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Testing Semi-Strong Market Efficiency for Leading Altcoins

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Abstract: This study probes semi-strong market efficiency in leading altcoins by examining how various regulatory and international events impact the daily returns of altcoins. We aspire to contribute valuable insights into the behavior of altcoins market in response to external stimuli, highlighting the implications for investors and market analysts in the rapidly evolving landscape of digital currencies. Several events over the period of 2018 to 2024 are considered categorized in two distinct groups namely, crypto-regulatory events and international events, ranging from outbreak of global pandemics, geo-political events and wars, including COVID-19 waves, vaccines authorizations, imposition of lockdowns, BREXIT post 2018, US withdrawal from Afghanistan, Russia-Ukraine war and Israel-Palestine conflict. Subsequently the impact of these events on the daily returns of five leading altcoins is assessed using the Auto-Regressive Component GARCH-Mean model. Altcoins have been responding to both positive and negative regulatory as well as international events. However, the significance of cumulative abnormal returns in the event window indicates signs of semi-strong market inefficiency. The findings provide new insights into the response of cryptocurrencies to various events at a global level, contributing to the understanding of market behavior and market efficiency, particularly, in the leading crypto-assets other than bitcoin. The findings can help altcoin investors devise trading strategies and build investment portfolios in an optimal manner, thereby minimizing the risks involved.

Keywords: altcoins; event study; semi-strong market efficiency; regulatory and international events.

JEL classification: XXX.

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1. INTRODUCTION

Warren Buffet, CEO of Berkshire Hathaway, commented in 2014: "Stay away from bitcoin since it is a mirage. The idea that it has some huge intrinsic value is just a joke in my view" (Crippen, 2014). Nakamoto (2008) suggested a peer-to-peer payments system using blockchain technology that triggered a revolution in the field of digital currencies and paved way for an eccentric mode of investment later known to be as cryptocurrencies. Cryptocurrency is a very unique type of digital currency that functions without the monitoring of any central bank and uses encryption techniques to control creation of units of money and verify movement of funds (Kramer, 2019). The upsurge of the first ever cryptocurrency, bitcoin, has remained controversial since its inception. Bitcoin's startling price rise in late 2017 and the following collapse in the early 2018 demonstrated its extraordinary volatility and raised serious concerns among the investors about its utility as a store of value. Amidst all the apprehensions surrounding bitcoin volatility, there are over 13000 different cryptocurrencies listed on Coinmarketcap.com as of December 2024 (CoinMarketCap, 2024) showing a significant boom in this market since 2008. With all the abrupt swings in the cryptocurrency market, a strong debate concerning the market efficiency of cryptocurrencies and its susceptibility to form financial bubbles has erupted in the academia and the investment industry around the world. Hence, the question arises whether the cryptocurrency market can be deemed efficient and to what degree.

Fama (1970) asserted that markets follow a random walk model and are fully efficient, meaning that the current prices fully reflect all available information about a security which follows that the future returns cannot be predicted based on the past returns; Hence, the return series follows a random walk. According to Fama (1970), there are three levels of market efficiency: weak, semi-strong, and strong. In the weak form efficiency, past data on financial assets cannot be used to forecast future asset prices, therefore, technical analysis is useless for forecasting the prices of an asset in the future; Publicly available information, according to semi-strong efficiency, is immediately reflected to the present price and is therefore useless for projecting future prices. According to strong form efficiency, market price adjustment is incredibly frictionless and responsive to any type of information, therefore, even private information like insider information has no relevance in forecasting the future price.

Lengyel-Almos and Demmler (2021) systematically reviewed and analyzed 25 highly ranked journal articles to determine whether bitcoin market meets the prerequisites of an efficient market as per Eugene Fama’s ground breaking Efficient Market Hypothesis (EMH) and concluded that academicians and financial professionals have not been able to come to an agreement on the market efficiency of bitcoin; However, a significant number of papers refute the EMH, also leading to the conclusion that speculative bubbles are likely to be formed in the bitcoin market.

Bitcoin values are so volatile that using them as a unit of account is impractical and worthless for communicating pricing, which is typically a basic characteristic of any type of money (Lengyel-Almos and Demmler, 2021). The extreme volatility in cryptocurrency can be witnessed by looking at its eccentric swings in the last few years. For example, bitcoin's price went from around 800 USD in early 2017 to over 19,000 USD by the end of the year before falling to 6,300 USD in February 2018. Prices again rose dramatically in the second half of 2020, from around 5,000 USD in March to over 40,000 USD by February 2021, and then reach an all-time high of around 49,000 USD by the end of February 2021. As of December 31, 2023, the bitcoin price plummeted to 42,265 USD whereas as of December

31st, 2024, bitcoin was worth over 93,000 USD making a significant milestone in its history (CoinDesk, 2024). Such price swings are indeed unprecedented for any financial asset.

Investors are still split on whether cryptocurrencies are financially sound investments or merely speculative assets, thereby necessitating further academic study on this topic. Despite the fact that the impact of cryptocurrencies on the world economy has been instrumental, there is a dearth of conclusive empirical studies on the topic. Cryptocurrencies are considered to be a controversial investment avenue, particularly in a developing country, like Pakistan, where it has not been yet accepted as one of the legal tenders by the regulators or even a viable investment avenue by the masses. According to The Federation of Pakistan Chambers of Commerce & Industries (2021), the use of cryptocurrencies in Pakistan has accelerated in recent years, and the nation is currently ranked third in the Global Crypto Adoption Index for 2020–21. Pakistan recorded a value of cryptocurrencies of roughly $20 billion, a 711 percent extraordinary rise in 2020-21. Nevertheless, the State Bank of Pakistan in 2018 urged the general public to avoid investing in cryptocurrencies because of its abnormally high price volatility.

Determining as to what extent cryptocurrency markets are efficient could help investors devise their trading strategies and build investment portfolios in an optimal manner. In order to achieve the aforesaid objective, this study attempts to test the market efficiency of cryptocurrencies. However, majority of the studies relating to market efficiency of cryptocurrencies in the last few years have centered around the weak form of efficiency and the results have been of varying nature. Moreover, majority of the market efficiency research on cryptocurrency has focused on bitcoin. Other cryptocurrency coins, referred to as altcoins, have been scarcely studied in this context. Altcoins have grown significantly in size and volume in the last few years with the market capitalization of almost half of the entire global crypto market (see Table no. 1). We aim to test market efficiency (other than weak-form) in the leading altcoins. We select five leading altcoins by market capitalization including, Ethereum, XRP, BNB, Cardano and Dogecoin over the period of 2018 to 2024 whereas the same time period has been marred by significant events, such as Covid-19, whereby the whole world witnessed a standstill of unprecedented nature. Other than that, the US exit from Afghanistan, Brexit, Russia-Ukraine war, Israel-Palestine conflict along with various crypto-regulatory events, warrant that altcoins shall be tested for market efficiency with regards to both positive and negative news surrounding the aforesaid events.

Therefore, this study aims to bridge this research gap in the existing body of knowledge on cryptocurrencies by investigating the semi-strong market efficiency in altcoins while focusing on the most recent significant global events which have transformed the world we live in and impacted almost every sphere of our lives. The set of events have been systematically chosen for this study keeping in mind their presumed colossal impact on the digital currencies as per the media reporting and the fact that these specific set of events have not been examined by past studies in the context of crypto assets. Only those momentous events have been finely selected which have been comprehensively reported by almost all major news streams across the globe since 2018 (see Annexe for Table no. A1 and no. A2), thus further contributing effectively to the resolution of the identified research gap.

The rest of this paper is organized as such that Section 2 presents a brief literature review followed by methodology in Section 3 whereas Section 4 presents the findings and Section 5 concludes.

2. LITERATURE REVIEW, THEORETICAL UNDERPINNINGS AND HYPOTHESES DEVELOPMENT

It is hardly surprising that there have been an overwhelming number of articles written about EMH because it is one of the fundamental tenets of finance. The main outcome of the seminal theory of (Fama, 1970) is straightforward: Asset prices promptly take all new information into account and there is absence of any information asymmetries thus investors cannot expect to earn abnormal profits. However, empirical findings suggest that financial markets cannot be relied upon to act completely rationally; Instead, bubbles are likely to form under specific circumstances, which foster a climate conducive to reckless investing.

Multiple factors causing financial bubbles include, lower interest rates prevailing for a prolonged period of time, emergence of new technologies creating overly optimistic sentiments among investors, behavioral biases and an overall irrational exuberance manifested by investors (Dhar and Goetzmann, 2006; Shiller, 2015). Presence of speculative financial bubbles is one of the characteristics of market inefficiencies. Cryptocurrency markets have been showing similar characteristics of market inefficiencies for the last many years, including, excessive volatility, presence of financial bubbles, repetitive events of boom and bust (Lengyel-Almos and Demmler, 2021). The overall rise in the speculative activity in cryptocurrencies weakens the effectiveness of the portfolio diversification methods and increases the sensitivity of cryptocurrency markets to abrupt price changes (Katsiampa, 2017).

Bitcoin prices, according to Bartos (2015), react quickly to the release of public information. Additionally, it asserts that Bitcoin can be viewed as a typical economic asset whose price is determined by the interaction of market supply and demand and denies that exogenous macroeconomic factors affect Bitcoin's price. Cheah *et al.* (2018) conducted different rigorous statistical tests to gauge market efficiency of Bitcoin market and concluded that markets are "moderate to highly inefficient", consequently rejects the EMH. Investors can, therefore, take advantage of the predicted long-term memory in pricing and profit from speculation. Urquhart (2016) examined the market efficiency of Bitcoin using a number of credible tests, such as the VAR test, Ljung-Box test, Bartel's test, AVR test, BDS test, and Hurst exponent (R/S Hurst), and came to the conclusion that bitcoin returns are significantly inefficient across the entire sample. However, when the sample is divided into two subsample periods, some tests show that bitcoin is efficient between 2013 and 2016; It was, therefore, concluded that the Bitcoin market may be on its way to becoming efficient. Subsequently, using eight distinct tests, Nadarajah and Chu (2017) demonstrated that a straightforward power transformation of the bitcoin returns does indeed satisfy the weak form of EMH hypothesis. Only the tests for independence yield negative results, indicating moderately efficient markets; all other tests yield positive results.

In the absence of exogenous stimuli, Garcia *et al.* (2014) discovered two positive feedback loops in the bitcoin market: one driven by word of mouth and the other by new bitcoin adopters. It was determined that EMH is not applicable in bitcoin market because of positive feedback loops and asset bubble development. Cheung *et al.* (2015) examined whether bitcoin exhibits bubbles and busts using the PSY approach. It was identified that three significant and several minor bubbles occurred between 2010 and 2014, including the crash of the Mt Gox exchange. Hence, it is inferred that bitcoin cannot be regarded as an efficient market. By using econometric modelling to analyze bitcoin prices, Cheah and Fry (2015) came to the conclusion that the cryptocurrency displays speculative bubbles. The EMH is therefore disproved. The writers also provided empirical support that bitcoin's intrinsic price is zero. Using the Detrended Fluctuation Analysis (DFA) test, Alvarez-Ramirez *et al.* (2018) examined long-range correlations and the informational efficiency of the Bitcoin market. They came to the conclusion that the market is not consistently efficient because anti-persistence of price returns appeared cyclically.

Using PWY and PSY models, Agosto and Cafferata (2020) looked into co-explosivity in crypto assets meaning whether the explosive behavior of one cryptocurrency causes the explosive behavior of other cryptocurrencies. They discovered significant relationships between the explosive behaviors of cryptocurrencies and discovered that the price dynamics of cryptocurrencies are highly interdependent among cryptocurrencies. Through these results, they essentially rejected the presence of EMH in five largest cryptocurrencies. Using the LPPL model, the VAR test, and the Granger causality test, Xiong *et al.* (2020) examined Bitcoin price cycles over a two-year period between 2017 and 2018 to examine the validity of the bubble theory. They used VAR and LPPL models to demonstrate that the Bitcoin bubble is dependent on production costs, and found that this approach had a high level of forecasting accuracy. They even predicted that the following Bitcoin bubble would occur at the end of 2020.

In the instance of the four biggest cryptocurrencies, Caporale and Plastun (2019) investigated price overreactions and the day of the week effect using a trading robot technique. They verified the existence of price trends following overreactions by using a number of parametric and nonparametric tests. The overreactions observed in the bitcoin market, however, do not present prospects for speculative profit-making. Hence, there was insufficient evidence to refute the existence of EMH. In their study of Bitcoin's semi-strong efficiency in the Bitstamp and Mt. Gox markets, Vidal-Tomás and Ibañez (2018) demonstrated how bitcoin responds to changes in monetary policy and other market-related events from 2011 to 2017. They employed GARCH-type models and came to the conclusion that bitcoin has become more responsive to its own market events over time. The semi-strong variant of EMH gets approved as a result. The results of this investigation also revealed that bitcoin is not impacted by news regarding monetary policy.

Comparable crypto-assets that are conditional on benchmarks and market segmentation were found to violate the weak-form market efficiency hypothesis of Koutsoupakis (2022). While the majority of market cap benchmark indices show positive excess returns at the end of the week, particularly on Friday and throughout the weekend, the majority of crypto-assets defy the Monday effect hypothesis. Using variance ratios, Nimalendran *et al.* (2025) evaluated the effects of liquidity and regulation on the efficiency of the cryptocurrency market, concentrating on crypto-assets with differing levels of control. The findings show that efficiency is increased and investor risks in crypto-assets are decreased when current regulatory standards are followed. Additionally, assets that voluntarily follow regulations can achieve the same level of efficiency as assets that are subject to government regulation.

With an emphasis on Bitcoin (BTC), Ethereum (ETH), Tether (USDT), and Binance Coin (BNB-USD), Mallesha and Archana (2024) examined the cryptocurrency market's efficiency. They employed the rolling window technique to determine if market efficiency is constant over time or fluctuates. The findings showed that, with the exception of USDT, the efficiency of the cryptocurrency market stays constant over time. The random walk hypothesis is supported by the results, which show that historical price fluctuations do not provide any indication of future prices. Hassanzadeh Tavakkol (2022) tested weak form of market efficiency on 8 altcoins by replicating previous studies while using new data set and concluded that weak form of market efficiency mainly holds in the altcoin market and the results form the previous studies stand verified for different time-spans and assets.

Hypotheses

Based on the existing literature reviewed on the market efficiency of cryptocurrencies, it can be inferred that there is a lack of consensus amongst researchers as to whether cryptocurrency markets are efficient and to what extent. Moreover, the semi-strong efficiency in crypto-assets clearly seems to be much less explored than weak form of efficiency. There are a greater number of studies, however, that refute the existence of EMH in bitcoin. Studies relating to testing of market efficiency in altcoins are meagre despite the fact that the altcoins represent around half of the global crypto-market as per CoinMarketCap (2024). In order to achieve the aforesaid research objectives and based on the existing literature, this study, therefore, hypothesizes as follows:

H1: *The prices of the leading altcoins fully and fairly reflect all publicly available significant information relating to cryptocurrency regulatory events and, therefore, are semi-strong efficient.*

H2: *The prices of the leading altcoins fully and fairly reflect all publicly available significant information relating to international events and, therefore, are semi-strong efficient.*

3. METHODOLOGY

Semi-strong market efficiency can be typically tested using an event study since it is deemed to be an appropriate method to gauge how an asset returns are impacted by publicly available news (Abraham, 2021; Kang *et al.*, 2022; Krishnan and Periasamy, 2022). This study employs event study methodology, adapted from Vidal-Tomás and Ibañez (2018) and Feng *et al.* (2018), as the method to examine semi-strong form of efficiency in the altcoin market. We select publicly available significant events in the global economy from the time period 2018 to 2024 (See Table no. A1 and no. A2) and assess their impact on the altcoin returns using the aforesaid event study in order to determine whether crypto markets in altcoins are semi-strong efficient.

The most well-known cryptocurrency globally is indeed bitcoin and has the largest market capitalization of approximately 1.85 trillion USD as of December 31st, 2024 as per CoinMarketCap (2024). Nonetheless, bitcoin always makes the news but cryptocurrency alternatives to bitcoin known as "altcoins" have gained popularity in the last few years and there are hundreds of different choices available. In order to account for the potential variance in the semi-strong market efficiency of different cryptocurrencies, this study does not investigate bitcoin, like most studies in the past, but rather uses data of the 5 leading altcoins by market capitalization including, Ethereum, XRP, BNB, Cardano and Dogecoin. All these coins vary in their characteristics in terms of when they were created and who created them, therefore, it can be reasonably presumed that the dynamics of semi-strong market efficiency may be different in these coins and hence this study would also allow for comparative examination of semi-strong market efficiency of various altcoins. As of December 31, 2024, the total market capitalization of the selected altcoins as a % of all altcoins is 84% whereas the total market capitalization of the selected altcoins as a % of global crypto market is 40%; Hence, the sample of the five leading altcoins selected for this study, based on market capitalization, is significantly a representative one. Market capitalization of the global crypto-market is further mentioned below in Table no. 1 as sourced from Coinmarketcap.com.

Table no. 1 – Approximate Market Capitalization of the Crypto-Market

Cryptocurrencies Market Cap in US$ as on December 31, 2024	
Global Crypto Market	3.5 trillion (100%)
Bitcoin	1.85 trillion (50.78%)
All Altcoins	1.65 trillion (49.22%)
Market Cap of the Sample of Selected Leading Altcoins in US$ as on December 31, 2024	
1. Ethereum	401 billion
2. BNB	101 billion
3. XRP	119 billion
4. Cardano	29.65 billion
5. Dogecoin	46.54 billion

We specifically use the global events of the last few years which were prima facie very significant ones considering the impact they have left on the global economy, including COVID-19 waves, Russia-Ukraine war, Brexit, US withdrawal from Afghanistan, Israel- Palestine war and cryptocurrency regulations around the world to carry out the event study which would help validate the hypothesis of semi-strong efficiency in altcoins. The database of events includes a total of 49 events: There are 19 events relating to cryptocurrency regulations and 30 events covering global affairs ranging from outbreak of global pandemics, geo-political events and wars. The international events have been taken from various sources as reported in the media while the crypto-regulation events have been sourced from coindesk.com (see appendix 1A & 1B). Events have been categorized as either positive or negative depending on the intrinsic nature of the events and their presumed impact on the asset prices.

The specific criteria for the selection of events are as follows: The events database composition method primarily follows the past studies that have employed event study in examining semi-strong market efficiency in crypto-assets (Feng *et al.*, 2018; Vidal-Tomás and Ibañez, 2018; Abraham, 2021). However, the specific events used in this study are unique per se, to the best of our knowledge. Since cryptocurrencies are considered to be global digital currencies as they are not regulated by the central bank of any country, the selection criterion mainly hinged upon the global impact of the events and is not confined to any specific country. The severity of the global impact was, therefore, determined by analyzing the news content as reported in the media. While the possibility of researcher bias in events selection cannot be entirely ruled out, efforts were made to ensure that the selection of events remained free from bias.

With the event study methodology employed in this research, it is assessed as to how the altcoins market reacts to certain events, characterized as either positive or negative, by quantifying their impact on the returns of the chosen currencies. Daily returns on the selective cryptocurrencies are used while applying natural log on prices at time t and $t-1$. Data of prices is extracted from Coinmarketcap.com, one of the most referenced price websites for crypto-assets. The dynamic behavior of the returns of the selected altcoins is modelled using Auto Regressive-Component Generalized Auto Regressive Conditional heteroskedasticity (AR-CGARCH) model while using the parallel events as independent variables.

The GARCH model is typically used when financial time-series data is heteroskedastic, which is usually the case, meaning the error term does not have a constant variance and zero mean (Engle, 2001). The component GARCH model is used in line with the recommendations by Katsiampa (2017) who examined various GARCH models to determine the goodness-of-fit for volatility in bitcoin prices and proposed AR-CGARCH as the most suitable one. According to the standard GARCH model, conditional variance of the financial time series is determined by its own historical values and the previous squared residuals. On the other hand, financial time series frequently display more intricate patterns and can be impacted by other elements, including market trends, macroeconomic data, and other external factors. In order to better represent the underlying dynamics of the volatility, the Component GARCH model introduces extra components in order to overcome this restriction. Component GARCH model is, therefore, an extension of the traditional GARCH that is more suitable for capturing the time-varying volatility in financial time series data by breaking it down into different components (Katsiampa, 2017). The behavior of altcoins returns in this study is modeled using the equation given below:

Equation 1: Baseline Model

$$r_t = c + \beta_1 r_{t-1} + \beta_2 ne_t + \beta_3 pe_t + u_t\,; \quad u_t = h_t z_t\,, \quad z_t \sim i.i.d\,(0, 1)$$
$$h^2_t = q_t + \alpha\,(u^2_{t-1} - q_{t-1}) + \gamma\,(u^2_{t-1} - q_{t-1})\, d_{t-1} + \varphi(h^2_{t-1} - q_{t-1}) \tag{1}$$
$$q_t = \omega + \rho\,(q_{t-1} - \omega) + \theta\,(u^2_t-1 - h^2_t-1)$$

where: r_t represents return on day t

ne_t represents the negative events on day t

pe_t represents the positive events on day t

u_t represents the error term

z_t represents white noise process

h^2_t represents conditional variance modelled through CGARCH equation

In the conditional variance, q_t represents the time-varying long-run volatility, γ represents the transitory leverage effects whereas d is the dummy variable that indicates the presence of negative shocks.

In CAR (-1,1), ne_t and pe_t are equal to 1/3 on days $t - 1$, t, and $t + 1$ respectively, and 0 for the remaining days, using AR_0, ne_t and pe_t are equal to 1 on the day of the event t and 0 for the remaining days. By examining the abnormal returns (AR) on the day of the event and the cumulative abnormal returns (CAR) across a 1-day timeframe, this study investigates the impact of each event. $AR_0/CAR_{(-1,1)}$ for negative events is represented by β_2, whereas $AR_0/CAR_{(-1,1)}$ for positive events is represented by β_3. Employing a larger event window could potentially make the results more robust (Hashemi Joo *et al.*, 2020; Abraham, 2021); However, due to the fact that a few events were overlapping, using an event window longer than three days has not been feasible in this study. Subsequently, the AR-CGARCH-M model is used in this study, and given its significance in each regression, the standard deviation of residuals $\sigma\,(u_t)$ with its associated coefficient (β_4) is added in the r_t equation.

3.1 Robustness checks

The findings are made more stringent by examining two specific scenarios, in line with Vidal-Tomás and Ibañez (2018) and using the baseline model (equation 1): In the first scenario (equation 2) the impact of each event is assessed on the time-varying long-run volatility, q_t, and in the second scenario, equation 3, the impact of each event is assessed on the transitory/short-run component, $h^2_t - q_t$. These additional statistical assessments should ensure the results are robust when subject to the evaluation on long-run and short-run volatility measures.

$$q_t = \omega + \rho\,(q_t{-}1 - \omega) + \theta\,(u^2_{t-1} - h^2_{t-1}) + \beta_5\, ne_t + \beta_5\, pe_t \qquad (2)$$

$$h^2_t - q_t = \alpha\,(u^2_{t-1} - q_{t-1}) + \gamma\,(u^2_{t-1} - q_{t-1})\, d_{t-1} + \varphi\,(h^2_{t-1} - q_{t-1}) + \beta_7\, ne_t + \beta\, pe_t \qquad (3)$$

3.2 Calculation of abnormal returns

For the calculation of abnormal returns (AR_0), this study followed the market risk-adjusted returns model as prescribed by . This model is considered to be a superior one as compared to other simpler models, such as mean-adjusted returns model or market adjusted returns model, as it regresses assets returns (r_t) with the returns on the market index (r_m) as follows: $r_t = \alpha + \beta\, r_m$. The abnormal returns were then calculated using the equation, $AR_t = r_t - (\hat{\alpha} + \hat{\beta}\, r_{mt})$. For the market returns, this study uniquely used CRYPTO20 index returns.

Launched in December 2017, CRYPTO20 is the first tokenized cryptocurrency index fund in the world that tracks the performance of the top 20 crypto-assets by market capitalization (CoinMarketCap, 2024).

4. EMPIRICAL RESULTS AND DISCUSSION

4.1 Descriptive statistics

Table no. 2 reports the descriptive statistics of the daily log returns of the five leading altcoins. It can be observed that Dogecoin is the most volatile (largest Std. Dev.) as compared to other altcoins coins despite having the least market capitalization amongst the five selected coins. The least volatile amongst the five coins is Ethereum while having relatively the largest market capitalization. Kurtosis is significantly higher for all currencies indicating tendencies of leptokurtic distribution because of the volatility clustering that causes periods of high volatility followed by periods of low volatility as this can lead to a higher peak (more data around the mean) and fatter tails (more extreme deviations). Vidal-Tomás and Ibañez (2018) obtained similar results for kurtosis in bitcoin.

Table no. 2 – Summary Statistics of the Selected Alt Coins

	Ethereum	XRP	BNB	Cardano	Dogecoin
Mean	0.0005	-0.0004	0.0016	-0.0001	0.0014
Median	0.0005	-0.0008	0.0010	0.0000	-0.0008
Min	-0.5507	-0.5504	-0.5428	-0.5037	-0.5149
Max	0.2307	0.5486	0.5292	0.2794	1.5162
Std. Dev.	0.0465	0.0548	0.0497	0.0540	0.0701
Skewness	-1.0383	0.5053	-0.1589	-0.1309	5.3973
Kurtosis	11.7283	17.7666	16.9584	5.8028	107.6123

4.2 Model diagnostics

Table no. 3 below reports results of various statistical tests to determine the suitability of the data. Augmented Dickey-Fuller (ADF) test is performed on the daily returns to ascertain whether the data has a unit root. P-values of all five altcoins are significant, therefore, the data of the daily returns are stationary and devoid of a unit root; Hence the data is suitable for reliable modeling and predictions.

In order to determine whether the data of daily returns have ARCH effects present, Engle ARCH test was applied at five lagged values in line with . The significant p-values indicate that the financial time series exhibit ARCH effects and hence the data suffers from conditional heteroskedasticity at the pre-estimation phase as expected. The ARCH effect indicates volatility clustering since it amply demonstrates that there are times of low volatility followed by times of high volatility. At the post-estimation stage, in order to assess the adequacy of the estimated models of AR-CGRACH and AR-CGRACH-M on the data, ARCH (5) test is again applied and the goodness-of-fit of the chosen models is found to be appropriate and hence the white noise is established after fitting the model for all five alt coins.

Table no. 3 – ADF and Engle ARCH Tests:

Currency	ADF Test		ARCH(5) Test (Pre-estimation)		ARCH (5) Test (Post-estimation) AR-CGRACH		ARCH (5) Test (Post-estimation) AR-CGRACH-M	
	Test	p-value	Test	p-value	Test	p-value	Test	p-value
Ethereum	-12.144	0.01	55.211	0.000	6.626	0.107	5.839	0.127
XRP	-13.278	0.01	78.753	0.000	4.630	0.657	3.370	0.721
BNB	-12.306	0.01	130.21	0.000	7.289	0.070	7.037	0.080
Cardano	-11.890	0.01	80.274	0.000	7.290	0.218	4.559	0.211
Dogecoin	-12.472	0.01	46.021	0.000	1.610	0.791	1.145	0.701

4.3 Main results

During the estimation of the parameters for the base line equation, different ARMA(p,q) specifications were used but the best results were obtained from ARMA(1,0) or simply AR(1) process. Tables no. 4 and no. 5 below present this study's principal findings. The beta coefficients in Table no. 4 denote the effects of events on the returns as extracted from AR-CGARCH model for all five altcoins whereas Table no. 5 reports beta coefficients for the effects of events on the returns as extracted from AR-CGARCH-M model. In the AR-CGARCH-M model, the standard deviations of residuals are added $\sigma(u_t)$ with its corresponding coefficient (β_4) in the r_t equation. Although, this study aims mainly at testing semi-strong market efficiency by evaluating effects of several events on the altcoins returns, there are other related findings as well that Tables no. 4 and no. 5 indicate: β_1 coefficients for r_{t-1} in both Tables no. 4 and no. 5 are always significant and mostly at 1 percent significance level which in fact alludes to the weak form of inefficiency in altcoins which are similar to the findings of Palamalai *et al.* (2021). The significant β_1 values for the autoregressive returns of order 1 shows that the present returns are dependent on the past returns; Hence the weak form of market efficiency cannot be established as it is characterized by independence in returns as per Fama (1970).

This study evaluates the effects of events in two different categories, i.e., crypto-regulation events and international events. For all five altcoins investigated in this study, the beta coefficients are significant in Tables no. 4 and no. 5 for both on the day of the events (AR_0) and in the event window ($CAR_{(-1,1)}$), except for a few instances in table 4 only where the coefficients for positive news are insignificant. This may be due to the fact that an overwhelming number of events are indeed negative. Moreover, the coefficients are significant for both international and regulatory events. Therefore, it can be inferred from the results of Tables no. 4 and no. 5 that all five altcoins have been responding to the events taking place on a global scale and in the regulatory domain.

Table no. 4 – AR-CGARCH Model: AR_0 and $CAR_{(-1,1)}$ Estimations

Currency	Crypto-Regulation Events			International Events	
	Variables	**AR_0**	**$CAR_{(-1,1)}$**	**AR_0**	**$CAR_{(-1,1)}$**
Ethereum	r_{t-1} , (β_1)	-0.501***	0.514***	-0.501***	0.513***
	n_{et} , (β_2)	0.403***	0.245*	0.309***	0.291***
	p_{et} , (β_3)	1.071	0.336	0.147***	0.088
XRP	r_{t-1} , (β_1)	-0.551***	0.554***	-0.549***	0.553***
	n_{et} , (β_2)	0.285**	0.210***	0.291**	0.286***
	p_{et} , (β_3)	-1.215	0.329*	0.096	0.355**
BNB	r_{t-1} , (β_1)	-0.493***	0.510***	-0.497***	0.513***
	n_{et} , (β_2)	0.497***	0.322***	0.200*	0.261***
	p_{et} , (β_3)	0.395**	-0.878**	0.118	0.142
Cardano	r_{t-1} , (β_1)	-0.499***	0.518***	-0.494***	0.514***
	n_{et} , (β_2)	0.369***	0.375**	0.329***	0.274***
	p_{et} , (β_3)	-0.237	0.218	0.112	0.214
Dogecoin	r_{t-1} , (β_1)	-0.544***	0.553***	-0.543***	0.551***
	n_{et} , (β_2)	0.500***	0.275**	0.264***	0.259***
	p_{et} , (β_3)	-0.569	0.368	0.160	0.137

Note: *** Significance at the 1% level; ** significance at 5% level; * significance at 10% level.

Table no. 5 – AR-CGARCH-Mean Model: AR_0 and $CAR_{(-1,1)}$ Estimations

Currency	Crypto-Regulation Events			International Events	
	Variables	**AR_0**	**$CAR_{(-1,1)}$**	**AR_0**	**$CAR_{(-1,1)}$**
Ethereum	r_{t-1} , (β_1)	-0.525***	0.522***	-0.530***	0.523***
	n_{et} , (β_2)	0.364***	0.224***	0.309***	0.290***
	p_{et} , (β_3)	2.067***	0.140***	0.146***	0.088***
	$\sigma(u_t)$, (β_4)	1.032***	-0.030***	1.023***	-0.023***
XRP	r_{t-1} , (β_1)	-0.571***	0.544***	-0.565***	0.548***
	n_{et} , (β_2)	0.288***	0.215***	0.292***	0.297***
	p_{et} , (β_3)	-1.149***	0.335***	0.096***	0.367***
	$\sigma(u_t)$, (β_4)	1.023***	-0.022***	1.025***	-0.024***
BNB	r_{t-1} , (β_1)	-0.508***	0.515***	-0.509***	0.515***
	n_{et} , (β_2)	0.495***	0.320***	0.200***	0.264***
	p_{et} , (β_3)	0.413***	-0.838***	0.115***	0.147***
	$\sigma(u_t)$, (β_4)	1.013***	-0.014***	1.010***	-0.010***
Cardano	r_{t-1} , (β_1)	-0.540***	0.531***	-0.505***	0.513***
	n_{et} , (β_2)	0.367***	0.374***	0.329***	0.278***
	p_{et} , (β_3)	-0.228***	0.216***	0.108***	0.221***
	$\sigma(u_t)$, (β_4)	1.015***	-0.015***	1.013***	-0.013***
Dogecoin	r_{t-1} , (β_1)	-0.597***	0.570***	-0.565***	0.542***
	n_{et} , (β_2)	0.498***	0.272***	0.264***	0.267***
	p_{et} , (β_3)	-0.562***	0.356***	0.161***	0.143***
	$\sigma(u_t)$, (β_4)	1.019***	-0.021***	1.025***	-0.024***

Note: *** Significance at the 1% level; ** significance at 5% level; * significance at 10% level.

Table no. 6 – AR-CGARCH Model: AR0 and CAR(-1,1) Estimations: Long Run Volatility

Currency	Crypto-Regulation Events			International Events	
	Variables	AR_0	$CAR_{(-1,1)}$	AR_0	$CAR_{(-1,1)}$
Ethereum	r_{t-1}, (β_1)	0.000***	0.000	0.000*	0.000**
	n_{et}, (β_2)	0.000***	0.000	0.000	0.000
	p_{et}, (β_3)	0.096***	0.001***	0.000***	0.000***
	n_{et}, (β_5)	0	0	0	0
	p_{et}, (β_6)	0	0	0	0
XRP	r_{t-1}, (β_1)	0.000	-0.001***	0.000	-0.001***
	n_{et}, (β_2)	0.000	-0.001	0.001**	0.000
	p_{et}, (β_3)	0.048***	0.000	0.001***	-0.002
	n_{et}, (β_5)	0***	0***	0***	0
	p_{et}, (β_6)	0	0	0	0
BNB	r_{t-1}, (β_1)	0.000***	0.000	0.000***	0.000***
	n_{et}, (β_2)	0.000	0.000**	0.000	0.000*
	p_{et}, (β_3)	0.004***	-0.006***	0.001***	-0.001***
	n_{et}, (β_5)	0	0	0	0
	p_{et}, (β_6)	0	0	0	0
Cardano	r_{t-1}, (β_1)	0.000	0.000	0.000**	0.000**
	n_{et}, (β_2)	0.000	0.000	0.000	0.000***
	p_{et}, (β_3)	0.018***	0.006***	0.001***	-0.001**
	n_{et}, (β_5)	0	0	0	0
	p_{et}, (β_6)	0	0	0	0
Dogecoin	r_{t-1}, (β_1)	0.000	-0.002***	0.000	-0.002***
	n_{et}, (β_2)	0.001**	-0.001	0.000	-0.002***
	p_{et}, (β_3)	0.011***	-0.002	0.004***	-0.003***
	n_{et}, (β_5)	0***	0***	0***	0***
	p_{et}, (β_6)	0	0	0	0***

Note: *** Significance at the 1% level; ** significance at 5% level; * significance at 10% level.

Table no. 7 – AR-CGARCH-Mean Model: AR0 and CAR(-1,1) Estimations: Long Run Volatility

Currency	Crypto-Regulation Events			International Events	
	Variables	AR_0	$CAR_{(-1,1)}$	AR_0	$CAR_{(-1,1)}$
Ethereum	r_{t-1}, (β_1)	0.000***	0.000***	0.000**	0.000***
	n_{et}, (β_2)	0.000*	0.000***	0.000	0.000
	p_{et}, (β_3)	0.036***	-0.001***	0.000***	0.000***
	$\sigma(u_t)$, (β_4)	0.000***	0.000	0.000*	0.000
	n_{et}, (β_5)	0.000	0.000	0.000	0.000
	p_{et}, (β_6)	0.000	0.000	0	0
XRP	r_{t-1}, (β_1)	0.000	0.000***	0.000	0.001***
	n_{et}, (β_2)	0.003*	0.002	0.001*	0.002***
	p_{et}, (β_3)	-0.004	0.001	0.001***	0.000
	$\sigma(u_t)$, (β_4)	0.002***	0.000	0.002***	-0.001***
	n_{et}, (β_5)	0.000	0.000	0.000	0.000
	p_{et}, (β_6)	0.000	0.000	0	0***
BNB	r_{t-1}, (β_1)	0.000**	0.000	0.000	0.000***
	n_{et}, (β_2)	0.000	0.001***	0.000	0.000**
	p_{et}, (β_3)	0.000	-0.001	0.001***	-0.001***
	$\sigma(u_t)$, (β_4)	0.000*	0.000***	0.000	0.000
	n_{et}, (β_5)	0.000	0.000	0.000	0.000

	p_{et} , (β_6)	0.000	0.000	0	0
Cardano	r_{t-1} , (β_1)	0.000	0.000***	0.000	0.000
	n_{et} , (β_2)	0.000	0.000	0.000	0.000***
	p_{et} , (β_3)	0.017***	-0.006***	0.001***	-0.001**
	$\sigma(u_t)$, (β_4)	0.000	0.000	0.000	0.000
	n_{et} , (β_5)	0.000	0.000	0.000	0.000
	p_{et} , (β_6)	0.000	0.000	0	0
Dogecoin	r_{t-1} , (β_1)	0.000	0.002***	0.000	0.001***
	n_{et} , (β_2)	0.000	0.002**	0.002***	0.003***
	p_{et} , (β_3)	-0.003	0.004	0.001**	0.002*
	$\sigma(u_t)$, (β_4)	0.003***	-0.001***	0.003***	-0.001***
	n_{et} , (β_5)	0.000***	0.000***	0.000	0.000***
	p_{et} , (β_6)	0.000	0.000	0	0***

Note: *** Significance at the 1% level; ** significance at 5% level; * significance at 10% level.

Table no. 8 – AR-CGARCH Model: AR0 and CAR(-1,1) Estimations: Short Run Volatility

Currency		Crypto-Regulation Events		International Events	
	Variables	**AR_0**	**$CAR_{(-1,1)}$**	**AR_0**	**$CAR_{(-1,1)}$**
Ethereum	r_{t-1} , (β_1)	0.001	0.004	0.000	0.004*
	n_{et} , (β_2)	0.020*	0.036***	-0.002***	0.023
	p_{et} , (β_3)	1.155***	0.117***	0.030***	0.023
	n_{et} , (β_7)	0*	0***	0.000***	0.000***
	p_{et} , (β_8)	0	0	0.000	0.000
XRP	r_{t-1} , (β_1)	0.003	-0.046***	0.000	-0.049***
	n_{et} , (β_2)	0.026	-0.033*	0.049**	-0.033**
	p_{et} , (β_3)	0.849***	-0.048	0.023*	-0.035
	n_{et} , (β_7)	0	0	0.000	0.000
	p_{et} , (β_8)	0	0	0.000	0.000
BNB	r_{t-1} , (β_1)	-0.010***	0.000***	-0.011***	0.003
	n_{et} , (β_2)	-0.005	-0.011	-0.008	0.011
	p_{et} , (β_3)	0.007	-0.007	0.029**	-0.029
	n_{et} , (β_7)	0	0***	0.000	0.000
	p_{et} , (β_8)	0***	0***	0.000*	0.000
Cardano	r_{t-1} , (β_1)	0.003	-0.006**	0.001	0.013***
	n_{et} , (β_2)	0.031**	0.004	0.009	0.019***
	p_{et} , (β_3)	1.016***	-0.011	0.012	0.003
	n_{et} , (β_7)	0	0	0.000	0.000
	p_{et} , (β_8)	0	0	0.000	0.000
Dogecoin	r_{t-1} , (β_1)	0.006	-0.042	0.006	-0.042***
	n_{et} , (β_2)	0.019	-0.049	0.019	-0.049***
	p_{et} , (β_3)	0.011	-0.041	0.011	-0.041*
	n_{et} , (β_7)	0	0	0.000	0.000
	p_{et} , (β_8)	0***	0	0.000***	0.000

Note: *** Significance at the 1% level; ** significance at 5% level; * significance at 10% level.

Table no. 9 – AR-CGARCH-Mean Model: AR0 and CAR(-1,1) Estimations: Short Run Volatility

Currency	Crypto-Regulation Events			International Events	
	Variables	AR_0	$CAR_{(-1,1)}$	AR_0	$CAR_{(-1,1)}$
Ethereum	r_{t-1}, (β_1)	0.016***	0.020***	0.016***	0.019***
	n_{et}, (β_2)	0.011	0.006	0.005	0.019***
	p_{et}, (β_3)	-2.540***	0.013	-0.001	-0.007
	$\sigma(u_t)$, (β_4)	0.035***	0.007***	0.037***	0.005***
	n_{et}, (β_7)	0	0	0.000	0.000
	p_{et}, (β_8)	0	0	0.000**	0.000
XRP	r_{t-1}, (β_1)	0.025***	0.026***	0.026***	0.025***
	n_{et}, (β_2)	0.005	0.099***	0.045**	0.047***
	p_{et}, (β_3)	-0.282	0.011	0.018	0.010
	$\sigma(u_t)$, (β_4)	0.097***	-0.032***	0.097***	-0.029***
	n_{et}, (β_7)	0	0	0.000	0.000
	p_{et}, (β_8)	0	0	0.000	0.000
BNB	r_{t-1}, (β_1)	0.020***	0.025***	0.019***	0.024***
	n_{et}, (β_2)	-0.003	0.036***	0.011	0.023***
	p_{et}, (β_3)	0.002	-0.004	-0.002	-0.007
	$\sigma(u_t)$, (β_4)	0.048***	0.006*	0.047***	0.003
	n_{et}, (β_7)	0	0	0.000	0.000
	p_{et}, (β_8)	0	0	0.000	0.000
Cardano	r_{t-1}, (β_1)	-0.011***	-0.019***	0.007***	0.015***
	n_{et}, (β_2)	0.023*	0.003	0.026	0.035***
	p_{et}, (β_3)	-0.050	-0.001	0.000	0.005
	$\sigma(u_t)$, (β_4)	-0.049***	0.005*	0.042***	-0.014***
	n_{et}, (β_7)	0	0	0.000	0.000
	p_{et}, (β_8)	0	0	0.000***	0.000
Dogecoin	r_{t-1}, (β_1)	-0.022***	-0.033***	-0.015***	-0.032***
	n_{et}, (β_2)	-0.020	-0.038***	0.025	-0.060***
	p_{et}, (β_3)	0.033	-0.026	0.009	-0.035*
	$\sigma(u_t)$, (β_4)	-0.043***	-0.029***	-0.062***	0.012***
	n_{et}, (β_7)	0	0	0.000	0.000
	p_{et}, (β_8)	0	0	0.000	0.000

Note: *** Significance at the 1% level; ** significance at 5% level; * significance at 10% level.

If abnormal returns for the event day AR_0 and cumulative abnormal returns for the event window $CAR_{(-1,1)}$ for each altcoins are examined separately, the validity of semi-strong hypotheses can be tested. Significance of AR_0 shows that the altcoins is responding to the events on the day of the events occurring and the coin has generated abnormally high returns as compared to the risk-adjusted benchmark returns whereas significance of cumulative abnormal returns in the event window (-1, 1) shows that the effect of the event has lingered on throughout the event window and therefore the market has not absorbed the information relating to the event instantaneously; If it had, the cumulative abnormal returns would not have been significant (Benninga, 2014). Hence the presence of significant cumulative abnormal returns indicates semi-strong market inefficiency. As illustrated in Tables no. 4 and no. 5, all five altcoins can be said to have semi-strong market inefficiency with respect to the crypto-regulation events and international events. Therefore, the results do not support the hypothesized statements (see Table no. 10).

Furthermore, Table no. 6 to Table no. 9 state results for coefficients for events in terms of their long-term and transitory/short-term components as extracted from the component GARCH model employed in this study in line with Katsiampa (2017) and Vidal-Tomás and Ibañez (2018). The beta coefficients in these cases produce overall mixed results with some significant and some insignificant values. The size of the coefficients has also been reduced because of controlling for the effect of each event on the long-term and short-term components.

Table no. 10 – Results of Hypothesized Statements

Hypotheses	Supported / Not Supported
H1: The prices of the leading altcoins significantly reflect publicly available information relating to regulatory events and, therefore, are semi-strong efficient.	*Not Supported*
H2: The prices of the leading altcoins significantly reflect publicly available information relating to international events and, therefore, are semi-strong efficient.	*Not Supported*

5. CONCLUSION AND RECOMMENDATIONS

There has been a plethora of studies examining market efficiency of bitcoin in the last few years since cryptocurrencies have emerged as an alternate avenue for investors worldwide, however, whether it is a viable investment choice is a controversial matter. As cited in the literature review, majority of the studies have focused on testing weak form of efficiency in bitcoin using various statistical tests. However, bitcoin has become too expensive and almost out of reach for a regular investor and nevertheless its volatility has been unprecedented. A new range of different cryptocurrencies have therefore emerged on various platforms as an alternate to bitcoin, i.e., altcoins. There is a dearth of studies in the existing literature examining market efficiency of altcoins. This study contributes to the existing literature by evaluating semi-strong market efficiency of altcoins using event study methodology and taking post 2018 events in two unique segments. Moreover, Component GARCH model was used to assess the effect of events on altcoin returns since it was proven to be the best GARCH model in modelling volatility of cryptocurrencies as corroborated by Katsiampa (2017) and Vidal-Tomás and Ibañez (2018).

Five major altcoins were chosen for this study, considering their large market capitalizations. Results have revealed that all five altcoins have been responding to both crypto-regulation and international events. Significant cumulative abnormal returns in the selected event window of three-days show that the semi-strong market efficiency in altcoins overall cannot be validated. However, certain events chosen for this study were of unusual nature, such as outbreak of COVID-19 waves, therefore, one could argue that these events were so significant that the resulting abnormal returns could be prolonged and hence the persistence of abnormal returns even in the event window may not indicate semi-strong market inefficiency but rather a natural response to the nature of the events itself. Nevertheless, it is difficult to infer the same for all the events, as a result, this study concludes that semi-strong market efficiency is not prevalent in the altcoins market.

This study uniquely contributes to the existing literature on the market efficiency of altcoins, such as Abraham (2021); Abreu *et al.* (2022); Koutsoupakis (2022) taking a comprehensive set of recent global events in two distinct categories to probe the semi-strong market efficiency. By exposing such a thorough spectrum of events to robust statistical tests, we provide an insight into the behavior of altcoin market in response to external stimuli and the ensuing results for market efficiency in the rapidly evolving landscape of digital currencies.

Furthermore, based on the results it is recommended that altcoin investors should diligently analyze the events occurring on a global scale and in the regulatory domain in order to earn extraordinary returns as these events appear to have a significant impact on the altcoin returns and the same is not instantaneously reflected in the prices. Since r_{t-1}, (β_1) coefficients were also significant, indicating weak-form market inefficiency, altcoin investors can also analyze past returns to beat the market. Therefore, engaging in fundamental as well as technical analysis is not going to be a futile exercise for altcoin investors. Furthermore, the policymakers should remain wary of their actions with respect to the imposed regulations since crypto-regulation events have a significant bearing on the altcoin returns and this market has not achieved sufficient semi-strong or even weak market efficiency thus far.

Based on the empirical results, following policy implications are further suggested: There is a space for further improvement with regard to transparency in the altcoin market to ensure that any pertinent information is disclosed uniformly and promptly. Some mechanism relating to market surveillance could be put into place to prevent market manipulation. Government and regulators should develop educational programs to guide retail investors on how to perform a risk assessment while investing in cryptocurrencies so as to help them make informed and prudent investment decisions.

This research used an event window of (-1, +1), however, this should have been extended given the unusual nature of the events, such as COVID-19 waves but because of the overlapping of multiple events scenarios, the window could not be expanded any further. Future research could employ an extended event window to enhance robustness of the event study methodology. Future studies could take a wide range of other altcoins and examine their semi-strong market efficiency for more generalizable results. More rigorous methodologies could also be identified to further test the strong form of market efficiency in altcoins to fill this dearth in the existing literature. Additionally, further research opportunities in testing market efficiency in altcoin market could include the use of machine learning and artificial intelligence-based methodologies in order to capture complex, non-linear dependencies in the time series data of altcoin returns.

The selection criteria for the events were derived mainly from the past studies and the presumed global impact of the events as reported in the media, however, the possibility of researcher bias cannot be entirely dismissed despite making the due efforts to remain value-free.

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ANNEX

Table no. A1 – Crypto-Regulatory Events as Reported in the Media

No.	Date	Effect	Country	Event News	Source
1	2-Jan-18	Negative	European Union (EU):	"The EU implemented the Fifth Anti-Money Laundering Directive (5AMLD), which brought cryptocurrency exchanges and wallet providers within the scope of anti-money laundering (AML) and know-your-customer (KYC) regulations."	https://www.coindesk.com/
2	1-Jul-18	Negative	USA	"The U.S. Securities and Exchange Commission (SEC) clarified its stance that some cryptocurrencies and initial coin offerings (ICOs) may be considered securities and subject to federal securities laws."	https://www.coindesk.com/
3	1-May-19	Negative	Japan	"Japan introduced new regulations requiring cryptocurrency exchanges to comply with more stringent AML and KYC requirements."	https://www.coindesk.com/
4	1-Jun-19	Negative	USA	"The Financial Action Task Force (FATF), an intergovernmental organization, released guidance recommending that its member countries implement AML regulations for cryptocurrencies."	https://www.coindesk.com/
5	1-Mar-20	Positive	India	"The Supreme Court of India lifted a banking ban that the Reserve Bank of India (RBI) had imposed on cryptocurrency transactions, allowing for greater cryptocurrency trading in the country."	https://www.coindesk.com/
6	1-Dec-20	Negative	USA	"The U.S. Department of the Treasury proposed new regulations requiring cryptocurrency exchanges and wallet providers to collect and report customer information."	https://www.coindesk.com/
7	22-Apr-21	Negative	USA	"The U.S. Treasury Department unveiled a proposal for requiring cryptocurrency transfers worth $10,000 or more to be reported to the Internal Revenue Service (IRS), in an effort to crack down on tax evasion."	https://www.coindesk.com/
8	18-May-21	Negative	China	"The People's Bank of China (PBOC) issued a notice directing financial institutions to refrain from providing cryptocurrency-related services, including trading, clearing, and settling transactions involving cryptocurrencies."	https://www.coindesk.com/
9	9-Jun-21	Negative	China	"Three key industry associations in China issued a joint statement reiterating the PBOC's warning and further emphasizing that financial institutions should not engage in cryptocurrency-related businesses."	https://www.coindesk.com/
10	18-Jun-21	Negative	China	"Chinese authorities in Sichuan, a major hub for Bitcoin mining, ordered the shutdown of cryptocurrency mining operations in the region. This action significantly impacted the mining industry,	https://www.coindesk.com/

No.	Date	Effect	Country	Event News	Source
				especially Bitcoin miners who operated in the area."	
11	1-Jul-21	Negative	European Union (EU):	"The EU proposed the Markets in Crypto-Assets (MiCA) regulation, aiming to create a regulatory framework for cryptocurrencies and crypto-assets in the EU."	https://www.coindesk.com/
12	28-Jul-21	Negative	USA	"The U.S. Senate passed the Infrastructure Investment and Jobs Act, which included provisions related to cryptocurrency tax reporting. It proposed that cryptocurrency exchanges and brokers would need to report transactions to the IRS, similar to traditional financial institutions."	https://www.coindesk.com/
13	1-Sep-21	Negative	USA	"U.S. regulators, including the Securities and Exchange Commission (SEC) and the Commodity Futures Trading Commission (CFTC), increased their scrutiny of the cryptocurrency industry and discussed potential regulations for stablecoins, which are digital currencies designed to maintain a stable value."	https://www.coindesk.com/
14	1-Jan-22	Negative	UK	"The UK Financial Conduct Authority (FCA) announced its intention to regulate some stablecoins as e-money, which involves oversight and compliance with financial regulations."	https://www.coindesk.com/
15	21-Apr-22	Negative	Australia	"Australia's Financial Regulator (The Australian Prudential Regulation Authority - APRA) aims to implement Crypto Regulation by 2025."	https://www.coindesk.com/
16	5-Jun-23	Negative	USA	"The U.S. Securities and Exchange Commission (SEC) Sues Crypto Exchange Binance and CEO Changpeng Zhao, Alleging Multiple Securities Violations."	https://www.coindesk.com/
17	7-Sep-23	Negative	European Union (EU)	"The European Union's Markets in Crypto Assets regulation, MiCA, is due to take effect in 2024, making it the first major jurisdiction in the world to introduce comprehensive, tailored rules for the sector."	https://www.coindesk.com/
18	13-Mar-24	Positive	-	"Ethereum Finalizes 'Dencun' Upgrade, in Landmark Move to Reduce Data Fees."	https://www.coindesk.com/
19	20-Mar-24	Negative	-	"Ethereum Exchange Traded Funds Hopes Dim Amid Regulatory Probe Reports."	https://www.coindesk.com/

Table no. A2 – International Events as Reported in the Media

No.	Date	Effect	Event News	Source
1	18-Jan-18	Negative	"The European Union (Withdrawal) Bill has its First Reading in the House of Lords."	https://researchbriefings.files.parliament.uk/documents/CBP-7960/CBP-7960.pdf
2	26-Jun-18	Negative	"The European Union (Withdrawal) Bill receives Royal Assent and becomes an Act of Parliament: the European Union (Withdrawal) Act."	https://researchbriefings.files.parliament.uk/documents/CBP-7960/CBP-7960.pdf
3	25-Nov-18	Negative	"The UK and the EU agreed to the terms of the Withdrawal Agreement, which included provisions for a transition period."	https://researchbriefings.files.parliament.uk/documents/CBP-7960/CBP-7960.pdf
4	15-Jan-19	Negative	"The UK Parliament rejected the Withdrawal Agreement negotiated by Theresa May in a historic defeat."	https://researchbriefings.files.parliament.uk/documents/CBP-7960/CBP-7960.pdf
5	17-Oct-19	Negative	"The UK and the EU agreed on a revised Withdrawal Agreement and Political Declaration."	https://researchbriefings.files.parliament.uk/documents/CBP-7960/CBP-7960.pdf
6	19-Oct-19	Positive	"The UK Parliament voted to delay Brexit, requesting an extension beyond the initial deadline of October 31, 2019."	https://researchbriefings.files.parliament.uk/documents/CBP-7960/CBP-7960.pdf
7	31-Dec-19	Negative	"The first cases of a novel coronavirus are reported in Wuhan, China."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
8	30-Jan-20	Negative	"The World Health Organization (WHO) declares the outbreak a Public Health Emergency of International Concern."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
9	31-Jan-20	Negative	"The UK formally left the EU at 11:00 pm GMT, marking the end of its EU membership. This date is commonly referred to as "Brexit Day."	https://researchbriefings.files.parliament.uk/documents/CBP-7960/CBP-7960.pdf
10	11-Mar-20	Negative	"The WHO officially declares the outbreak a global pandemic. Many countries around the world implement lockdowns and travel restrictions."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
11	13-Mar-20	Positive	"COVID-19 Solidarity Response Fund launched to receive donations from private individuals, corporations and institutions."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
12	18-Mar-20	Positive	"WHO and partners launch the Solidarity Trial, an international clinical trial that aims to generate robust data from around the world to find the most effective treatments for COVID-19. "	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
13	19-May-20	Positive	"The 73rd World Health Assembly, the first ever to be held virtually, adopted a landmark resolution to bring the world together to fight the COVID-19."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
14	11-Aug-20	Positive	"Sputnik vaccine authorized for use against COVID-19."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
15	28-Sep-20	Positive	"WHO joined with partners to make 120 million affordable, quality COVID-19 rapid tests available for low- and middle-income countries."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
16	2-Dec-20	Positive	"The Pfizer-BioNTech vaccine received emergency use authorization (EUA) against COVID19."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!

No.	Date	Effect	Event News	Source
17	18-Dec-20	Positive	"The Moderna vaccine received emergency use authorization (EUA)."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
18	30-Dec-20	Positive	"AstraZeneca vaccine authorized for use in various countries."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
19	1-Jan-21	Negative	"The UK fully left the EU's Single Market and Customs Union, marking the complete implementation of Brexit."	https://researchbriefings.files.parliament.uk/documents/CBP-7960/CBP-7960.pdf
20	1-May-21	Negative	"The United States initiated its withdrawal from Afghanistan as part of an agreement reached in 2020 between the U.S. and the Taliban during the Trump administration."	https://www.bbc.com/news
21	30-Aug-21	Negative	"The final withdrawal of U.S. troops was completed on August 30, 2021, ahead of the initially announced deadline."	https://www.bbc.com/news
22	26-Nov-21	Negative	"WHO designated the variant B.1.1.529 a variant of concern, named Omicron, on the advice of WHO's Technical Advisory Group on Virus Evolution."	https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#!
23	24-Feb-22	Negative	"Russia invaded its neighboring country, Ukraine."	https://www.usnews.com/news/best-countries/slideshows/a-timeline-of-the-russia-ukraine-conflict?onepage
24	11-Sep-22	Negative	"Ukraine Forces Russian Retreat."	https://www.usnews.com/news/best-countries/slideshows/a-timeline-of-the-russia-ukraine-conflict?onepage
25	5-Oct-22	Negative	"Russia Annexes Four Ukrainian Regions."	https://www.usnews.com/news/best-countries/slideshows/a-timeline-of-the-russia-ukraine-conflict?onepage
26	1-Feb-23	Negative	"Russia Appears to Launch New Offensive in Ukraine."	https://www.usnews.com/news/best-countries/slideshows/a-timeline-of-the-russia-ukraine-conflict?onepage
27	5-May-23	Positive	"The World Health Organisation (WHO) declared the end of the global emergency status for COVID-19 on May 5, over three years since its initial declaration."	https://www.business-standard.com/world-news
28	7-Oct-23	Negative	"The Israel-Hamas conflict in Gaza broke out when Hamas launched a surprise attack on Israel on October 7 and the retaliatory assault on Gaza by Israel ensued."	https://www.business-standard.com/world-news
29	1-Apr-24	Negative	"Strike on an Iranian consular building that is widely blamed on Israel. Iran promises revenge."	https://www.pbs.org/newshour/world/a-timeline-of-recent-events-that-led-to-irans-assault-on-israel
30	14-Apr-24	Negative	"Iran launches major aerial assault on Israel".	https://www.pbs.org/newshour/world/a-timeline-of-recent-events-that-led-to-irans-assault-on-israel