seen from Figures 3.2 to 3.7, where many indicators' significant losses originated from that year. While the financial crisis might seem like a good opportunity for short-selling, bear markets are often highly volatile (Carlson, 2017). If you don't want too much risk in trading, it might be wiser to stand outside the market and wait, re-entering once the stock market has stabilized.

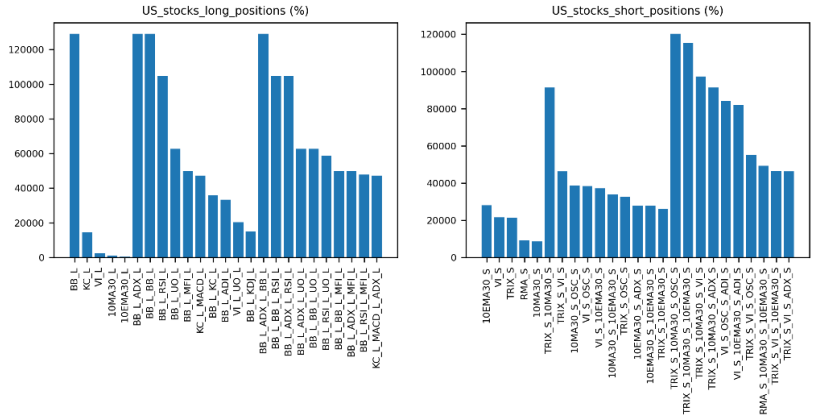

Figure 3.1 The best performing indicators of the U.S. Stock Market

BEST_single (long position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
BB_L	185	2.01	38332	96050	0.40	1.68	-5.11	0.33	0.08	17.64	129029.49	37.90
KC_L	171	1.66	33371	96251	0.35	1.27	-4.61	0.28	0.07	14.86	14547.28	25.07
VI_L	157	1.34	17634	50850	0.35	0.62	-6.62	0.09	0.08	33.46	2511.67	15.76
10MA30_L	158	1.35	23691	67387	0.35	0.82	-5.81	0.14	0.07	26.00	880.78	10.79
10EMA30_L	137	1.00	17376	62553	0.28	-0.03	-5.10	-0.01	0.07	27.08	384.54	7.34
WORST_single (long position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
REX_L	143	1.05	67980	242512	0.28	0.05	-2.28	0.02	0.03	7.30	26.47	1.06
10TEMA30_L	148	1.15	51793	141442	0.37	0.29	-3.59	0.08	0.05	11.23	28.98	1.15
UO_L	157	1.29	117136	275076	0.43	0.31	-2.90	0.11	0.03	6.24	33.73	1.31
5MA10_L	145	1.08	72686	196438	0.37	0.13	-3.09	0.04	0.03	9.00	58.39	2.08
20DEMA_L	147	1.11	97799	331406	0.30	0.09	-1.95	0.05	0.02	5.22	65.99	2.30
BEST_single (short position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
10EMA30_S	208	3.20	44706	64243	0.70	2.20	-7.49	0.29	0.06	24.19	27974.73	28.78
VI_S	199	2.65	32276	51227	0.63	2.15	-8.22	0.26	0.09	30.32	21642.37	27.31
TRIX_S	190	2.26	40701	67171	0.61	2.23	-7.82	0.29	0.07	24.63	21269.70	27.21
RMA_S	201	2.68	55195	84455	0.65	1.76	-6.89	0.26	0.06	17.91	9232.78	22.57
10MA30_S	202	2.81	43040	67975	0.63	1.98	-7.19	0.28	0.06	22.66	8505.23	22.12
WORST_single (short position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
KC_S	166	1.47	67330	101455	0.66	0.65	-5.13	0.13	0.05	13.54	-27.89	-1.46
BB_S	152	1.24	60182	99215	0.61	0.51	-5.88	0.09	0.05	15.79	-18.51	-0.91
EMV_S	157	1.29	419759	739970	0.57	0.08	-1.93	0.04	0.01	2.33	22.18	0.90

DPO_S	150	1.16	135517	300167	0.45	0.12	-2.49	0.05	0.02	5.80	58.26	2.08
10DEMA_S	177	1.74	313158	467766	0.67	0.29	-2.78	0.10	0.02	3.68	75.23	2.55

Table 3.1 Statistical results of the performance of single indicators in the U.S. Stock Market

BEST_double (long position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
BB_L_ADX_L	185	2.01	38332	96050	0.40	1.68	-5.11	0.33	0.08	17.64	129029.49	37.90
BB_L_BB_L	185	2.01	38332	96050	0.40	1.68	-5.11	0.33	0.08	17.64	129029.49	37.90
BB_L_RSI_L	185	2.01	38360	96045	0.40	1.59	-5.13	0.31	0.08	17.39	104664.88	36.61
BB_L_UO_L	180	1.88	39387	95932	0.41	1.62	-5.04	0.32	0.07	16.05	62663.14	33.51
BB_L_MFI_L	184	1.96	39253	95711	0.41	1.78	-5.02	0.36	0.07	16.17	49801.49	32.14
KC_L_MACD_L	133	1.22	3275	8288	0.40	0.98	-5.89	0.17	0.17	11.23	47178.37	31.82
BB_L_KC_L	179	1.83	39351	96063	0.41	1.60	-5.09	0.31	0.07	15.77	35837.53	30.21
BB_L_ADI_L	173	1.71	19882	50233	0.40	1.18	-4.47	0.26	0.08	16.72	33289.59	29.78
VI_L_UO_L	168	1.57	19823	46937	0.42	1.17	-5.70	0.20	0.07	21.07	20258.13	26.93
BB_L_KDJ_L	180	1.82	42094	94615	0.44	1.48	-4.62	0.32	0.06	12.98	15142.67	25.30
WORST_double (long position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
10TEMA20_L_10MA30_L	119	0.79	19992	58299	0.34	-0.16	-2.12	-0.08	0.03	5.48	-72.14	-5.57
KC_L_RMA_L	89	0.74	557	1717	0.32	-0.59	-2.52	-0.23	0.10	3.50	-72.04	-5.56
RMA_L_10MA30_L	117	0.79	4183	13351	0.31	-0.55	-4.20	-0.13	0.07	18.33	-70.17	-5.28
BB_L_REX_L	74	0.64	339	932	0.36	-1.05	-2.78	-0.38	0.06	3.50	-69.55	-5.19
UO_L_10MA30_L	125	0.83	52219	122786	0.43	-0.11	-2.36	-0.05	0.02	4.80	-61.14	-4.15
VI_L_30TEMA_L	123	0.83	16113	43979	0.37	-0.14	-2.66	-0.05	0.03	6.14	-58.70	-3.89
UO_L_OSC_L	127	0.86	51976	123551	0.42	-0.10	-2.45	-0.04	0.02	5.14	-56.98	-3.71
KC_L_10EMA30_L	97	0.67	1295	4119	0.31	-0.41	-1.82	-0.22	0.03	5.84	-56.76	-3.69
10TEMA30_L_10MA30_L	116	0.77	15118	45281	0.33	-0.18	-2.27	-0.08	0.03	6.24	-55.52	-3.57
UO_L_10EMA30_L	126	0.85	51961	123430	0.42	-0.12	-2.41	-0.05	0.02	5.16	-55.08	-3.53
BEST_double (short position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
TRIX_S_10MA30_S	181	2.23	15403	25631	0.60	1.91	-7.21	0.26	0.09	18.45	91294.84	35.78
TRIX_S_VI_S	183	2.29	13304	21541	0.62	2.11	-6.26	0.34	0.08	17.54	46266.57	31.71
10MA30_S_OSC_S	201	2.87	28988	45099	0.64	2.12	-7.75	0.27	0.08	22.22	38560.10	30.64
VI_S_OSC_S	205	3.11	25209	39136	0.64	2.30	-8.07	0.28	0.08	25.06	38476.29	30.63
VI_S_10EMA30_S	206	3.17	25327	39156	0.65	2.24	-8.02	0.28	0.08	24.92	37082.76	30.41
10MA30_S_10EMA30_S	200	2.82	29398	45597	0.64	2.14	-7.62	0.28	0.08	22.13	33903.42	29.89
TRIX_S_OSC_S	191	2.48	18869	31056	0.61	2.19	-7.00	0.31	0.08	18.30	32654.33	29.67
10EMA30_S_10EMA30_S	208	3.20	44706	64243	0.70	2.20	-7.49	0.29	0.06	24.19	27876.75	28.76
10EMA30_S_ADX_S	208	3.20	44706	64243	0.70	2.20	-7.49	0.29	0.06	24.19	27876.75	28.76
TRIX_S_10EMA30_S	191	2.48	19373	31786	0.61	2.25	-7.10	0.32	0.07	18.02	25912.81	28.34

WORST_double (short position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
BB_S_30TEMA_S	134	1.02	11389	17144	0.66	0.03	-4.17	0.01	0.05	7.31	-86.00	-8.44
KC_S_MOM_S	94	0.92	661	1177	0.56	-0.13	-2.16	-0.06	0.06	2.78	-83.63	-7.80
BB_S_MACD_S	113	0.97	2524	4023	0.63	-0.08	-3.06	-0.03	0.05	7.00	-75.19	-6.06
KC_S_RMA_S	119	1.08	1678	2593	0.65	0.12	-3.10	0.04	0.05	4.05	-68.67	-5.07
BB_S_OSC_S	136	1.17	6533	9929	0.66	0.30	-4.10	0.07	0.04	5.90	-59.75	-4.00
BB_S_REX_S	91	0.86	703	1229	0.57	-0.36	-3.13	-0.12	0.05	4.25	-59.62	-3.99
BB_S_RMA_S	114	1.02	1621	2595	0.62	0.03	-2.83	0.01	0.04	3.74	-53.85	-3.41
BB_S_10MA30_S	134	1.04	6104	11233	0.54	0.04	-2.14	0.02	0.03	2.44	-51.21	-3.17
BB_S_VI_S	152	1.29	12885	21936	0.59	0.26	-2.90	0.09	0.03	5.13	-48.98	-2.97
BB_S_KC_S	152	1.23	59253	99212	0.60	0.38	-5.51	0.07	0.05	14.44	-40.91	-2.33

Table 3.2 Statistical results of the performance of double indicators in the U.S. Stock Market.

BEST_triple (long position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
BB_L_ADX_L_BB_L	185	2.01	38332	96050	0.40	1.68	-5.11	0.33	0.08	17.64	129029.49	37.90
BB_L_ADX_L_RSI_L	185	2.01	38360	96045	0.40	1.59	-5.13	0.31	0.08	17.39	104664.88	36.61
BB_L_BB_L_RSI_L	185	2.01	38360	96045	0.40	1.59	-5.13	0.31	0.08	17.39	104664.88	36.61
BB_L_ADX_L_UO_L	180	1.88	39387	95932	0.41	1.62	-5.04	0.32	0.07	16.05	62663.14	33.51
BB_L_BB_L_UO_L	180	1.88	39387	95932	0.41	1.62	-5.04	0.32	0.07	16.05	62663.14	33.51
BB_L_RSI_L_UO_L	180	1.88	39401	95927	0.41	1.64	-5.04	0.32	0.07	15.99	58636.37	33.11
BB_L_ADX_L_MFI_L	184	1.96	39253	95711	0.41	1.78	-5.02	0.36	0.07	16.17	49801.49	32.14
BB_L_BB_L_MFI_L	184	1.96	39253	95711	0.41	1.78	-5.02	0.36	0.07	16.17	49801.49	32.14
BB_L_RSI_L_MFI_L	183	1.93	39254	95704	0.41	1.67	-5.03	0.33	0.07	16.16	47863.86	31.91
KC_L_MACD_L_ADX_L	133	1.22	3275	8288	0.40	0.98	-5.89	0.17	0.17	11.23	47178.37	31.82
WORST_triple (long position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
REX_L_UO_L_RSI_L	151	1.18	72636	239920	0.30	0.15	-2.13	0.07	0.02	5.32	68.70	2.37
5MA10_L_MFI_L_KC_L	151	1.18	77981	181969	0.43	0.23	-2.75	0.08	0.02	5.66	72.82	2.48
REX_L_MFI_L_RSI_L	147	1.11	71338	237062	0.30	0.08	-2.14	0.04	0.02	5.39	73.92	2.51
5MA10_L_UO_L_KC_L	147	1.11	79244	183741	0.43	0.22	-2.74	0.08	0.02	5.60	74.79	2.54
5MA10_L_PSAR_L_KC_L	158	1.32	49998	115070	0.43	0.20	-2.58	0.08	0.03	5.50	77.58	2.61
UO_L_WR_L_BB_L	176	1.71	102869	202359	0.51	0.41	-2.65	0.16	0.03	4.31	91.21	2.95
UO_L_KC_L_WR_L	177	1.74	102677	202229	0.51	0.43	-2.66	0.16	0.03	4.37	95.89	3.06
UO_L_KC_L_BB_L	168	1.51	109346	237838	0.46	0.34	-2.79	0.12	0.03	5.24	99.43	3.15
EMV_L_KC_L_RSI_L	190	2.13	286192	654912	0.44	0.32	-1.39	0.23	0.01	2.35	102.54	3.22
REX_L_PSAR_L_RSI_L	147	1.12	36375	118630	0.31	0.11	-2.33	0.05	0.03	5.70	103.42	3.24
BEST_triple (short position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
TRIX_S_10MA30_S_OSC_S	183	2.35	14873	24534	0.61	2.04	-7.02	0.29	0.09	17.88	120205.13	37.46

TRIX_S_10MA30_S_10EMA30_S	183	2.35	14989	24699	0.61	1.96	-7.10	0.28	0.09	17.74	115302.65	37.21
TRIX_S_10MA30_S_VI_S	178	2.28	11054	17997	0.61	2.10	-6.50	0.32	0.10	16.41	97232.06	36.16
TRIX_S_10MA30_S_ADX_S	181	2.23	15403	25631	0.60	1.91	-7.21	0.26	0.09	18.45	91294.84	35.78
VI_S_OSC_S_ADI_S	191	2.65	11999	19078	0.63	2.14	-9.40	0.23	0.09	24.66	84200.11	35.29
VI_S_10EMA30_S_ADI_S	189	2.55	12048	19080	0.63	2.09	-9.37	0.22	0.09	24.37	81876.37	35.12
TRIX_S_VI_S_OSC_S	178	2.20	12129	19597	0.62	2.11	-6.30	0.34	0.10	16.43	55165.79	32.75
RMA_S_10MA30_S_10EMA30_S	189	2.63	7033	10653	0.66	1.68	-6.63	0.25	0.07	17.38	49199.22	32.07
TRIX_S_VI_S_10EMA30_S	176	2.12	12224	19721	0.62	2.11	-6.55	0.32	0.09	16.35	46386.42	31.72
TRIX_S_VI_S_ADX_S	183	2.29	13304	21541	0.62	2.11	-6.26	0.34	0.08	17.54	46266.57	31.71
WORST_triple (short position)	**0+_m**	**RAR**	**0+_cnt**	**all_cnt**	**PRT**	**med**	**mdd**	**MAR**	**std**	**dur**	**TGR**	**cagr**
KC_S_REX_S_10EMA30_S	52	1.33	102	173	0.59	0.72	-3.50	0.21	0.10	4.50	-60.43	-4.07
KC_S_MACD_S_10EMA30_S	12	0.86	16	31	0.52	-0.22	-3.00	-0.07	0.11	2.00	-59.08	-3.93
KC_S_REX_S_MACD_S	111	1.17	824	1304	0.63	0.27	-2.38	0.11	0.04	4.20	-16.57	-0.81
KC_S_MACD_S_ADI_S	113	1.06	1387	2336	0.59	0.24	-4.26	0.06	0.05	9.74	-6.05	-0.28
BB_S_MAE_S_OBV_S	149	1.19	55868	84822	0.66	0.07	-1.78	0.04	0.01	1.93	10.20	0.44
BB_S_EMV_S_OBV_S	149	1.24	27487	44604	0.62	0.09	-1.66	0.05	0.02	1.73	12.09	0.51
BB_S_ADI_S_MAE_S	135	1.00	23938	45413	0.53	0.00	-4.61	0.00	0.05	10.45	15.90	0.66
KC_S_10EMA30_S_PSAR_S	64	1.23	159	273	0.58	0.64	-4.97	0.13	0.10	7.50	16.42	0.68
BB_S_ADI_S_OBV_S	158	1.42	25888	39398	0.66	0.14	-2.03	0.07	0.02	1.97	21.71	0.89
BB_S_MAE_S_EMV_S	143	1.13	26670	46540	0.57	0.06	-1.88	0.03	0.02	2.12	22.11	0.90

Table 3.3 Statistical results of the performance of triple indicators in the U.S. Stock Market.

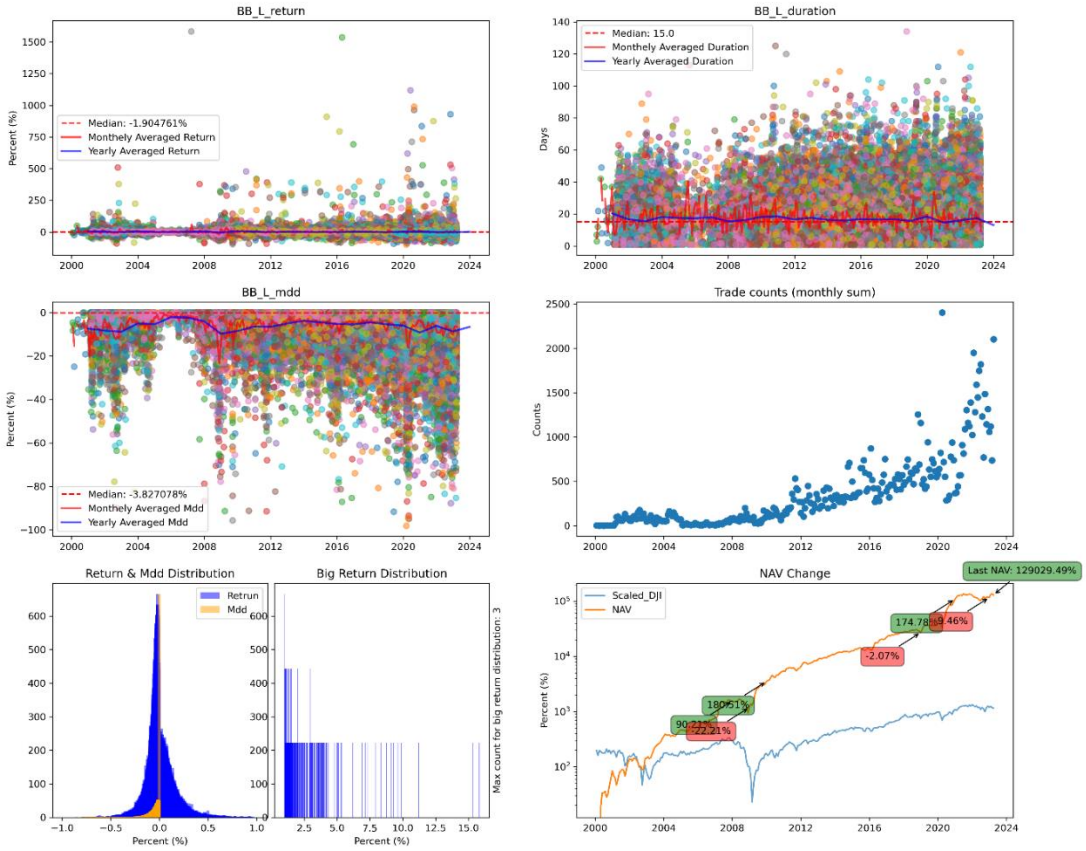

Figure 3.2 Best-performing indicators in the U.S. Stock Market (long position).

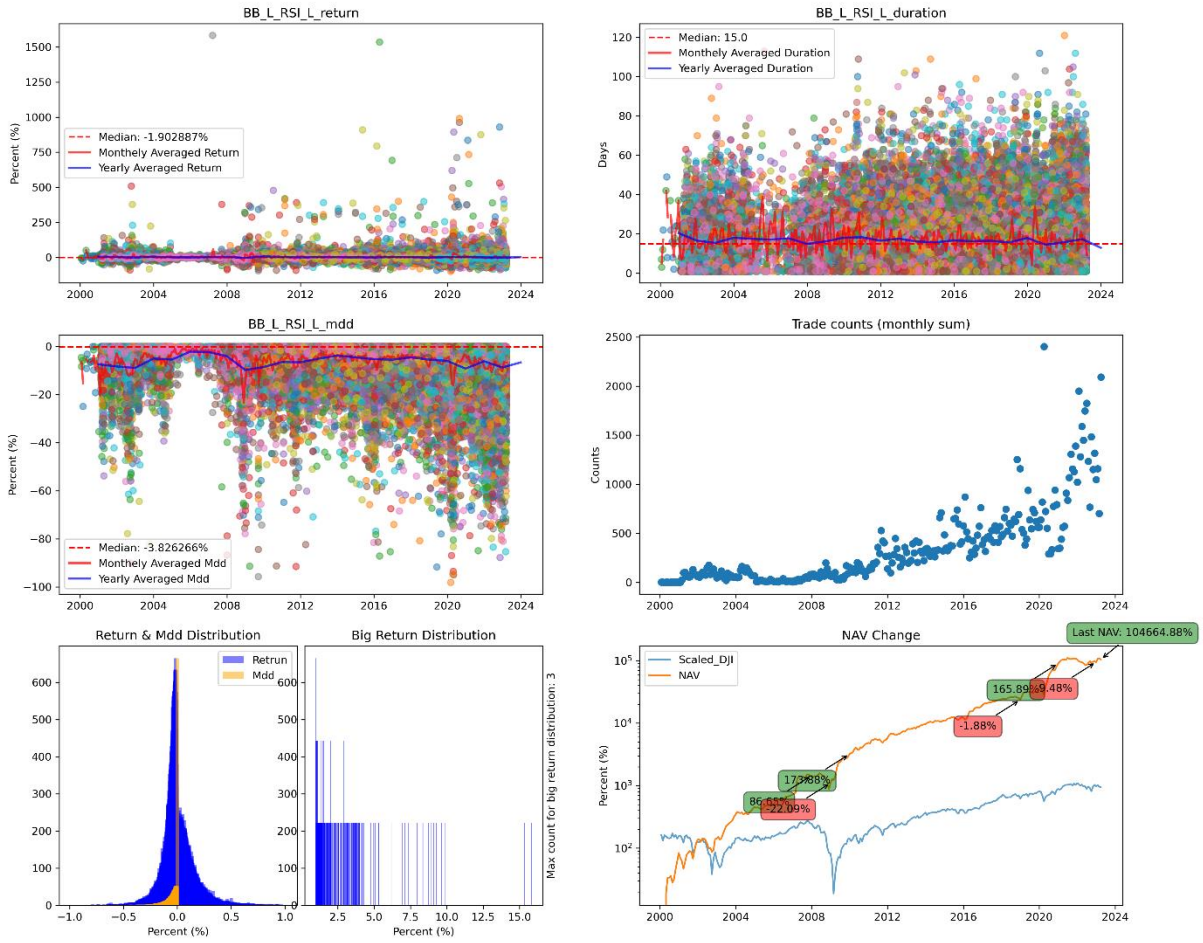

Figure 3.3 Second best-performing indicators in the U.S. Stock Market (long position).

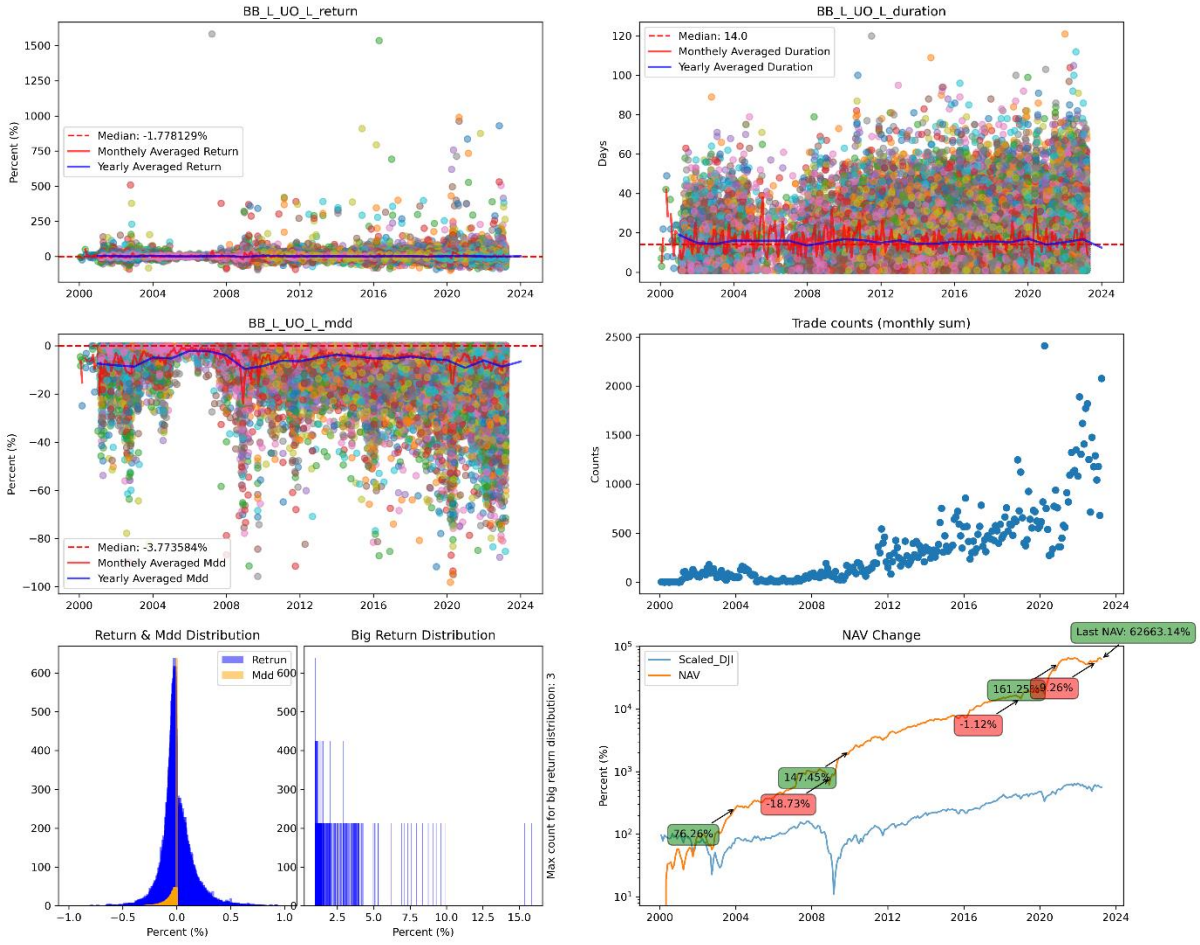

Figure 3.4 Third best-performing indicators in the U.S. Stock Market (long position).

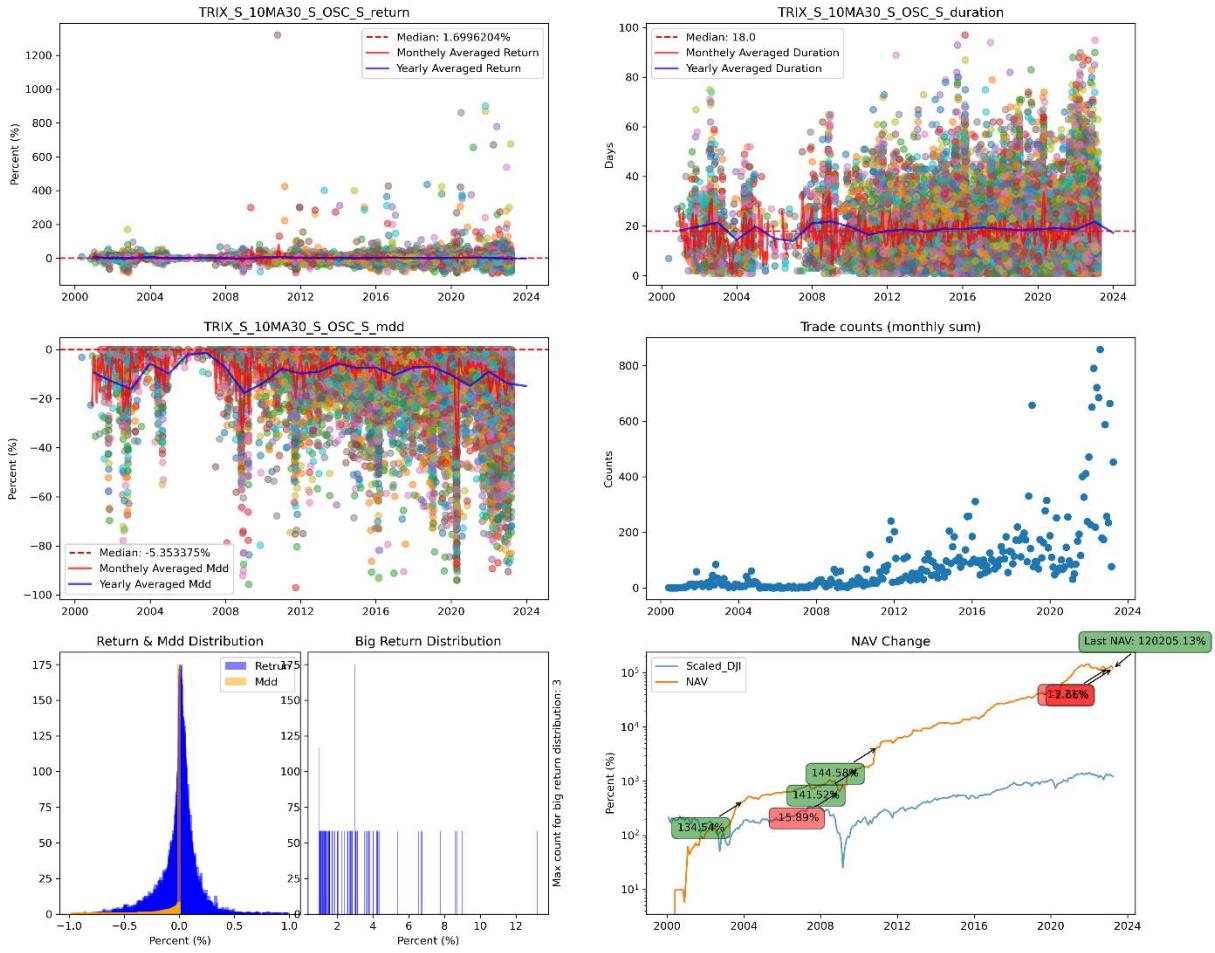

Figure 3.5 Best-performing indicators in the U.S. Stock Market (short position).

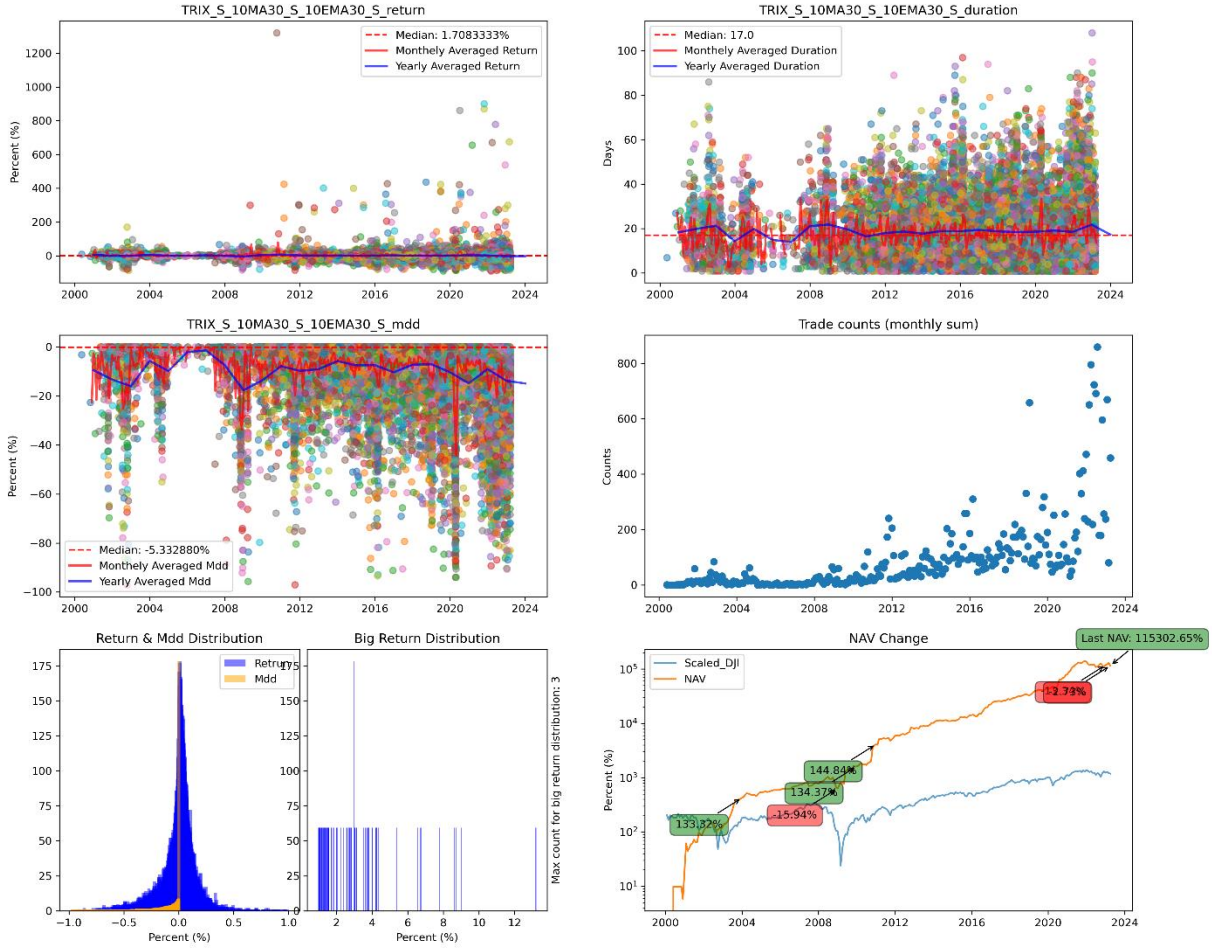

Figure 3.6 Second best-performing indicators in the U.S. Stock Market (short position).

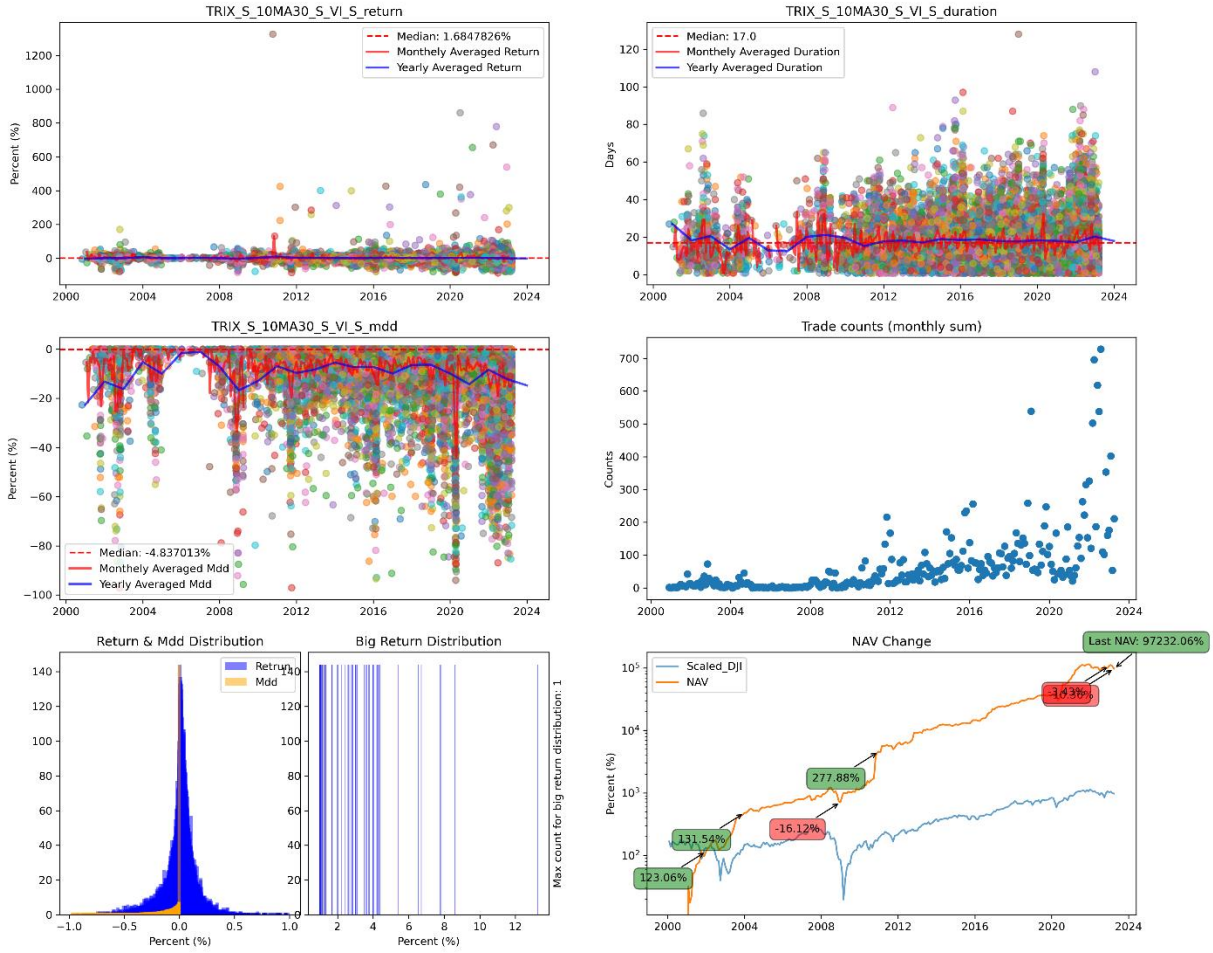

Figure 3.7 Third best-performing indicators in the U.S. Stock Market (short position).

4 Indicator Applications in Deep Learning

In recent years, with the development of deep learning models, more and more studies have been applied to the stock market. We have used LSTM and GRU models for price prediction, achieving good results.

We first used 94 types of indicators and 57 candlestick patterns, and used PCA to reduce the dimensions of indicators to 8. Candlestick patterns were divided into 5 categories based on bullish or bearish trends for separate analysis. Finally, we combined these with date, open, high, low, close, and volume to obtain 19 feature dimensions. We then used the GRU model to predict the daily lowest price of stocks, with an accuracy of about 97.5%. This model can serve as a risk indicator, and daily traders can use the predicted lowest price and the previous day's closing price to assess the potential risk of a stock.

We further experimented with using the indicators that performed well in this paper for prediction. The performance was close to using all indicators, with MSE and Accuracy similar to those obtained by combining 150 features. Specifically, we used Date, Open, High, Low, Close, Volume, and Bollinger Bands (BB) as features.

Then, we tried removing auxiliary features and solely used Date, Open, High, Low, and Close for prediction. The performance was also very good. Thus, for deep learning, basic features such as price trends and trading volume are completely sufficient, which is also in line with the Dow Theory (Schannep, 2012). Higher accuracy might require the integration of real-time news sentiment analysis and company fundamental text analysis.

The accuracies of the three models are listed in Table 4.1.

OHLC indicates open, high, low, close price.

All_features, single_Indicator, No_Indicator indicates different deep learning model inputs.

ARR is a randomly selected stock, outside of the training, validation, and test sets.

Features				Train MSE		Val MSE		Test MSE	Early Stop	Total Paras	MSE on ARR	Acc on ARR
				Final	Lowest	Final	Lowest					
All_features	Date, OHLC, VOL	8 PCA Indicators	5 CDL Patterns	2.28E-04	2.11E-04	2.34E-04	2.16E-04	2.72E-04	45/100	54,463	1.52E-04	97.68%
Single_Indicator	Date, OHLC, VOL	1 Indicator BB	Nan	2.11E-04	2.11E-04	2.15E-04	2.15E-04	2.62E-04	100/100	50,353	1.52E-04	97.72%
No_Indicator	Date, OHLC, VOL	Nan	Nan	2.09E-04	2.09E-04	2.14E-04	2.14E-04	2.59E-04	100/100	47,053	1.50E-04	97.71%

Table 4.1 Comparison of accuracy between different models.

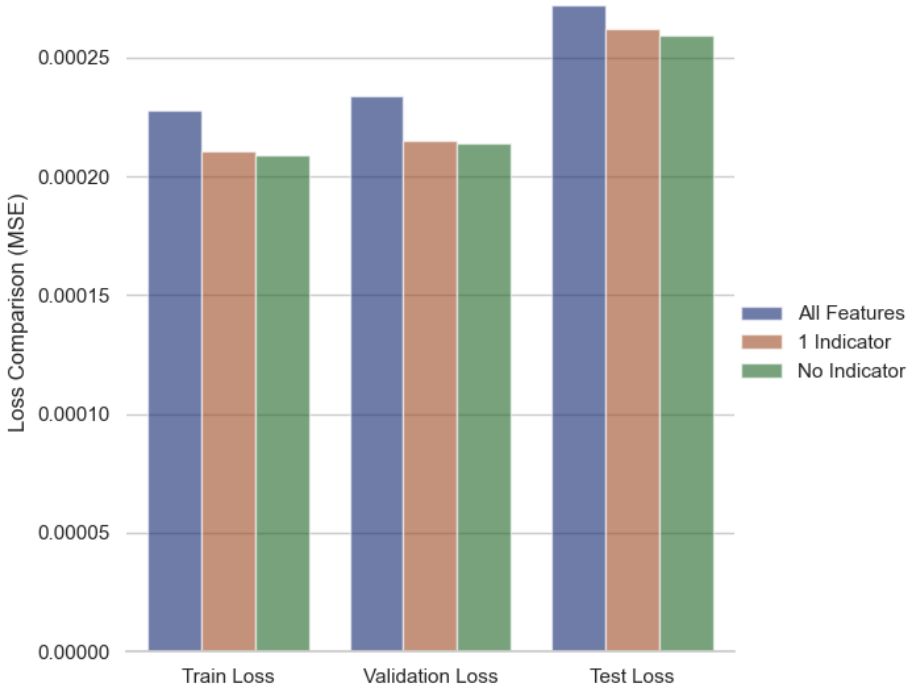

Figure 4.1 Comparison of accuracy between different models.

The differences between the three models lie only in the different inputs, and the corresponding GRU structures are removed after the input. The rest of the neural network structures are the same.

For the data preprocessing part, the inputs of different groups were normalized (minmaxscalar) and then fed into their respective GRU networks, with a time length of 60 trading days. The neural network part, most parameters and structures are shown in Figure 4.1. Other detailed parameters are in Table 4.2.

activation_function	GRU: tanh	Dense: relu			
optimizer	adam: lr = 0.01				
reduce_lr	monitor: val_loss	factor: 0.2	patience: 10	min_lr: 0.00001	verbose: 1
early_stop	monitor: val_loss	patience: 20	verbose: 1		
loss_function	mse				
batch_size	100				
epoch	100				

Table 4.2 Specific parameters of the deep learning model.

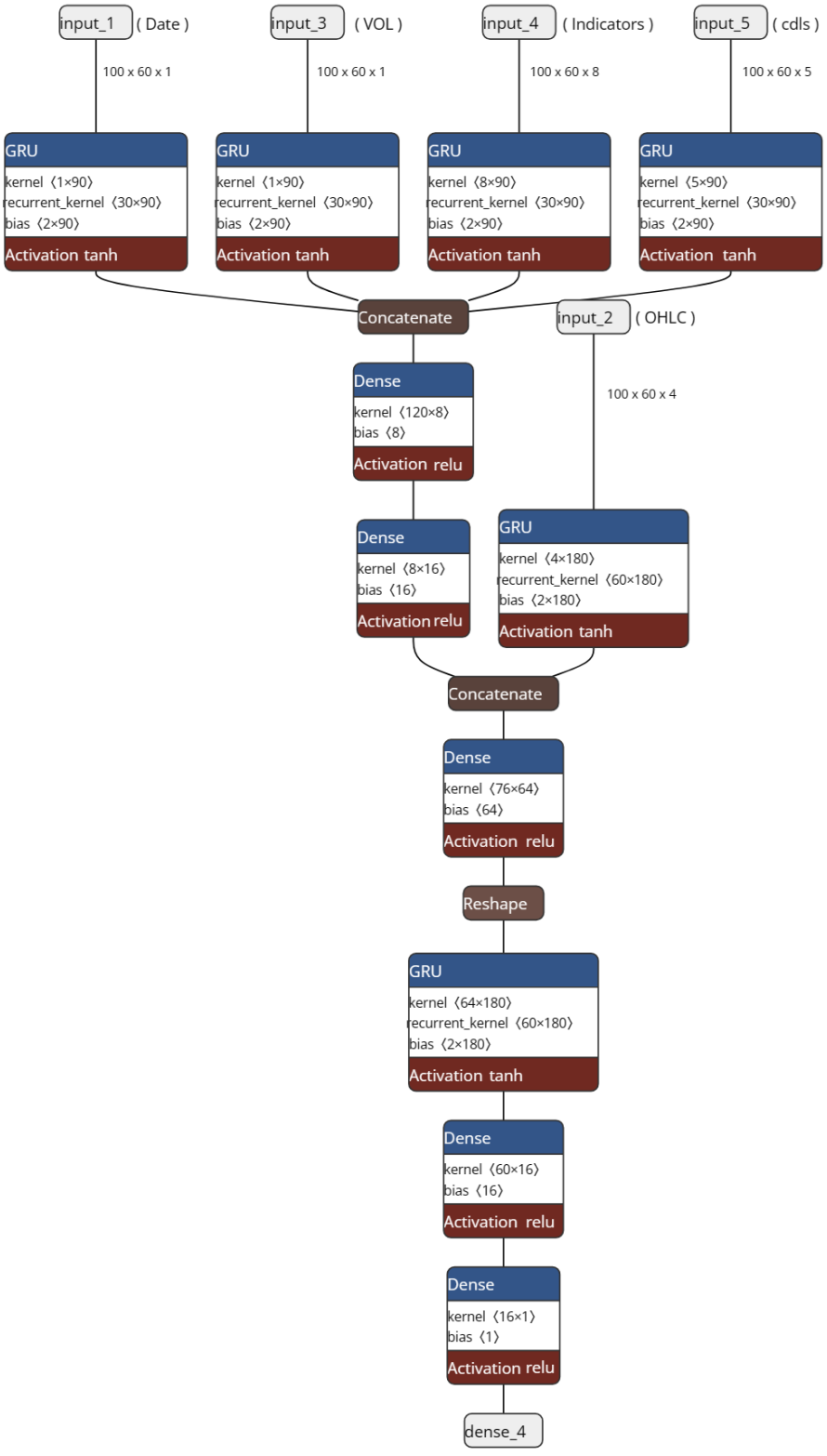
input_1
(Date)
input_3
(VOL)
input_4
(Indicators)
input_5
(cdls)
100 x 60 x 1
100 x 60 x 1
100 x 60 x 8
100 x 60 x 5
GRU
kernel ⟨1×90⟩
recurrent_kernel ⟨30×90⟩
bias ⟨2×90⟩
Activation tanh
GRU
kernel ⟨1×90⟩
recurrent_kernel ⟨30×90⟩
bias ⟨2×90⟩
Activation tanh
GRU
kernel ⟨8×90⟩
recurrent_kernel ⟨30×90⟩
bias ⟨2×90⟩
Activation tanh
GRU
kernel ⟨5×90⟩
recurrent_kernel ⟨30×90⟩
bias ⟨2×90⟩
Activation tanh
Concatenate
input_2
(OHLC)
100 x 60 x 4
Dense
kernel ⟨120×8⟩
bias ⟨8⟩
Activation relu
Dense
kernel ⟨8×16⟩
bias ⟨16⟩
Activation relu
GRU
kernel ⟨4×180⟩
recurrent_kernel ⟨60×180⟩
bias ⟨2×180⟩
Activation tanh
Concatenate
Dense
kernel ⟨76×64⟩
bias ⟨64⟩
Activation relu
Reshape
GRU
kernel ⟨64×180⟩
recurrent_kernel ⟨60×180⟩
bias ⟨2×180⟩
Activation tanh
Dense
kernel ⟨60×16⟩
bias ⟨16⟩
Activation relu
Dense
kernel ⟨16×1⟩
bias ⟨1⟩
Activation relu
dense_4

Figure 4.2 Neural Network Structure.

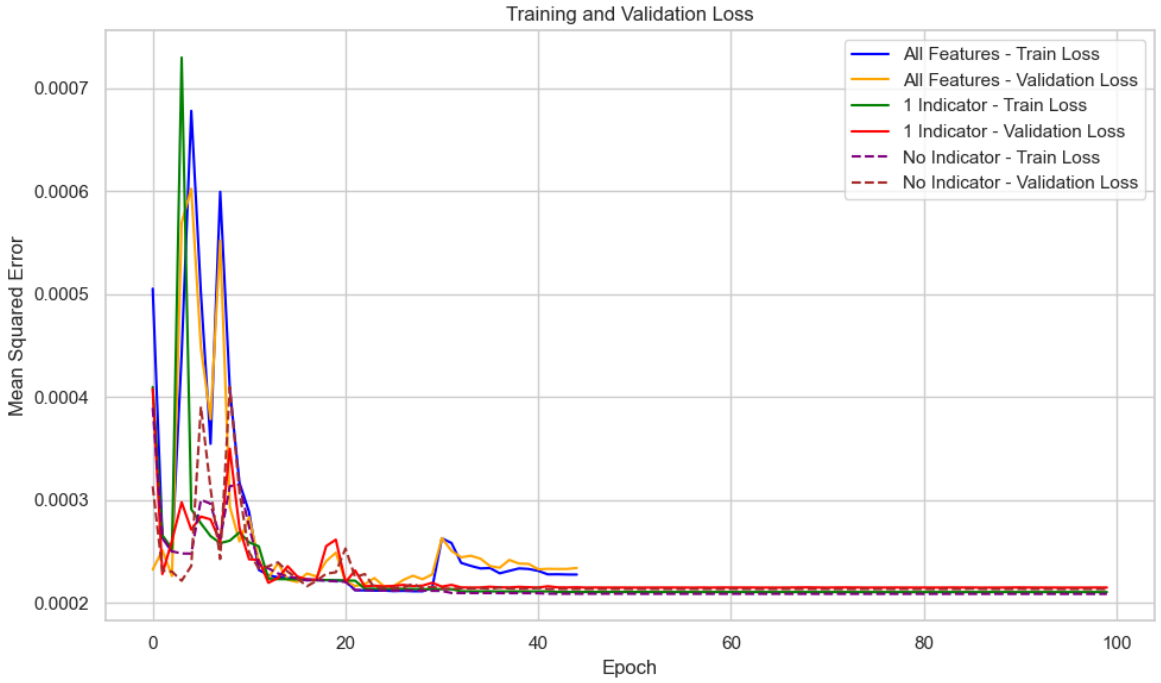

Figure 4.3 Loss Comparison.

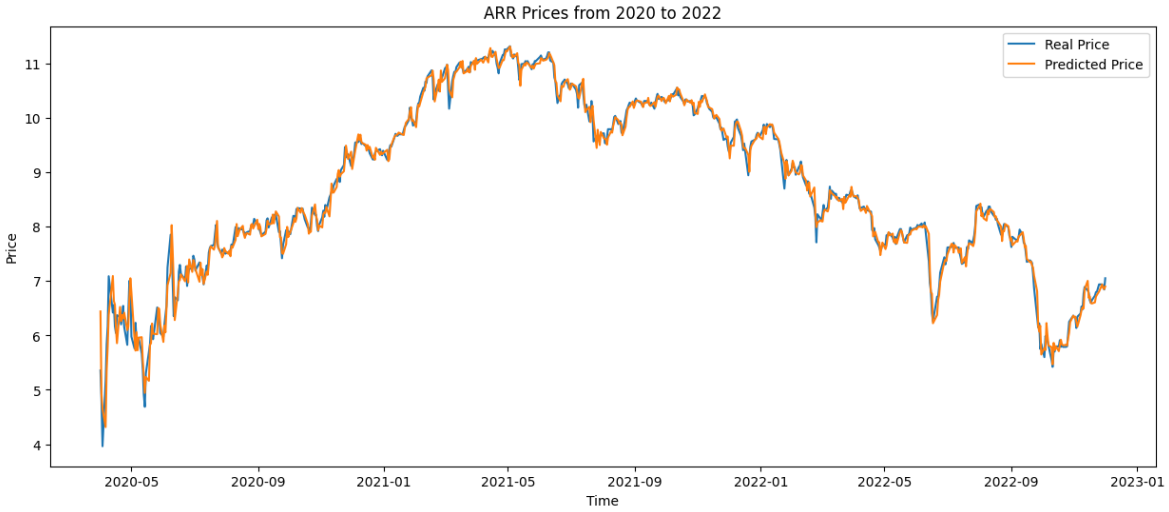

Figure 4.4 Stock Price (Daily Low Price) Prediction Results Based on the No_Indicator Model.

5 Discussion

Although some stock indicators show promising backtesting results, stock trading, especially short-term trading, remains highly risky for beginners. If you are completely unfamiliar with the stock market, you should be cautious about investing a large amount of money.

Readers can also choose specific indicators based on their preferences from those presented in Section 3, and then combine them with stop-loss strategies, capital allocation, and hedging strategies to build more complex trading models. For instance, the famous Turtle Trading System (Covel, 2007) achieved notable results by combining the MA indicator with stop-loss and other technical analysis techniques.

Initially, our deep learning models were only tested using all indicators, and the results were quite optimistic, aligning with most findings in research papers. However, when we reduced the number of features, we found that the results were still very good. Although we did not comprehensively search for the performance of all indicator combinations with OCHL and VOL in deep learning models, mainly due to the computational requirements exceeding our equipment's capacity, our limited experiments suggest that from a technical perspective, OCHL combined with VOL seems to already provide sufficient accuracy. Further improvement in accuracy might require sentiment analysis of current news, specific company fundamental text analysis, industry analysis, and market fundamental analysis to achieve higher accuracy.

6 Conclusion

The Bollinger Bands (BB) indicator performs very well in the long position and can achieve a good rate of return when combined with many indicators, such as the commonly used RSI. However, the BB indicator is highly volatile and does not perform well in short positions. When combined with certain indicators, such as the MACD, it can even be among the worst performers. Therefore, careful selection of combinations is needed when constructing a trading system. In the short position, the TRIX indicator shows good performance.

The ADX indicator, when used as an auxiliary indicator, often yields results akin to those produced by the standalone CROSS indicator. Hence, the ADX indicator is excluded when comparing auxiliary indicators.

For deep learning models, indicators are not very helpful. Basic information such as price and volume can achieve good results. If better results are needed, it is necessary to combine news sentiment, company fundamentals, and industry fundamentals to achieve this.

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8 Appendix 1

In the subsequent indicators:

- "C" represents for the closing price,
- "O" represents the opening price,
- "H" represents the high price,
- "L" represents the low price,
- "VOL" represents the trading volume,
- "n" represents the period,
- "t-1" represents the previous day's price,
- "k" represents other adjustable independent variables, and
- "(2)" implies that there are two ways to utilize this indicator.

ADI:

$$MFM = (C - L)/(H - \boldsymbol{C})/(\boldsymbol{H} - \boldsymbol{L})$$
$$MFV = MFM * VOL$$
$$AD = AD_{t-1} + MFV$$

- CROSS: Not applicable.
- AUX: Long positions may be opened, or short positions may be closed when the ADI is greater than zero. Conversely, when the ADI is less than zero, short positions may be opened, or long positions may be closed.

ADX: n=14

$$TR = \max[(H - L), abs(H - C_{t-1}), abs(L - C_{t-1})]$$
$$+DI = 100 * (H - H_{t-1})/TR$$
$$-DI = 100 * (L_{t-1} - L)/TR$$
$$DX = 100 * abs(+DI + -DI)/(+DI - -DI)$$
$$ADX = ADX_{n-1} * (n - 1) + DX/n$$

- CROSS: Not applicable.
- AUX: Long or short positions can be initiated when the ADX exceeds 25.

BB: n=20, k=2

$$MB = MA(C, n)$$
$$STD = sqrt(sum(pow(C - MB, 2), n)/n)$$
$$Upper = MB + k * STD$$
$$Lower = MB - k * STD$$

- CROSS: For long positions, the buying point occurs when the price crosses above the lower boundary, and the selling point arises when the price crosses below the lower boundary or above the upper boundary. For short positions, the buying point is when the price crosses below the upper boundary, and the selling point is when the price crosses above the upper boundary or below the lower boundary.
- AUX: Long positions can be initiated, or short positions should be closed when the stock price is below the lower boundary. Conversely, short positions can be initiated, or long positions should be closed when the stock price is above the upper boundary.

CCI: n=20

$$TP = (H + L + C)/3$$
$$MA = MA(TP, n)$$
$$MD = sum(abs(TP - MA), n)/n$$
$$CCI = (TP - MA)/(0.0015 * MD)$$

- CROSS: Not applicable.

- AUX: Long positions can be initiated, or short positions should be closed when the CCI value falls below -100. Conversely, short positions can be initiated, or long positions should be closed when the CCI value exceeds 100.

DEMA: n=10, n=20

$$EMA1 = EMA(C, n)$$
$$EMA2 = EMA(EMA(C, n), n)$$
$$DEMA = 2 * EMA1 - EMA2$$

- CROSS (2): For long positions, the buying point is when the stock price crosses above the DEMA for a specified period (10), and the selling point is when the stock price crosses below the DEMA for the same period (10). For short positions, the opposite applies.
- AUX: Long positions can be initiated, or short positions should be closed when the stock price is above the DEMA for a certain period. Conversely, short positions can be initiated, or long positions should be closed when the stock price is below the DEMA for a certain time period.

DPO: n=10

$$N = (n + 1)/2$$
$$DPO = C - MA(C, N)$$

- CROSS: Not applicable.
- AUX: Long positions can be initiated, or short positions should be closed when the DPO value is greater than zero. Conversely, short positions can be initiated, or long positions should be closed when the DPO value is less than zero.

EMA: n=5, n=10, n=30

$$EMA(n) = (2 \times (C - EMA(n - 1)))/(n + 1) + EMA(n - 1)$$

- CROSS (2): For long positions, the buying point is when the short-term EMA crosses above the long-term EMA, and the selling point is when the short-term EMA crosses below the long-term EMA. The opposite applies for short positions. Indicators with adjacent time periods are paired together. For instance, in the EMA, a buying point occurs when the 5-day EMA crosses above the 10-day EMA, and a selling point occurs when the 5-day EMA crosses below the 10-day EMA. A buying point also occurs when the 10-day EMA crosses above the 30-day EMA, and a selling point occurs when the 10-day EMA crosses below the 30-day EMA.
- MA-like: The buying and selling points for MA-like indicators are often the same. In subsequent scenarios, the buying and selling points for MA-like indicators will be abbreviated as "MA-like buying and selling points".
- AUX: Long positions can be initiated, or short positions should be closed when the 10-day EMA is greater than the 30-day EMA. Conversely, short positions can be initiated, or long positions should be closed when the 10-day EMA is less than the 30-day EMA.

EMV: n=9

$$EMV = ((H + L)/2 - (H_{t-1} + L_{t-1})/2)/(V/10000 * (H - L))$$
$$EMV_{MA} = MA(EMV, n)$$

- CROSS: For long positions, the buying point occurs when the EMV crosses above the EMV_{MA}, and the selling point occurs when the EMV crosses below the EMV_{MA}. For short positions, the conditions are reversed.
- AUX: Long positions can be initiated, or short positions should be closed when the EMV is greater than 0. Conversely, short positions can be initiated, or long positions should be closed when the EMV is less than 0.

KC: n=20

$$TR = \max[(H - L), abs(H - C_{t-1}), abs(L - C_{t-1})]$$
$$ATR = MA(TR, n)$$
$$MA_n = MA(C, n)$$
$$Upper = MA_n + K * ATR$$
$$Lower = MA_n - k * ATR$$

- CROSS: The buying point for long positions occurs when the price crosses above the lower boundary, and the selling point occurs when the price crosses below the lower boundary or above the upper boundary. Conversely, for short positions, the buying point is when the price crosses below the upper boundary, and the selling point occurs when the price crosses above the upper boundary or below the lower boundary. This is similar to the Bollinger Bands method (refer to BB).
- AUX: Long positions can be opened, or short positions should be closed when the stock price is below the lower boundary. Conversely, short positions can be opened, or long positions should be closed when the stock price is above the upper boundary. This method also resembles the Bollinger Bands strategy.

KDJ: n=9

$$RSV = (C - \min(L, 9))/(\max(H, 9) - \min(L, 9)) \times 100$$
$$K_{t+1} = 2/3 \times K_t + 1/3 \times RSV$$
$$D_{t+1} = 2/3 \times D_t + 1/3 \times K_{t+1}$$
$$J = 3 * K - 2 * D$$

- CROSS: The selling point for a long position is established when the K line crosses above the D line, while the buying point is determined when the K line crosses below the D line. For short positions, the strategy is simply the opposite.
- AUX: Long positions can be opened, or short positions should be closed when the J line is less than 20. Conversely, short positions can be opened, or long positions should be closed when the J line is greater than 80.

MA: n=5, n=10, n=30

$$MA(n) = \frac{1}{n}\sum_{1}^{n} C_n$$

- CROSS (2): Refer to EMA for MA-like buying and selling points.
- AUX: Long positions can be opened, or short positions should be closed when the 10MA is greater than the 30MA. Conversely, short positions can be opened, or long positions should be closed when the 10MA is less than the 30MA.

MACD:

$$DIF(9) = EMA(12) - EMA(26)$$
$$DEA(9) = 8/10 \times DEA(9 - 1) + 2/10 \times DIF(9)$$

- CROSS: For a long position, the buying point is when the DIF crosses above the DEA, and the selling point is when the DIF crosses below the DEA. For a short position, the rules are reversed.
- AUX: Long positions can be opened, or short positions should be closed when the 10MA is greater than the 30MA. Conversely, short positions can be opened, or long positions should be closed when the 10MA is less than the 30MA.

MAE: k=3

$$Upper = MA_{20} + MA_{20} * k/100$$
$$Lower = MA_{20} - MA_{20} * k/100$$

- CROSS: Not applicable.
- AUX: When the stock price falls below the lower envelope of the MAE, it's suitable to enter a long position or necessary to close a short position. Conversely, when the

stock price rises above the upper envelope of the MAE, one can either enter a short position or must close a long position.

MFI: n_1=14, n_2=9

$$TP = (H + L + C)/3$$

$$Positive\ Money\ Flow = \sum_{0}^{n_1} TP * VOL \quad (if\ VOL > VOL_{t-1})$$

$$Negative\ Money\ Flow = \sum_{0}^{n_1} TP * VOL \quad (if\ VOL < VOL_{t-1})$$

$$Money\ Ratio = Positive\ Money\ Flow / Negative\ Money\ Flow$$

$$MFI = 100 - 100/(1 + Money\ Ratio)$$

$$MFI_{MA} = MA(MFI, n_2)$$

- CROSS: For a long position, the buying point is when the MFI crosses above the MFI_{MA}, and the selling point is when the MFI crosses below the MFI_{MA}. For a short position, the rules are reversed.
- AUX: When the MFI value is less than 20, it's suitable to open a long position or necessary to close a short position. Conversely, when the MFI value is greater than 80, one can either open a short position or must close a long position.

MOM: n(t) = 14

$$MOM = C - C_{t-14}$$

- CROSS: Not applicable.
- AUX: Long positions can be opened, or short positions should be closed when the MOM value is greater than 0. Conversely, short positions can be opened, or long positions should be closed when the MOM value is less than 0.

OBV:

$$OBV = OBV_{t-1} + VOL$$

- CROSS: Not applicable.
- AUX: When the OBV value is greater than 0, it's suitable to take long positions or necessary to close short positions. Conversely, when the OBV value is less than 0, one can either take short positions or must close long positions.

OSC: n_s=12, n_l=26

$$EMA_s = EMA(C, n_s)$$

$$EMA_l = EMA(C, n_l)$$

$$OSC = EMA_s - EMA_l$$

- CROSS: Not applicable.
- AUX: Long positions can be opened, or short positions should be closed when the OSC value is greater than 0. Conversely, short positions can be opened, or long positions should be closed when the OSC value is less than 0.

PSAR: $AF_{increment}$=0.02, AF_{max}=0.2

$$AF = AF_{t-1} + AF_{increment} \quad (if\ AF_{t-1} < AF_{max})$$

$$AF = AF_{max} \quad (if\ AF_{t-1} = AF_{max})$$

$$AF = 0 \quad (if\ trend\ changes)$$

$$EP = \max(H, trend_{up}) \quad (if\ current\ trend\ is\ up)$$

$$EP = \min(L, trend_{down}) \quad (if\ current\ trend\ is\ down)$$

$$PSAR = PSAR_{t-1} + AF * (EP - PSAR_{t-1})$$

- CROSS: Not applicable.

- AUX: Long positions can be opened, or short positions should be closed when the price is above the PSAR value. Conversely, short positions can be opened, or long positions should be closed when the price is below the PSAR value.
- AF: When the trend reverses, the AF value is reset to zero, and the calculation starts anew.
- EP: If the current trend is an uptrend, the EP value is the maximum value of that trend. If the current trend is a downtrend, the EP value is the minimum value of that trend.
- Trend: If the price continues to stay above the PSAR value, it can be considered that the uptrend is continuing. Conversely, if the price crosses below the PSAR value, it can be considered that the trend is starting to reverse. Similarly, if the price continues to stay below the PSAR value, it can be considered that the downtrend is continuing. On the other hand, if the price crosses above the PSAR value, it can be considered that the downtrend is reversing. Monitoring these price interactions with the PSAR value can provide insights into the ongoing uptrend or downtrend, as well as potential reversals, helping traders make informed decisions about entry and exit points.

REX: n_s=2, n_l=10

$$EMA_s = EMA(C, n_s)$$
$$EMA_l = EMA(C, n_l)$$
$$REX = (EMA_s - EMA_l)/EMA_l$$

- CROSS: For a long position, the buying point is when the REX value crosses above the zero line, and the selling point is when the REX value crosses below the zero line. The approach is reversed for a short position, where selling occurs when the REX value crosses above the zero line, and buying occurs when the REX value crosses below the zero line.
- AUX: Long positions can be opened, or short positions should be closed when the REX value is greater than 0. Conversely, short positions can be opened, or long positions should be closed when the REX value is less than 0.

RMA: n=10, n=30

$$RMA = ((n-1) * RMA_{t-1} + C)/n$$

- CROSS: MA-like buy and sell point. See EMA.
- AUX: Long positions can be opened, or short positions should be closed when the 10RMA is greater than the 30RMA. Conversely, short positions can be opened, or long positions should be closed when the 10RMA is less than the 30RMA.

RSI: n=14

$$AG = \sum_{0}^{n} (C - C_{t-1}) \quad if\ (C > C_{t-1})$$
$$AL = \sum_{0}^{n} (C - C_{t-1}) \quad if\ (C < C_{t-1})$$
$$RS = AG/AL$$
$$RSI = 100 - 100/(1 + RS)$$

- CROSS: Not applicable.
- AUX: Long positions can be opened, or short positions should be closed when the RSI value is less than 30. Conversely, short positions can be opened, or long positions should be closed when the RSI value is greater than 70.

TEMA: n=10, n=20, n=30

$$EMA_1 = EMA(C, n)$$
$$EMA_2 = EMA(EMA_1, n)$$
$$EMA_3 = EMA(EMA_2, n)$$
$$TEMA = 3 * EMA_1 - 3 * EMA_2 + EMA_3$$

- CROSS: MA-like buy and sell point. See EMA.
- AUX: Long positions can be opened, or short positions should be closed when the 10TEMA is greater than the 30TEMA. Conversely, short positions can be opened, or long positions should be closed when the 10TEMA is less than the 30TEMA.

TRIX: n=12, n=24

$$EMA_1 = EMA(C, n)$$
$$EMA_2 = EMA(EMA_1, n)$$
$$EMA_3 = EMA(EMA_2, n)$$
$$TRIX = (EMA_3 - EMA_{3_{t-1}})/EMA_{3_{t-1}} * 100$$

- CROSS: MA-like buy and sell point. See EMA.
- AUX: Long positions can be opened, or short positions should be closed when the 12TRIX is greater than the 24TRIX. Conversely, short positions can be opened, or long positions should be closed when the 12TRIX is less than the 24TRIX.

UO: n_1=7, n_2=14, n_3=28, n_s=3, n_l=7

$$BP = C - \min(L, L_{t-1})$$
$$TR = \max(H, L_{t-1}) - \min(L, C_{t-1})$$
$$AVG_{n_1} = sum(BP, n_1)/sum(TR, n_1)$$
$$AVG_{n_2} = sum(BP, n_2)/sum(TR, n_2)$$
$$AVG_{n_3} = sum(BP, n_3)/sum(TR, n_3)$$
$$UO = 100 * (4 * AVG_{n_1} + 2 * AVG_{n_2} + AVG_{n_3})/(4 + 2 + 1)$$
$$UO_s = MA(UO, n_s)$$
$$UO_l = MA(UO, n_l)$$

- CROSS: For a long position, the buying point is when UO_s crosses above UO_l, and the selling point is when UO_s crosses below UO_l. The approach is reversed for a short position, where selling occurs when UO_s crosses above UO_l, and buying occurs when UOs crosses below UO_l.
- AUX: Long positions can be opened, or short positions should be closed when the UO value is less than 30. Conversely, short positions can be opened, or long positions should be closed when the UO value is greater than 70.

VI: n=14

$$TR = \max(H, L_{t-1}) - \min(L, C_{t-1})$$
$$PD = H - L_{t-1}$$
$$VM+= MA(PD, n)/MA(TR, n)$$
$$ND = H_{t-1} - L$$
$$VM-= MA(ND, n)/MA(TR, n)$$
$$VI+= MA(VM+, n)$$
$$VI-= MA(VM-, n)$$
$$VI = abs(VI + -VI -)/(VI + +VI-)$$

- CROSS: For a long position, the buying point is when VI+ crosses above VI-, and the selling point is when VI+ crosses below VI-. The approach is reversed for a short position, where selling occurs when VI+ crosses above VI- and buying occurs when VI+ crosses below VI-.

- AUX: Long positions can be opened, or short positions should be closed when the VI+ value is greater than the VI- value. Conversely, short positions can be opened, or long positions should be closed when the VI+ value is less than the VI- value.

W%R: n=14

$$W\%R = (\max(H, n) - C)/(\max(H, n) - \min(L, n)) * (-100)$$

- CROSS: Not applicable.
- AUX: Long positions can be opened, or short positions should be closed when the W%R value is less than -80. Conversely, short positions can be opened, or long positions should be closed when the W%R value is greater than -20.

9 Appendix 2

Abbreviations related to indicators:

- CROSS: represents indicators that can be used independently.
  - Details on Section 2.2.
  - Used in Table 1.1; Table 1.2; Appendix 1.
- AUX: represents auxiliary indicators, cannot be used independently.
  - Details on Section 2.2.
  - Used in Table 1.1; Table 1.2; Appendix 1.
- Indicator_L: represents indicators used for long position.
  - Details on Section 2.2.
  - Used in all Tables.
- Indicator_S: represents indicators used for short position.
  - Details on Section 2.2.
  - Used in all Tables.
- Double indicators: An indicator that combines one CROSS indicator with 1 AUX indicator.
  - Details on Section 2.3.
  - Example: CROSS_L_AUX_L; CROSS_S_AUX_S
  - Used in Table 1.3; Table 1.4; Table 2.1; Table 3.2; Figure 3.3; Figure 3.4.
- Triple indicators: An indicator that combines one CROSS indicator with 2 AUX indicator.
  - Details on Section 2.5.
  - Example: CROSS_L_AUX1_L_AUX2_L; CROSS_S_AUX1_S_AUX2_S
  - Used in Table 1.5; Table 2.2; Table 3.3; Figure 3.5; Figure 3.6; Figure 3.7.

Abbreviations in Statistical Tables:

- 0+m: represents the number of months with positive average returns, same as the red triangles in Figure 2.3.
- RAR: is the ratio of months with positive average returns to months with negative average returns.
- 0+_cnt: refers to the number of trades with positive returns out of all trades made.
- all_cnt: is the total number of all trades made.
- PRT: is the ratio of 0+_cnt to all_cnt.
- med: indicates the median profit of all trades made.
- mdd: is the median maximum drawdown at the time of stop-loss or earlier for all trades.
- MAR: is the ratio of med to mdd.
- std: represents the standard deviation of all trades made.
- dur: is the median duration of holding time for all trades.
- TGR: denotes the total return rate over 22.29 years.
- Cagr: is the annual average return rate derived from TGR.
- The details and usage scenarios of the above abbreviations are the same.
  - Details on Section 2.6.
  - Used in Table 2.1; Table 2.2; Table 3.1; Table 3.2; Table 3.3.

Abbreviations in Figures:

- Buy_signal: indicates that the indicator gives a buy signal. (Green dots on Figures).
  - Used in Figure 2.1; Figure 2.2; Figure 2.4.
- Sell_signal: indicates that the indicator gives a sell signal. (Red dots on Figures).
  - Used in Figure 2.1; Figure 2.2; Figure 2.4.
- ExBP: indicates the buy signals discarded using double indicators comparing to using single indicators. (Blue)

  - Details on Section 2.3.
  - Used in Figure 2.2.
- ExBP 1->2: same as ExBP (Blue dots on Figures).
  - Details on Section 2.5.
  - Used in Figure 2.4.
- ExBP 2->3: buy signals discarded using triple indicators comparing to using double indicators. (Orange).
  - Details on Section 2.5.
  - Used in Figure 2.4.
- TGR: same as TGR used in Tables.
  - Used in Figure 2.3; Figure 3.1.
- Trade counts: the number of trades generated each month.
  - Details on Section 3.3.
  - Used in Figure 3.2 to Figure 3.7.
- Big Return Distribution: The number of individual trades with returns greater than 100%.
  - Details on Section 3.3.
  - Used in Figure 3.2 to Figure 3.7.
- NAV: Net Asset Value, with an initial value of 1.
  - Details on Section 3.3.
  - Used in Figure 3.2 to Figure 3.7.
- Scaled_DJI: The price of DJI after scaling.
  - Details on Section 3.3.
  - Used in Figure 3.2 to Figure 3.7.