A Comparative Study between RSI and MACD to predict opportunities in cryptocurrency market from 2020 to 2022

دراسة مقارنة بين RSI وMACD للتنبؤ بالفرص في سوق العملات المشفرة بين 2020 و2022

Ziet Adel
(LERM) Setif 1 University, Algeria
adel.ziet@univ-setif.dz

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Abstract:

This paper intends to study the best technical analysis tool to predict future prices movement on cryptocurrency market. We have focused on two among the strongest technical analysis tools, the Moving Average Convergence and Divergence (MACD) and Relative Strength Index (RSI). For this purpose, we have used a backtest program to evaluate the profitability of the two technical trading strategies on ten cryptocurrencies. The results show that the two indicators generate several buying and selling signals, which help the investors to take their investment decision. However, the RSI was more accurate than the MACD in its signal. The RSI has an important role to detect the overbought and oversold situations and help the investors to diagnostic the price whether is it undervalued, overvalued or suitable value. But we cannot skip the important flexibility of the MACD to recognize robust trend and trend reversals.

Keywords: cryptocurrencies; RSI; MACD; Backtest; trading strategies.

Jel Classification Codes : C02 ; C15 ; C53

الملخص:

حاولنا من خلال هذه الورقة دراسة أفضل أداة تحليل فني للتنبؤ بحركة الأسعار المستقبلية في سوق العملات المشفرة. ولقد ركزنا على اثنتين من أقوى أدوات التحليل الفني، وهما مؤشر تقارب وتباعد المتوسطات المتحركة (MACD) ومؤشر القوة النسبية (RSI). لهذا الغرض، استخدمنا برنامج اختبار لتقييم ربحية استراتيجيتي تداول على عشر عملات مشفرة. النتائج المتحصل عليها أظهرت أن المؤشرين يولدان عدة إشارات بيع وشراء تساعد المستثمرين على اتخاذ قراراتهم الاستثمارية، غير أن مؤشر القوة النسبية كان أكثر دقة من MACD في مصداقية الإشارات التي أنتجها. كما أن الدراسة بينت أن مؤشر القوة النسبية يمكن استخدامه في اكتشاف حالات ذروة الشراء والبيع ومساعدة

المستثمرين على تشخيص السعر سواء كان مقومًا بأقل من قيمته أو مبالغ فيه أو قيمة مناسبة في حين أن MACD يعتبر أداة هامة للتعرف على الاتجاهات القوية وانعكاسات الاتجاه.

الكلمات المفتاحية: العملات المشفرة، مؤشر القوة النسبية؛ مؤشر تقارب وتباعد المتوسطات المتحركة؛ برنامج اختبار؛ استراتيجية التداول.

Jel Classification Codes : C02 ; C15 ; C53

Introduction:

The ultimate goal of an investor is the maximization of profits and the reduction of the risk involved in stock trading. To reach this goal, he must choose the right asset for investment at the right time by forecasting their prices in the future. The forecasting process uses two types of analyses which are the fundamental analysis and technical analysis. In short term, technical analysis is widely used especially in currency, equity, fixed income and commodity markets. It is defined as that aspect of analysis which is based upon phenomena arising out of the market itself, to the exclusion of fundamental and all others factors (W.SCHABACKER, 2005, p. 6). It is based on Internal market data and generated by the process of trading such as stocks, futures commodities and collected by the trading exchange (Chande, 1997, p. 15). They attempt to identify profitable buying and selling opportunities.

In recent practice, technicians more commonly favor several newer indicators that also use mathematical functions to determine when to buy or sell, such as relative strength indicator (RSI) and moving average convergence divergence (MACD). These indicators as other modern technical analysis was originally developed in the context of the stock market, but their advocates argue that they can be applied in one form or another to all asset markets like cryptocurrency market.

Problematic of the study:

While numerous studies have been conducted on the profitability of RSI rules in the equity and foreign exchange market, the cryptocurrency market has never been directly addressed. Relative to other assets, the historical returns on crypto currencies are astounding. One euro invested in Bitcoin for example on January 02, 2015 grew twenty-four time on January 02, 2020, after hitting a peak value of sixty-four time on December 16, 2017. The same investment in the Euro Stoxx 50 stock index grew to only one point time over the same period. The main contribution of this paper is to apply a backtest manager to check the following problematic:

Which of the two indicators is the best to predict the best moment of buying or selling?

To test the most efficient indicator to determine the optimal timing of buying and selling, we applied a test program to simulate the investment process according to the strategy proposed by the RSI and MACD. Following the buying and selling signals generated by the program, regardless of whether it is true or false, we had given a return achieved report at the end of the period and had confirmed that any of these strategies is the best.

In our analysis, we focus on ten cryptocurrencies, Bitcoin, Ethereum, USDcoin, XRP, Binance USD, Digecoin, Cardano, Solana, Polkadot and Avalanche. These cryptocurrencies are within the top 15 currencies by market capitalization.

Objectives of the study: the paper:

- Aim to start a new debate about technical analysis efficiency in cryptocurrency market.
- Analyze some cryptocurrencies using RSI and MACD
- Analyze the recent pattern in the movement of cryptocurrency price to determine the timing of investment.

The paper is organized as follows. The next section gives a brief review of the existing literature. Section 2 discusses the simple technical indicators, which are used in this study. Section 3 discusses the data and research method. Empirical results are contained in Section 4, followed by some concluding comments in the final section.

1.Literature review:

There are thousands of papers published on technical analysis in cryptocurrency. Hence, it is impossible to provide a review of all papers. Here, we have montionned six of the most important papers:

- Neely and Weller (2011), "Technical Analysis in the Foreign Exchange Market". The Survey evidence shows that technical analysis dominates fundamental analysis at short horizons first at all in the London market. These findings have subsequently been confirmed in other markets. The paper finds that some simple technical methods had disappeared by the early 1990s. The main result of this survey is that the risk adjustment methods have failed to eliminate observed profits, they are not simply compensation for risk incurred, that means the market is not efficient (Neely & Weller, 2011).

- Tilehnouei and Shivaraj,(2013), "A Comparative Study of Two Technical Analysis Tools: Moving Average Convergence and Divergence V/S Relative Strength Index: A Case Study of HDFC Bank ltd Listed in National Stock Exchange of India (NSE).

The main conclusion of this paper is that MACD Performance Index is better than RSI Performance Index. However, this conclusion must not hide the role of RSI in overbought and oversold, and its ability to spot the undervalued or

overvalued in price. Finally, this study finds the two indices which are necessary for technical analysis of price sharing, MACD is used for the purpose of buying, holding and selling signals and RSI is used for the purpose of diagnosing the overbought and oversold signals (Tilehnouei & Shivaraj, 2013).

- Chong, Ng, and Liew (2014) "Revisiting the Performance of MACD and RSI Oscillators".

This study finds that the centerline crossover of the RSI has a predictive ability in the Italian and Canadian stock markets. In particular, the RSI (21,50) rule which performs well in the Milan Comit General Index. The RSI (14,30/70) rule is also profitable in the Dow Jones Industrials Index. Comparing the two rules, the study finds that the performance of centerline crossover is better (Chong et al 2014).

- Yu (2017), Empirical Analysis of RSI Based on Vocational Education Sector of Listed Companies. The paper analyzes the practicability of RSI expert system with the win rate, annual rate of return and net profit rate that investors pay the most attention to as the management objective. The result shows that the annual rate of return and net profit margin of RSI expert system were 44.4% and 44.3% of Shanghai Composite Index which shows that the investment in vocational education sector under the guidance of RSI expert system cannot outperform the market index. RSI expert system with 100% win rate provides a safe investment plan for investors. The investment plan is obviously popular with the investors who hate risks. The results show that 8.33% of annual rate of return is 4.76 times annual of interest rate on bank deposits is obviously considerable (Yu, 2017).

- Chan, Chu, Nadarajah and Osterrieder (2017), "A Statistical Analysis of Cryptocurrencies". This paper analyses the data for two years and half to know the best parametric distribution to the exchange rate of some cryptocurrencies versus the U.S. Dollar. The results obtained show that none of the distributions used gives the best fit jointly across the data for all of the seven cryptocurrencies. In fact, while the generalized hyperbolic distribution gives the best fit for the Bitcoin and Lite Coin, the normal inverse Gaussian distribution is better for Dash, Monero, and Ripple. Generalized t-distribution and Laplace distribution gives the best fit to Doge coin and Maid Safe Coin respectively (Chan, Chu, Nadarajah, & Osterrieder, 2017).

- Detzel, Liu, Strauss, Zhou, and Zhu, (2018), "Bitcoin: Learning and Predictability via Technical Analysis". Since Bitcoin has no obvious fundamentals to analyze, it is therefore a natural laboratory to use technical analysis. The result of this paper confirms the ability of moving averages of

prices over different horizons to predict Bitcoin returns. In addition, the profitability of technical strategies relative to a buy-and-hold largely stems from their capacities to exit a downward-trending market, thereby decreasing the length and severity of drawdowns (Detzelet al, 2018).

2.The relative strength index vs MACD

2.1. The relative strength index: The Relative Strength Index (RSI) was mentioned by the American engineer Welles Wilder in June 1978 (Ţăran-Moroşan, 2011, p. 5856). Later, RSI became an extremely useful and popular momentum oscillator, and it was widely applied to trade in commodities, futures and securities.

a. Definition: The RSI is defined as an oscillator used in technical analysis to show price strength by comparing the movement of (Yulius & Lily , 2018, p. 25). It constitutes an extremely useful and popular momentum oscillator which compares the magnitude of its recent gains to the magnitude of its recent losses by transforming that information into a number which ranges from 0 to 100 (Indranarain , 2017, p. 133). In other word the RSI compare the magnitude of recent gains and losses over a specified period and measure speed and change of price movements of a stock, to attempt and identify the overbought or oversold conditions in the trading of a stock.

b. Relative Strength Index evaluation process: Relative Strength Index evaluation process starts with the calculation of up change UC and down change DC of closing prices in market. If the price increases, the symbol "UC" is used, and if the price decreases, then the symbol "DC" is used to describe it. We can define the UC and DC by (Annex 1):

- When yesterday closing price and today closing price are the same, UC and DC are equal to zero,
- When today closing price is bigger than yesterday closing price, DC = 0 and UC value is the difference between today closing price and yesterday closing price.
- When yesterday closing price is bigger than today closing price, UC = 0 and DC value is the difference between yesterday closing price and today closing price.
- Both DC and UC must be non-negative values.

The average value of UC and DC are the core of the formula and they compute relative strength (RS). The RS is calculated based on the Exponential Moving Average (EMA) by using the n-day factor. The exponential moving average (EMA) is determined for UC and for DC using a "multiplier" (α) calculated by the formula (3), based on a certain number of days “N” and a simple

arithmetic average (SMA) (formula (4)), of the data for the first "N" days in the string under consideration (Ţăran-Moroşan, 2011, p. 5857).

$$\alpha = \frac{1}{N+1} \qquad (03)$$

$$SMA_N = \frac{X_1 + X_2 + \cdots + X_N}{N} \qquad (04)$$

The α in the formula associates different degrees of importance to the data considered in the calculation, depending on their age. Thus, older data will weigh less in the EMA, and the latest will weigh more.

The exponential moving average of the N+1 day is determined as follows:

$$EMA_{N+1} = \alpha X_{N+1} + (1-\alpha) SMA_N \qquad (05)$$

Generally, 9th day and 14th day are used for short and medium term investments, while 56th day, 100th day and 200 th day may be used for long-term investment. The RS can be seen in Equation (Anderson & Li, 2015, p. 93):

$$RS = \frac{EMA(UC, n)}{EMA(DC, n)} \qquad (06)$$

To sum up, the formula of RS takes the last "n" periods and divides the gross positive changes per period by the gross negative changes. That means more prices move higher in that "n" period and the RSI value became higher. Vice versa when the price moves in the opposite direction. The RS is converted to RSI by the following formula:

$$RSI = 100 - \frac{100}{1 + RS} \qquad (07)$$

The relative strength index measures at every moment the force with which supply and demand act, based on the variations in prices in a given period. Its result fluctuates between 0 and 100. When the value is close to 100, there is an overbought situation, generating a favorable moment to sell. While, if the value approaches 0, it is considered a market oversold, the signal favors the purchase operation. In other words, when the RSI exceeds the value of 70 points from top to bottom, it is considered as a sell signal, and when it exceeds the value of 30 units from bottom to top it is considered as a buy signal.

However, this does not mean, the market will immediately reverse when either of these levels is reached. It is more likely that the market will pause to consolidate, resulting in a more neutral RSI value when it is close to 50.

2.2.Moving Average Convergence and Divergence (MACD):

Moving Average Convergence and Divergence oscillator is commonly referred to as MACD, which is pronounced Mack Dee. The MACD was invented in 1978 by Gerald Appel an analyst and money manager, and it's

considered as one of the top five most popular technical indicators in existence (Schlossberg, 2006, p. 87). The MACD is a trend-fellowing momentum indicator that shows the relationship between two moving averages (Tu, 2021, p. 8). The main benefits of MACD relates to its strong flexibility to recognize robust trend and trend reversals.

The embedding core component of MACD pertains to the identification of the convergence and divergence between two moving averages of closing prices. The MACD is the difference between a short-term and long-term moving average of security‘s price. Hence MACD consists of three expential moving averages (EMA). The first is the shorter EMA (for example a 12-day EMA). The second is a longer EMA (for example 26 day-EMA). The A 12, 26 and 9 formulas are widely used. In other word, the MACD is the difference between 12-day EMA and 26-day EMA and then 9-day EMA superimposed on the chart. The MACD is constructed by calculating two lines, the MACD line and the signal line (Tilehnouei & Shivaraj, 2013, p. 192).

- MACD line: difference between two exponentially smoothed moving averages, generally 12 and 26 days (any combination of moving averages can be used) (Indranarain , 2017, p. 130). The faster or shorter moving average, usually shown by a 12-day exponential Moving Average (EMA), is used to depict the shorter-term market trends. The slower or longer moving average, shown usually by a 26 day, depict the longer-term market trends

In 1986 Thomas Aspray improved on appel’s original idea by inventing the MACD histogram. This technical tool is simply the visual representation of the difference between the MACD line and its trigger line (Schlossberg, 2006, p. 87). The MACD histogram oscillates around the zero line, which is the point at which the MACD and the trigger line cross each other. In other word, the MACD histogram is used as a confirmation tool. For instance, when the fast line is moving up at a faster pace than the slow line, the MACD histogram rises into a positive territory and confirms the move higher in the cryptocurrency price.

- Signal line: exponentially smoothed average of MACD line, generally 9 days the indicator oscillates around zero and has no upper or lower limit (Tilehnouei & Shivaraj, 2013, p. 192).

Rather than using a set overbought –oversold Range for MACD, the analyst compares the current level with the historical performance of the oscillator for a particular security to determine when a security’s price is out of its normal sentiment range.

MACD is used in three ways. The first is to note crossovers of the MACD line and the signal line. Crossovers of the two lines may indicate a change in trend. The second is to look for times when the MACD is outside its normal

range for a given security. The third is to use trend lines on the MACD itself (Tilehnouei & Shivaraj, 2013, p. 192).

When the MACD is trending in the same direction as price, this pattern is convergence, and when the two are trending in opposite directions, the pattern is divergence. MACD is calculated by subtracting the 26-day exponential moving average (EMA) from the 12-day moving average. A nine-day EMA of the MACD, called the "Signal line" is the plotted-on top of the MACD, functioning as a trigger for buy and sell signals.

The MACD is constructed based on exponential moving averages. It is calculated by subtracting the longer exponential moving average (EMA) of window length N from the shorter EMA of window length M, where the EMA is computed as follows (Chong et al 2014, p. 12):

$$EMA_t(N) = \left[\frac{2}{N} * (P_t - EMA_{t-1}(N))\right] + EMA_{t-1}(N) \text{ .....(08)}$$

where EMA_t is the exponential moving average at time t, N is the window length of the EMA, and is the value of index at time t. Two different MACD rules are examined (Chong et al 2014, p. 4):

Rule 1:

A buy signal is produced when MACD crosses zero from below, while a sell signal is obtained when MACD crosses zero from above. This trading rule is denoted as MACD (N, M, 0).

Rule 2:

A buy signal is generated when MACD crosses the nine-day EMA of the MACD from below, while a sell signal is obtained when MACD crosses the nine-day EMA of the MACD from above. This trading rule is denoted as MACD (N, M, 9).

3.Data and research method:

3.1.data

The dataset contains daily records of the transactions executed on the coin-market cap web site from September 2020 to October 2022.This period was deliberately chosen so that we can analyze ten of the top twenty cryptocurrencies, ranked by their market capitalization, as of October 2022. The ten cryptocurrencies chosen to be part of this study are: Bitcoin, Ethereum, USD Coin, XRP, Binance USD, Dogecoin, Cardano, Solana, Polkadot and Avalanche.

We believe that the chosen cryptocurrencies cover the most prominent currencies, and indeed, they represent 75,29% of the market capitalization as of October 30, 2022. We assume also, that the period of two years is enough to assert the credibility of the results and to generalize the obtained results.

3.2. Computing of cryptocurrency RSI and MACD:

a. Computing cryptocurrency RSI:

Compute cryptocurrency RSI (30-70,14) start by finding the difference between the closing pricing and calculate the SMA for UP and DOWN change. Table 1 shows Bitcoin USD price on Coin Market Cap and UP, DOWN change.

Table number (01): BITCOIN USD price and UP, DOWN change.

Date	Closing price	UC	DC
15/10/2022	19068,7	0	113,1
16/10/2022	19261,9	193,2	0
17/10/2022	19548,2	286,3	0
18/10/2022	19328,2	0	220
19/10/2022	19123,9	0	204,3
20/10/2022	19042,9	0	81
21/10/2022	19162,6	119,7	0
22/10/2022	19204,8	42,2	0
23/10/2022	19571,2	366,4	0
24/10/2022	19331,5	0	239,7
25/10/2022	20082,7	751,2	0
26/10/2022	20769,5	686,8	0
27/10/2022	20292,9	0	476,6
28/10/2022	20594,4	301,5	0
29/10/2022	20809,8	215,4	0
30/10/2022	20626,3	0	183,5

Source: Author Calculation

Simple arithmetic average for UP and DOWN change is calculated as follow:

$$SMA_{UP} = \frac{193.2 + 286.3 + 119.7 + 42.2 + \cdots + 686.8 + 301.5}{14} = 196.23$$

&

$$SMA_{DP} = \frac{113.1 + 220 + 204.3 + 81 + 239.7 + 254.7 + 476.6}{14} = 95.34$$

The value of the "multiplier" α in the formula of EMA is calculated by dividing 2 by 15 days (N+1).

The value of EMA_{N+1} Up and DC are calculated as follow:

$$EMA_{14+1}UC = 0.133 * 175.96 + (1 - 0.133) * 196.23$$

=193.53

$$EMA_{14+1}DC = 0.133 * 104.95 + (1 - 0.133) * 95.33$$

=96.62

Therefore, RS value is:

$$RS = \frac{196.23}{96.62}$$

$$RS = 2$$

The RSI is calculated by using the formula n°07 and its value is:

$$RSI = 66.67$$

The value of RSI 66.67 means there is no overbought or oversold situation. The same method is used to compute RSI for the ten cryptocurrencies. The results on October 30, 2022 are resumed in the following table.

Table number (02): RSI (14, 30/70) value as of 10/30/2022.

Crypto Currency Name	Sigel	Market Cap (billion USD)	RSI (14)
Bitcoin	BTC	396.07	66.67
Ethereum	ETH	194.67	66.57
USDCOIN	USDC	43.70	43.04
XRP	XRP	22.96	47.64
Binance USD	BUSD	21.39	46.59
Dogecoin	DOGE	15.63	87.02
Cardano	ADA	13.94	53.83
Solana	SOL	11.83	58.36
Polkadot	DOT	7.53	61.12
Avalanche	AVAX	5.45	63.77

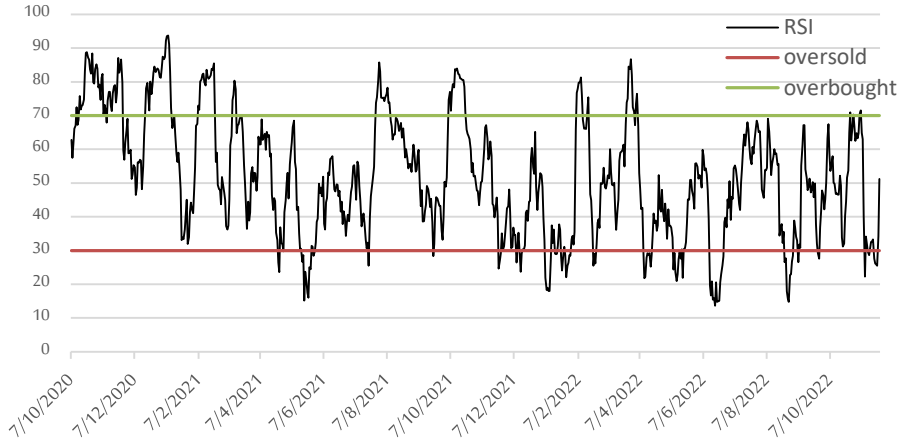
Source: Author Calculation

Table 2 shows the market capitalization and the value of the RSI computed on October 30, 2022 of the ten cryptocurrencies understudy. In column 1 and 2, the cryptocurrencies are arranged according to their market capitalization (column3). We can see that the bitcoin is the most important cryptocurrency with a capitalization of 396 billion dollar. Following by the etherum, in second place with a capitalization of 194 billion. The capitalization of the others cryptocurrencies does not exceed the 45 billion, but it still be the most important in the market. In column 4, the calculated RSI is presented for each cryptocurrency. We can see that the majority of the values are between 40 and sixty-six. That means that there is no overbought or oversold situation. The exception here is for the dogecoin which records 87.02. This value means there is an overbought situation.

Graphically, two horizontal lines represent the RSI oscillator. An upper line where demand exceeds supply (overbought), and a lower in which supply is greater than demand (oversold). These two lines are symmetrical to a central line or neutral zone, which indicates an equality between the forces of supply

and demand. As it is stated above, the oversold and overbought are set at 30 and 70 respectively, corresponding to the neutral zone a level of 50.

Figure number (01): Bitcoin RSI_{14} value.



Source: Author Calculation

Having briefly examined the summary RSI result of the ten cryptocurrencies, we provide a visual representation of the oversold and overbought situation. Figure 1 shows the value of the bitcoin RSI_{14} between October 2020 and October 2022. From the plot, we find that there are several cases of overbought and oversold situations. That means more earning opportunities are offered in this market. The same results are found for the other cryptocurrencies.

The RSI triggers a buy or sell signal in one of the following manner, 'Touch', 'Peak', 'Retracement and '50 Crossover methods (Wong et al, 2003).

- The Touch method, when RSI falls below oversold zone (< 30) and rises above 30 again, a buy signal is obtained. A sell signal is produced when the RSI rises above the overbought zone (> 70) and falls below 70 again.
- The peak method generates a buy signal (or a sell signal) when the RSI passes over the lower bound (the upper bound) and turns back.
- The retracement method generates a buy (or sell) signal when the RSI has crossed the lower (or upper) bound and retraced back to the same lower (or upper) bound or higher.
- The 50 crossover method generates a buy signal when the oscillator rises above 50 and a sell signal when its falls below 50.

b. Computing cryptocurrency MACD and Histogram:

As we have seen above the indicator consists of two lines: the MACD line and the signal line. The MACD line essentially plots the difference

between the cryptocurrency pair's 12-periode and 26-periode. This is called the (fast) MACD line (Tu, 2021, p. 8).

$$MACD_{FAST} = EMA_{12} - EMA_{26} \ldots.(09)$$

The mathematical expression of EMA is (K.Thomas, 2012, p. 228):

$$EMA_N = P_{t+1} * H + EMA_t * (1 - H) \ldots\ldots\ldots(10)$$

Where H = 2/(N+1), P = cryptocurrency price, t = time point and N = the chosen time span (26 or 12).

Table number (03): Bitcoin MACD and Histogram.

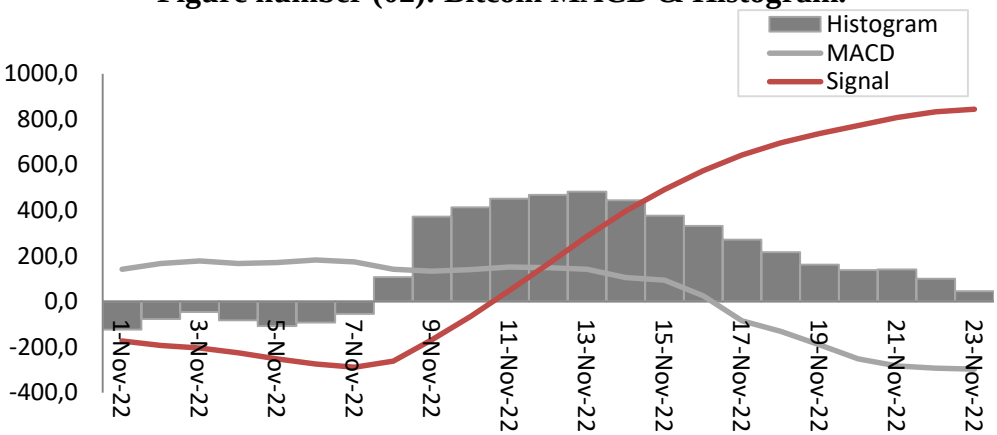
Date	close	EMA 12	EMA 26	MACD	Signal	Hist
01/11/2022	20483,5	19917,1	20213,6	-296,4	-173,3	-123,1
02/11/2022	20154,4	19934,7	20204,5	-269,8	-192,6	-77,2
03/11/2022	20206,4	19954,8	20204,8	-249,9	-204,1	-45,9
04/11/2022	21145,9	20043,1	20349,6	-306,5	-224,6	-81,9
05/11/2022	21301,6	20136,3	20496,0	-359,7	-251,6	-108,1
06/11/2022	20916,3	20194,1	20560,7	-366,6	-274,6	-92,0
07/11/2022	20589	20223,3	20565,0	-341,7	-288,0	-53,7
08/11/2022	18527,4	20097,7	20251,6	-153,9	-261,2	107,3
09/11/2022	15886,9	19785,8	19580,1	205,7	-167,8	373,5
10/11/2022	17589,1	19623,1	19273,8	349,3	-64,4	413,7
11/11/2022	17049,9	19432,5	18931,6	500,8	48,7	452,2
12/11/2022	16795,2	19237,1	18603,0	634,2	165,8	468,4
13/11/2022	16324,5	19021,4	18252,4	768,9	286,4	482,5
14/11/2022	16613,7	18843,0	18000,3	842,7	397,7	445,1
15/11/2022	16895,1	18698,7	17830,3	868,5	491,8	376,6
16/11/2022	16540,5	18538,9	17631,9	907,0	574,9	332,2
17/11/2022	16691,2	18402,0	17487,1	914,9	642,9	272,0
18/11/2022	16638,3	18271,4	17356,5	914,8	697,2	217,6
19/11/2022	16699,2	18154,9	17255,4	899,5	737,7	161,8
20/11/2022	16286,7	18016,5	17106,4	910,1	772,2	137,9
21/11/2022	15776,2	17850,6	16901,7	948,8	807,5	141,3
22/11/2022	16212,9	17729,3	16795,8	933,5	832,7	100,8
23/11/2022	16470,2	17636,0	16745,7	890,3	844,2	46,1

Source: Author Calculation

The table above shows the Closing Price, MACD and Signal Line, and MACD Histogram of bitcoin, for the period of twenty-three days (from 1st

November, 2022 to 23th November, 2022). It is observed that Bitcoin was range bound for this period between the prices of 15776.2 and 17589.1 EURO. MACD is computing using the formula n°9. The value of the histogram is the difference between the MACD and the signal line. The MACD is also plotted with its trigger line, which is simply the 09-periode EMA of the MACD itself. The signal line is simply the 9-periode EMA of the (fast) MACD. We use the mathematical expression n° 10 to calculate it.

Figure number (02): Bitcoin MACD & Histogram.



Source: Author Calculation

To predict the price behavior and the favorable time to buy and sell, the MACD, the signal line and the histogram are plotted in the same chart. The trading rule is based on the crossover between the MACD and signal lines. When the fat MACD line crosses above the slow signal line, a buy is generated. When the fast line crosses below the slow line, a sell signal is implemented. This trading rule is similar to the crossover between a 12-periode EMA and 26-periode EMA. The trader will buy when the first one crosses over and is above the second. He will sell when the 12-periode EMA crosses over and is below the 26-periode EMA (K.Mak, 2006, p. 143).

From figure 1, we can observe that MACD of Bitcoin has generated one Signal Line Crossovers and one Centre Line Crossovers during the taken time frame. A Strong Bullish Crossover signal is generated on 12 November 2022. It signifies that MACD turns up and crosses above the signal line. It generates buy signal. To confirm the rise or the fall in the cryptocurrency market the MACD histogram is used. In this case, when the fast line is moving up at a faster pace than the slow line, the histogram must rise into a positive territory and confirms the move higher in the market prices. If the market price is rallying and MACD histogram is not moving higher, the rally is not confirmed and is likely to prove a short-lived. The same analysis is used during market declines. In our graph, there is a confirmation about the market

trend. Through MACD Histogram of BITCOIN, the positive and negative MACD have been identified. Positive MACD Histogram constructed above the Zero Line and Negative MACD Histogram constructed below the Zero Line. Positive MACD indicates that the 12-day EMA is above the 26-day EMA and it means upside momentum is increasing. Negative MACD indicates that the 12-day EMA is below the 26-day EMA and it means down side momentum is increasing.

4. RESULTS AND DISCUSSION

We applied a backtest manager to check the profitability of cryptocurrency trading. The trading guideline is the "buy and sell signal" provided by the RSI and MACD indicator. The backtest is a program designed by ABCBOURSE to do effectiveness tests of technical analysis indicators in an earlier period (two years in our case). It simulates an investment process according to the strategy proposed by each technical indicator separately. Following the buying and selling signals generated by the two indicators, regardless of whether it is true or false, the test program let us to:

-produce a report on the return achieved at the end of the period;

- confirm which strategy is the best.

The paper attempts to check the profitability of 100.000 USD investments following the strategy based on touch and 50 crossover forms of RSI, and the crossover between the MACD and signal lines as below:

- For the strategy based on RSI rule **the buying strategy** starts by buying the cryptocurrency when the RSI rises above 50 (Market entry signal) and selling the asset when the RSI rises above overbought zone 70 (Market exit signal). **The selling strategy** begins by selling the cryptocurrency when the RSI falls below the neutral zone 50 (Market entry signal) and buying it when the value of the RSI falls below the oversold bare (Market exit signal).
- For the strategy based on MACD the buying strategy starts by buying the cryptocurrency when the fat MACD line crosses above the slow Signal line. The selling strategy is implemented when the fast line crosses below the slow line.

To let more buy and sell signals appear, we limited the losses and gains to 10 percent of the amount invested. In other words, the transaction will be closed when the profit or loss exceeds 10 percent of the amount invested. To evaluate the buying and selling strategies supported by the RSI and MACD indicators, we compare their global signals and returns in the same period.

By applying the above-described buying and selling strategies, we obtained the results summarized in Table 3:

Table number (04): Buying and selling strategy signals.

Indicator	Strategy	Total signals	Successful signals	Losing signal
RSI	Buy	122	62	60
	Sell	113	62	51
Total		235	124	111
MACD	Buy	138	57	81
	Sell	132	69	63
Total		270	126	144

Source: Author Calculation

The table provides important information about the application of the two strategies in all cryptocurrencies. First, the total signals issued from the simulation are two hundred thirty-five for the RSI and two hundred seventy for the other strategy. That means, the MACD is better than the RSI regarding the number of signals provided. Secondly, the two indicators provide more buying signals than selling signals, this point doesn't matter as it's in correlation with the evolution of the cryptocurrency trend line. However, taking the losing cases in buying and selling signals in account, we found an important dominance of the losing one in both buying strategies, which means that the two strategies do not confirm their reliability in this trading strategy. Thirdly, the percentage of losing signal is higher in the MACD trading strategy. According to the market principal, it means that the investor has more chances to take the right decision following the RSI indicator.

Contrary to what we expected, more or less significant benefits were generated depending on the strategy applied. The table below summarizes the global returns of each trading strategy.

Table number (05): Buying and selling strategy results.

Thousand euro

Indicator	Strategy	Total gain	Total loos	Final result
RSI	Buy	582.6	(602.2)	(19.6)
	Sell	561.2	(518.8)	42.3
	Total	1143.8	(1121.0)	22.8
MACD	Buy	564.9	(676.1)	(111.2)
	Sell	693.7	(581.6)	112.1
	Total	1258.6	(1257.7)	0.9

Source: Author Calculation

According to the dominance of the loss signals in the buying strategies, both indicators generated a total loss of one hundred and thirty thousand euros

(19.6 for the RSI and 111.2 for the MACD). We must emphasize in this case that the losses caused by the RSI are less significant. On the other hand, we found that the profits are significantly more in the MACD, which apparently shows it to be more successful, but the high level of loss signals belies this. Overall, the RSI trading strategy generates more profits (22.8 thousand) than the MACD (9 hundred euros). Based on the latter score, the RSI can be considered as the best in terms of performance

Summary statistics of the trading strategies return of the ten crypto-currencies are given in tables 06. We see a strong reflection of how accurate the two indicators are in each cryptocurrency to give the right decision to the investor.

Table number (06): buying and selling strategies result by cryptocurrency.

Thousand euro

strategy / Cryptocurrency	Buying and Selling strategy Based on RSI indicator		Buying and Selling strategy Based on MACD indicator	
	Total loos/gain	Signal of strategy	Total loos/gains	Signal of strategy
Bitcoin	13.2	↗	(31.4)	↘
Ethereum	(27.1)	↘	(29.7)	↘
USDCOIN	(0.6)	↘	(2.0)	↘
XRP	(25.1)	↘	2.8	↗
Binance USD	8.9	↗	1.5	↗
Dogecoin	17.1	↗	(28.3)	↘
Cardano	23.7	↗	(5.9)	↘
Solana	(37.7)	↘	55.2	↗
Polkadot	30.0	↗	(11.6)	↘
Avalanche	20.4	↗	50.3	↗
Total	22.8	↗	0.9	↗

Source: Author Calculation

It can clearly be seen that the MACD indicator is less significant, and at the time of this study, the indicator made earns only with four cryptocurrencies. The indicator failed to grow the initial investment in the other cryptocurrencies. In final we found that the total loses are approximately equal to the total earns. We can see also that the indicator made most of its profits in just two currencies with 55 thousand in Solana and 50 thousand in

avalanche. In the other earning cryptocurrencies, the indicator made a weak result. On the other hand, we find that the realized losses were distributed better among the losing cryptocurrencies. In fact, four cryptocurrencies out of six achieved losses of more than 10% of the original investment. This supports the evidence that the MACD is a trend following indicator. This means that the indicator gives its signals as the trend occurs, not before it starts. Therefore, if you are looking to recognize an upcoming trend, the MACD is not the best indicator for this function.

In contrast, being the most popular momentum oscillators, the RSI is more significant. The number of earning-cryptocurrency and the total trading strategy profit was more than the recorded by the MACD. In fact, six cryptocurrencies out of ten achieved an average profit more than eighteen thousand euro. In terms of profit, the table shows that the Polkadot recorded the heighest score with a profit more than thirty thousand euro for two years of trading. Cordano, Avalanche, Dogecoin and Bitcoin achieved profits of more than 13% of the original investment. In the other cryptocurrencies, the trading strategy was not accurate, in fact the strategy achieved losses ranging from six hundred euros for USDcoin to thirty-seven thousand euros for Solana. This result confirms that the RSI traders essentially try to take advantage of trend direction to make decisions, attempting to predict what the price will do next. The RSI's main goal is to identify overbought or oversold conditions in a cryptocurrency market.

Conclusion:

This paper tries to find out the best indicator to predict the best time of buying and selling the cryptocurrency. Before applying the backtest, we had computed the two indicators for ten cryptocurrency for two years. We have intentionally chosen the most important cryptocurrency by her capitalization because we want to compare them and to generalize the results.

We report several interesting findings. First, the two indictors provide several buying and selling signals for all cryptocurrency, which is an important precondition that these two indicators can provide a return and can be used in the comparison.

The second finding is that the RSI indicator proved its efficiency in determining the optimal timing of buying and selling in 60% of the currencies understudied, it failed to do so in the remaining currencies. The results show that the positive signals are more than the negative one and the profits exceed losses by more than twenty-two thousand euro. Which means that the index's ability to increase investment performance in the market is good. The efficiency of the MACD is less efficient. The negative signals are divided equally between the currencies. That may be a negative sign to the indicator

if the losses outweigh the profits. In the current study, we find that profits exceed losses, but the earning are so minim and do not exceed 9 hundred euro.

Although this good profit especially on the RSI trading strategy, the results remain inaccurate for two reasons:

- There is a considerable results disparity between the selling and buying strategy, the both strategies generate a profit on the selling operation and loses on the buying operation.
- Through the results recorded in each of the currencies under study, we find that the two strategies were not accurate in half of the cases.

Future studies can extend this research by taking another technical indicator and compare their results. For instance, more and more indicators are used in different markets. These indicators are based on the assumption that all investors have the same behavior in the same situation and their reaction are so predictable.

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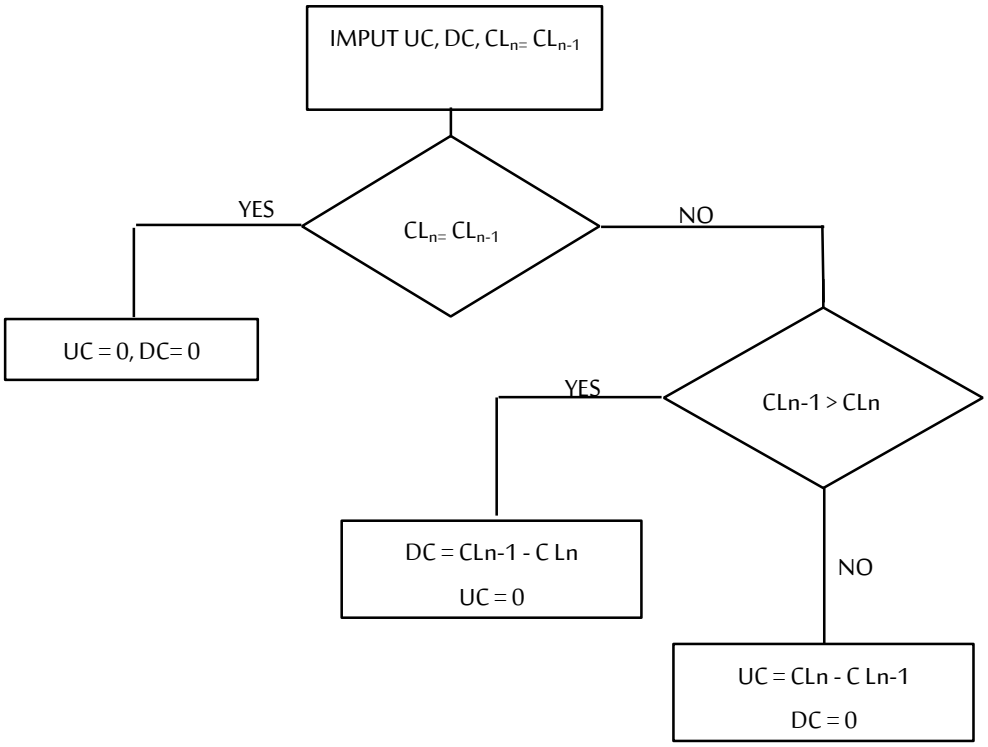
Annex : change algorithm definition



Source: Author's

Where: CLn-1 is Closing price yesterday;
CLn is closing price today;
UC is up change;
DC is down change.