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PRACTICAL USE OF THE MAXIMUM PRICE OF BITCOIN DYNAMICS AND THE MACD HISTOGRAM TO FORMULATE TRADER'S FORECASTS

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ПРАКТИЧНЕ ВИКОРИСТАННЯ ДИНАМІКИ МАКСИМАЛЬНОЇ ЦІНИ БІТКОЇНА І ГІСТОГРАМИ MACD ДЛЯ ФОРМУВАННЯ ПРОГНОЗІВ ТРЕЙДЕРА

The research article is devoted to the study of the degree of correlation between the MACD histogram and the maximum price of bitcoin on the weekly timeframe as one of the prerequisites for the formation of traders' forecasts within the framework of technical investment analysis. The main task of the study was to determine whether the maximum price of bitcoin increased or decreased compared to the previous week with the growth of the MACD, as well as to determine the average and maximum series separately for the price and MACD. The article discusses in detail the relationship between these two indicators and demonstrates how their combined use can help traders make more efficient and informed trading and investment decisions.

The study found that in 62.84% of cases, a trader can expect an increase in the maximum price of bitcoin this week if the MACD histogram showed an increase in the previous week, or a decrease in the maximum price of bitcoin this week if the MACD histogram showed a decrease in the previous week. A trader can expect a continuation of the overall medium-term trend in the bitcoin market if the MACD histogram series is below average and the end of the trend if the MACD histogram series is above average. For the rising series of the MACD histogram, the probability of the trend ending is 60.53% (approximately 5 weeks), and for the falling series — 64.86% (approximately 4 weeks). A trader can expect that the maximum price of bitcoin will continue its direction of movement in the second week in 52.17% of cases, and will end this movement after the 4th week with a probability of 90.68%.

Thus, the analysis of the dynamics of the maximum price of bitcoin in interaction with the MACD histogram shows that this indicator can be a valuable tool for predicting medium-term trends in the cryptocurrency market. Together with other indicators, a trader can make more informed investment decisions in order to gain additional profit. At the same time, it should be understood that the MACD histogram is not a universal tool for accurate trader forecasts, as the cryptocurrency market is

characterized by high volatility and the influence of numerous external factors that make it difficult to accurately predict future price movements. Therefore, investors should approach the use of MACD with caution and understand that it is only one of many factors that should be taken into account when making trading decisions.

Стаття присвячена дослідженню ступеню взаємозв'язку між гістограмою MACD та максимальною ціною біткоїна на тижневому тайм-фреймі як однієї з передумов для формування прогнозів трейдерів в рамках технічного інвестиційного аналізу. Основним завданням дослідження було визначити збільшувалася чи зменшувалася максимальна ціна біткоїна у порівнянні з попереднім тижнем при рості MACD, а також визначити середні та максимальні серії окремо для ціни і MACD. У статті детально розглянуто взаємозв'язок між цими двома індикаторами та продемонстровано, як їх спільне застосування може допомогти трейдерам у прийнятті більш ефективних та зважених торгово-інвестиційних рішень.

В результаті дослідження встановлено, що у 62,84% випадків трейдер може очікувати збільшення максимальної ціни біткоїна на поточному тижні, якщо гістограма MACD на попередньому тижні показувала зростання, або зменшення максимальної ціни біткоїна на поточному тижні, якщо гістограма MACD на попередньому тижні показувала зниження. Трейдер може очікувати продовження загального середньострокового тренду на ринку біткоїна, якщо серія гістограми MACD триває менше за середню, і закінчення тренду, якщо серія гістограми MACD триває більше за середню. Для серій зростання гістограми MACD ймовірність закінчення тренду становить 60,53% (приблизно 5 тижнів), а для серій падіння — 64,86% (приблизно 4 тижні). Трейдер може очікувати, що максимальна ціна біткоїну продовжить напрямок свого руху на другому тижні в 52,17% випадків, і закінчить цей рух після 4 тижня з ймовірністю 90,68%.

Таким чином, проведений аналіз динаміки максимальної ціни біткоїна у взаємодії з гістограмою MACD демонструє, що цей індикатор може бути цінним інструментом для передбачення середньострокових трендів на крипто валютному ринку. У сукупності з іншими індикаторами трейдер може приймати більш зважені інвестиційні рішення з метою отримання додаткового прибутку. В той же час, варто розуміти, що гістограма MACD не є універсальним інструментом для точних прогнозів трейдера, адже криптовалютий ринок характеризується високою волатильністю та впливом численних зовнішніх факторів, що ускладнюють точне передбачення майбутніх рухів ціни. Тому, інвесторам слід підходити до використання MACD з обережністю і розуміти, що він є лише одним з багатьох факторів, які слід враховувати при прийнятті торгових рішень.

Key words: Cryptocurrency, Bitcoin, MACD, MACD histogram, forecasting.

Ключові слова: Криптовалюта, біткоїн, MACD, гістограма MACD, прогнозування.

PROBLEM STATEMENT

The rapidly evolving world of cryptocurrency offers traders a wealth of opportunities to make a profit. Bitcoin, as the most famous cryptocurrency, continues to occupy a central place in discussions about the future of finance and, despite significant fluctuations in its price and regulatory challenges, remains one of the most well-known, relevant and discussed topics in the world of investment and technology.

However, the high volatility of the cryptocurrency market requires investors to constantly search for effective tools to analyze and predict future trends. The formation of trader forecasts is not just an assumption about the future, but an attempt to systematize the available information and build a logical model of crypto market behavior. For a trader, forecasts perform several key functions, the most important of which are: determining the direction of bitcoin price movement (with forecasts, a trader can try to predict whether the price of

a cryptocurrency will rise or fall, allowing him to make decisions about buying or selling assets), risk management (helps a trader develop an effective strategy for managing his assets), and profitability optimization (with accurate forecasts, a trader can choose the most profitable moments to enter and exit the crypto market).

According to the authors, the dynamics of the maximum price of bitcoin and the MACD histogram are among the most effective technical indicators that allow traders to make informed forecasts. The MACD, which is based on the difference between short-term and long-term moving averages, helps to identify buy or sell signals, thereby facilitating informed decision-making. Accordingly, the article is intended to examine in detail the relationship between these two indicators and demonstrate how their joint application can help traders make more efficient and informed trading and investment decisions.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Interest to bitcoin as a decentralized digital currency has emerged relatively recently. The first publications on this topic appeared in the early 2010s and initially had more of a technical overview and forecasts for the further development of block chain technology. Subsequently, with the growing popularity of bitcoin, the range of research has expanded significantly, covering a wide range of economic, technological, social and legal issues.

Among the latest numerous studies of cryptocurrency market development trends are publications by such authors as Gonak I. and Buchynska T. [1], Denysenko V. [2], Popova A. [5], Tkalenko S. et al. [8], Troyan K. [9]. The researches of Pylypchenko O. et al. [4], Tarasov V. [6], Tesliuk N. et al. [7], Elder A. [12], Kukacka J. & Kristoufek L. [16] are devoted to the application of technical analysis for the analysis of the cryptocurrency market; and the analysis of trends in the bitcoin price is considered in the works of Biedscheid Z.S. [11], Ignatenko A. [14, 15], Poyser O. [17], Samizadeh I. [18].

Despite a fairly large volume of publications, there is no consensus on the potential, consequences of the widespread introduction of cryptocurrencies, methodology for analyzing and forecasting the behavior of traders in the cryptocurrency market, and price forecasting strategy. Moreover, there is currently no research on the relationship between the MACD histogram and the maximum price of bitcoin, and thus the topic of this article is very relevant.

PURPOSE OF THE ARTICLE

The purpose of the article is to analyze the degree of correlation between the MACD histogram and the maximum price of bitcoin on the weekly timeframe as one of the prerequisites for forming traders' forecasts in the framework of technical analysis.

The main task of the study was to determine whether the maximum price of bitcoin increased or decreased compared to the previous week's changes in the MACD histogram, as well as to determine the average and maximum series separately for the price and the MACD histogram.

METHODOLOGY

It is known that MACD (Moving Average Convergence Divergence) is a trend tracking tool developed by J. Appel in the late 1970s, which uses moving averages to determine the momentum of a stock, cryptocurrency or other trading asset [10].

The main task of the MACD indicator is to evaluate the previous price movement, which helps traders in making investment decisions: they can assess the strength of the trend, predict changes in the trend direction and receive signals to sell or buy assets.

The article uses statistical methods to analyze the weekly maximum price of bitcoin and the MACD histogram based on the closing prices of each week (the sample size was 346 weeks for the period 2018-04-02 — 2024-11-11) [15]. The MACD indicator was chosen due to its advantages: ease of use, versatility, and multifunctionality.

The calculations were based on the following indicators:

1. Exponential moving averages (EMA):

$$EMA_{week} = (Price_{week} \times Multiplier) + (Price_{last_week} \times (1 - Multiplier)) \quad (1)$$

where $Price_{week}$ — current closing price
 EMA_{last_week} — EMA value for the previous week
 $Multiplier$ — multiplier

$$Multiplier = \frac{2}{N+1} \quad (2)$$

where N — period EMA

2. Moving Average Convergence Divergence (MACD)

$$MACD = EMA_{12} - EMA_{26} \quad (3)$$

where EMA_{12} — 12-period exponential moving average (for a short period)

EMA_{26} — 26-period exponential moving average (for a long period)

3. The signal line (9-period EMA from MACD) is an exponential moving average (EMA) calculated on the basis of MACD values for the last 9 periods and is used to smooth out MACD values, as well as helps to identify points of intersection with the main line for buy/sell signals.

$$Signal\ Line = EMA_9(MACD) \quad (4)$$

where $MACD$ — MACD values obtained from the difference between EMAs with periods of 12 and 26.

4. MACD Histogram, which shows the difference between the MACD and the signal line and helps to visualize how much the MACD deviates from its signal line.

$$Histogram = MACD - Signal\ Line \quad (5)$$

where $MACD$ — MACD values obtained from the difference between EMAs with periods of 12 and 26

$Signal\ Line$ — 9-period EMA from MACD.

Data processing based on the proposed methodological tools was carried out in the following sequence:

- price changes and MACD histograms were represented in a binary system, where each price increase or MACD histogram was taken as "1", and each price decrease or MACD histogram was taken as "0";

- calculation of continuous series of such increases in the MACD histogram and price;

- calculation of the relationship between the price and the MACD histogram from week to week, as well as the relationship between changes in the current week and price changes in the next week;

- dividing values into sectors of the beginning of the series depending on whether the MACD histogram started its change below or above the zero line;

- measurement of the total length of the series, as well as separately of the rising and falling series; calculation of the rising and falling series when the MACD histogram starts below or above the zero line.

PRESENTATION OF THE BASIC MATERIAL OF THE RESEARCH

The cryptocurrency market is a dynamic and volatile system that is constantly changing under the influence of various factors, from regulatory news to technological breakthroughs. It is this unpredictability that makes it both attractive to investors and extremely risky.

Analyzing the price of bitcoin over a long period of time is critical to understanding its dynamics and

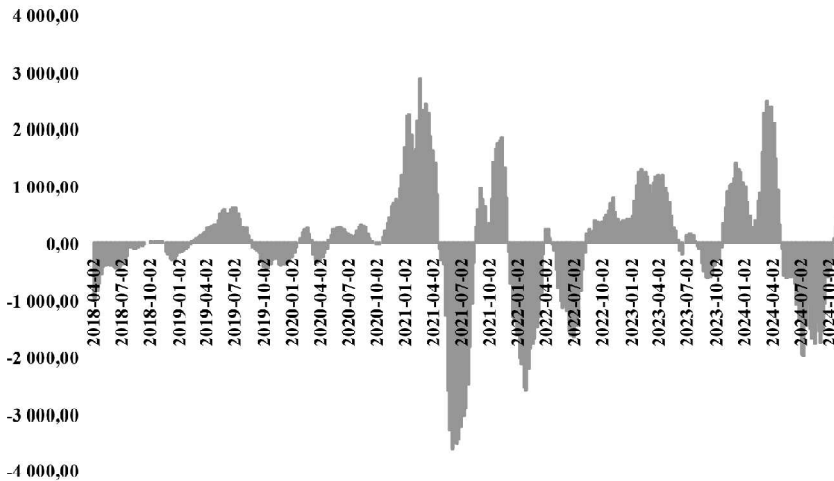


Figure 1. Histogram of MACD by closing prices of each week for the period 2018-04-02 – 2024-11-11

Source: developed by the authors.

predicting future trends. This is due to several key aspects:

- market volatility (analysis of price changes over a long period helps to understand general trends and determine whether short-term fluctuations are part of a larger trend);
- identification of long-term trends;
- identification of market cycles (by analyzing data over a long period of time, it is possible to identify recurring boom and bust cycles, which allows to predict possible future changes in the market;
- risk assessment (as the knowledge of past price fluctuations and market reactions to various events helps traders to anticipate possible risks and develop strategies to minimize them);
- developing investment strategies based on historical data and trends.

The MACD histogram, in turn, is also an important tool for analyzing and building trading strategies in the cryptocurrency market, as it allows you to: detect changes in market direction when the bars form a top and start changing height in the other direction, which can be a signal to open or close positions; assess the strength of the trend, which is reflected by the height of the MACD histogram bars; synchronize with other indicators, such as RSI or Bollinger Bands, to improve the accuracy of analysis and further forecasts.

Thus, the MACD histogram is a conditional indicator of the trend direction and strength, and if it is growing, a trader can expect the maximum price to increase, and if it is decreasing, the maximum price to decrease. However, it is important to know how often this trend is repeated and what decisions a trader should make, and this is what this study is devoted to.

Using the above methodological tools and statistical data on the weekly maximum price of bitcoin (the closing price of each week 15), we built a MACD histogram (Fig. 1).

At the first stage of the analysis, the correlation between the MACD histogram and the maximum price of bitcoin on the weekly timeframe was determined as one of the prerequisites for making traders' forecasts within the framework of technical analysis. The results of the calculations showed that if we determine the correlation between the numerical values of the price and the MACD histogram, it is

absent (the correlation coefficient is 0.06), but if we determine the correlation between the price and the MACD histogram (in binary), there is a moderately positive correlation between the arrays from week to week (the correlation coefficient is 0.45) and a weak positive correlation between the arrays shifted by 1 week (the price array is shifted by 1 week ahead of the MACD histogram array, the correlation coefficient is 0.22).

The study found that the number of weeks with rising prices and MACD histograms was higher than the number of weeks with falling prices, which indicates a general bull trend over the previous period (Table 1).

At the same time, the number of series with rising and falling prices is almost the same, but the series started

from the zone above the zero MACD line more often than from the zone below the zero line (Table 2).

Accordingly, it has been determined that the average and maximum lengths of growth series are longer than those of decline series (Table 3). This confirms the overall bullish trend in the bitcoin market.

For a more in-depth analysis, it is proposed to consider the average length of bitcoin price series and MACD histograms in terms of two components:

1. The average and maximum length of bitcoin price and MACD series, taking into account the starting zone of the series.

Table 1. Number of weeks by direction of bitcoin price change and MACD

Direction of change	MACD, weeks	MACD, %	Price, weeks	Price, %
Rise	196	56.82	183	53.04
Down	149	43.19	160	46.38
Equal	0	0	2	0.58

Source: calculated by the authors on the basis of [15].

Table 2. Number of series with rising and falling bitcoin prices and MACD

	Total number of series, pcs.	Rise (growth series), pcs.	Down (fall series), pcs.	Equal (equality series), pcs.	Below series, pcs.	Above series, pcs.
MACD	75	38	37	0	33	42
Price	161	80	79	2	74	87

Source: calculated by the authors on the basis of [15].

Table 3. Average and maximum series lengths of bitcoin price and MACD

Direction of change	MACD		Price	
	Average length of series, weeks	Maximum length of series, weeks	Average length of series, weeks	Maximum length of series, weeks
All	4.59	24	2.14	9
Rise	5.16	24	2.29	9
Down	4.03	15	2.03	8
Equal		0	1	1

Source: calculated by the authors on the basis of [15].

Table 4. Average and maximum series lengths of bitcoin price and MACD, taking into account the starting zone of the series

Indicators	MACD		Price	
	Length of series from Above zone, weeks	Length of series from the Below zone, weeks	Length of series from Above zone, weeks	Length of series from the Below zone, weeks
Total average series length, weeks	4.33	4.94	2.01	2.30
Average length of growth series, weeks	3.71	6.33	2.31	2.26
Average length of fall series, weeks	4.76	2.5	1.75	2.37
Maximum length of growth series, weeks	10	24	7	9
Maximum length of drop series, weeks	15	5	5	8

Source: calculated by the authors on the basis of [15].

The study has shown that the average and maximum length of histogram and price series with the beginning below the zero MACD line is longer than with the beginning above the zero MACD line. A series of MACD histogram growth starting from the zone below the zero line is significantly longer than the one starting from the zone above the zero line. In other words, the second peak on the MACD has a shorter rising slope on average, as it does not last long. The same is true for the series of MACD drops starting from the zone below the zero line — the difference is almost 2 times (Table 4).

In trading practice, this is a very important parameter, since if a trend resumes in the previous direction after a short-term reversal, it is expected to last for a short time, i.e. a quick trend reversal.

Table 5. Average and maximum length of MACD series in per cent

MACD series length, weeks	Total length of MACD series, %	Length of growth series, %	Length of fall series, %	Length of series from the Below zone, %	Length of series from the Above zone %
1	29.33	26.32	32.43	33.33	26.19
2	40.00	34.21	45.95	39.40	40.48
3	54.67	47.37	62.16	54.55	54.76
4	61.33	57.90	64.87	60.61	61.91
5	66.67	60.53	72.97	66.67	66.67
6	73.33	71.05	75.68	72.73	73.81
7	81.33	78.95	83.78	78.79	83.33
8	84.00	78.95	89.19	78.79	88.10
9	86.67	81.58	91.89	81.82	90.48
10	90.67	89.47	91.89	87.88	92.86
11	93.33	92.11	94.60	90.91	95.24
12	96.00	94.74	97.30	93.94	97.62
13	97.33	97.37	97.30	96.97	97.62
14	97.33	97.37	97.30	96.97	97.62
15	98.67	97.37	100.00	96.97	100.00
16	98.67	97.37		96.97	
17	98.67	97.37		96.97	
18	98.67	97.37		96.97	
19	98.67	97.37		96.97	
20	98.67	97.37		96.97	
21	98.67	97.37		96.97	
22	98.67	97.37		96.97	
23	98.67	97.37		96.97	
24	100.00	100.00		100.00	

Source: calculated by the authors on the basis of [15].

However, the situation is different for the price: the average length of the rise from different zones is almost the same — about 2.37 weeks. In turn, the average length of a price drop from the zone above the zero MACD line is 1.75 weeks, which is significantly lower than the average drop from the zone below the zero MACD line of 2.3 weeks. This trend is also true for the maximum length of the price series of the respective MACD zones. In trading practice, this means that when trading on a bearish trend in the zone below the zero MACD line, you can expect a longer series of declines in the maximum price. Accordingly, a trader can place an asset for sale with more confidence.

2. Average and maximum series length of bitcoin price and MACD in percentage.

The analysis shows that the average length of the MACD histogram growth series of 5.16 weeks is included in 60.53% of the started series, and the average length of the falling series of 4.03 weeks is included in 64.86% of the started series. For the starting zones, such lengths have approximately the same percentages (Table 5).

From a practical point of view, this allows a trader to focus on the length of the series in the process of making more informed investment decisions. For example, if a series is approaching its average length, the probability of its expiration increases, and the closer it is to the maximum length, the higher this probability is.

As for price series, the following conclusions can be drawn: with the average length of price growth series at 2.29 weeks and price decline series at 2.03 weeks, the percentages for them are 70.00% and 78.48%, respectively. And all series longer than 4 weeks inclusive are included in 90.68% of all series that started (Table 6).

From a practical point of view, this means that if a trader sees the price move in one direction for 2—4 weeks in a row, he is more likely to expect a trend reversal and, accordingly, close or reduce his position, as he sees a warning of possible risks — the so-called "leading" indicator. In addition, almost half of all series (47.83%) ended with a single event, but slightly more than half of the rest were other series with more than one event. This means that there is a 52.17% chance that the series of price movements will continue after the first event, i.e. there will be at least one more such event. And if other indicators confirm this trend, a trader can bet in the direction of the movement with more confidence, which is good enough for medium-term strategies for 1-2 weeks.

Finally, the study revealed that the price repeated the direction of the MACD histogram movement in the previous week. For the MACD histogram series with one event, the price moved in the same direction on average 66.67% of the time, and for the cases when the MACD histogram started below the zero line and moved downwards, this value was 91.67% (Table 7). In practice, this means that when the MACD histogram fell after a slight increase in the zone below the zero line, 91.67% of the time, the price also fell the following week.

In general, in 68.45% of cases, the price repeated the movement of the MACD histogram the following week. However, if we look only up to week 15 (i.e., excluding the

longest 24-week series from the sample), the percentage is already 62.84%, which is a more reliable result, since there was only one 24-week series during the entire study period and the price on it followed the MACD movement in almost every event. If the price next week does not repeat the direction of the MACD movement in the current week, the probability of a trend change of the MACD itself increases, since the longest MACD series in all cases ended in zero, i.e. the price did not repeat the MACD direction.

To summarize the research, the following conclusions can be drawn:

- in 62.84% of cases, a trader can expect an increase in the maximum price of bitcoin this week if the MACD histogram showed an increase in the previous week, or a decrease in the maximum price of bitcoin this week if the MACD histogram showed a decrease in the previous week;

- a trader can expect the general medium-term trend in the bitcoin market to continue if the MACD histogram series lasts less than the average, and the trend to end if the MACD histogram series lasts longer than the average. For the rising MACD histogram series, the probability of the trend ending is 60.53% (approximately 5 weeks), and for the falling series — 64.86% (approximately 4 weeks);

- a trader can expect that the maximum price of bitcoin will continue its direction of movement in the second week in 52.17% of cases, and will end this movement after week 4 with a probability of 90.68%.

CONCLUSIONS

Thus, the analysis of the dynamics of the maximum price of bitcoin in interaction with the MACD histogram shows that this indicator can be a valuable tool for predicting medium-term trends in the cryptocurrency market. Together with other indicators, it gives traders the opportunity to make more informed investment decisions in order to gain additional profit (or reduce the amount of loss).

At the same time, although the MACD histogram can be a useful indicator for analyzing the dynamics of bitcoin prices, it is not a universal tool for accurate forecasts. The cryptocurrency market is characterized by high volatility and the influence of numerous external factors that make it difficult to accurately predict future price movements. Therefore, investors should use MACD with caution and understand that it is only one of many factors that should be taken into account when making trading decisions.

For a deeper understanding of bitcoin price formation, it is necessary to conduct a more comprehensive study, which includes an analysis of the current week's MACD change and other types of prices for the next

Table 6. Average and maximum length of bitcoin price series in percentage terms

Length of price series, weeks	Total length of the price series, %	Length of price growth series, %	Length of price drop series, %	Length of price equality series, %	Length of price series from Below zone, %	Length of price series from Above zone, %
1	47.83	45.00	49.37	100.00	48.65	47.13
2	74.53	70.00	78.487		70.27	78.16
3	85.09	83.75	86.08		82.43	87.36
4	90.68	90.00	91.14		90.54	90.81
5	95.03	92.50	97.47		93.24	96.55
6	96.27	95.00	97.47		93.24	98.85
7	96.89	96.25	97.47		93.24	100.00
8	99.38	98.75	100.00		98.65	
9	100.00	100.00			100.00	

Source: calculated by the authors on the basis of [15].

week: the lowest and closing price. In addition, it is important for traders to monitor other indicators (for example, trading volume, RSI) and remember that if institutional investors with large capital decide to buy or sell at any price, they will not take technical indicators into account.

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Table 7. Length of series of price repetition of the MACD movement direction

MACD series length, weeks	Total length of MACD series with price repeating the same direction, %	Length of MACD series with price repeating the same direction (start zone - Below, direction - Rise), %	Length of MACD series with price repeating the same direction (start zone - Below, direction - Down), %	Length of MACD series with price repeating the same direction (start zone - Above, direction - Rise), %	Length of MACD series with price repeating the same direction (start zone - Above, direction - Down), %
1	66.67	61.91	91.67	64.71	60
2	60.38	46.67	85.71	61.54	61.11
3	57.78	64.29	66.67	63.64	42.86
4	47.06	50.00	66.67	37.50	45.46
5	62.07	63.64	0.00	80.00	63.64
6	48.007	54.55		50.00	40.00
7	60.007	77.78		50.00	44.44
8	64.29	85.71		100.00	33.33
9	75.00	71.43		100.00	75.00
10	66.67	60.00		0.00	100.00
11	71.43	75.00			66.67
12	80.00	66.67			100.00
13	33.33	50.00			0.00
14	100.00	100.00			100.00
15	50.00	100.00			0.00
16	100.00	100.00			
17	0.00	0.00			
18	100.00	100.00			
19	100.00	100.00			
20	100.00	100.00			
21	100.00	100.00			
22	100.00	100.00			
23	100.00	100.00			
24	0.00	0.00			

Source: calculated by the authors on the basis of [15].

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