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Designing and Evaluating Trading Strategies Based on Algorithmic Trading in Iran's Capital Market

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ABSTRACT

One of the important factors for achieving profitability in financial markets is the ability to respond quickly and accurately to market events, which can only be accomplished by thoroughly examining all aspects of the market. Nowadays, the use of trading algorithms has become essential to tackle this challenge. Trading algorithms can be defined as computer-controlled transactions that are monitored and executed through algorithms. Depending on their type and purpose, these algorithms analyze various aspects of the market and, based on predefined strategies, make decisions and generate signals for order placement. The utilization of algorithmic trading is rapidly expanding worldwide, particularly in robust and developed financial markets. Proper implementation of algorithmic trading reduces transaction costs and enhances investors' accuracy in their investments. One of the most commonly employed strategies in algorithmic trading is the trend-following strategy, which is favored by many traders. This strategy can be implemented in various ways and using different trading tools. In this study, five types of these strategies were examined and implemented on one of the most actively traded symbols on the Tehran Stock Exchange. The objective of this study is to implement popular strategies in algorithmic trading and provide an overview of algorithmic trading, its strategies in the Iranian stock market, and an analysis of its advantages and disadvantages. The study adopts a cross-sectional retrospective and field survey approach in terms of its applied purpose and data collection.

1 Introduction

In recent years, financial and capital markets have experienced significant changes and advancements in information technologies, leading to the emergence of various investment solutions and the pursuit of higher profits. As a result, algorithmic trading, driven by computer algorithms, has gained more prominence than ever before with the digitization of trading methods.

The concept of algorithmic trading involves the use of computers to facilitate trading activities, with its origins dating back to the 1970s. In recent times, advancements in technology have further propelled the adoption of these algorithms [1]. Given the dynamic nature of the capital market and the

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potential for trading rates to increase exponentially within seconds, the risk associated with trading also escalates. Therefore, employing appropriate strategies in algorithmic trading becomes crucial, leveraging automated processes and employing modern intelligent techniques. Traditional methods, which involve manual review, analysis, algorithm comprehension, and manual order placement, are prone to decision-making errors due to the aforementioned disadvantages. Thus, with today's technological advancements and the complexities present in financial markets and transactions, it is possible to automate these transactions without direct human intervention [2]. This research focuses on algorithmic trading, which is a pivotal topic in today's research landscape due to the growing utilization of electronic tools and technological advancements in financial markets, as well as traders' interest in automated trading. The objective of this study is to implement several popular strategies in algorithmic trading while introducing the concept itself [3].

Algorithmic trading involves examining various aspects of the market, utilizing powerful equipment and computers to recommend and execute transactions, all under the control of one or more algorithms. Each algorithm follows a specific strategy. In this research, the researchers have made efforts to introduce multiple algorithms and trading strategies. They implemented and obtained output from five of the most important strategies using the Python programming language, comparing their profitability. These strategies utilize the adjusted price as a key factor [4].

2 Theoretical Framework and Review of Literature

Due to the rapid advancement of technology and the complexities of the financial markets and transactions, the use of up-to-date and intelligent trading techniques has become inevitable. Considering the capabilities and possibilities of today, it is possible to automate these transactions without direct human intervention. All of these methods and techniques eventually lead to smart trades and the use of computer processing power in these trades, which are known in financial markets as "algorithmic trades". Considering that the present research is applied in terms of purpose and survey and cross-sectional in terms of data collection. Also, in terms of subject, field type, and in terms of time, it is among the retrospective research. Dastri et al. [5] argue that in today's world, capital markets due to the advancement of computer technology and the use of information technology infrastructure have increased the possibility of profitability through high-frequency transactions and by implementing two models of trading algorithm and algorithm.

Fuzzy statistical quality control of the research results was presented and at the end, the results showed that the modified algorithm in the same period of investment was able to generate a 95.57% return while the basic model had a 17.46% return for investors. [5]. Studies have shown that in the stock market, shareholders, due to reasons such as lack of accurate and timely information and inability to properly analyze information in their decisions, instead of paying attention to internal information and intrinsic value of shares, to the volume of home transactions. They pay attention to important and influential factors. [6]. Research conducted in the Tehran Stock Exchange confirms that trading volume has a positive relationship with the price effect. Therefore, by breaking large orders into small orders and thus trading in smaller volumes, the price effect can be reduced. [7]. Due to the constant market changes, the rapid response of computers to today's changing conditions, and the efficient processing and complex calculations, this equipment is very helpful for the challenges of today's market. [4]. Algorithmic trading has grown from 3% of the trading volume in 1990 to 85% in recent years [8]. In recent years, financial markets have witnessed the increasing presence of algorithmic trading, a process of automated trading based on predetermined strategies, and as a result, the need to understand its characteristics has become very important [9]. What is today known as algorithmic

transactions actually stems from "paired trades" in the 1980s in Gerald Bamberger's company, and over time was also called statistical arbitrage. This pair trading progressed fast due to its very rapid profitability and has become very popular on Wall Street [4]. In the graph below, you can see the use of algorithmic transactions in different types of financial assets from 2001 to 2010 [10]

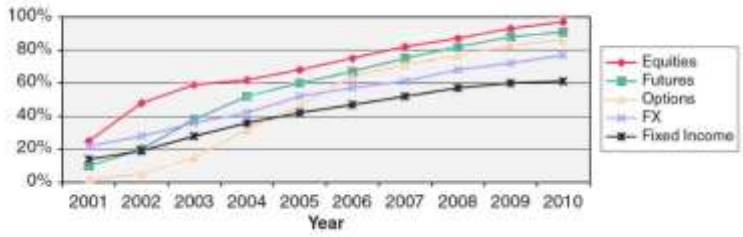

Fig. 1: Use of Automated Transactions Capabilities Between 2001 and 2010.

Table 1: Examines the Topics of Several Conducted Research Studies in This Field and Their Results.

Row	Reference	Main Topic	Sub-topics and results
1	Lu, Mamayski, and Wang [12]	Study of technical analysis as a traditional method of transactions	Identifying technical patterns using non-parametric regression and applying them to U.S. stock exchange data and concluding the significant effectiveness of some of these patterns
2	Teixeira and Oliveira [13]	Investigating the possibility of using a smart system for price forecasting according to historical trading data	Presenting a new method for automated trading based on technical analysis and clustering, comparing the results with the results of purchasing and maintenance strategy
3	Preis, Moat & Stanley [14]	Considering internet resources for market forecasting and other contributing factors	Trying to predict market behavior according to searches in a financial context in Google and concluding the high potential of the mentioned method in predicting market behaviors
8	Fong, Paroda, and Yang [15]	The effect of algorithmic transactions on the performance of mutual funds	The investigation of the positive and negative effect of algorithmic transactions on the performance of investment funds according to different trading strategies
9	Mukherjee, Chang, Walsh, and Xiang [8]	The effect of algorithmic transactions on simulated asset market	Finding the difference between researchers' theoretical results and real-world results
10	Panomaro, Oseldets, and Cichaki [16]	The use of stochastic forest learning in algorithmic transactions problems	Likening stock exchange transactions to a game with Markov's feature includes moods, actions, and rewards
11	Fukuma and Kadogawa [9]	A review of algorithmic transactions in foreign financial markets and its effect on market liquidity	Algorithmic transactions leading to improved market liquidity, and even, based on available evidence, its liquidity provision was maintained under the influence of COVID-19 pandemic from late February to March 2020

As observed, algorithmic transactions are one of the subjects of interest to researchers, and this shows the importance of this issue. Considering the extent and diversity of this issue, various aspects and specialized fields have been investigated in different research studies the results of which can be used to design automated trading system and use it in real conditions by examining the results of different tests on them.

3 Methods and Materials

By converting the rules of a trader's trading strategy into computer codes, an automated trading sys-

tem can be achieved that the computer implements its rules and instructions with the help of the trading software. In fact, the trading system finds trading opportunities that match the strategies set by the trader and then the order is registered fully automatedly by the trader's robot or semi-automatically (signaling to the trader). To get the desired result from algorithmic trading, three main requirements are needed:

1. Market matchers or data power supply: Converting the format of the information on the market to the trader's desired format through the application programming interface (API)
2. Advanced Processing Engine: Processing conditions using the specified strategy, performing calculations, and decided to order
3. Sending orders to capital market through algorithms: Algorithm language coding based on capital market language

3.1 Types of Algorithmic Trading

There are various algorithms for implementing algorithmic trading including:

- Trade Execution Algorithms (TEA)
- Strategy Implementation Algorithms (SIA)
- Monitoring Algorithms
- Position Trading Algorithms
- High Frequency Trading (HFT)

3.2 Algorithmic Trading Strategies

It is inevitable to use a suitable strategy in various subjects, and in financial markets, someone who has a suitable and logical trading strategy (command, leading trades, and capital) can succeed. Now, in algorithmic trading, algorithms make decisions instead of humans, and as a result, these algorithms must follow a specific strategy. The strategies used in algorithmic trading algorithms are divided into several categories:

Trend following strategies, arbitrage opportunities in algorithmic trading, periodical pre-embed trading of index funds, strategies based on mathematical models, mean reversion, volume-weighted average price (VWAP), time-weighted average price (TWAP), Percentage of Volume (POV), the deficit of application and implementation, correlation strategy, each of which can be implemented in several ways and through various instruments.

One of the most common strategies among these is trend sequence strategy, which is highly welcomed by traders and investors due to its ease of use and its logic, and taking into account this issue and consultation with experienced people in the field of algorithmic trading activities, in this study, the implementation and investigation of five famous and common types of these strategies have been discussed. It is worth noting that each of these strategies has parameters for performing calculations that generally have standard and accepted values and they are used in many cases. In the present study, these suggested values are considered for parameters, and in case of the absence of the suggested value for these parameters, the opinions of expert traders in this field have been taken into account. To do so, data was first collected and then cleaned. Also, for the high accuracy of using these strategies, only data related to 2019 were considered, which, of course, this amount of review can be different due to the dynamics of the code, and the code can even be used for exchange data abroad. The statistical population used in this study was selected from among the companies listed in Tehran Stock Exchange because these companies are accepted in the stock exchange after passing through different stages and meeting the conditions and criteria of admission, and the auditing process, providing in-

formation, etc. in each period is performed with high precision. The sampling method was to select stocks from the index of 30 large companies. This index was based on free-floating stocks and calculated through weighted average and measured the performance of these 30 largest companies accepted in Tehran Stock Exchange. In this study, according to experts' opinions in this field, Fars was selected from the index of 30 major companies to review and implement trading strategies.

Table 2. Data Sample Collected from the Fars

date	open	high	low	adjClose	value	volume	count	**close**
2013-04-16	7500.0	7500.0	7500.0	7500.0	10500000000	1400000	1	7500.0
2013-04-17	7700.0	7800.0	7680.0	7788.0	620595738957	79684517	8176	7800.0
2013-04-20	7900.0	7940.0	7560.0	7754.0	235468238335	30366404	5599	7604.0
2013-04-21	7609.0	7849.0	7520.0	7713.0	284391672389	36871260	4884	7840.0
2013-04-22	7950.0	8021.0	7903.0	8003.0	83996412783	10496140	890	8021.0
.....	.....	.....	.....	.....	.....	.....	.....	.....
2013-04-19	31500.0	33070.0	30110.0	32590.0	2093635153170	64250353	23217	33070.0
2013-04-20	33500.0	34000.0	30970.0	31480.0	1271843895110	40401377	18041	30970.0
2013-04-21	29910.0	30500.0	29910.0	29960.0	570970764230	19058589	5074	30400.0
2013-04-22	31350.0	31450.0	28760.0	30630.0	1546517065510	50483130	17409	31450.0
2013-04-23	31400.0	32160.0	31030.0	32030.0	1435819852150	44833525	15133	32160.0
1688rows×8columns								

The implementation environment includes Jupiter Notebook, an open-source and interactive platform for data mining and statistical analysis of data. Due to the user-friendly environment and the possibility of running the code the line-to-line in Jupiter Notebook, this environment was used to implement trading strategies. First, we collected shares data using the pytse_client library. If we extract the excel output from this section, all data related to the desired index will be obtained; there are 1688 data for Fars from 2013 to 2020. The obtained data using this library include the initial price, highest price, lowest price, adjusted price, value, volume, the number of trades, and the closing price per trading day for the desired share.

Table 3: Sample Data Collected from Fars in 2019

date	open	high	low	adjClose	value	volume	count	**close**
2019-01-02	4600.0	4600.0	4436.0	4533.0	5647797165	1252390	534	**4480.0**
2019-01-05	4500.0	4620.0	4462.0	4565.0	14688301574	3216593	343	**1520.0**
2019-01-06	4522.0	4650.0	4500.0	4584.0	11788098047	2571733	305	**4560.0**
2019-01-07	4590.0	4590.0	4451.0	4498.0	10316836706	2293769	530	**4451.0**
2019-01-08	4462.0	4520.0	4400.0	4467.0	9767393881	2186528	488	**4401.0**
.....	.....	.....	.....	.....	.....	.....	.....	.....
2019-12-28	8365.0	8450.0	8113.0	8368.0	77910723823	9310856	1413	**8445.0**
2019-12-29	4899.0	8570.0	8300.0	8426.0	51168304605	6072549	940	**8512.0**
2019-12-30	8500.0	8847.0	8430.0	8724.0	169002742854	19372813	1985	**8847.0**
2019-12-31	9144.0	9144.0	8900.0	9001.0	75302861213	8366109	1523	**9114.0**

In this study, to increase the accuracy of calculations and get reliable results due to the extensive changes in the market, only the data related to 2019 was investigated.

Table 4: Statistical Reports of the Obtained Factors Related to Fars

	open	high	low	adjclose	value	volume	count	close	log_return	Simple_return	log_return1
count	233.000000	233.000000	233.000000	233.000000	2.330000e+02	2.330000e+02	233.000000	233.000000	233.000000	233.000000	**232.000000**
mean	5624.098712	5703.373391	5526.111588	5617.064378	1.088995e+07	1.088995e+07	1005.622318	5614.270386	0.003017	5617.064378	**0.002957**
std	1292.108953	1301.466717	1263.012919	1284.596005	1.343832e+07	1.43832e+07	638.404000	1289.502410	0.01712 6	1284.596005	**0.017138**
min	3769.000000	3800.000000	3740.000000	3766.000000	9.332940e+05	9.332940e+05	251.000000	3769.000000	-0.045616	3766.000000	**-0.045616**
25%	4498.000000	4590.000000	4420.000000	4498.000000	3.787843e+06	3.787843e+06	590.000000	4500.000000	-0.005387	4498.000000	**-0.005394**
50%	5771.000000	5833.000000	5700.000000	5791.000000	7.213752e+06	7.213752e+06	829.000000	5790.000000	0.000634	5791.000000	**0.000449**
75%	6830.000000	6890.000000	6715.000000	6799.000000	1.246754e+07	1.246754e+07	1239.000000	6788.000000	0.009195	6799.000000	**0.009125**
max	9200.000000	9299.000000	8997.000000	9156.000000	9.507218e+07	9.507218e+07	3985.000000	9114.000000	0.062765	9156.000000	**0.062765**

As can be seen, the number, mean, standard deviation, minimum, maximum, and first, second, and third quarter of each factor can be found from these statistical reports. For example, for the adjusted price factor, there are 233 data with an average of 5,617.0644 and a standard deviation of 1,284.596. The lowest and highest adjusted prices recorded in 2019 are 3,766 and 9,156 units, respectively. The price chart of Fars in 2019 is as follows:

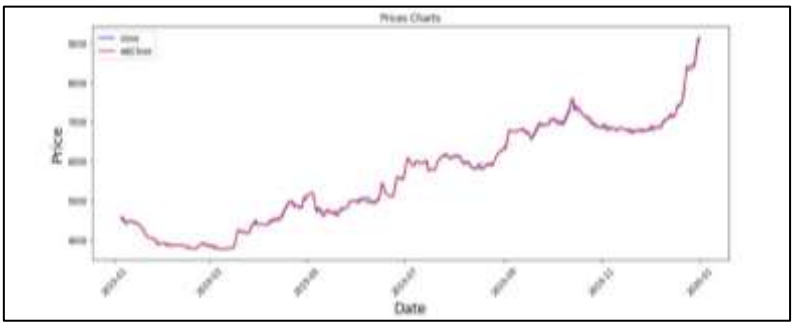

Fig 2: Price chart in 2019.

From the above diagram, it is understood that the actual price and adjusted price are close to each other in most cases, but taking into account the way the adjusted price is calculated, this factor is usually the basis of other calculations and estimates.

3.3 Trend Trial Strategies

Considering the popularity of the trend trail strategy among traders and its popularity in financial markets and experts in this field, the implementation of five types of this strategy was carried out in this research, and the implementation of other strategies and comparing the results is recommended for future research studies. It is worth noting that in all strategies, the initial capital is considered 100 million Rials, which is therefore assumed according to the share price at the beginning of 2019 so that 22,060 shares have been purchased and the return of each strategy has been calculated according to

this number of shares and initial capital.

3.4 Moving Average Strategy

This strategy is one of the subsets of the trend trail strategy. In this strategy, we get an average for the price of one share, and we buy and sell shares according to this amount. In this case, when the share price reached the calculated average, we will buy (if the previous value is less than the current value - positive slope) or sell (if the previous value is greater than the current value - negative slope). But in this case, the number of purchases and sales is very high and will not have a good return. Due to its being obvious, this part was not implemented.

3.5 Double Moving Average Strategy

This strategy is the more advanced strategy of the mentioned moving average strategy. This strategy aims to reduce the number of purchases and sales in the moving average strategy. In this strategy, we calculate two short-term moving averages and long-term moving averages. When the short-term moving average has reached the long-term moving average and passes through it, it represents a growing trend, and as a result, we buy shares. If on the other way, the short-term moving average is less than the long-term moving average, it represents a decreasing trend, and as a result, we sell shares.
In this strategy, the number of days intended for the long-term moving average and the short-term moving average is 100 and 20 days, respectively, which are the well-known numbers for this strategy. According to the existing data from 2019 and the calculations made in this field, only once in 2019, the signal was issued, which is also related to April 8th, 2019. On this date, due to the short-term moving average passing through the long term, a buy signal was issued, and this average has not been less than the long-term moving average at any other point according to the existing data, and as a result, the sales signal was not issued, but if we assume that the shares would be sold at the end of the year, then 4,725 units of profit were obtained (For the sake of making different strategies comparable, we consider this assumption in all strategies).

Fig. *2*. Signaling chart using double moving average strategy.

Table 5. Information on Buying and Selling Dates Using the Double Moving Average Strategy

date	open	high	low	adjclose	close	weekday	short_mavg	long_mavg	orders
4/8/2019	4331	4580	4210	4431	4501	Monday	1	4048/383333	1
13/31/2019	9144	9144	8900	9001	9114	Tuesday	1	6835/52	0

As can be seen, if we buy on the date of the purchase signal and sell at the end of the year – we consider the amount of the traded share at all stages equal to 1 – it will be as much as 4,570 units. The return of this strategy was 0.81%, which is not an acceptable return according to the interest rate of

the year (15%) at 9001-4431= 4570, and the above strategy is not suitable for the current stock (Fars).

3.6 Naïve Trading Strategy

This strategy is based on the number of times the price increases or decreases and is based on the historical trend of prices. A price threshold is set, and by counting the number of times the price increases or decreases, and according to this threshold, traders buy and sell. If the number of times the price has increased reached the threshold, traders buy and if the number of times the price decreases reaches this range, shares will be sold. In this strategy, the desired threshold is considered five days, which means that if the number of price increases reached this number, the purchase signal will be issued, and if the number of price decreases reached this threshold, the sales signal will be issued. The five-day threshold is one of the most widely used numbers for implementing this strategy.
According to 2019 data, signals have been issued only twice, once related to sales and once related to purchases. Considering that the first received signal was related to the sale and was on January 13th, 2019 and the last received signal was related to the purchase and was on April 22th 2019, if we consider these two transactions as the basis of the profit, we will lose 530 units, but given the buy and sell times, assuming that on the first trading day of 2019, we have bought and on the last day we sell – still a share unit is the basis of the trades- our profit will be 4010 units.
4452–4982=-530
-4533+4452–4982+9001=4010
The return of this strategy is -11.54%, and this strategy is detrimental

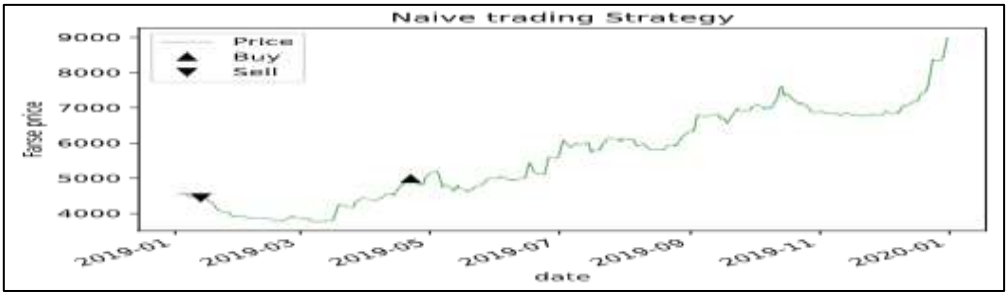

Fig. 3: Signaling chart using the naïve trading strategy.

Table 6. Information on Buying and Selling Dates Using the Naïve Trading Strategy

date	open	high	low	adjclose	close	weekday	orders
1/2/2019	4600	4600	4436	4533	4480	Wednesday	0
1/13/2019	4470	4500	4416	4452	4429	Sunday	-1
4/22/2019	5080	5080	4885	4982	4947	Monday	1
12/31/2019	9144	9144	8900	9001	9114	Tuesday	0

3.7 Turtle Strategy

This strategy is also one of the strategies in the trail trend process, but its difference with previous strategies is that it does not use moving averages but makes decisions according to the number of days and minimum and maximum prices. For example, when the share price reaches the highest price in the previous x days, we will buy a share, if it reaches the lowest price, we will sell, and if it reaches the moving average of these x days, we will exit the trade. Here, the number of days considered for price comparison is 50 days, which is one of the most common numbers for this strategy.

Fig. 4: Signaling chart using the turtle strategy.

Table 7. Information on Sales Dates Using the Turtle Strategy

date	open	high_x	low_x	adjclose	close	week-day	or-ders	high_y	low_y	avg	long_entry	short_entry	long_exit	short_exit
4/9/2019	4360	4580	4360	4481	4460	Tuesday	-1	4431	3766	3973/4	TRUE	FALSE	FALSE	**TRUE**
4/16/2019	4503	4650	4490	4564	4500	Saturday	-1	4529	3766	3984/68	TRUE	FALSE	FALSE	**TRUE**
4/16/2019	4650	4777	4561	4703	4600	Tuesday	-1	4601	3766	4013/64	TRUE	FALSE	FALSE	**TRUE**
4/20/2019	4810	4983	4810	4943	4983	Saturday	-1	4746	3766	4042/3	TRUE	FALSE	FALSE	**TRUE**
4/23/2019	4911	5089	4826	4911	4829	Tuesday	-1	4982	3766	4084/78	FALSE	FALSE	FALSE	**TRUE**
4/30/2019	5140	5290	4970	5082	5009	Tuesday	-1	5040	3766	4184/4	TRUE	FALSE	FALSE	**TRUE**
5/4/2019	5150	5255	5131	5200	5199	Saturday	-1	5136	3766	4234/08	TRUE	FALSE	FALSE	**TRUE**
6/17/2019	5302	5511	5227	5434	5459	Monday	-1	5249	4382	4804/42	TRUE	FALSE	FALSE	**TRUE**
6/30/2019	5710	5710	5451	5574	5530	Sunday	-1	5589	4502	4935/24	FALSE	FALSE	FALSE	**TRUE**
7/2/2019	5799	5949	5703	5931	5949	Tuesday	-1	566	4611	4977/98	TRUE	FALSE	FALSE	**TRUE**
7/6/2019	6100	6100	5775	5882	5900	Saturday	-1	6074	4611	5029/1	FALSE	FALSE	FALSE	**TRUE**
7/27/2019	6122	6189	6105	6131	6189	Saturday	-1	6134	4611	5327/2	FALSE	FALSE	FALSE	**TRUE**
8/31/2019	6300	6390	6250	6308	6780	Saturday	-1	6181	5001	5807/94	TRUE	FALSE	FALSE	**TRUE**
9/2/2019	6320	6400	6285	6305	6400	Monday	-1	6312	5100	5855/34	FALSE	FALSE	FALSE	**TRUE**
9/4/2019	6500	6790	6470	6787	6787	Wednesday	-1	6467	5100	5895/26	TRUE	FALSE	FALSE	**TRUE**
9/14/2019	6890	6890	6730	6814	6771	Saturday	-1	6801	5329	7146/06	TRUE	FALSE	FALSE	**TRUE**
9/24/2019	7000	7000	6841	6918	6948	Tuesday	-1	6986	5737	6152/24	FALSE	FALSE	FALSE	**TRUE**
10/1/2019	7180	7180	6891	7062	7039	Tuesday	-1	7040	5737	6252/76	TRUE	FALSE	FALSE	**TRUE**
10/5/2019	6940	7195	6901	7023	6940	Saturday	-1	7082	5798	6290/38	FALSE	FALSE	FALSE	**TRUE**
10/13/2019	7500	7643	7453	7571	7544	Sunday	-1	7282	5798	6436/64	TRUE	FALSE	FALSE	**TRUE**
10/15/2019	7740	7744	7223	7348	7290	Tuesday	-1	7603	6766	6496/32	FALSE	FALSE	FALSE	**TRUE**
12/23/2019	7800	8043	7785	8030	8043	Monday	-1	7660	6767	6997/94	TRUE	FALSE	FALSE	**TRUE**
12/25/2019	8394	8445	8150	8314	8401	Wednesday	-1	8363	6768	7045/96	FALSE	FALSE	FALSE	**TRUE**
12/29/2019	8499	8570	8300	8426	8512	Sunday	-1	8368	6769	7100/12	TRUE	FALSE	FALSE	**TRUE**
12/31/2019	9144	9144	8900	9001	9114	Tuesday	-1	7824	6770	7146/06	TRUE	FALSE	FALSE	**TRUE**

As can be seen, the number of orders in this strategy is significantly higher than the number of orders of the previous strategy, and therefore, the return of this strategy will be much higher than that of the previous strategy. In this strategy, 25 buy signals and 25 sales signals have been issued. Taking the assumption of buying a share on the first day of 2019 and selling on the last day of the same year into consideration, the profit of this strategy will be 6,801 units per share. The return of this strategy on the Fars is 50.03%, which is a very acceptable return according to the interest rate of 15%.

Table 8: Information on Purchase Dates Using the Turtle Strategy

date	open	high_x	low_x	adjclose	close	weekday	orders	high_y	low_y	avg	long_entry	short_entry	**long_exit**
4/8/2019	4331	4580	4210	4431	4501	Monday	1	4428	3766	3972/78	TRUE	FALSE	**FALSE**
4/10/2019	4498	6208	4420	4529	4495	Wednesday	1	4481	3766	3977/72	TRUE	FALSE	**FALSE**
4/15/2019	4489	4709	4489	4601	4590	Monday	1	4564	3766	4002/64	TRUE	FALSE	**FALSE**
4/17/2019	4499	4855	4553	4746	4780	Wednesday	1	4703	3766	4027/08	TRUE	FALSE	**FALSE**
4/22/2019	5080	5080	4885	4982	4947	Monday	1	4943	3766	4062/98	TRUE	FALSE	**FALSE**
4/29/2019	4895	5076	4793	5040	5076	Monday	1	4982	3766	4161/16	TRUE	FALSE	**FALSE**
5/1/2019	5099	5180	5000	5136	5121	Wednesday	1	5082	3766	4208/7	TRUE	FALSE	**FALSE**
6/16/2019	5100	5251	5100	5249	5251	Sunday	1	5200	4321	4785/86	TRUE	FALSE	**FALSE**
6/26/2019	5570	5595	5460	5589	5595	Wednesday	1	5434	4502	4914/74	TRUE	FALSE	**FALSE**
7/1/2019	5578	5760	5462	5666	5700	Monday	1	5589	4601	4965/68	TRUE	FALSE	**FALSE**
7/3/2019	6049	6181	6003	6074	6090	Wednesday	1	5931	4611	5002/54	TRUE	FALSE	**FALSE**
7/24/2019	6119	6149	6062	6134	6122	Wednesday	1	6074	4611	5299/1	TRUE	FALSE	**FALSE**
8/28/2019	6200	6500	6060	6181	6190	Wednesday	1	6134	4976	5783/84	TRUE	FALSE	**FALSE**
9/1/2019	6350	6360	6263	6312	6320	Sunday	1	6308	5100	5834/08	TRUE	FALSE	**FALSE**
9/3/2019	6400	6549	6382	6467	6510	Tuesday	1	6312	5100	5872/76	TRUE	FALSE	**FALSE**
9/11/2019	6750	6897	6750	6801	6807	Wednesday	1	6787	5102	5993/08	TRUE	FALSE	**FALSE**
9/23/2019	6889	7080	6889	6986	6904	Monday	1	6814	5737	6134	TRUE	FALSE	**FALSE**
9/30/2019	7230	7230	6982	7040	7070	Monday	1	6986	5737	6231/04	TRUE	FALSE	**FALSE**
10/2/2019	7074	7194	6885	7082	7050	Wednesday	1	7062	5737	6274/92	TRUE	FALSE	**FALSE**
10/12/2019	7140	7351	7090	7282	7351	Saturday	1	7082	5798	6411/26	TRUE	FALSE	**FALSE**
10/14/2019	7799	7799	7420	603	7470	Monday	1	7571	5798	6466/94	TRUE	FALSE	**FALSE**
12/22/2019	7500	7770	7470	7660	7758	Sunday	1	7603	6766	6985/2	TRUE	FALSE	**FALSE**
12/24/2019	8239	8431	8080	8363	8394	Tuesday	1	8030	6766	7019/12	TRUE	FALSE	**FALSE**
12/28/2019	8365	8450	8113	368	8445	Saturday	1	8363	6766	7072/78	TRUE	FALSE	**FALSE**
12/30/2019	8500	8847	8430	8724	8847	Monday	1	8426	6766	7123	TRUE	FALSE	**FALSE**

3.8 Triple Moving Averages

This strategy is also one of the trend trail strategies, and it can be considered as a more complex mode of the double moving average. In this strategy, three values of the long-term moving average, middle-term moving average, and short-term moving average are used. The length of time for each one is generally 200-100-50 or 100-50-20 (or 10) days. In this strategy, if the middle-term moving average is higher than the short-term moving average and the long-term moving average is higher than the middle-term moving average, the purchase signal is issued, and when the long-term moving average is lower than the middle-term moving average, we exit the trade. Also, if the middle-term moving average is lower than the short-term moving average and the long-term moving average is less than the middle-term moving average, the sales signal is issued, and when the long-term moving average is higher than the middle-term moving average, we exit the trade.

In this study, according to the experts' opinions in this field, the period for calculating short-, middle- and long-term moving averages was considered as 5, 21, and 36 days, respectively. In this strategy, only one buy signal was issued on May 1st, 2019, after which the first sell signal was issued on August 1st, 2019, resulting in a net profit of -98.0 units per share. If we consider the assumption of buying a share on the first trading day and selling it on the last trading day, the profit will eventually be 4,370.0 units per share.

4467–4565= -98

9001+4467–4565–4533=4370

The efficiency of the three moving averages strategy is -3.6%, and as a result, this strategy has no good return on Fars.

Fig. 5. Price Chart and Short-, Middle- and Long-Term Moving Averages in 2019.

Fig. 6: Signaling Chart Using Three Moving Averages Strategy.

Table 9. Information on Buying and Selling Dates Using the Three Moving Averages Strategy

date	open	high	low	adj close	close	weekday	short	middle	long	buy_signal_price	sell_signal_price
1/2/2019	4600	4600	4436	4533	4480	Wednes-day	4533	4533	4533		
1/5/2019	4500	4620	4462	4565	4520	Saturday	4543/667	4534/73	4534/73	4565	
1/8/2019	4462	4520	4400	4467	4401	Tuesday	4513/938	4531/574	4531/574		4467
12/31/2019	9144	9144	8900	9001	9114	Tuesday	7793/333	7490/608	7490/608		

3.9 Moving Average Convergence Divergence (MACD)

MACD is one of the most widely used indicators in technical analysis. This strategy is also one of the trend-sequence strategies. This strategy uses two lines, the nature of which is the actually exponential moving average (EMA). When these two lines cross each other and the MACD line reaches the top of the signal line, the purchase signal, and when the MACD line is less than the signal line, the sales signal is issued, otherwise, no order is registered. The duration of the period used for long-term and short-term exponential moving averages is 26 and 12 days, respectively. A 9-day period was also considered to calculate the signal line. The trend of these two lines is depicted in the below diagram:

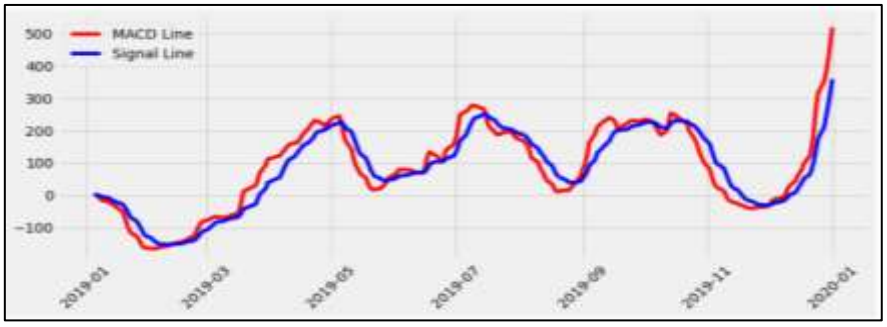

Fig. 7: MACD's line and the signal line in 2020.

Using this strategy in 2019, 8 purchase signals and 7 sales signals were issued. So, the profit from this strategy is -5,146, and this strategy will be detrimental per share. If we assume buying a unit at the beginning of 2019 and selling it at the end of the year, the final profit will be -678.

-5146+4468 = -687

As is seen, the efficiency of this strategy is negative and is equal to -114.96%, indicating a very high loss of this strategy on Fars.

Fig. *8.* Signaling chart using MACD's indicator strategy.

Table 10: Information on Buying and Selling Dates Using MACD's Indicator Strategy.

date	open	high	low	adjclose	count	close	weekday	MACD	signal line	Buy_ signal_price	**sell_ signal_price**
1/2/2019	4600	4600	4436	4533	534	4480	Wednesday	0	0		
1/5/2019	4500	4620	4462	4565	343	4520	Saturday	2/552707	0/510541311	4565	
1/8/2019	4462	4520	4400	4467	488	4401	Tuesday	-3/94094	0/540904162		**4467**
2/13/2019	3822	3890	3802	3852	513	3853	Wednesday	-145/182	-147/00976	3852	
5/6/2019	5140	5270	4901	4928	989	4901	Monday	222/5996	224/733306		**4928**
5/29/2019	5000	5098	4930	4990	763	4981	Wednesday	53/51177	46/70153816	4990	
6/24/2019	5150	5151	5070	5102	1375	5149	Monday	101/3777	104/2618333		**5102**
6/25/2019	5155	5357	5090	5329	2051	5357	Tuesday	111/2908	105/6676349	5329	
7/16/2019	5900	5900	5704	5737	986	5790	Tuesday	233/0478	247/5949891		**5737**
8/31/2019	6300	6390	6250	6308	1269	6280	Saturday	61/45125	4317260693	6308	
10/6/2019	7200	7200	6700	6974	1002	6950	Sunday	215/2847	223/4984906		**6971**
10/13/2019	7500	7643	7453	7571	751	7544	Sunday	229/0503	2114947751	7571	
10/22/2019	7080	7199	6803	7103	994	7100	Tuesday	218/8318	227/6874189		**7103**
12/1/2019	6795	6936	6753	6839	900	6797	Sunday	-30/1997	-31/2019951	6839	
12/31/2019	9144	9144	8900	9001	1523	9114	Tuesday	471/2891	317/87926645		

3.10 Buy and Hold Strategy

Contrary to the previous strategies, this strategy is not a trend trail strategy, and traders who use this strategy buy shares with the aim of long-term hold and believe that the value of shares will increase in the long run. The reason for expressing this strategy is to provide the possibility of comparing the results of the previous strategies and the efficiency of algorithmic trading against this relatively simple strategy. If we assume that we buy a share at the beginning of 2019 and sell it without any special processing at the end of 2019, the profit per share is 4,468.0 units.

9001-4533= 4468

Also, if we consider the initial capital at the beginning of the year as 10 million Tomans, 22,060 shares can be purchased, and by selling the same number of shares at the end of 2019, we will reach a return of -1.44% for the purchase and hold strategy, which will also be detrimental to Fars.

4 Conclusion

In this research, algorithmic transactions were introduced and its various aspects were investigated. Several well-known strategies in that area were also implemented and reviewed. Advances in technology and the revolution in financial markets have led to the growth of algorithmic trading methods

and, ultimately, electronic methods. However, the large volume of data and the different methods of analyzing them have challenged the decision-making and execution of automated transactions. Today, the use of trading algorithms to solve this challenge has become inevitable. Algorithmic transactions can be considered as transactions made by computers, which are controlled and checked through algorithms. Proper implementation of algorithmic transactions leads to reduced trading costs and increased accuracy of investors in their investments. Also, this trading method helps increase liquidity and market efficiency. The first step to developing this trading instrument and benefiting from its benefits is to conduct various research studies in this field and to investigate its various aspects so that with sufficient knowledge, we can discover and implement the ways to implement it and take action in line with them. In other words, due to the everyday improvement of computers and related technologies and their efficiency, speed, and accuracy compared to humans, the use of electronic trading methods is inevitable and with such applied research studies, the implementation of these systems can be actualized. In the end, it is worth comparing the implemented strategies:

Table 10. Comparing the Efficiency of Implemented Strategies

Row	Strategy	Returns
1	Double Moving Average Strategy	0.81%
2	Naïve Trading Strategy	-11.54%
3	Turtle Strategy	50.03%
4	Three Moving Averages Strategy	-3.6%
5	MACD Indicators Strategy	-114.96%
6	Buy and Hold Strategy	-1.44%

As can be seen, only two strategies (i.e., double moving average and turtle strategy) have non-negative returns so that if we consider interest rates as 15% (according to tariffs of 2019 and 2020), among these two strategies, the return of the double moving average strategy is not acceptable, but the return of the turtle strategy is remarkable and can be used on Fars.

According to the present research, using different strategies in algorithmic transactions will be very effective, different aspects of which should be examined. One of the most widely used strategies among these is the trend trail strategy which is welcomed by many traders. This strategy can be implemented in different ways through different trading instruments, five of which were in the present research investigated and implemented on one of the symbols of the Tehran Stock Exchange (Fars). However, due to the complexities of financial markets as well as algorithmic transactions, the results for one symbol are not necessarily true for another symbol and it should be re-examined, but ultimately it seems that the mentioned strategies can be implemented in a real project, in which, of course, external and uncontrollable factors can also lead to different results. Also, some differences in the real world will lead to differences in results. Finally, given that algorithmic trading has recently been recognized in the Tehran Stock Exchange and licensed to several legal entities, also considering the importance of choosing the appropriate strategy in designing algorithms as a criterion for Evaluating Algorithms It is recommended that market participants, such as large institutional clients who decide to buy and sell large volumes of stocks, use such algorithms and thus devise appropriate strategies for their transactions. After conducting this research and reviewing the results and various dimensions, suggestions for future research are presented as follows:

- Comparing sheriff level strategies with each other and examining different aspects
- Review of the above strategies in international and foreign financial markets
- Comparing the returns of strategies in the Tehran Stock Exchange market and foreign markets

- Investigating the returns of different strategies on different symbols and industries of Tehran Stock Exchange market.

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