Journal of System Management (JSM)
Online ISSN: 2538-1571, Print ISSN: 2322-2301
Doi: 10.30495/JSM.2022.1937933.1509
8(1), 2022, pp. 37-50

Received: 16/08/2021
Accepted: 13/01/2022

RESEARCH ARTICLE **Open Access**

Trading strategies based on trading systems: Evidence from the performance of technical indicators

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Abstract

This study examines trading strategies based on trading systems by analyzing the performance of 11 technical indicators. The data used for analysis were financial data of all firms listed on the Teh-ran Stock Exchange in the period from 2010 to 2020. Excluding the firms whose data were not available for the period under study, 135 firms were selected as the research sample. The results showed that the signals containing three indicators of moving average, exponential moving average, and relative strength over a weekly up to six-month period to buy or sell stocks (as a strategy) could be used more confidently compared to other indicators to achieve higher returns and profitability. As a result, investors can use the signals that these three indicators in weekly (EMA) and monthly (MA, RSI) periods and the quarterly (MA) and six-month (RSI, EMA) periods to determine buying and selling strategies with the lowest investment risks. It is also recommended that investors use a combination of these three indicators to invest, and extend their investment period over a longer period of time to bear less risk, and more returns.

Keywords: Trading Strategies, Technical Indicators, Performance, Risk, Return.

Introduction

Technical analysis is one of the tools of financial market analysis. It is a means to predict prices and markets by studying historical market data. Given the factors examined in this type of analysis, a set of indicators are developed and presented to facilitate making decisions about the stress of buy-ing and selling in the financial markets (Abbasi et al., 2020). Monitoring stock market changes and careful tracking of its positive and negative fluctuations are effective in appropriately using emotional factors in an investor's decision making. Availability of information and getting information about the dominant trend in the stock market affect the investor's decision making process (Salmani Danglani et al., 2019). Supply and demand, trading volume, price fluctuations, commodity rates, interest rates, and other items are reflected in the price chart through the reactions of investors and market participants, and all of these factors can be observed by studying price changes or market indicators (Kenny, 2005).

In general, risk and return are two important factors that are taken into account by retail investors when making decisions. Unlike major investors who have access to a wide range of tools and facilities to balance these two variables, individual investors often lack such tools. Furthermore, high rates of economic and

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political fluctuations, unstable laws and regulations, etc., increase the risk of decision-making in the stock market. All these factors cause the capital market to face a secondary risk due to individualism and unpredictability of the behavior of individual investors (Ebrahimi Sarve Olia et al., 2017). Technical analysis is a method that enables investors or traders to operate in financial markets to determine the most appropriate time and price to buy or sell stocks and other tradable assets (Bader et al., 2018). Over the past few decades, researchers have conducted extensive studies on the profitability of technical indicators and have reached a variety of results (Jasdeep et al., 2019). Each of the technical indicators of the stock market can generate conflicting signals about the future performance of the analyzed stocks (Alfonso & Ramirez, 2020). Accordingly, the present study aims to investigate trading strategies based on trading systems using the evidence from the performance of technical indicators. The following section presents the theoretical framework of the study followed by the literature review, methodology (the procedure and data analysis), and the results that are presented in the subsequent sections.

Literature Review

Determining a trading signal that can provide the investor with the best entry and exit points of the financial market when investing in the financial markets is very important. However, this is a difficult task and has become a very popular research topic in finance. Investors or investment managers are faced with the choice of buying or selling stocks in any stock trading. Any mistake in investing decisions will incur losses for investors. Therefore, a thor-ough and reliable analysis is needed to be used as a basis for investment decisions (Ahmar, 2017). Stock market prices fluctuate due to constant buying and selling in the market. There are basically two methods used to analyze stock price movements. They are the fundamental approach and the technical ap-proach(Asha,2014. Turner, 2007). Both approaches aim to analyze and predict changes in supply and demand (Turner, 2007). Therefore, both pursue the same goal: buy at a lower price and sell at a higher price to get a good return on investment. However, there is a big difference between the basic concepts of these two approaches (Asha, 2014). - Fundamental analysis involves studying the fundamentals of a business such as revenues and expenses, market position, annual growth rate, etc., however, technical analysis is only concerned with price and volume data, especially price patterns and volume growth (Turner, 2007).

Price and volume data are readily available in true-time, making technical analysis suitable for short-term trading volatility. The basic assumption in technical analysis is that stock prices evolve in a certain order, forming reliable and predictable price and volume patterns that reflect market psychology and can be used to determine changes in demand and supply (Turner, 2007). Technical analysis attempts to predict future prices by studying past prices and a few other related summary statistics on secure trades. A technical analyst is always concerned about price movements. The oldest technical analysis technique is attributed to Charles Dow in the late 1800s. Most techniques have been used for over 60 years. These techniques can reveal very simple to very precise and complex methods to discover the hidden relationship in stock returns (Asha, 2014). Fama(1970), developed ideas about market behavior and investor performance and proposed the ef-ficient market hypothesis (EMH), which essentially assumes that prices reflect all available infor-mation. Technical analysis is a challenge for the efficient market hypothesis (EMH), especially in its weak form (Nti et al, 2019). In fact, this type of analysis tries to estimate the power of buyers and sellers in fi-nancial markets by analyzing three factors of price, trading volume, and time (Eddie, 2014). One of the strengths of technical analysis is the simplicity of this method. Instead, there are significant prob-lems with this method. One of

the drawbacks of this method is that its assumptions contradict the efficient market hypothesis. In addition, the analyst's lack of attention to the true price of stocks can lead to potential investment risks because the stock price is affected by the interaction between supply and demand, and if this supply and demand are not due to logical factors, they can lead to unrealistic and misleading stock prices (Reilly & Brown, 2011). Izadikhah et al (2017), describe the three assumptions on which technical analysis is based: 1) All information is included in prices, 2) Prices follow a trend, and 3) History repeats itself in the markets. According to these three assumptions, if the mar-ket has a strong performance (M'ng, 2018), and the random walk theory is established, this type of analysis does not perform optimally (Kristjanpoller & Minutolo, 2018).

Traders who trade based on fundamental analysis do most of their trading with long-term assets. Technical analysis tools are effective if they maximize returns and minimize trading risks, and this is a challenge that researchers face. Sometimes, the results of using different indicators in the tech-nical analysis of the price chart are different. In this case, the analyst is skeptical and they confuse the predicted results to decide to rely on which technical analysis indicator. Therefore, the analyst should not focus only on the result of one indicator and thus they should consider several different indicators together. This complicates the task of a technical analyst (Abbasi et al., 2020). Ou & Penman (1989) argue that there are significant abnormal earnings in some of the fundamental signals that arises from the market inability to completely and immediately process all the price signal information (Quoted by Taheri et al.). Roberts (2005), found that technical regulations generate significant profits in only two of the 24 futures markets studied. In another study, Park and Irwin (2007), found that out of 95 studies reviewed, 56 had technical trading strategies that were profitable, 20 studies had unprofitable results, and 19 studies had different results. Research has shown that technical variables outperform eco-nomic variables in developing economies (liu & Pan, 2020). Banga and Brorsen (2019), predicted profitability using a combination of buy and sell signals that used technical indicators as inputs. In addition to price variance, the inputs also included trend□ following and mean□reversal technical indicators. Because each of the technical indicators alone can not show all the psychological dimensions of the market, this study combines these indicators to provide a more complete view of the discovery of stock trading signals. In this study, 11 technical indicators were used. The present study uses technical indicators as inputs to identify buy and sell signals. In the following, Table 1 presents a summary of the researches.

Table 1.
Summary of research background

Researcher	Year	Title	Research Result
Dai et al.	(2021)	New technical indicators and stock returns predictability	the stock returns forecasts generated by new technical indicators were statistically and economically significant both in-sample and out-of-sample prediction performance. Besides, when multivariate information was used to predict stock returns, its predictability was also significant.
Pramudya & Ichsani	(2020)	Efficiency of technical analysis for the stock trading,	efficiency and effectiveness, a combination of several types of indicators is better than using single indicators.
Liu and Pan	(2020)	Forecasting stock market volatility: the role of technical variables	A combination of technical variables in the autoregressive model can predict fluctuations more accurately.
Alfonso and Ramirez	(2020)	A nonlinear technical indicator selection approach for stock markets	Provide a hybrid nonlinear technical index approach to identify appropriate combinations of stock technical indices as input to nonlinear models.

Researcher	Year	Title	Research Result
Abbasi et al.	(2020)	Performance evaluation of the technical analysis indicators in comparison with the buy and hold strategy in tehran stock exchange indices	A significant difference between the returns using some of the technical analysis indicators in some indices and the buy and hold strategy. the effectiveness of technical analysis strategies varies across industries and EMA & SMA with respectively 6 & 5 repetitions are the best strategies.
Jasdeep et al.	(2019)	Profitability of alternative methods of combining the signals from technical trading systems	Inputs were signals from trend□following and mean□ reversal technical indicators in addition to the variance of prices. Both neural networks and statistical meth-ods did not show consistent profitability.
Abdolbaghi et al.	(2019)	The effectiveness of the automatic system of fuzzy logic-based technical patterns recognition: evidence from tehran stock exchange	A comparison of the conditional distribution of daily returns under the condition of the discovered patterns with the mean returns of all normalized market indicators suggested that after recognizing the pattern, all patterns at the confidence level 0.95 with a fuzzy point 0.5 contained useful information, practically leading to abnormal returns.
Bashir Khodaparasti et al.	(2019)	A comparison of the efficiency of technical analysis ideas in the period of capital market recession and boom in more active manufacturing companies.	The average returns from the relative strength index during the period of recession are not significantly different from other indicators in the capital market boom period. However, there is a significant difference between the average returns of moving average, crossover average, and convergence-divergence mov-ing average in boom and depression periods.
Vezeris et al.	(2018)	Take Profit and Stop Loss Trading Strategies Comparison in Combination with an MACD Trading System	Take profit strategies based on faster take profit signals on MACD were not better than a simple MACD strategy.

As can be seen, in most studies, the indicators have been reviewed and compared with purchasing and maintenance strategies. Part of the technical analysis is to use several indicators. These indicators of technical analysis are the relationships of trend, volatility, and movement, which identify the various aspects of a financial data set (Kampouridis & Otero, 2017). Pramodia and Echsani (2020) examined the performance of technical analysis for stock trading. The results showed that efficiency and effectiveness, a combination of several types of indicators is better than using single indicators. Therefore, this study provides a more complete view of signal detection by combining the indicators. There are many indicators, but the main basis of most of them is volume and moving average. Therefore, 11 indicators, which are the most important indicators and technical oscillators, were used. In addition, these cases have been among the most widely used technical analyzes in most domestic and foreign studies. The results of this study are expected to be useful for traders as a strategy for evaluating investment. The following is a conceptual framework of the research shown in Figure (1).

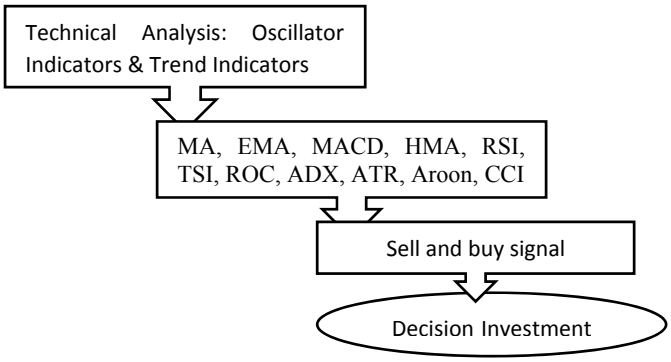

Figure 1. The conceptual framework of the study

Given what was mentioned earlier, the main question addressed in this study is stated as follows: What are the most effective trading strategies for a weekly to six-month period based on tech-nical indicators?

Method

The present study is a descriptive study that was conducted using the analysis of variance. The research population included all firms listed on the Tehran Stock Exchange during the period from 2010 to 2020. The sample firms were selected using a systematic elimination method (purposive sampling). Accordingly, the sample under study included the firms listed on the Tehran Stock Exchange with the following conditions: The firm should not have stopped trading its shares for more than one month. The firm should not have been one of the investment companies, leasing companies, and financial and banking institutions.The firm should have had all the required data in the studied period. By applying the constraints detailed above, 135 firms were selected as the research sample. The data required to measure the research variables were collected using library techniques from the databases of Rahavardnovin, and the official statistics published by the Tehran Stock Exchange. In the next step, the collected data were coded and the research variables were calculated. Finally, the research hypotheses were tested.

Procedure

The present study was conducted through the following steps:

1-The technical sub-indicators were calculated and the buy and sell signals were identified. As shown in Table 2, Code 1 indicates a strong signal to buy stocks and Code 0 indicates a strong signal to sell stocks.

2-After calculating the indicators, the interval returns for the weekly, monthly, quarterly, and six-month data were calculated for each stock and indicators using Eq. (1):

$$Return = ln\frac{P_t}{P_t - 1} \qquad (1)$$

Where P_t is the exit price (the sell signal) and P_t-1 is the entry price (the buy signal).

Table 2.
The technical sub-indicators and calculated

Indicator	Symbol	Measurement	Buy or sell signals
Moving Average	MA	MAr(n)= n-1$\sum_{i=0}^{n-1} p_{t-i}$	If the price curve is high, MA tends to continue the upward trend, indicating a strong sell signal. If the price curve is low, MA tends to continue the downtrend, indicating a weak sell signal.

Indicator	Symbol	Measurement	Buy or sell signals
Exponential Moving Average	EMA	EMAt (n)= EMA t-1 (n)× (1-$\frac{2}{n+1}$) + Xt × $\frac{2}{n+1}$	If the price curve is bullish and cuts the EMA chart, it indicates a strong buy signal. If the price curve is bearish and cuts the EMA chart, it indicates a strong sell signal
Moving Average Convergence Divergence	MACD	MACD t (n)= EMA t (s) - EMA t (l)	If the curve is bullish more than zero, it indicates a strong buy signal. If the curve is in a downtrend less than zero, it indicates a weak buy signal
Price Rate Of change	ROC	ROCt (n)= $\frac{x_t - x_{t-n}}{x_{t-n}}$	If the ROC chart is bullish and above zero, it indicates a strong buy signal. If the ROC chart is down and below zero, it indicates a weak buy signal
Relative strength Index	RSI	RSI= 100 - $\frac{100}{1+RS}$ First RS= (Average Gain/ Average Loss	If the RSI curve is bullish and exceeds 30. Strong buy signal, If the RSI chart falls below 70 in a downtrend trend, it shows a strong sell signal
True Strength Index	TSI	TSI= (PCDS/ APCDS) * 100 PCDS= PC double smoothed APCDS= Absolute PC double smoothed PC = Price changes	If the TSI value is bullish, it indicates a strong sell signal. If the TSI value is down, it indicates a weak sell signal.
Average Directional Movement Index	ADX	+ DI: Positive directional indicator -DI: Negative directional indicator	When the + DI chart is higher than -DI, it indicates a bullish or upward trend and indicates a strong buy signal. When the –DI chart is higher than + DI, it indicates a bearish market or a downward trend, showing a weak sell signal.
Average True Range	ATR	TR= max [(high- low), abs (high – close prev), abs (low- close prev)] ATR (n)= n-1$\sum_{i=0}^{n} TR$	If the ATR changes are positive, it indicates a strong sales signal. If the ATR changes are negative, it indicates a weak sales signal.
Hull Moving Average	HMA	HMAr (n) = WMAt (floor ($\sqrt{n}$)) of (2 × WMA t (floor ($\frac{n}{2}$) – WMA t (n))	If the HMA slope changes from negative to positive, it indicates a strong sell signal. If the HMA slope changes from positive to negative, it indicates a weak sell signal.
Trend changes	Aroon	Aroon Up= 100 × (25- Days Since 25-Day High) / 25 Aroon Down= 100 × (25- Days Since 25-Day Low) / 25	When Aroon is high and above 70, it indicates a strong uptrend and a strong buy signal. When Aroon is lower than 70, it indicates a strong downtrend and a strong sell signal.
Commodity Channels Index	CCI	CCI= $\frac{PRICE-MA}{0.015*D}$	If the CCI chart is bullish and above zero, it indicates a strong buy signal. If the CCI chart is bearish and below zero, it indicates a weak sell signal

3-In this step, the research hypotheses were tested using analysis of variance (ANOVA) and Fisher's least significant difference (LSD) test. This method is typically used to compare the mean equality of several groups.

Findings

Panels 1 and 2 in Table 3 present the descriptive statistics for the returns from the trading signals of 11 indicators. . The first panel shows the weekly data and the second panel presents the monthly data.

Table 3.
Descriptive statistics for the returns in the weekly and monthly data

Indicator	Average	Std. Deviation	Skewness	Kurtosis	Min	Max
Panel 1. ***Descriptive statistics for the distribution of returns on weekly data sell signals***						
MA	0/0868	0/0711	1/012	4/291	-1/208	0/9972

Indicator	Average	Std. Deviation	Skewness	Kurtosis	Min	Max
EMA	0/0967	0/3419	4/22	8/0351	-11/320	10/7145
MACD	0/0712	0/2335	-1/013	12/183	-1/369	0/9876
ROC	0/0512	0/2008	21/099	7/642	-1/583	6/8748
RSI	0/0912	0/3488	20/06	5/51	-1/5459	9/7210
TSI	0/0419	0/1898	-3/804	2/342	-1/584	0/6238
ADX	0/0705	0/0819	0/324	7/306	-1/429	1/4081
ATR	0/0548	0/1121	-8/219	4/301	-1/377	1/3810
HMA	0/0625	0/2009	4/609	2/744	-1/228	10/6822
Aroon	0/0744	0/4903	18/611	3/431	-1/810	12/3194
CCI	0/0483	0/1203	-1/085	5/798	-1/625	1/7026
Panel 2. ***Descriptive statistics for the distribution of returns on monthly data sell signals***						
MA	0/1146	0/1756	3/72	25/821	-1/0746	1/7127
EMA	0/1222	0/2127	2/132	32/555	-2/234	1/6176
MACD	-0/2008	0/8364	-2/472	10/441	-5/5289	1/7261
ROC	0/0105	0/2847	-4/019	23/724	-2/6843	0/3563
RSI	0/0875	0/2983	-0/128	9/092	-1/300	1/5948
TSI	-0/0819	0/5620	-1/816	5/11	-2/4940	1/3844
ADX	0/0854	0/1954	1/067	6/911	-0/7963	1/3528
ATR	0/0094	0/2570	-1/048	10/173	-1/4626	1/553
HMA	0/0246	0/2200	-3/204	18/228	-1/6068	1/0830
Aroon	0/0656	0/8243	14/46	25/299	-2/1326	14/0563
CCI	0/0192	0/4276	8/198	15/979	-2/798	6/7222

As can be seen, the exponential moving average, relative strength index, and the moving average are equal to 0.096, 0.091, and 0.086, respectively, showing the highest returns and the highest profitability strength. Of the 11 weekly trading signals, true strength and commodity channels have the lowest returns, indicating lower profitability. In the case of monthly interval investment, the average index return, moving average and exponential moving average, and relative strength with the values of 0.114, 0.122, and 0.075 have the highest returns and the highest potency in profitability. Among the 11 monthly buy and sell signals, true strength and divergent moving average have the lowest returns, and all indices have a low standard deviation. The low standard deviation means that in these indicators, decisions are made well for the buying and selling signal that it has a relatively high skewness and kurtosis that is one of the characteristics of financial skewness and kurtosis and indicates a deviation from the normal distribution of returns. Considering weekly and monthly investment amounts, monthly information has a higher return than daily information, which indicates that with the increase of the period, 11 return indicators have increased significantly. Figure (2) presents the mean values for 11 indicators in the weekly and monthly periods:

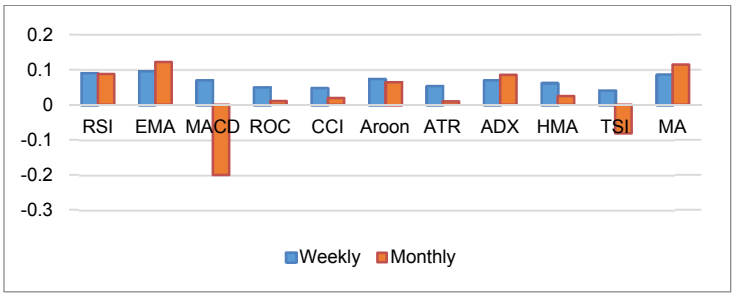

Fig 2. Average returns on 11 indicators in the weekly and monthly periods

Panels 1 and 2 in Table 4 show the descriptive statistics for the returns from the trading signals of 11 indicators. The first panel shows the quarterly data, and the second panel presents the six-month data.

Table 4.
Descriptive statistics for the returns in the quarterly and six-month data

Indicator	Average	Std. Deviation	Skewness	Kurtosis	Min	Max
Panel 1. ***Descriptive statistics of the distribution of returns of sell signals of Three -month data***						
MA	0/1287	0/3831	-1/157	41/162	-3/8754	2/8028
EMA	0/1319	0/3526	3/162	16/308	-1/5437	2/8027
MACD	-0/0437	1/0329	-0/432	0/826	-2/678	2/6105
ROC	-0/0423	0/5065	-1/708	7/166	-2/442	1/7922
RSI	0/1303	0/4986	-1/48	8/385	-2/7078	1/7348
TSI	0/0690	0/4652	1/818	13/233	-1/2299	2/9212
ADX	0/0877	0/4109	0/461	4/762	-1/6057	1/5526
ATR	0/0163	/3793	-0/85	5/595	-1/5828	1/6104
HMA	0/0506	0/3062	-1/997	11/76	-1/6343	1/5455
Aroon	0/0894	0/4402	0/234	5/922	-1/5626	2/098
CCI	0/0179	0/4349	-2/458	10/775	-2/399	1/6134
Panel 2. ***Descriptive statistics of the distribution of returns of sell signals of six-month data***						
MA	0/6366	1/5315	-0/412	4/001	-5/4905	4/544
EMA	0/5479	1/3533	0/553	3/915	-4/0123	4/5442
MACD	-2/1394	1/7269	-0/212	-1/559	-5/2963	-0/2124
ROC	0/3808	1/2966	0/827	0/549	-0/5786	4/4053
RSI	0/9928	2/1475	2/644	2/443	-1/5569	6/3834
TSI	-0/6339	1/9843	-0/206	0/434	-3/9980	4/437
ADX	0/1695	1/4482	/044	0/527	-3/6429	3/368
ATR	0/5110	1/4810	1/933	4/225	-1/7243	5/992
HMA	0/5175	1/9137	0/36	1/313	-4/6059	5/385
Aroon	0/1064	1/1412	0/879	0/289	0/5963	7/324
CCI	/0511	0/1021	-1/658	7/615	-0/3987	0/2154

As can be seen, the exponential moving average, relative strength index, and the moving average are equal to 0.131, 0.130, and 0.128, respectively, representing the highest returns and the highest profitability strength and among the buy and sell signals of the 11 quarterly indicators, the convergent moving average and the price change rate have the lowest returns, indicating the lower profitability strength. In the case of investing in the six-month, the average return of the index, the average relative strength and the moving average, and the exponential moving average with the values of 0.992, 0.636, and 0.547 have the highest returns and the highest strength in profitability and among the trading signals for the 11 six-month indices, true strength, and divergent moving average have the lowest returns, and all indicators have a low standard deviation. The low deviation of the standard means that in these indicators, decision making on the buy and sell signal is made well and has a relatively high kurtosis, which is one of the characteristics of financial information is high kurtosis and indicates a deviation from the normal distribution of returns. Figure (3) presents the mean values for 11 indicators in the quarterly and six-month periods:

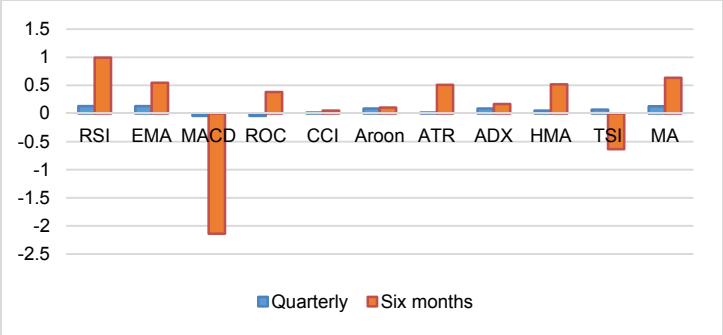

Fig 3. Average returns on 11 indicators in the quarterly and six-month periods

Comparing average returns in the weekly and monthly indicators

This section compares the average returns of the 11 indicators in the weekly and monthly periods. The weekly data in Table 5 show that the mean difference between the relative strength returns and the returns of all indicators (except the exponential moving average and moving average convergence divergence) is significant and the difference in the returns between relative strength and true strength is 0.049, implying the highest significant difference is between the relative strength returns index with true strength returns. Besides, the difference in the returns between relative strength and trend change is 0.016 indicating the smallest significant difference between relative strength returns and trend change returns. The weekly data also suggest that the mean difference between the exponential moving average returns and the returns of all indicators (except relative strength and moving average convergence divergence) is significant and the difference in the returns between the exponential moving average and True Strength Index is 0.054, implying that greatest significant difference is between the exponential moving average returns and True Strength Index. Moreover, the difference in the returns between the exponential moving average and trend change is 0.022 indicating the lowest significant difference between these two variables. The average returns of the moving average convergence divergence do not show any significant difference with other indicators. The same trend can be observed for a majority of indicators. However, there is a positive significant difference between the relative strength and the exponential moving average in the weekly data suggesting that their returns point to a better (buy) signal.

Furthermore, a comparison of the monthly data (Table 5) suggests that the mean differences between the relative strength returns and the returns of all indicators (except the exponential moving average, trend changes, average directional movement, and the moving average) are significant. Besides, the difference in the returns between the relative strength and the moving average convergence divergence is 0.28, suggesting the highest significant difference in the returns between the relative strength and the moving average convergence divergence. Moreover, the difference in the returns between the relative strength and Hull moving average is 0.062 pointing to the smallest significant difference between the relative strength and Hull moving average returns. The monthly data also suggest that the mean differences between the exponential moving average returns and the returns of all indicators (except the moving average) are significant and the difference in the returns between the exponential moving average and the moving average convergence divergence is 0.32, implying that the greatest significant difference is between the exponential moving average and the moving average convergence divergence returns. Moreover, the difference in the returns between the exponential moving average and the average directional movement is 0.047 indicating the lowest significant difference

between these two variables. The average returns of the moving average convergence divergence show significant differences with other indicators (except for the relative strength and the exponential moving average). In other words, the average returns for the moving average convergence divergence are smaller than those of the other indicators. Furthermore, the mean differences between the moving average returns and the returns for all indicators (except for the relative strength and the exponential moving average) are significant and the difference in the returns between the moving average and the moving average convergence divergence is 0.316 indicating the greatest significant difference between these two variables. Moreover, the relative strength, the exponential moving average, the moving average, and the moving average convergence divergence show the greatest significant difference in the monthly data suggesting that their return show a better (buy) signal, and a greater number of indicators show significant differences with other indicators in terms of returns in the monthly data compared to the weekly data.

Table 5.
A comparison of the average returns for different (weekly and monthly) indicators

Indicator	1	2	3	4	5	6	7	8	9	10	11
RSI(1)	0/00	-0/005 (0/44)	0/019 (0/29)	0/039 (0/00)	0/042 (0/00)	0/016 (0/04)	0/036 (0/00)	0/020 (0/007)	0/028 (0/00)	0/049 (0/00)	0/004 (0/53)
EMA(2)	-0/035 (0/13)	00/0	0/025 (0/16)	0/045 (0/00)	0/048 (0/00)	0/022 (0/001)	0/042 (0/00)	0/026 (0/00)	0/034 (0/00)	0/054 (0/00)	0/009 (0/053)
MACD(3)	0/28 (0/00)	0/321 (0/00)	00/0	0/020 (0/28)	0/022 (0/21)	-0/003 (0/86)	0/016 (0/36)	0/0007 (0/96)	0/0008 (0/63)	0/029 (0/13)	-0/015 (0/39)
ROC(4)	0/076 (0/003)	0/111 (0/00)	-0/211 (0/00)	00/0	0/002 (0/69)	-0/023 (0/003)	-0/003 (0/64)	-0/019 (0/005)	-0/011 (0/093)	0/009 (0/36)	-0/354 (0/00)
CCI(5)	0/066 (0/012)	0/102 (0/00)	-0/221 (0/00)	-0/010 (0/64)	00/0	-0/026 (0/001)	-0/006 (0/371)	-0/022 (0/001)	-0/014 (0/02)	0/006 (0/52)	-0/384 (0/00)
Aroon(6)	0/028 (0/30)	0/063 (0/003)	-0/259 (0/00)	-0/484 (0/044)	-0/037 (0/11)	00/0	0/019 (0/009)	0/003 (0/58)	0/011 (0/087)	0/032 (0/002)	-0/012 (0/068)
ATR (7)	0/077 (0/00)	0/111 (0/00)	-0/210 (0/00)	0/001 (0/96)	0/011 (0/60)	0/049 (0/034)	00/0	-0/015 (0/01)	-0/007 (0/208)	0/012 (0/203)	-0/032 (0/00)
ADX(8)	0/011 (0/63)	0/047 (0/007)	-0/275 (0/00)	-0/064 (0/002)	-0/054 (0/010)	-0/016 (0/46)	-0/065 (0/001)	00/0	0/008 (0/16)	0/028 (0/003)	-0/016 (0/004)
HMA(9)	0/062 (0/010)	0/097 (0/00)	-0/225 (0/00)	-0/014 (0/49)	-0/003 (0/86)	0/034 (0/11)	-0/015 (0/44)	0/050 (0/006)	00/0	0/020 (0/030)	-0/024 (0/00)
TSI(10)	0/160 (0/00)	0/204 (0/00)	-0/118 (0/012)	0/092 (0/011)	0/102 (0/005)	0/140 (0/00)	0/091 (0/011)	0/157 (0/00)	0/106 (0/002)	00/0	-0/044 (0/00)
MA (11)	-0/028 (0/21)	0/007 (0/64)	-0/316 (0/00)	-0/104 (0/00)	-0/094 (0/00)	-0/056 (0/006)	-0/105 (0/00)	-0/040 (0/017)	-0/090 (0/00)	-0/19 (0/00)	00/0

The first value in the table is the difference between the means of the two variables and the second value is the significance level (P-value) between the two variables. All values with a significance level of 0.05 (the confidence level 0.95) are significant.

Comparing the average returns in the quarterly and six-month data

This section compares the average returns of the 11 indicators in the quarterly and six-month periods. The quarterly data in Table 6 suggest that the mean difference between the relative strength returns and the returns of the moving average convergence divergence, price changes, commodity channels, and the true average returns are significant. Besides, the difference in the returns between relative strength and the moving average convergence divergence is 0.174, implying the highest significant difference between the relative strength returns

and the moving average convergence divergence. Moreover, the difference in the returns between relative strength and commodity channels index is 0.112 indicating the smallest significant difference between relative strength returns and commodity channels. The six-month data also suggest that the mean differences between the exponential moving average returns and the returns of the moving average convergence divergence, price changes, commodity channels, and the true average returns are significant and the difference in the returns between the exponential moving average, the moving average convergence divergence, and price changes is 0.180, implying that the exponential moving average returns have the greatest significant difference with the moving average convergence divergence and price changes. Moreover, the difference in the returns between the exponential moving average and commodity channels index is 0.022 indicating the lowest significant difference between these two variables. The average returns of the moving average convergence divergence do not show any significant difference with other indicators (except for the average directional movement and the moving average). The same trend can be observed for a majority of indicators. However, there is a greater positive significant difference between the relative strength and the exponential moving average in the quarterly data implying that their returns point to a better (buy) signal.

Furthermore, the analysis of the six-month data (Table 6) suggests that the mean differences between the relative strength returns and the returns of all indicators (except the moving average) are significant. Besides, the difference in the returns between the relative strength and the moving average convergence divergence is 3.132, suggesting the highest significant difference in the returns between the relative strength and the moving average convergence divergence. Moreover, the difference in the returns between the relative strength and Hull moving average is 0.457 pointing to the smallest significant difference between the relative strength and Hull moving average returns. The six-month data also suggest that the mean differences between the exponential moving average returns and the returns of all indicators (except the price changes, the true average, Hull moving average, and the moving average) are significant and the difference in the returns between the exponential moving average and the moving average convergence divergence is -2.68, implying that the greatest significant difference between the exponential moving average and the moving average convergence divergence returns. Moreover, the difference in the returns between the exponential moving average and the trend change is 0.44 indicating the lowest significant difference between these two variables. The average returns of the moving average convergence divergence show negative significant differences with other indicators. In other words, the average returns for the moving average convergence divergence are smaller than those of the other indicators. Furthermore, the mean differences between the moving average returns and the returns for all indicators (except for the exponential moving average, the relative strength, price changes, the true average, and Hull moving average) are significant. What's more, the relative strength, the exponential moving average, the moving average, and the moving average convergence divergence show the greatest significant difference in the six-month data suggesting that their return show a better (buy) signal, and a greater number of indicators show significant differences with other indicators in terms of returns in the six-month data compared to the quarterly data. In general, as the changes in the returns on the indicators move from weekly to six-month periods, there would be a higher significance difference, indicating that the returns on the indicators have better signals in longer periods.

Table 6.

A comparison of the average returns for different (quarterly and six-month) indicators

Indicator	1	2	3	4	5	6	7	8	9	10	11
RSI(1)	00/0	-0/001 (0/86)	0/174 (0/01)	0/173 (0/001)	0/112 (0/01)	0/047 (0/32)	0/113 (0/009)	0/042 (0/351)	0/079 (0/06)	0/061 (0/23)	-0/001 (0/98)
EMA(2)	0/444 (0/02)	00/0	0/180 (0/004)	0/180 (0/00)	0/119 (0/002)	0/054 (0/17)	0/120 (0/001)	0/049 (0/18)	0/086 (0/012)	0/068 (0/12)	0/005 (0/85)
MACD(3)	3/132 (0/00)	-2/687 (0/00)	00/0	-0/0005 (0/99)	-0/061 (0/35)	-0/126 (0/058)	-0/060 (0/34)	-0/13 (0/04)	-0/094 (0/13)	-0/112 (0/10)	-0/175 (0/005)
ROC(4)	0/612 (0/00)	0/167 (0/321)	-2/520 (0/00)	00/0	-0/061 (0/28)	-0/126 (0/01)	-0/059 (0/19)	-0/131 (0/006)	-0/093 (0/04)	-0/112 (0/03)	-0/174 (0/00)
CCI(5)	0/941 (0/00)	0/4968 (0/00)	-2/190 (0/00)	0/329 (0/00)	00/0	-0/064 (0/15)	0/001 (0/97)	-0/070 (0/10)	-0/032 (0/43)	-0/050 (0/31)	-0/113 (0/004)
Aroon(6)	0/886 (0/00)	0/4415 (0/00)	-2/245 (0/00)	0/274 (0/062)	-0/0553 (0/00)	00/0	0/066 (0/119)	-0/005 (0/90)	0/032 (0/44)	0/013 (0/78)	-0/048 (0/22)
ATR (7)	0/481 (0/03)	0/036 (0/371)	-2/650 (0/00)	-0/130 (0/098)	-0/459 (0/00)	-0/404 (0/00)	00/0	-0/071 (0/07)	-0/034 (0/36)	-0/052 (0/26)	-0/115 (0/001)
ADX(8)	0/823 (0/00)	0/378 (0/063)	-2/308 (0/00)	0/211 (0/061)	-0/118 (0/42)	-0/063 (0/921)	0/341 (0/058)	00/0	0/037 (0/34)	0/019 (0/69)	-0/043 (0/24)
HMA(9)	0/475 (0/001)	0/030 (0/450)	-2/656 (0/00)	-0/136 (0/071)	-0/6462 (0/00)	-0/411 (0/00)	-0/006 (0/921)	-0/348 (0/073)	00/0	-0/018 (0/69)	-0/080 (0/02)
TSI(10)	1/626 (0/001)	1/181 (0/00)	1-/505 (0/00)	1/014 (0/00)	0/685 (0/00)	0/740 (0/00)	1/144 (0/00)	0/803 (0/00)	1/151 (0/00)	00/0	-0/062 (0/16)
MA (11)	0/356 (0/059)	0/356 (0/059)	-2/776 (0/00)	-0/255 (0/054)	-0/585 (0/00)	-0/530 (0/00)	-0/125 (0/13)	-0/467 (0/00)	-0/119 (0/15)	-1/270 (0/00)	00/0

The first value in the table is the difference between the means of the two variables and the second value is the significance level (P-value) between the two variables. All values with a significance level of 0.05 (the confidence level 0.95) are significant.

Results and Discussion

This study explored the trading strategies based on trading systems by analyzing the performance of 11 technical indicators in the firms listed on the Tehran Stock Exchange from the period from 2010 to 2020. The results showed that in the weekly data, the exponential moving average, the relative strength index, and the moving average had the highest returns. Besides, the true strength and commodity channels had the lowest returns. Furthermore, the analysis of the monthly data indicated that the moving average, the exponential moving average, and relative strength index produced the highest returns, and the true strengths and the convergent-divergent average had the lowest returns. In addition, the period data indicated the exponential moving average, relative strength index, and moving average had the highest return rates. It was also shown that price changes and the convergent-divergent average had the lowest returns. The analysis of the six-month data indicated the average returns of the relative strength index, moving average, and exponential moving average produced the highest return rates, while the true strength and convergent-divergent mean yielded the lowest returns. As a result, it can be concluded that the signals produced by the three indicators of the moving average, the exponential moving average, and relative strength in different periods (weekly, monthly, quarterly, and six months) to buy or sell stocks (as a strategy) can be used more confidently than other indicators as the produced higher return rates. Therefore, these three indicators (EMA, RSI, MA) can be used by investors as the most effective trading strategies with smaller risks.

The highest significant difference was observed in the average returns of the moving average and the moving average convergence divergence. What's more, the relative strength, the exponential moving average, the moving average, and the moving average convergence

divergence showed the greatest significant difference in the monthly data suggesting that their return had a better (buy) signal, and a greater number of indicators showed significant differences with other indicators in terms of returns in the monthly data compared to the weekly data. Besides, the relative strength, the exponential moving average, the moving average, and the moving average convergence divergence showed the greatest significant difference in the six-month data suggesting that their returns showed a better (buy) signal, and a greater number of indicators show significant differences with other indicators in terms of returns in the six-month data compared to the quarterly data. In general, as the changes in the returns on the indicators moved from weekly to six-month periods, there would be a higher significance difference, indicating that the returns on the indicators showed better signals in longer periods. Therefore, to obtain higher returns and profits, investors can used a combination of these three indicators in the weekly (EMA) and monthly (MA and RSI) periods and quarterly (RSI and EMA) and six-month (MA) periods, respectively to adopt a buy and sell strategy that exposes fewer risks to their investments. The results also showed that efficiency and effectiveness, a combination of several types of indicators is better than using single indicators which is in line with the research of Pramodia and Echsani (2020). Also the results of this research are in line with the researches of Dai et al. (2021), Liu and Pan (2020), Pramodia and Echsani (2020) and Bashir Khodaparasti et al. (2019). Therefore, it is suggested that investors set their investment horizon long-term and use a strategy for investment by combining these three indicators. It is suggested that in future research, investment strategies using genetic algorithms and combined signals of these three indicators be examined. Also, in a study combining the signals of these three indicators, an automated trading system should be designed using a learning machine.

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