Effect of social media messages on cryptocurrency market efficiency: An event study approach

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Abstract: This paper contributes to empirical evidence of semi-strong market efficiency focused on cryptocurrency market, specifically examines the persistence of random walk in the Bitcoin and Dogecoin exchange rates. Using an event study approach and abnormal returns methodology authors verify the reaction of selected cryptocurrency exchange rates to the statements releases through social media platform during the time-period from 2020 to 2022. The results show that celebrity statements on social media can influence investor behaviour, which is especially reflected in the increased volatility of cryptocurrency rates.

Keywords: cryptocurrency, social media, market efficiency, event study
JEL Classification: G14

1 Introduction

Cryptocurrency is a decentralized digital currency stored in an online form designed to be not under the control of third parties and created to replace classic fiat currency. Cryptocurrencies are used not only as a medium of exchange, but also as an investment asset, which has recently seen rapid growth and increased popularity among investors, who try to use the high volatility of cryptocurrency prices to achieve above-average returns. However, these above-average returns contradict the efficient market theory (Fama, (1970)). Fama's study suggests that changes in the prices of financial assets are random and unpredictable and achieving the above-average returns in the long term is unrealistic.

The question of the efficiency of the crypto-bitcoin market has been addressed by many studies in the past, but their conclusions are contradictory. Studies published by Nadarajah & Chu (2017), Bartos (2015) or Vidal-Tomás & Ibañez, (2018) confirm the existence at least weak form market efficiency. However, most authors are inclined to the opinion that Bitcoin and other cryptocurrencies does not follow a random walk and reject the efficient market hypothesis (by Kuriara & Fukushima (2017), Wei (2018), Bundi & Wildi (2019) or Hu et al. (2019)). Other studies even point to the susceptibility of cryptocurrencies (Bitcoin, Ethereum) to the formation of speculative bubbles (Hayes (2019), Cretarola & Figà-Talamanca, (2020)). Herd behaviour is believed to be the source of speculative bubbles in the cryptocurrency markets (Kallinterakis & Wang (2019)).

Lack of fundamentals and sentiment trading can be listed among the main sources of irrational behaviour of investors, which is additionally amplified by information published in social media and social platforms. The importance of social media in investment decision-making is confirmed, for example, by studies by Polasik et al. (2015), Panagiotidis et al. (2018) or Chuffart (2022), who identified growth in the volume of Google Trends or Google Search as one of the most important variables explaining Bitcoin returns and consider this search to be a good predictor of the cryptocurrency market. Social platforms as Twitter, Facebook or Reddit are also a popular place for investors to discuss and share their views on future developments in the cryptocurrency market, as well as being an important source of information for their investment decisions. For example, Shen et al. (2019) found that the number of tweets is a significant driver of next-day trading volume. Furthermore, there is also evidence that Twitter message volume is also a price predictor of cryptocurrency returns (Kraaijeveld and De Smedt (2020)).

This contribution follows up on the above-mentioned papers and examines the impact of short posts, published on the social platform Twitter (X), on the future price development and market efficiency of Bitcoin and Dogecoin. During the monitored period from 2020 to 2022, the impact of six short messages that had the potential to significantly influence investor behaviour and disrupt the effectiveness of the cryptocurrency market was examined. Five of these six messages were published by E. Mask, who ranks among the richest people today, the last one was posted by N. Bukele, the President of El Salvador. Event study approach and abnormal-return methodology was used for testing of semi-strong form market efficiency.

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2 Methodology and data

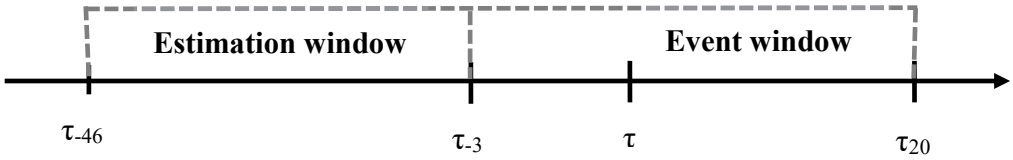
2.1 Data

This study investigates the impact of six short messages related to two cryptocurrencies - Bitcoin and Dogecoin, posted on the social media platform Twitter during the years 2020, 2021, and 2022. To assess the influence of these messages, authors utilize the daily spot exchange rates for Bitcoin and Dogecoin. For calculation both the above-average and cumulative average returns was used the six distinct periods, each covering the timeframe from 46 days prior to the message publication to 20 days following its publication. Cryptocurrency spot prices were downloaded from Yahoo.finance.com website.

2.2 Methods

The Event study methodology is used to test semi-strong market efficiency, which examines the reaction of the market price of an investment instrument due to the specific observed event. The first step in the application of this method is to define the investigated investment instrument and the event that should affect the market price. In this article, short messages published on the social platform Twitter (so-called tweets) containing comments about Bitcoin and Dogecoin represent the monitored event. In the second step of the analysis, the day of the event, the estimated window and the event window must be defined. The day of the event indicates the time when the event occurred. In this study, the event day represents the day the tweet was posted. Subsequently, the development of the cryptocurrency market price before and after posting the tweet will be analysed. The period preceding the event day is referred to as the estimated window. In our case, it starts 46 days before and ends 3 days before the event day. This chosen length of the estimation window should ensure a stable estimate of the normal behaviour of market prices for selected cryptocurrencies. The length of second period, called the event window, can vary depending on the nature of the event being studied and the expected time it takes for the market to fully incorporate the information. In this study, the event window starts 3 days before and ends 20 days after the event day. The event window period also includes the 3 days preceding the published information for the purpose of capturing the influence of yet unpublished news on the cryptocurrency spot price and thus revealing the possible existence of insider trading. The time structure of the entire monitored period is shown in Figure No. 1.

Figure 1 Time structure of the observed period



2.2.1 Abnormal returns

Generally, the calculation of abnormal returns is based on comparing the actual achieved returns with the expected returns that would have been achieved if the price-setting information had not been published. In the next step of the analysis, it is necessary to determine the actual and expected returns. Abnormal return can be determined in several different ways. In this study the abnormal return are calculated using Mean adjusted model (MAR) and Market adjusted model (MKAR).

Mean-adjusted model (MAR)

This model is based on the difference between the expected return and the actual return. The expected return of an investment instrument is calculated as the average daily return ⌀Rj over the period of the estimated window.

Mathematically, this relationship can be written using the following formula:

$$MAR_t = R_t - \varnothing Rj \tag{1}$$

Where:
MAR_t abnormal returns at time t
R_t actual return of an investment instrument at time t
$\varnothing R_j$ average return over the estimated window

The actual return R_t is calculated as daily log return during the event window period as follows:

$$R_t = ln\left(\frac{P_t}{P_{t-1}}\right) \quad (2)$$

Where:
P_t market price at time t
P_{t-1} market price at time t-1

Market-adjusted model (MKAR)

Another way to determine abnormal returns is the Market-adjusted model, which is based on the difference between the actual return R_t and the market return R_{mt}. The calculation of market-adjusted returns can be written as follows:

$$MKAR_t = R_t - \mathrm{R}mt \quad (3)$$

Where:
$MKAR_t$ abnormal returns at time t
R_t actual return of an investment instrument at time t
Rm_t market return at time t

Unlike the previous model, here the average return $\varnothing R_j$ is replaced by the market return R_{mt}. The market return at time t is calculated as the daily relative change of the market index during the event window. The market index (IT) is calculated as a simple arithmetic average of the market prices of 10 major tradable cryptocurrencies. Namely the market index consists of Bitcoin, Binance Coin, Bitcoin Cash, Cardano, Dogecoin, Ethereum, Litecoin, Polkadot, Uniswap and Ripple. The calculation of the cryptocurrency market index can be written as follows:

$$IT = \frac{\sum_{i=1}^{N} P_{i,t}}{N} \quad (4)$$

Where:
IT_t market index
N number of cryptocurrencies in index
$P_{i,t}$ the price of the cryptocurrency i at the time t

Cumulative abnormal return (CAR)

Cumulative abnormal return allows to monitor the impact of the overall effect of the event during the event widow. In this study, the cumulative abnormal return derived from the abnormal returns calculated by the Mean adjusted model.

The cumulative abnormal return is calculated as the sum of abnormal returns.

$$CAR_{(t_1, t_2)} = \sum_{t1}^{t2} AR_t \quad (6)$$

Where:
$CAR_{(t1,t2)}$ sum of abnormal return between dates t_1 and t_2
AR_t abnormal returns at time t

3 Research results

This study examines the price reaction of Bitcoin and Dogecoin to statements published during the period from 2020 to 2022 on the social platform Twitter (X), in which these cryptocurrencies were explicitly mentioned. The investigated tweets are listed in Table 1. This table also contains the cryptocurrency to which the statement refers, the name of the author and the date of the statement's publication. The posts are further supplemented with information containing the expected reaction of cryptocurrency price.

Table 1 Statements published on social platform

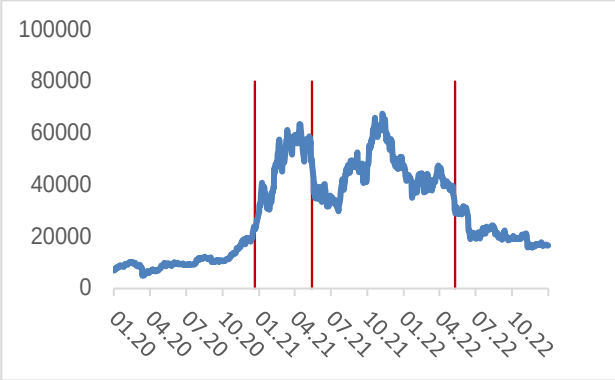
No.	Time	Autor	Currency	Exp. reaction	Content
1.	20.12.2020	E. Musk	Bitcoin	Neutral	*„Bitcoin is my safe word "*
2.	20.12.2020	E. Musk	Dogecoin	Neutral	*„One word: Doge "*
3.	15.04.2021	E. Musk	Dogecoin	Neutral	*„Doge Barking at the Moon"*
4.	13.05.2021	E. Musk	Bitcoin	Negative	*„Tesla has suspended vehicle purchases using Bitcoin, we are concerned about rapidly increasing use of fossil fuels for Bitcoin mining and transactions, especially coal, which has the worst emissions of any fuel. "* *„Tesla will not be selling any Bitcoin and we intend to use it for transactions as soon as mining transitions to more sustainable energy. We are also looking at other cryptocurrencies that use <1% of Bitcoin's energy transactions. "*
5.	09.05.2022	N. Bukele	Bitcoin	Positive	*„El Salvador just bought the dip! 500 coins at an average USD price of $30 744"*
6.	27.05.2022	E. Musk	Dogecoin	Positive	*„Tesla merch can be bought with Doge, soon SpaceX merch too"*

Source: Own processing

Five of six investigated tweets included in table 1 were posted by E. Musk. Two of these statements refer to Bitcoin and three to Dogecoin. Furthermore, three of these statements have no rational basis and are evaluated as neutral with no influence on the future development of the market price. The fourth post is associated with negative sentiment and refers to the high carbon footprint associated with Bitcoin mining and the end of Tesla stores accepting payments in this currency. E. Musk's fifth statement can be evaluated positively. In this statement, he admits the possibility of payments for the Tesla and Space X brands. The author of the sixth rated statement is the president of El Salvador N. Bukele, who announces the purchase of 500 bitcoin coins, which should serve as the country's official currency. This statement should be associated with positive expectations of investors.

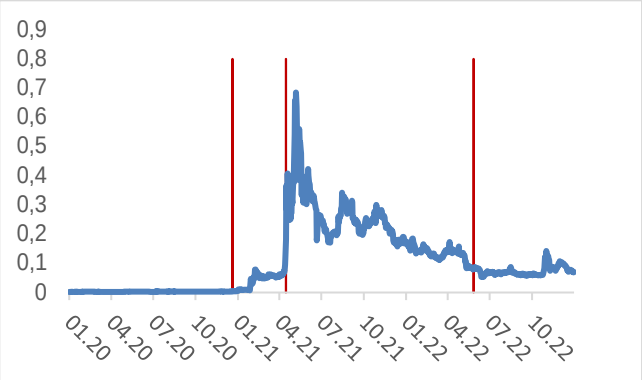
For greater clarity, the published statements were plotted in charts 2 and 3, which show the price development of Bitcoin and Dogecoin cryptocurrencies during the years 2020 to 2022. It can be seen from the graphs that the reports were published at a time of high volatility on the cryptocurrency market. The market price of Bitcoin in the monitored period ranged between the minimum value of 4 971 BTC/USD recorded on 12.03.2020 and the maximum value of 67 567 BTC/USD on 08.11.2021. The Dogecoin cryptocurrency market was similarly volatile, reaching its minimum of 0.00154 DOGE/USD on 12.03.2020. The maximum market price in the monitored period was 0.68478 DOGE/USD and was recorded on 05.07.2021. Tweets were posted in both rising and falling phases of the market.

Figure 2 Bitcoin price development in the period 2020 -2022



Source: Own processing

Figure 3 Dogecoin price development in the period 2020 - 2022



Source: Own processing

3.1.1 Bitcoin – abnormal return

Mean-adjusted model (MAR) and Market-adjusted model (MKAR) were used to calculate abnormal returns. A basic overview of the development on the Bitcoin market at the time of publication of individual tweets is summarized in Table 2.

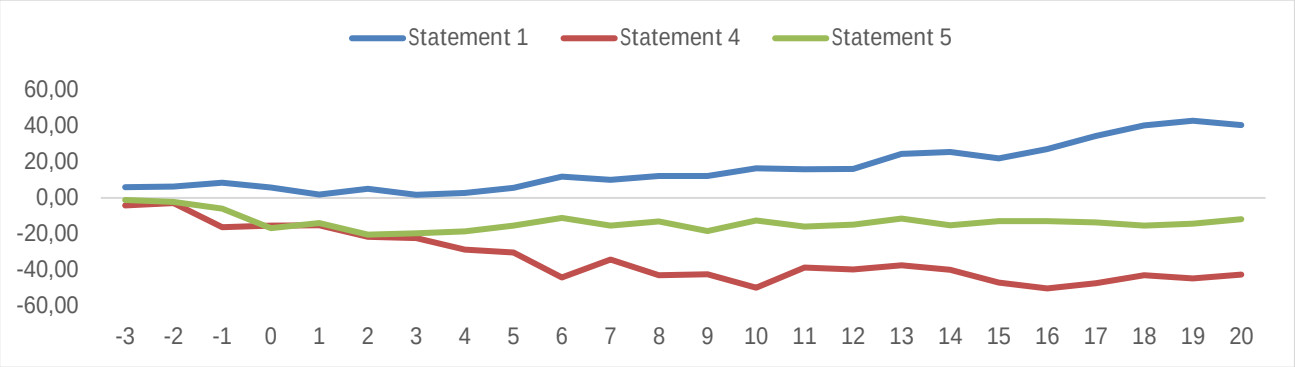
Table 2 Bitcoin – Abnormal return

	Avg. real return (%)	Avg. expected return (%)		Avg. abnormal return (%)	
		MAR	MKAR (⌀ Rmt)	MAR	MKAR
Statement 1	2,75	1,05	2,75	1,69	0,00
Statement 4	-1,62	0,15	-1,61	-1,77	-0,01
Statement 5	-0,83	-0,33	-0,88	-0,50	0,06

Source: Own processing

The highest average real daily returns were achieved by Bitcoin after the first neutral post (2,75 %). Conversely, the lowest return was found for negative contribution No. 4 (-1,62 %). Post No. 5 published by N. Bukele, despite its positive tone, was accompanied by a decline in the market associated with a negative average return (-0,83 %). A more detailed picture of market dynamics is obtained when we compare the actual returns with the expected returns. In the case of the Mean adjusted model, actual returns observed during the event window period are compared to the average return identified during the estimation window period. This comparison confirms the positive impact of the first contribution and the negative influence of the fourth and fifth contributions on the price of Bitcoin. This was also reflected in the values of average abnormal returns, which amounted to 1,69 %, -1.77%, and -0,50 %. The Market adjusted model calculates abnormal returns as the difference between actual returns and market returns during the event window period. In this case, the results are inconclusive, and the average abnormal returns for all contributions approach 0. This outcome is influenced by the market return calculation. Since the market portfolio also includes Bitcoin and the other cryptocurrencies included in the market index show a high correlation with Bitcoin, the market's returns are very similar to Bitcoin's returns. A more detailed insight into the dynamics of Bitcoin price development after the release of individual statements is provided by Figure 4, which displays the evolution of cumulative returns during the event window. The cumulative returns were determined using the Mean adjusted model.

Figure 4 Bitcoin cumulative abnormal return - Mean adjusted model



Source: Own processing

The cumulative abnormal return for the first 3 days of the event window captures the market trend without the influence of the released statement, which is disclosed at time 0. In the subsequent 3 to 4 days following the release of the statement, cumulative returns remain approximately at the same level as on the event day. For posts No. 1 and No. 4, cumulative returns continue in the pre-event day trend, suggesting that these statements merely reinforced the existing market price trend. The negative returns before the event day for contribution No. 5 indicate that it was released during a market downturn. After the contribution's release, cumulative returns show approximately the same value, indicating a halt to the bearish market. The question remains whether the contribution caused the cessation of the price decline or was released when the market had already reached its lowest point, as suggested by the contribution's content.

3.1.2 Dogecoin – Abnormal return

As in the previous chapter, for evaluating the impact of published statements on the price of Dogecoin, abnormal returns were calculated using both the Mean-adjusted model and Market-adjusted model. The market price of Dogecoin showed a lower degree of correlation with the market index and therefore in this case the Market-adjusted model has a higher explanatory power than it was for Bitcoin. An overview of the results is presented in Table No. 3.

Table 3 Dogecoin – Abnormal return

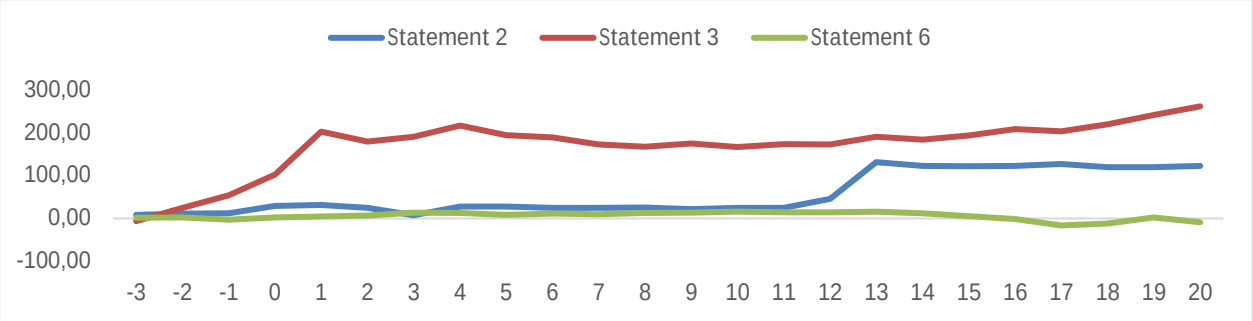
	Avg. real return (%)	Avg. expected return (%)		Avg. abnormal return (%)	
		MAR	MKAR (⌀ Rmt)	MAR	MKAR
Statement 2	5,92	0,84	2,75	5,08	3,18
Statement 3	11,97	1,10	0,06	10,88	11,91
Statement 6	-1,53	-1,15	-1,42	-0,38	-0,10

Source: Own processing

The price of Dogecoin showed a sharp growth after the publication of statements No. 2 and No. 3, which was also reflected in the high values of actual returns (5, 92 % and 11,97 %) measured during the event window. These actual returns exceeded the expected returns calculated by both the Mean-adjusted model and the Market-adjusted model, indicating a strong positive response to posted tweets regardless of their non-specific content. Abnormal returns after the publication of statement No. 6, which was the only one containing specific information, showed negative values both in the case of the Mean-adjusted model (-0.38) the Market-adjusted model (-0.10).

Positive cumulative return for statements No. 2 and No. 3 at time 0 indicate positive sentiment even before these statements were published. After publication of statement No. 2, there was a slight increase in cumulative return, and in post No. 3, a sharp increase cumulative return. The sharp increase in cumulative return on the 12th day after the release of statement No. 2 may suggest a delayed response to the statement or a reaction to other undisclosed information. The release of statement No. 6 was accompanied by a mild increase in prices, resulting in positive cumulative return; however, by the end of the observed period, these returns began to decline. The dynamics of the cumulative return for individual contributions during the event window is shown in Figure 5.

Figure 5 Dogecoin cumulative abnormal return- Mean adjusted model



Source: Own processing

4 Conclusions

This paper, using event study methodology, investigates the responses of Bitcoin and Dogecoin prices to statements published on the social media platform Twitter (X) during the period from 2020 to 2022. A total of 6 statements were examined. Three of these statements were about Bitcoin and another three mentioned Dogecoin. The impact of statements commenting on Bitcoin is not entirely clear, but it seems that statements published on the social media platform Twitter (X) have the potential to influence the market price of Bitcoin, especially when their content aligns with market sentiment. Statements commenting on Dogecoin have a more significant impact on the market price of this cryptocurrency compared to Bitcoin. This fact is confirmed by the higher abnormal returns and by the cumulative return dynamics, which consistently increase, especially in the four days following the statement's publication. The content of the posts seems to be unimportant for the development of market prices and the strength of the reaction is mainly influenced by the market sentiment at the time of publication of the post. Dogecoin's sharp market price reactions to the published posts can be explained by Dogecoin's approximately 60x lower market capitalization compared to Bitcoin. High abnormal returns and the gradual reaction of the exchange rate for the examined statements indicate a delayed reaction of the cryptocurrency exchange rate and contradicts the hypothesis of market efficiency in its semi-strong form, at least in the case of Dogecoin. In further research, the authors want to focus on analysing the influence of different types of social media on the market price of cryptocurrencies and the possibility of market manipulation through social media posts.

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