Investor Attention in Cryptocurrency Markets: Examining the Effects of Vaccination and COVID-19 Spread through a Wavelet Approach

Maher Abida[1], Emna Mnif[2]*

[1]Higher Institute of Business Administration, University of Sfax, Tunisia, [2]Graduate School of Commerce of Sfax, University of Sfax, Tunisia. *Email: emnamnifmasmoudi@gmail.com

ABSTRACT

The main goal of this paper is to determine how vaccination and the spread of COVID-19 have influenced investor interest in cryptocurrency. The paper quantifies the reproduction number of COVID-19 worldwide and in specific countries. It evaluates cryptocurrency volatility using various time scale frequencies by employing the Wavelet approach. Additionally, this research examines how investor interest in these sectors was impacted by immunizations and pandemic transmission. Our research demonstrates that during the COVID-19 epidemic, cryptocurrency volatility is greater across extended trade horizons and decreases following the introduction of immunizations. Furthermore, vaccination levels and the spread of COVID-19 significantly affect investor attention in the top three cryptocurrency markets. This work has several implications, such as highlighting the effect of COVID-19's spread in increasing the volatility of cryptocurrency markets and the role of vaccinations in reducing risks and increasing investor attention. The results of this study aid in forecasting bitcoin market activity and price movements, creating trading opportunities in the bitcoin market. The empirical findings will provide valuable insights for policymakers and investors, enabling them to develop better investment strategies. To the best of our knowledge, this study is the first to employ the R-number to calculate the effect of the COVID-19 vaccine and dissemination on cryptocurrency markets.

Keywords: Contagion Spread, Investor Attention Reproduction Number, COVID-19, Cryptocurrency, Wavelet Approach
JEL Classifications: G10, G13, G4

1. INTRODUCTION

The economic downturn caused by the COVID-19 pandemic started in China and continued in Europe and the USA with an approximately 1-month delay. This crisis implies that the economy will contract for the 1st time since 1976, towards the conclusion of the Cultural Revolution. The spread of the pandemic is picking up speed and causing more economic damage. The epidemic of COVID-19 is taking lives and has killed more than 400000 people worldwide. It is also threatening livelihoods unprecedentedly. The quarantine measures have contributed to the slowdown of the virus, the crash of the stock markets, and cutting paycheques for workers and

businesses already struggling worldwide (McIntyre and Lee, 2020). Many authors declare that the current downturn could easily prove the steepest since the end of the second world war (Abubakar, 2020; Hevia and Neumeyer, 2020; Vidal-Tomás, 2021). Rates are being lowered by governments and central banks all across the world, and rescue packages are being offered that have not been seen in decades. A trillion-dollar plan to revive the faltering US economy, however, was defeated in the senate due to disagreements between republicans and Democrats. The impact of the COVID-19 pandemic on financial markets and accounting has been covered in a number of papers (Corbet et al., 2021; Hepburn et al., 2020). The COVID-19 spread intensity (Shim et al., 2020) and duration (Zhang et al., 2020) have

attracted more attention in the literature because they can predict the crash length and downturns. The average number of persons that will get the virus from one sick person in a community that is completely susceptible is shown by COVID-19's reproduction number R_0. The importance of the R_0 on financial markets can be significant, as it can impact investor sentiment, consumer behavior, and overall economic activity (Mnif et al., 2022). Financial markets responded to the COVID-19 pandemic in the early stages with extreme volatility and uncertainty since the R_0 was still mostly unknown. Investors were more worried about the pandemic's possible economic effects as the virus progressed and the R_0 was anticipated to be fairly large. This lead to market sell-offs, as investors worried about reduced consumer spending, supply chain disruptions, and lower corporate profits (Khalfaoui et al., 2021).

Governments and central banks throughout the world attempted a range of strategies to lessen the pandemic's economic impact, including fiscal stimulus plans and changes to monetary policy. Despite persistent worries about the R0 and the virus's spread, these steps served to calm financial markets and sustain economic growth. The usefulness of the R-number R_0 estimation in predicting the future infected instances and the extent of an epidemic duration is proved by Dashraath et al. (2020) and Zhang et al. (2020). In addition, vaccination policies have demonstrated their effectiveness to stop the epidemic spread (Saban et al., 2022). The impact of immunizations on lowering stock market volatility has also been studied in several research (Khalfaoui et al., 2021; Rouatbi et al., 2021). During this pandemic crisis, researchers have extensively examined the herding behavior of cryptocurrency investors (Mnif et al., 2020; Mandaci and Cagli, 2021; Yarovaya et al., 2021). Additionally, the majority of research, like Subramaniam and Chakraborty (2020), have examined investor interest in cryptocurrencies. However, there hasn't been much actual research on how vaccination affects bitcoin prices and investor interest. According to the author's knowledge, academic studies have not extensively examined the investor interest in cryptocurrency markets that was sparked by the spread of the pandemic and vaccines. This study investigates the impact of COVID-19 dissemination and vaccines on bitcoin volatility and market sentiment in response to this gap in the literature.

The findings indicate that during the COVID-19 epidemic, cryptocurrency volatility is greater over extended trade horizons and decreases once vaccination programs are put in place. Furthermore, vaccination levels and the COVID-19 spread significantly affect investor attention in the three top cryptocurrency markets.

This is how the rest of the paper is organized. The main related works were summarized in the second section. The following section describes the data and develops the methodology. The fourth section presents and discusses the main results, and finally, the last section closes with considerable implications and concluding remarks.

2. STATE OF THE KNOWLEDGE

Numerous foreign agencies concurred that COVID-19 had a negative impact on the economy (Gharib et al., 2021). The statistical behavior of the COVID-19 spread and its effect on financial markets have been the subject of several academic studies. The first body of literature contrasted how the financial market changed throughout the COVID-19 epidemic. The financial markets' reactions to sixty-four nations were examined by Ashraf (2020). He demonstrated how the overabundance of COVID-19-infected patients damages stock market performance during this epidemic.

Through the wavelet coherence technique and Markov switching autoregressive model, Caferra and Vidal-Tomás (2021) looked at how the stock market and cryptocurrency marketplaces behaved during the COVID-19 pandemic. Their findings point to a financial contagion in March, when the values of stocks and cryptocurrencies both fell precipitously. Cryptocurrencies rebounded fast, however stock markets continued to be in a bear market period, demonstrating that different market types experienced different price dynamics throughout the epidemic. Iqbal et al.'s (2021) investigation of the COVID-19 pandemic's extraordinary effects on the cryptocurrency market. They specifically examined how the changing intensity of the pandemic, as represented by the daily addition of new infections worldwide, affects the daily returns of the top 10 cryptocurrencies by market capitalization. Using the Quantile-on-Quantile Regression (QQR) approach, they found that the changing intensity levels of COVID-19 have an asymmetric impact on both the Bearish and Bullish market scenarios of cryptocurrencies. Furthermore, there are variations in the responses of these currencies to changes in the pandemic's intensity. While most currencies experienced positive gains in response to small shocks caused by COVID-19, they failed to withstand significant changes, except for Bitcoin, ADA, CRO, and to some extent, Ethereum. Their findings showed that this new asset class has novel and asymmetric dynamics in the face of a highly stressful and unpredictably occurring event like COVID-19. They also discovered that these findings held true even when the intensity of the pandemic is gauged using a different proxy (deaths from COVID-19).

Similar to this, Mnif et al. (2020) looked at how COVID-19 affected the effectiveness of top-capitalized cryptocurrencies. They also looked into if there was any herding behavior during the epidemic. They demonstrated how the COVID-19 outbreak dramatically boosted cryptocurrency efficiency and herding tendency. A wavelet technique was used by Goodell and Goutte (2021) to examine the effect of COVID-19 on Bitcoin. Their findings demonstrate that COVID-19 influenced Bitcoin prices, particularly in April.

The primary focus of the second stream of empirical research has been on understanding and addressing the contagion issues associated with the disease, with the aim of making the most accurate predictions regarding its spread. Most empirical health care and infectious disease science studies employed the reproduction number (R-number). The estimation of the R-number was performed using the transmission rate (Shim et al., 2020) and the stochastic transmission model (Hellewell et al., 2020). Three methods for estimating the instantaneous R-number were also investigated, including the exponential growth rate-based

method (EGR), Poisson likelihood-based (ML), and stochastic Susceptible-Infected-Removed dynamic (SIR) (You et al., 2020). According to Pham et al. (2023), the introduction of COVID-19 vaccinations is anticipated to have a favorable influence on international financial markets by reducing the pandemic's severe negative impacts. These results demonstrate that immunizations can dramatically lower the degree of G7 country-to-country stock volatility connectivity, suggesting that when vaccination rates increase, the benefits of diversification for international equities portfolios can be increased throughout the pandemic.

The third stream has been primarily concerned with gauging investor interest during the COVID-19 epidemic. According to Smales (2021), investor interest significantly influenced how the US stock market sectors responded to the COVID-19 issue. Investor attention-seeking industries including technology and healthcare had favorable anomalous returns. In contrast, less popular industries like energy and materials had negative abnormal returns. Early on in the crisis, investor attention had a greater influence and had a greater impact on sector performance than underlying fundamentals. According to these results, it is crucial to take investor attention into account when choosing an investing strategy during a crisis.

In the same way, Al Guindy (2021) investigated the relationship between cryptocurrency price volatility and investor attention. The author used daily data on Bitcoin and Ethereum prices and Google Trends data on the search volume of these cryptocurrencies to analyze the data. The findings demonstrated that investor focus had a positive impact on cryptocurrency prices, and that cryptocurrency prices had a positive influence on investor focus. The study also indicated that during times of extreme price volatility, the effect of investor attention on bitcoin prices was more pronounced. The results imply that investor focus is a key factor in the bitcoin market and can influence price volatility. Following this line of inquiry, Smales (2022) looked into how investor attention affected bitcoin market results. The author used Google Trends data on the search volume of Ethereum and Bitcoin to measure investor attention and found that it significantly impacted cryptocurrency returns. The study also discovered that investor attention had a greater influence on Bitcoin than Ethereum during times of intense market turbulence. According to the study, paying close attention to investor behavior is crucial when examining bitcoin market results.

The last strand of studies has focused on evaluating the role of vaccinations in reducing stock markets' volatility. Chan et al. (2022) investigated how vaccination announcements affected financial markets throughout the world. The analysis of data from 20 nations by the authors using the event research approach revealed that stock market returns were considerably and favorably affected by vaccination announcements. The effect was more substantial in countries with higher COVID-19 infection rates and in sectors related to tourism and travel. The study also discovered that vaccination news had a bigger effect on stock market returns than other COVID-19 news, such infection rates and lockdown procedures. These results imply that vaccination announcements have a considerable and favorable impact on the world stock markets, particularly in those industries that have been severely impacted by the epidemic. Similar to this, To et al. (2023) emphasized that, even before widespread immunizations start, worldwide financial markets are already reflecting the economic benefits of COVID-19 vaccine research. They looked at the role vaccination rates have in lowering volatility in the world's stock markets, using the GJR-GARCH model. They showed that a higher rate of vaccine initiation has a favorable effect on stock markets worldwide, particularly in developed countries and regions with rates above their average. These findings hold up even when using alternative models to project volatility and different estimates of the independent variables. Mass immunization can also ease investor concerns about prolonged COVID-19 effects and government measures to address the pandemic.

Nevertheless, Lin (2021) looked at how investor attention affected the performance of cryptocurrencies. The author used Bitcoin and Ethereum data and Google Trends data on the search volume of these cryptocurrencies to analyze the data. The findings revealed that investor interest had a favorable influence on cryptocurrency prices and trading volumes, proving its significance in the cryptocurrency market. Overall, the research reveals that when examining bitcoin performance, investor attentiveness is a crucial component to take into account. Nevertheless, there is a lack of empirical investigations on the contribution of the vaccination and the COVID-19 spread in stimulating investor attention on cryptocurrency markets. Therefore, the main contributions of this paper are the estimation of the effect of the vaccination and COVID-19 spread on cryptocurrency volatilities and investor attention.

3. DATA AND METHODOLOGY

We need to comprehend and use indicators that can measure the illness's pace in order to depict the evolution of the COVID-19 disease spread and compare its dynamics between nations. For this matter, this section clarifies the usefulness of the reproduction number in the first subsection. This section presents the data and methodology in the second and third subsections.

3.1. Reproduction Number
All Authorities worldwide are paying very close attention to the rate of the spread of COVID-19, using the reproduction number or R-value as an essential indicator.

The transmission of the SARS-COVID-19 occurs via droplet, contact, and aerosol transmission. The incubation period is the time between infection and symptom onset for an illness. The estimates for the COVID-19 incubation period vary between 2 and 14 days, but it is generally assumed to be around 5 days. There is more debate about the latent period, which is the time between infection and infectiousness. Besides, people can be infectious before showing symptoms, and therefore, the latent period is shorter than the incubation period. The imported case occurs when a traveler is infected and reported as sick in another area. Local transmission occurs if that travel infects others or a cluster of cases locally, and the spread is easily traced. Community transmission occurs when there is no apparent source of infection. Infectivity can be measured using R naught, a necessary epidemiology jargon

for reproduction number. If R naught is equal to 2, then an infected person will infect an average of two other people while they are infectious. There are two significant variants of the R naught: The first is the basic reproduction number which represents the maximum potential of a pathogen to infect people. The second variant is the effective reproduction number which describes the current vulnerability of a population based on whether people have immunity thanks to vaccination or prior exposure. The effective R number decreases throughout an outbreak. Both basic and effective reproduction numbers depend on the environment and demographics. In addition to the pathogen's infectiousness, public health interventions aim to keep R naught down to <1 as this would cause the disease to die out over time. The seasonal flu has an R naught ranging from 0.9 to 2.1. There is a lot of debate about the R naught of COVID-19, with estimates from more recent data ranging from 2.7 to 4.2. Different model assumptions and a dearth of data are mostly to blame for the variation in these estimations. For example, models that assume the possibility of being infectious before symptom onset have assessments that are around 0.5 higher. These R naught estimates indicate that there is much greater potential for the spread of COVID-19 than for the flu.

Basic R-number is defined by Fraser et al. (2009) as the estimated cases' number directly generated by one case in a population where all individuals are susceptible to infection, meaning that no individuals are immunized (naturally or through vaccination). This empirical study uses the reproduction number worldwide and for some specific countries selected according to the highest fatalities and confirmed cases to quantify the spread extent of COVID-19 and their implications on investor interest in the markets for Bitcoin, Ethereum, and Tether. The historical data of the reproduction rate are downloaded directly from the "Our world in data" and Github websites[1].

3.2. Data
The employed data in this paper is collected from various sources. The reproduction rates for the USA, United Kingdom, Germany, France, Italy, Australia, and worldwide are retrieved from the "Our world in data" website. The geographical interest justifies the choice of these countries for each cryptocurrency deduced from "Google Trends," as reported in Figure 1. The investor attention is constructed based on search volume data extracted from the "Google Trends" website.

It is expected that the introduction of successful vaccines will become a game-changer for the dynamics of virus spread and economic recovery, like Pfizer, a global pharmaceutical company, announced

[1] https://ourworldindata.org/explorers/coronavirus-data-explorer and https://github.com/owid/covid-19-data/tree/master/public/data

on November 18, 2020, that its jointly developed vaccine candidate (BNT162b2) met all primary efficacy endpoints in the Phase 3 trial. Vaccination data are retrieved from the GitHub website. All data are explored between January 22, 2020, and February 10, 2022.

Financial data also includes the top three cryptocurrencies (Bitcoin, Ethereum, and Tether) during the same periods extracted in weekly frequency according to their availability and market capitalization from www.coinmarketcap.com. The returns of cryptocurrencies are defined as:

$$r_t = Log(\frac{p_t}{p_{t-1}}) \quad (1)$$

"Where r_t is the cryptocurrency return at date t, and P_t represents their corresponding prices at date t."

3.3. Methodology
Previous research has shown that psychological variables have a role in the development of cryptocurrency prices (Karalevicius et al., 2018; Daniel et al., 2017). Investor sentiment can be evaluated by direct measurement derived from surveys and questionnaires or indirect measures such as financial indicators that interpret upward or downward trends. Previous studies have widely explored investor attention and its contribution to predicting prices (Da et al., 2011; Mnif et al., 2020). This study aims to investigate characteristics influencing investor attention to cryptocurrencies during the COVID-19 epidemic, as well as investor behavior. To do this, we estimate the volatility of cryptocurrencies using continuous wavelets, which break down economic relationships into time-domain frequencies (Grinsted et al., 2004). Our utilization of the continuous wavelet method is justified as it allows for greater flexibility in selecting appropriate wavelets based on the length of the data, enabling us to interpret concealed information and patterns (Aguiar-Conraria and Soares, 2011). This method is capable of capturing the optimal time scale for the top three cryptocurrencies during the COVID-19 epidemic, as market participants often engage in both short and long-term actions.

In the same way, this work employs the continuous wavelet because it conserves information in time and frequency (Aguiar-Conraria et al., 2008) as well as the strength of the correlation, and it is applicable for both stationary and no stationary series as detailed by (Gozgor et al., 2019). Using the mortlet wavelet, the continuous wavelet $N_a(p, q)$ is defined as:

$$N_a(p, q) = \int_{-\infty}^{\infty} a(t) \frac{1}{\sqrt{q}} \psi(\overline{\frac{t-p}{M}}) dt \quad (2)$$

The power spectrum of the continuous wavelet is plotted in Figure 2, visualizing the local variance of each variable where time is explained in days and frequency in the power of two ranging

Figure 1: Geographical interest for Bitcoin, Ethereum, and Tether
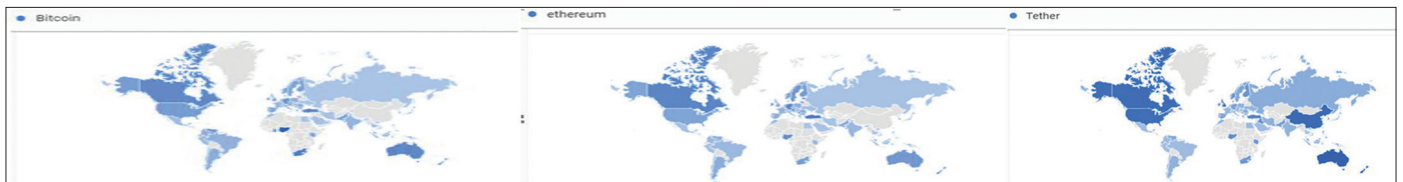
from 4 days (bottom of the plot) to 32 days (top of the plot). The dark black contour lines in regions with energy show a significant estimation from the Monte Carlo simulation at 5% level. The area outside the thin white contour represents the cone of influence.

Therefore, we assess the effect of the COVID-19 spread, vaccinations, price evolution, and returns on investor attention with Newey-West regression to make more accurate results. The dependant variable $A_{i,t}$, which is the investor attention, is quantified by search volume queries of the cryptocurrency term (j) identified by Da et al. (2011). The COVID-19 spread, vaccines, and cryptocurrency proxies measured by reproduction rates, total vaccinations per hundred, and cryptocurrency prices and returns make up the independent variables. Because it more accurately depicts how the dependent and independent variables change over time, we used the Newey-West regression (Ashraf, 2017). In addition, it addresses problems related to estimating bias, heteroscedasticity, and multicollinearity (Wooldridge, 2002; Baltagi and Baltagi, 2005). Therefore, we regress the attention data $A_{i,t}$ on the weekly COVID-19 reproduction rates predictors $RN_{i,t-1}$ in various countries (i). $\varepsilon_{i,t}$ represents the error term.

$RN_{i,t-1}$ incorporates global reproduction rates as well as the nation where cryptocurrency-related search terms are most popular, as shown in Figure 1. These countries are selected according to their sensitivity to the epidemic with the highest fatalities and confirmed cases. "$R_{i,t}$ et $P_{i,t}$ are respectively the cryptocurrency prices and returns at date t."

$VAC_{i,t}$ represents the total vaccination per hundred worldwide and in the selected countries. Therefore, we estimate investor attention as:

$$A_{j,t} = \alpha_0 + \alpha_1\,RN_{i,t} + VAC_{i,t} + R_{j,t} + P_{j,t} + \varepsilon_{i,t} \qquad \text{(Model 1)}$$

4. RESULTS

The given findings in Table 1 provide an overview of each variable's statistics. The R number's mean value in France reaches the greatest value (1.266), demonstrating the severity of the disease's spread there. The lowest mean value of the R number is attributed to the United Kingdom (1.104) compared with the other selected countries. The effective reproduction rate reaches its ultimate value in the United States of America (3.65) (Table 1 and Figure 3), showing that the contagion is ultimately spread in the USA. However, the lowest level of this rate is found in Australia (0.37), indicating that this country's COVID-19 spread is well minimized. Figure 2 shows that vaccinations reached their ultimate values in the United Kingdom compared with other countries.

Besides, the results in Table 1 and Figure 3 indicate that investor attention is more considerable after vaccinations. Similarly, search volume queries are more intensive in Bitcoin, Ethereum, and Tether. The attention span of web visitors varies from 5 to 100 for Bitcoin, 2 to 100 for Ethereum, and 18 to 100 for Tether. These time series are not steady, as seen by the findings in Table 1.

Furthermore, Figure 4 shows that the reproduction rates (R-number) estimates are getting closer to 1 after March 2020, which shows that government response and policies are relevant to combat this pandemic.

The continuous wavelet (Figure 2) visualizes the movements of each variable in the frequency and time scale in the studied

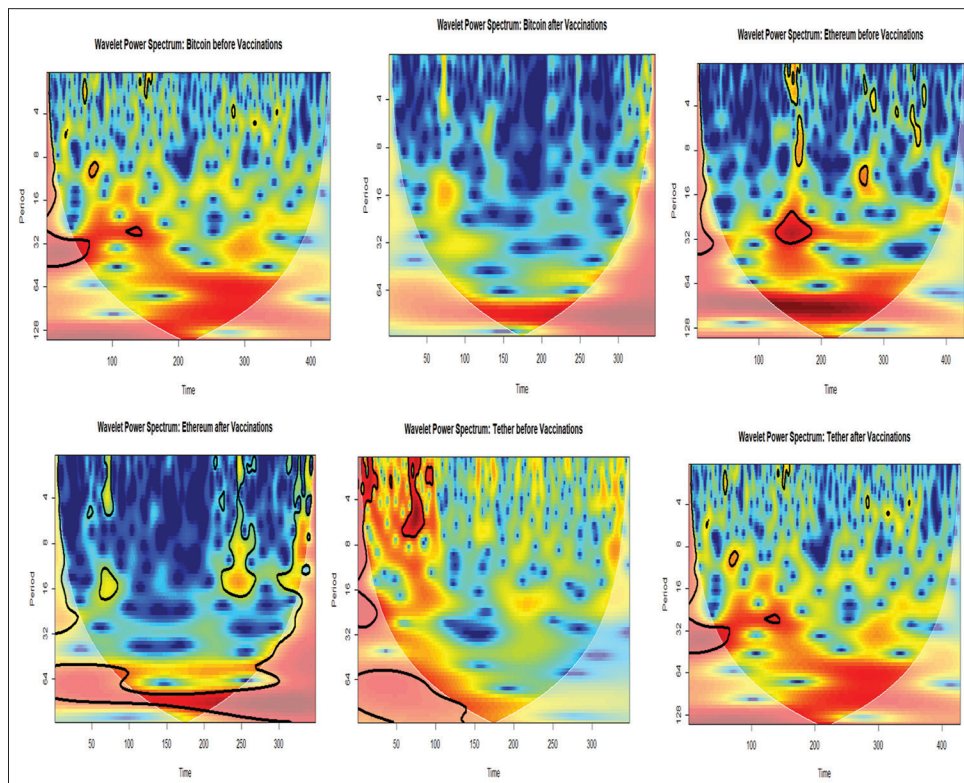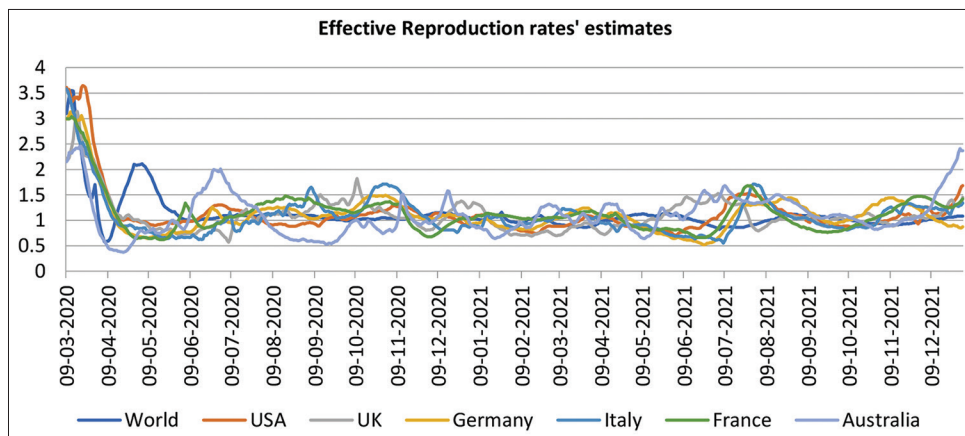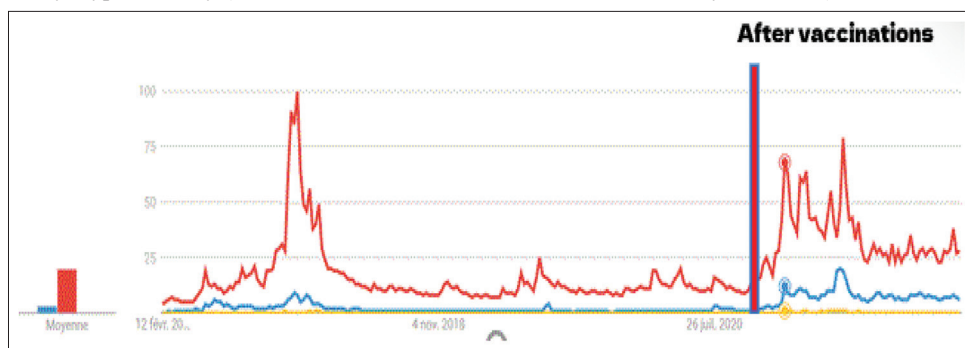Figure 2: Continuous wavelet spectrum before and after vaccinations

Figure 3: Evolving R number over countries

Source: Our World in Data website

Figure 4: Interest by cryptocurrency (Bitcoin [red line], Ethereum [Blue color], Tether [yellow line]) before and after vaccinations

parts of the world. Figure 2 shows the continuous wavelet of the daily frequency cryptocurrency price data before and after the first vaccination date, which corresponds to December 13, 2020. Figure 2 depicts significant short-, medium-, and long-term volatility for all cryptocurrencies immediately following the COVID-19 outbreak. The hazards associated with cryptocurrencies are also higher over long trading horizons (>64 days) than over short horizons (1-4 days), with a major risk island colored red for all the cryptocurrencies under consideration.

Additionally, Figure 2 demonstrates that after vaccinations, the volatility of all the examined cryptocurrencies diminishes. These results show that the cryptocurrency markets initially reacted to the announcement of the COVID-19 outbreak, followed by other market shocks. However, vaccination benefits the cryptocurrency markets, mainly in the short and medium horizons.

The estimation findings in Table 2 demonstrate that investor attention is considerably influenced by global reproduction rates in all cryptocurrency marketplaces (Bitcoin, Ethereum, and Tether). The effective reproduction rates of Italy and the United Kingdom also have a big impact on Bitcoin. Although there has been a noticeable change in investor interest in Ethereum cryptocurrency as a result of the pandemic's expansion in the USA and Australia. In the same way, the total vaccinations per hundred worldwide have a highly considerable effect on Ethereum market attention. Nevertheless, Bitcoin's attention is influenced by the total vaccinations in the USA, United Kingdom, and Italy. However, the

Ethereum market attention is influenced by the total vaccination in the USA and France. Besides, Bitcoin returns and price fluctuations significantly impact investor attention.

These findings are consistent with the majority of research on the COVID-19 pandemic investor interest (Wan et al., 2021; Smales, 2021; Iyke and Ho, 2021; Wang et al., 2021; Subramaniam and Chakraborty, 2020).

We provide two explanations for these results. Firstly, vaccine deployment improves cryptocurrency market returns and decreases their volatility. Secondly, vaccine rollout helps countries' financial markets to be more resilient to external shocks.

Therefore, the study of the influence of COVID-19 vaccination on investor attention and market returns has several potential implications. In fact, COVID-19 vaccination rates affect market volatility caused by abnormal investor behaviors, which could lead to increased demand for several stocks, driving up prices and potentially growing market volatility. In addition, studying these interrelations could also help investors better understand how different sectors of the economy are affected by vaccination rates, potentially reflecting investor fear and market stress. In other words, this study could provide insights into the degree investor sentiment is affected by COVID-19 vaccination rates. Besides, this study finds that increased vaccination rates are associated with positive market returns, which could incentivize policymakers to promote vaccination efforts. Overall, studying

Table 1: Summary statistics

Series	Min	Max	Mean	SD	Skewness	Kurtosis	Shapiro-test
$A_{bitcoin', t}$	5	100	21.16	16.4212	2.125	8.195	0.752
$A_{ethereum', t}$	2	100	16.08	17.216	1.821	7.1206	0.75443
$A_{tether', t}$	18	100	30.67	10.216	2.358	12.093	0.79289
$RN_{world, t}$	0.57	3.55	1.107	0.139	1.464	5.551	0.86337
$RN_{UK, t}$	0.57	3.14	1.104	0.187	0.721	2.784	0.93064
$RN_{USA, t}$	0.71	3.65	1.125	0.239	0.763	2.635	0.92262
$RN_{Australia, t}$	0.37	2.46	1.105	0.324	0.977	3.713	0.92341
$RN_{Italy, t}$	0.55	3.58	1.089	0.302	0.6458	3.114	0.95222
$RN_{Germany, t}$	0.52	3.13	1.1115	0.27	−0.245	1.9109	0.94267
$RN_{France, t}$	0.62	3.04	1.129	1.079	1.546	5.376	0.84793
$VAC_{world, t}$	14.52	118.53	66.1	30.699	−0.0705	1.8	0.95182
VAC_{UKt}	69.7	196	132.9	31.132	0.047	2.784	0.98107
$VAC_{USA, t}$	74.63	154.38	115	19.901	0.204	2.264	0.97623
$VAC_{France, t}$	29.71	183.59	115.27	43.223	−0.47	2.0104	0.92803
$VAC_{Germany, t}$	29.86	178.40	110.32	37.3924	−0.485	2.461	0.94623
$VAC_{Italy, t}$	29.56	184.22	116.28	42.526	−0.505	2.109	0.93465
$VAC_{Australia, t}$	7.64	167.85	84.51	54.868	0.088	1.469	0.89703
$R_{Bitcoin, t}$	−0.47	0.286	−0.077	0.161	−0.148	2.562	0.98916
$R_{Ethereum, t}$	−0.2864	0.2166	0.01	0.067	−1.935	4.89	0.97431
$R_{Tether, t}$	−0.034	0.0236	−0.0002	0.0037	−1.935	35.911	0.63972
$P_{Bitcoin, t}$	918.5	64398.6	14727	16253.9	1.7186	4.667	0.70258
$P_{Ethereum, t}$	10.51	4644.61	716.17	992.548	2.148	6.832	0.64835
$P_{Tether, t}$	0.915	1.03	1.0004	0.0094	−4.605	40.843	0.56009

Table 2: Estimation results (Model 1)

Investor Attention (Dependant variable)	Bitcoin	Ethereum	Tether
Constant	−2.1526e+02*** (6.1889e+01)	−1.7367e+01 (4.4139e+01)	89.7933 (68.145)
Reproduction rate			
World	−5.3875e+01* (2.5133e+01)	−1.0429e+02*** (2.2593e+01)	−71.525** (22.631)
USA	−2.8728 (1.8339)	−42.063** (14.762)	−6.644 (13.435)
UK	2.5658e+01** (8.3901)	−2.1777 (4.5199)	5.734 (9.5401)
Autralia	4.4636 (9.5335)	25.061** (7.5673)	18.592 (11.235)
Italy	3.0253* (1.203)	6.28545.3514	−6.852 (8.8306)
France	−1.8643 (1.117)	4.9235e−01 (9.1549e−01)	−0.458 (0.875)
Germany	−8.6836 (7.8766)	6.2854 (5.3514)	7.726 (7.428)
Total vaccinations per hundred			
World	9.4530e−01 (1.4534)	2.2909* (1.0982)	−1.0083 (1.952)
USA	4.0697*** (1.2106)	1.5648* (6.2325e−01)	1.459 (1.347)
UK	−9.4877** ((1.4534)	−6.9631e−02 (5.1046e−01)	0.0389 0.831
Autralia	−7.6407e−01 (5.9252e−01)	−4.1770e−01 (4.3405e−01)	0.401 (0.663)
Italy	2.39 (1.0213)*	1.1923 (9.0697e−01)	0.575 (1.256)
France	−1.8467 (1.0508)	−3.1360** (9.9661e−01)	−1.083 (1.27)
Germany	−1.1981 (1.6106)	−3.1360 9.9661e−01	0.312 (0.87)
Return	−56.271** (21.593)	7.7612e−01 (7.281)	153.424 (132.978)
Prices	9.4530e−01** (1.4534)	3.4868e−04 (2.3244e−03)	−123.99 (98.555)

the influence of COVID-19 vaccination on investor attention and market returns could provide valuable insights for investors and policymakers alike, helping inform investment decisions and public health policies.

In the same context, this study could have potential managerial implications, such as investment strategy, employee engagement, and risk management. Companies may need to consider the potential risks associated with COVID-19 vaccination, such as supply chain disruptions or negative public perception, if the company's vaccination efforts are perceived as inadequate. This study could also have implications for employee engagement. In fact, successful companies in their vaccination efforts may be viewed more positively by employees, which could positively affect morale and productivity. Overall, the study of the influence

of COVID-19 vaccination on investor attention and market returns could have important implications for how companies manage their reputation, investment strategy, risk management, and employee engagement.

5. CONCLUSION

Amidst the COVID-19 pandemic, news of clinical trials for vaccines and mass vaccinations have brought renewed hope for stabilizing the economy and financial markets. However, investor anxiety and skepticism towards government policies in dealing with economic disruptions have contributed to stock market volatility. This study investigated how the COVID-19 pandemic's pace and spread affected the bitcoin market's volatility before and after vaccination. Using weekly data, we calculate the impact of the

total number of vaccines per hundred and the reproduction rates (R number) on investor interest in three different cryptocurrency marketplaces. The reproduction rates (R-number) estimates are getting closer to 1 after March 2020, which shows that government response and policies are relevant to combat this pandemic.

The findings indicate that the cryptocurrency volatility is more substantial in the long trading horizons and becomes weaker after vaccination implementations. In the same way, both the COVID-19 spread and vaccination levels significantly affect investor attention. Overall, our results align with the pioneer studies on cryptocurrency during the COVID-19 pandemic through various time scales (Wan et al., 2021; Smales, 2021; Iyke and Ho, 2021; Wang et al., 2021). Furthermore, this study has practical implications by offering instruments and measurement tools to predict market dynamics. The findings of this research hold significant relevance for cryptocurrency traders and policymakers as they gain a deeper understanding and ability to anticipate financial market outcomes in the face of the coronavirus crisis. This has direct implications for cryptocurrency investments. Firstly, the study reveals that cryptocurrency volatility is more pronounced in long-term perspectives during the COVID-19 pandemic. Secondly, it highlights the impact of COVID-19's transmission rates and spread on investor attention, leading to behavioral biases and market imperfections. Thirdly, the study demonstrates the substantial influence of vaccination policies on investor attention. As a result, these findings provide valuable insights for governments and policymakers to implement appropriate regulations that promote market stability.

Research on how COVID-19 immunization affects investor focus and market results is an issue that is expected to remain important in the future. The rate of immunization and its effects on the economy and financial markets may fluctuate as the COVID-19 pandemic develops and new strains appear.

Future research could explore the influence of vaccination progress on various sectors of the economy and how investors react to these developments. Additionally, investigating the effects of vaccination on investor behavior and sentiment could uncover valuable patterns and trends that could aid in investment decision-making. Another potential avenue for future exploration is studying the impact of vaccination progress on different types of investors, such as retail investors versus institutional investors or investors in different global regions. This analysis could unveil dissimilarities in perception and behavior attributed to factors like culture, geography, or investment strategies.

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