

Algorithms for trading on online exchanges

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MOTIVATION

Automation has played a significant role in many domains and trading is no exception. A computer program that executes trades is known as **algorithmic trading**. Algorithmic trading is much better than manual trading in terms of speed and accuracy, which are very important aspects of profitable trading. The trading logic that decides when to buy and sell an asset is generally referred to as a **trading strategy**. Validating the performance of any predefined trading strategy on historical data plays a significant role in its live performance and is known as **backtesting**, which is a key feature of algorithmic trading.

The motivation for solving this problem is that **algorithmic trading offers many advantages** in addition to the ability to think the strategy ahead. A person as a trader is spared emotional involvement in the trade in real time, which is one of the main sources of burnout not only among beginning traders. Automated algorithms can perform **complex mathematics** in real time and make required decisions based on a defined strategy **without human intervention** and send trade orders for execution automatically from the computer to the exchange. A computer can trade **hundreds of problems simultaneously** using advanced algorithms with **layers of conditional rules**.

AIMS OF THE THESIS

Identify effective trading strategies based on selected technical indicators, namely Relative Strength Index (RSI), Commodity Channel Index (CCI), Money Flow Index (MFI), Bollinger Bands (BB), Simple Moving Average (SMA), Exponential Moving Average (EMA), Weighted Moving Average (WMA) and Hull Moving Average (HMA).

Design a trading robot which with using trading algorithms will be able to carry out trades on the exchange for the user.

Deal with samples of data obtained during backtesting of selected trading strategies.

Establishment of global null statistical hypotheses based on data exploration.

Hypothesis testing and **multiple comparisons**.

Report on the statistical and material results of the research.

METHODOLOGY

Data source

We decided to use **cryptocurrencies** as opposed to stocks or forex, as cryptocurrencies are a commodity that is traded non stop on various exchanges around the world and therefore, they do not have a regulator and are not subject to closing and opening markets.

Data collection

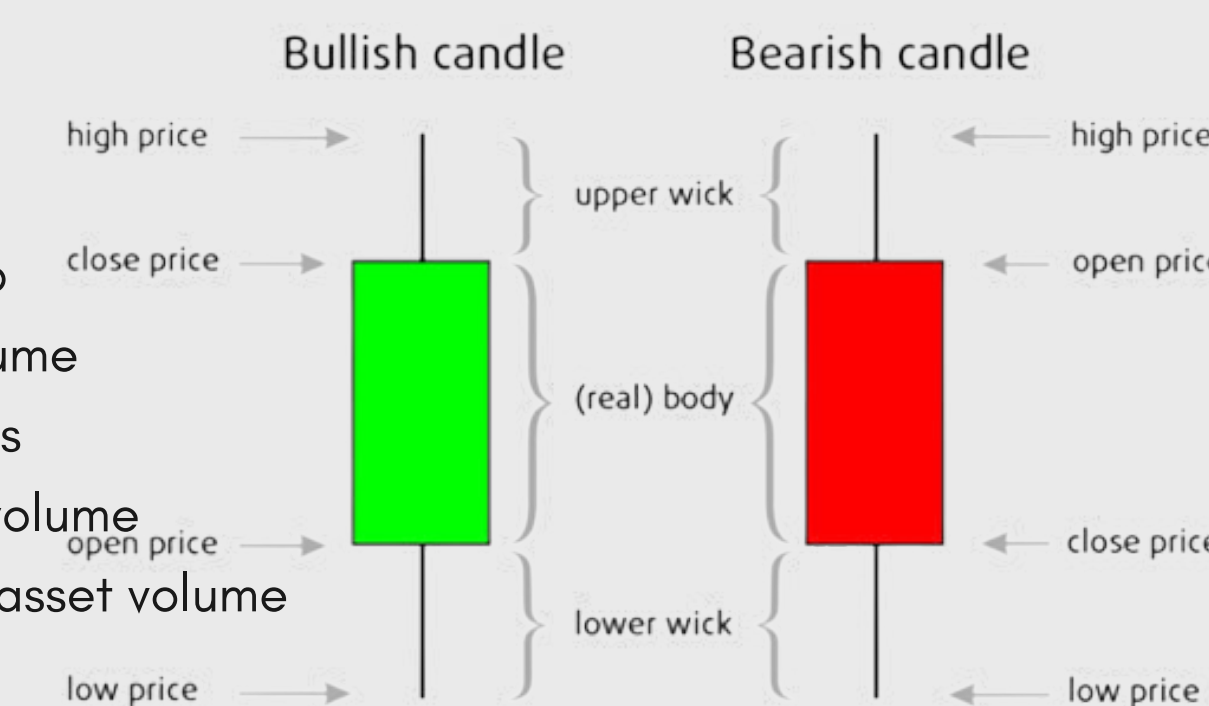
We obtained the data using an **API requests** for the selected exchange.

The logic of data collection, processing and analysis was programmed in scripts and can be seen in our trading robot model.

Data preview

Data after decoding into json format have the following form, which we can see on the left side and graphic visualization on the right side.

```
1607444700000, // Open timestamp
"18879.99", // Open
"18900.00", // High
"18878.98", // Low
"18896.13", // Close
"492.363", // Volume
1607444759999, // Close timestamp
"9302145.66080", // Quote asset volume
1874, // Number of trades
"385.983", // Taker buy asset volume
"7292402.33267", // Taker buy quote asset volume
"0" // Ignore
```



Technical indicators and trading strategies

Subsequently, when we had obtained the necessary data, we could start calculating **the values of the indicators**, which will serve as **conditions for opening trades** and therefore looking for opportunities on the crypto market.

It is also worth mentioning that all indicators were calculated **using original formulas** and **no libraries or extensions** were used in the scripts, mainly due to **the experimental approach** and the possibility of adjusting indicators according to needs.



Each indicator had conditions for buying and selling the asset (as shown in the figure above), but all indicators had **the same parameters**.

Backtesting

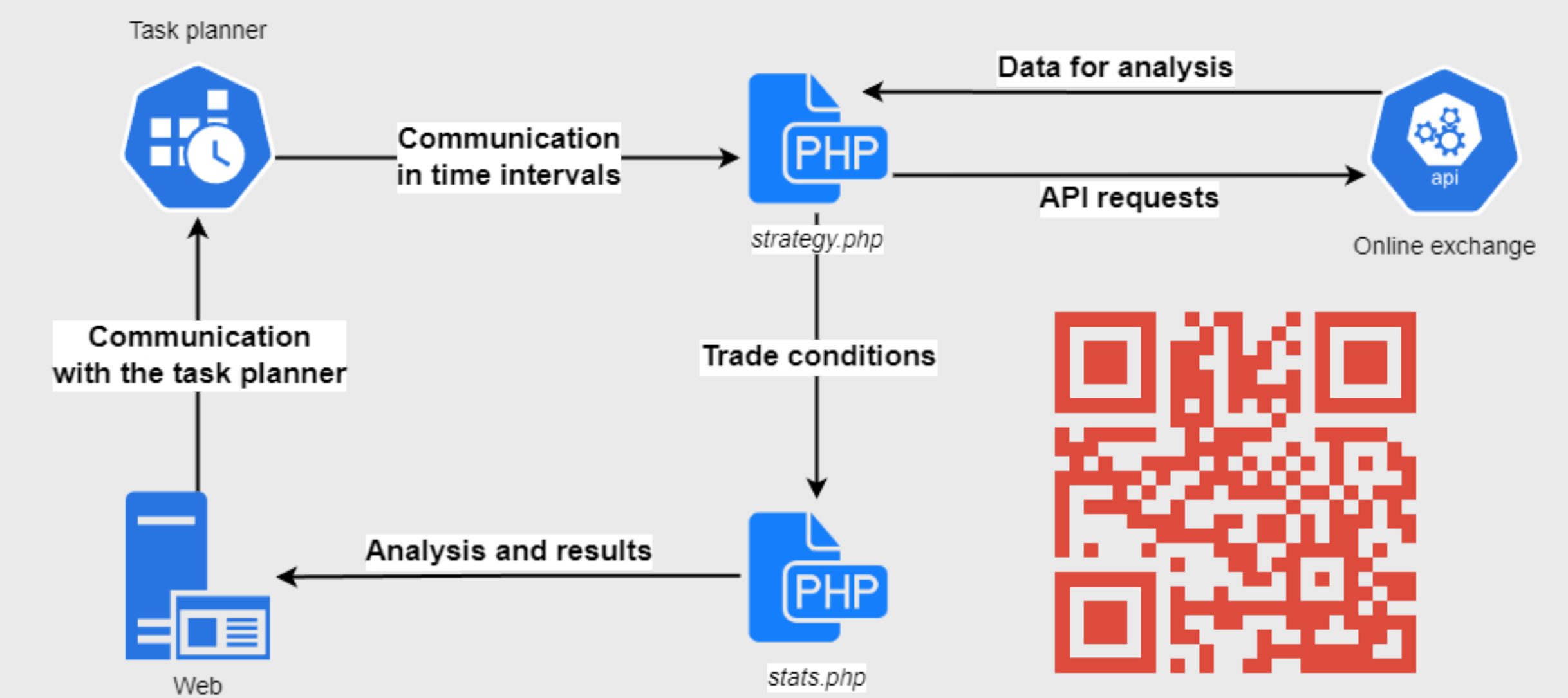
We have **one independent variable** and **six grouping variables** (risk to reward ratio, budget risk in %, timeframe, number of symbols, indicator length and buy and sell level), which represent our **input variables**.

All these variables are **nominal**, of which two are **polytomous** (strategy and buy/sell level) and the remaining five are **dichotomous**.

Technical indicator based strategy represented our independent variable, specifically we used the technical indicators mentioned in aims of the thesis.

Output variables are metrics for analysis backtesting performance, namely number of trades, number of winning trades, winratio, final capital, max and min achieved capital, return, drawdown, profit factor, RoMaD, average trade duration.

Trading bot model



ACHIEVED RESULTS

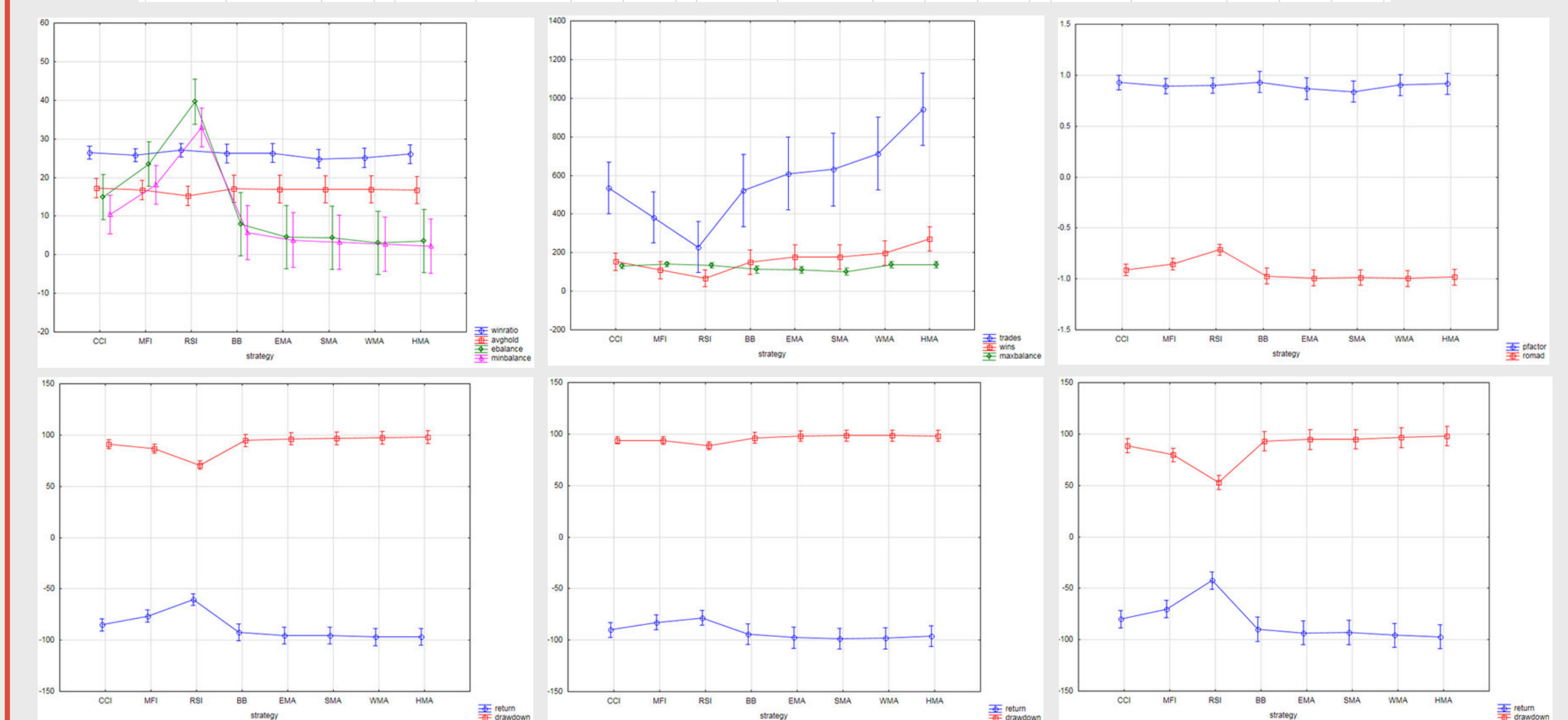
A total of 352 backtests evaluated 182,748 trades and stored the recorded data in the database, which we then used to test the results of our research. Our goal was to find **the best possible settings** for the indicator and the trade, and to confirm this by analyzing the results and evaluating the established hypotheses.

Simple analysis of variance of sorting:
Results of hypothesis testing

strategy	winratio	Mean	1	2	3	strategy	romad	Mean	1	2	3	strategy	trades	Mean	1	2	3	Variable	Test statistic	F	p-value
SMA	24.79312	****	WMA	-0.993750	****	RSI	229.1562	****	pfactor	0.473	0.8337	MFI	382.4063	****	****	****	****	romad	10.096	****	0.0000
WMA	25.11469	****	EMA	-0.989688	****	MFI	521.6875	****	avghold	0.2258	0.9790	BB	521.6875	****	****	****	trades	6.9515	****	0.0000	
MFI	25.76719	****	SMA	-0.985938	****	HMA	534.3125	****	****	****	****	CCI	609.4375	****	****	****	wins	4.9429	****	0.0000	
HMA	26.06812	****	HMA	-0.982500	****	BB	609.4375	****	****	****	****	EMA	630.9375	****	****	****	ebalance	15.4825	****	0.0000	
BB	26.22188	****	BB	-0.971875	****	EMA	713.7500	****	****	****	****	SMA	943.3125	****	****	****	maxbalance	2.868	****	0.0063	
EMA	26.36219	****	CCI	-0.912344	****	MFI	-0.853906	****	****	****	****	WMA		****	****	****	minbalance	14.6553	****	0.0000	
CCI	26.45891	****	MFI	-0.853906	****	RSI	-0.712500	****	****	****	****	HMA		****	****	****	return	15.501	****	0.0000	
RSI	27.05375	****	RSI	-0.712500	****			****	****	****				****	****	****	drawdown	14.667	****	0.0000	

strategy	avghold	Mean	1	strategy	drawdown	Mean	1	2	3	strategy	return	Mean	1	2	3	strategy	minbalance	Mean	1	2	3
RSI	15.29625	****	RSI	70.83516	****	WMA	-96.9572	****		HMA	2.22906	****				HMA	2.22906	****			
HMA	16.71938	****	MFI	86.75547	****	HMA	-96.4916	****		WMA	2.70469	****				WMA	2.70469	****			
MFI	16.82750	****	CCI	91.35766	****	SMA	-95.6078	****		SMA	3.23563	****				SMA	3.23563	****			
SMA	16.88375	****	BB	94.64875	****	EMA	-95.4619	****		EMA	3.79781	****				EMA	3.79781	****			
WMA	16.89062	****	EMA	96.35719	****	BB	-92.0950	****		BB	5.70437	****				BB	5.70437	****			
EMA	17.01312	****	SMA	96.73563	****	CCI	-85.0945	****		CCI	10.38469	****				CCI	10.38469	****			
BB	17.13625	****	WMA	97.49219	****	MFI	-76.4848	****		MFI	18.08406	****				MFI	18.08406	****			
CCI	17.31437	****	HMA	98.09969	****	RSI	-60.3744	****		RSI	32.97531	****				RSI	32.97531	****			

strategy	pfactor	Mean	1	strategy	maxbalance	Mean	1	2	3	strategy	ebalance	Mean	1	2	3	strategy	wins	Mean	1	2	3
SMA	0.839687	****	SMA	102.5834	****	WMA	3.06250	****		RSI	67.7813	****				RSI	67.7813	****			
EMA	0.868125	****	EMA	110.6666	****	HMA	3.50844	****		MFI	109.4063	****				MFI	109.4063	****			
MFI	0.891250	****	BB	113.0812	****	SMA	4.39500	****		BB	152.0625	****				BB	152.0625	****			
RSI	0.899531	****	CCI	129.7555	****	EMA	4.57187	****		CCI	153.6875	****				CCI	153.6875	****			
WMA	0.903437	****	RSI	133.4519	****	BB	7.93875	****		SMA	176.5625	****				SMA	176.5625	****			
HMA	0.915312	****	HMA	137.4491	****	CCI	14.91672	****		EMA	179.3125	****				EMA	179.3125	****			
CCI	0.927969	****	WMA	137.9387	****	MFI	23.51516	****		WMA	198.1250	****				WMA	198.1250	****			
BB	0.932500	****	MFI	139.5130	****	RSI	39.62000	****		HMA	272.3125	****				HMA	272.3125	****			



CONCLUSION

The analysis of the results, their objective interpretation and the evaluation of the hypotheses showed us how much **the individual settings** of the indicators and **the conditions** of the trading itself **matter**. **The number of parameters** on which the trade depends and **the experimental approach** is something that we consider as **the biggest contribution** of this work and **a recommendation for future practice**.