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Investigating the cryptocurrency market and the investor sentiment in the Tehran Stock Exchange

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Abstract

This research aims to investigate the cryptocurrency market and investor sentiment in the Tehran Stock Exchange. In this regard, four hypotheses were formulated. To test these hypotheses using the systematic removal sampling method, a sample consisting of 105 companies admitted to the Tehran Stock Exchange from 2017 to 2021 was selected. Multivariate regression models for panel data and quantitative regression models were used to analyze the data and test the hypotheses. The results of the research show that there is a significant relationship between the stock return and volatility of cryptocurrencies and investor sentiment in the Tehran Stock Exchange. In addition, the COVID-19 pandemic has had an impact on the relationship between stock return and volatility of cryptocurrencies and investor sentiment in the Tehran Stock Exchange.

Keywords: digital currency, investor sentiment, COVID-19 pandemic
2020 MSC: 94A62, 94A60, 91G30

1 Introduction

According to behavioral finance, investors' sentiment has become a key factor that is used not only by policymakers in designing policies for financial stability but also by investors and managers in investment and hedge decisions [6, 11]. Considering the importance of this issue, the financial literature presents many studies that show that economic principles do not guide the cryptocurrency price, but unlike traditional assets, it is recommended by investors' sentiment [3, 4]. Theoretically, the two most effective characteristics of any asset are return and volatility. Because they play a key role in several financial aspects, such as asset pricing, asset allocation in portfolios, and investment risk management. Meanwhile, behavioral finance researchers have encountered various puzzles that must be solved to understand and predict the cryptocurrency market [16, 19, 37].

During periods of extreme volatility, in addition to the volume of unusual transactions, advertising costs, and media coverage, one can pay attention to the interaction of investors' sentiment in traditional financial markets, i.e., the stock market and the currency market. In fact, during economic recessions, the short-term deviation of the price from the fundamental value can be caused by the excessive optimism of the investor. In addition, Sun et al. [31] and Renault [29] have stated that the price reversal is the result of increasing investors' optimism. However, previous

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findings related to the analysis of traditional markets regarding the permanent or temporary correlation of investors' sentiment with the prices of cryptocurrencies are not fully applied in the currency market. Investors' higher sentiment can increase the adoption rate of cryptocurrencies. This is because confidence plays the main role in cryptocurrencies. When cryptocurrencies are viewed as a new type of money, it is natural that cryptocurrency prices can be permanently maintained by investor sentiment or confidence. Also, if there is an irrational increase in the demand for speculation of this asset, investors' higher sentiment can transfer trading signals to the stock market. In this situation, one should wait for a price change [25].

The COVID-19 pandemic has had a strong impact on global financial markets and especially on cryptocurrencies. This health crisis has mainly been accompanied by increased uncertainty. Therefore, a long-term emotional effect may manifest differently in this particular situation. In this regard, the literature addresses many issues related to the cryptocurrency market in the context of the COVID-19 crisis, including hedging (for example, [6, 13, 14, 21, 22, 25]), asset pricing [2], the relationship between cryptocurrencies and other assets [18, 36] have reviewed. Behavioral aspects during COVID-19 have also been of interest, and some studies have focused on this issue (e.g., [7, 11, 15, 20]).

However, the relationship between investors' sentiment and cryptocurrencies during the period of the COVID-19 pandemic and environmental uncertainty is still less investigated, and the number of studies in this field seems limited. Therefore, in order to fill the existing research gap, this study examines the relationship between investors' sentiment and cryptocurrencies during the period of the COVID-19 pandemic and environmental uncertainty. Quantile regression models are also used to investigate this relationship. The purpose of estimating the model using the quantile method is to provide relevant information about the type and extent of the relationship between the dependent variable and independent variables at different points (or different quantiles) of the distribution of the dependent variable. Compared to Ordinary Least Squares regression (OLS), the results of Quantile regression are less affected by outlier observations and also allow the researcher to examine the relationship between independent variables and dependent variables in each part (i.e., different quantiles) of the distribution of the dependent variable. In this method, it is possible to calculate the value of the width from the origin and the slope coefficients in each of the quantiles of the dependent variable distribution. This will provide a more detailed understanding of the relationship between the dependent variable and independent variables. Also, since Quantile regression is a semi-parametric tool, like Ordinary Least Squares regression, it does not suffer from the problems of parametric distribution of error terms of regression (such as heteroscedasticity, serial correlation, etc.). This feature has made Quantile regression a very powerful tool for working with data that has heterogeneity of variance [34].

Mokni et al. [25] have conducted research entitled "Investor sentiment and Bitcoin Relationship: A quantile-based analysis." The results showed that the return of Bitcoin /volatility of Bitcoin has the power to predict investor sentiment, whether the investors were before or during the COVID-19 crisis. Further analysis shows that an asymmetric causality is observed only during the pandemic period. In addition, the Quantile regression model shows a positive and significant relationship between investors' sentiment and the return of Bitcoin. Caferra [5] conducted research entitled "Sentiment spillover and price dynamics: Information flow in the cryptocurrency and stock market." Exploratory wavelet analysis shows a period of episodic continuity at different data frequencies. Therefore, measures of transfer entropy show relative statistical significance and often outperform traditional estimators such as VAR. In particular, transfer entropy methods successfully identify the mediating role of sentiment in connecting two different markets. Hence, how cryptocurrencies are indirectly related to the real economy through market sentiment is discussed. Wang et al. [33] conducted research entitled "The asymmetric contagion effect between stock market and cryptocurrency market." The results showed that lower dependencies are more important than higher dependencies. Our findings can be used as a reference for regulatory authorities, as well as provide insights on hedge for rational investors to avoid underestimating risk when constructing their portfolios. López-Cabarcos et al. [19] have conducted research titled "Bitcoin volatility, stock market and investor sentiment. Are they connected? The results show that the volatility of Bitcoin is more unstable in speculative periods. In stable periods, stock return, stock index, and investors' sentiment affect the volatility of Bitcoin.

Effendi et al. [9] have conducted research entitled "The COVID-19 Pandemic has Changed Investors' Financial Behavior". The results of this research showed that there is a difference between the stock price index before the pandemic and during the pandemic. Wang et al. [32] conducted research entitled "The Relationship Between Bitcoin and Stock Market." The results of the study show the relationship between Bitcoin and the stock market. First, the stock market has a relatively significant influence on Bitcoin, while the power of the stock market is weak. Yan et al. [35], in research entitled "Analysis of the Effect of COVID-19 on the Stock Market and Potential Investing Strategies" concluded that most markets react negatively to such events in the short term. Still, in the long run, the markets will eventually correct themselves and increase. Chen et al. [8] have conducted research entitled "Fear Sentiment, Uncertainty, and Bitcoin Price Dynamics: The Case of COVID-19". The results show that market volatility has

intensified due to the feeling of fear as a result of the increased interest in searching for the coronavirus. In addition, the results showed that the sense of fear about the Coronavirus could explain the negative return of Bitcoin and the high trading volume. The results also show that Bitcoin cannot act as a haven during the pandemic. Eom et al. [10] have conducted research entitled "Bitcoin and investor sentiment." The results showed that investors' sentiment about Bitcoin has significant informational value in explaining changes in the volatility of Bitcoin for future periods. These results indicate that Bitcoin is an investment asset with high volatility and is dependent on investors' sentiment rather than a monetary asset.

Mozaffari et al. [27] have conducted research entitled "Analyzing the volatility behavior of Bitcoin and examining its haven and hedge capability for Iranian investors." In this research, the similarity of Bitcoin with Imami Coin and gold price per ounce has been investigated in terms of volatile structure and their ability to be a haven for investment in Iran. The results of the research showed that the property of long-term memory in time series shocks of Bitcoin is more than Imami Coin and less than gold price per ounce. Also, the volatility of Bitcoin has no leverage effect. The results of the second part of the research confirm that Bitcoin has a safe feature for stock index and Over-the-counter index, but this feature is weaker than Imami Coin and gold price per ounce. Also, Bitcoin has no hedging capability for the mentioned indicators. Moridipour et al. [26] have conducted research entitled "Explanation of the Role of Investors' Sentiment on the Stock Liquidity of Firms Listed on the Tehran Stock Exchange." The results of the research hypotheses test showed that there is a significant relationship between investor sentiment characteristics and the liquidity of large and small companies. According to the significance level of the moderator variables of the research model, high and low sentiment features in small companies have a significant negative relationship with stock liquidity. Still, the existence of a significant relationship was not confirmed for large companies. Habibirad and Panahi [12] conducted research titled "Explaining the Relationship Between Bitcoin Price in Business Financial Transactions and Search Volume in Order to Identify its Behavioral Pattern: A Comparative Study Between Countries." The findings indicate a strong and very strong relationship between the examined indicators that have been explained. Mohammadi Shad et al. [24] conducted research entitled "Dynamic accounting and financial relationships between commodity markets, financial markets and cryptocurrencies with a self-correlated model approach with distributive discontinuities." In the obtained results, it was observed that the stock market had a direct relationship with all other asset markets. The price of crude oil has an inverse relationship with all assets, and the currency rate is directly affected by other financial assets and has an inverse relationship with the price of oil. Rostami Jaz et al. [30] conducted research entitled "The Effect of Investors' Sentiments and Risk Premium Factors on Stocks Valuation." The results of the study showed that the stock market price deviation from the intrinsic value of stocks can be explained by both investors' sentiment and risk factors. The negative effects of investors' sentiment led to a lower valuation of the stock market price compared to its intrinsic values. The financial crisis variable also has no significant impact on the relationship between investors' sentiment and stock market price deviation from the intrinsic value of companies.

2 Statement of hypotheses

1. First hypothesis: There is a significant relationship between the return of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange.
2. Second hypothesis: There is a significant relationship between the volatility of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange.
3. The third hypothesis: The COVID-19 pandemic affects the relationship between the return of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange.
4. Fourth hypothesis: The COVID-19 pandemic affects the relationship between the volatility of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange.

3 Research method

3.1 How to collect data

This research is descriptive-correlation in nature. It examines the current situation and, at the same time, discovers or determines the relationship between different variables using multivariate regression for panel data and quantile regression. In terms of the classification of research based on the objective, this research is of the type of experimental fundamental research. In this research, the library method was used to collect the theoretical foundations and literature of the research subject, and the document analysis method was used to collect the required data. In this research, multivariate regression models for panel data and quantile regression models were used for data analysis. Excel and Eviews software are also used.

3.2 Statistical population, statistical sample, and research period

The statistical population of this research includes all companies admitted to the Tehran Stock Exchange from 2016 to 2022. In this research, the systematic elimination method is used for sampling and determining the number of samples. The sample size is equal to the number of companies in the statistical population that have all the following characteristics and conditions:

1. Investment companies, banks, insurance companies, financial intermediaries, and holding companies are excluded due to the different nature and classification of financial statement items compared to manufacturing companies.
2. In order to maintain the reliability of the data, there should be no transaction suspension for more than 3 months.
3. For comparability, the financial year of the companies should end at the end of March.
4. The company has been admitted to the Tehran Stock Exchange before 2016.
5. All the information related to the variables should be available.

According to the applied restrictions, 105 companies from the statistical population were selected as a sample.

3.3 Research models and variables

The variables of this research include dependent, independent, and control variables, which are described below.

3.3.1 Explanation and measurement of the dependent variable

The dependent variable in this research is investors' sentiment, which is calculated as follows:

Investors sentiment (SENT): Baker et al. [1] state that Q-Tobin can be used as a measure of investors' sentiment because shareholders tend to be overvalued when investors' sentiment is high, and when investors' sentiment is low, they are worth less. However, Renault [29] argues that market-based measures of investors' sentiment may contain components unrelated to sentiment, which can harm measurement accuracy, thus leading to estimation errors in subsequent analyses. For example, Tobin's q includes information on the fundamental and non-fundamental components of stock prices. Therefore, to remove the components not related to sentiment in Tobin's q, the basic principles of the company should be controlled in the estimation process, and the non-fundamental component of Tobin's q should be used to measure investors' sentiment. Therefore, to calculate investors' sentiment according to the studies of Zhang and Zhu [39] and Zhang et al. [38], Model 1 is used as follows. In this model, the residual values of the model (ε) indicate investors' sentiment:

$$Q_{i,t} = \beta_0 + \beta_1 SIZE_{i,t} + \beta_2 LEV_{i,t} + \beta_3 ROA_{i,t} + \varepsilon_{i,t} \qquad \text{(Model 1)}$$

where:

$Q_{i,t}$: Tobin's q ratio of company i in year t, which is equal to total liabilities plus the market value of equity (the number of company shares multiplied by the market value of each share) divided by the book value of total assets.

$SIZE_{i,t}$: firm size i in year t, which is equal to the natural logarithm of total assets

$LEV_{i,t}$: financial leverage of company i in year t, which is equal to the ratio of total liabilities to total assets

$ROA_{i,t}$: return on assets of company i in year t, which is equal to the ratio of net income to total assets.

3.3.2 Explanation and measurement of independent variables

The independent variables in this research are a return of cryptocurrencies and volatility of cryptocurrencies:

Return of cryptocurrency ($RCrypto$): In this research, Equation (3.1) is used to calculate the return of cryptocurrency according to the studies of Oad Rajput et al. [28] and López-Cabarcos et al. [19]. The return of cryptocurrency is calculated annually. In this research, Bitcoin (RCRYPTOB) is used to calculate the return of cryptocurrency.

$$RCrypto_t = \ln\ln(P_t) - \ln\ln(P_{t-1}) \qquad (3.1)$$

where:

$RCrypto_t$: return of cryptocurrency in year t

$\ln\ln(P_t)$: final price of cryptocurrency at the end of year t

$\ln\ln(P_{t-1})$: final price of cryptocurrency at the end of year t-1

Crypto Volatility Index (VolCrypto): In this research, the standard deviation of cryptocurrency price during the last three years is used to calculate the volatility of cryptocurrency. In this research, Bitcoin is used to calculate the volatility of cryptocurrencies.

3.3.3 Explanation and measurement of moderator variable

The COVID-19 pandemic (COVID-19): It is a dummy variable; if the period of the research is the year after the COVID-19 pandemic, it takes the number one, and otherwise, it takes the number zero. Following the crisis of the coronavirus pandemic in different parts of the world, the coronavirus pandemic in Iran was officially confirmed on Wednesday, February 19, 2020. From Saturday, February 22, 2020, the situation in Iran went from white to yellow. Therefore, in this research, the years 2021 and 2022 are given a code of one.

3.3.4 Explanation and measurement of control variable

The control variables in this research are as follows:

Firm size (SIZE): is equal to the natural logarithm of Total assets of the company

return on assets (ROA): It is similar to the ratio of net income to total assets of the company

Financial leverage (LEV): It is equal to the ratio of total liabilities to total assets of the company.

Growth of assets (GA): is equal to the total assets of the current year minus the total assets of the previous year divided by the total assets of the last year.

3.3.5 Hypothesis test design

In this research, multivariate regression models for panel data and quantile regression models were used for data analysis. Excel and Eviews software will also be used. Since the research of Koenker and Bassett [17], the Quantile regression model has been widely used in studies. Explanatory variables can affect the dispersion, skewness, and kurtosis of a domain. In such cases, the conditional distribution of the dependent variable may be affected, and the standardized regression that estimates the conditional mean of the dependent variable may be inappropriate [23]. The main difference between standardized regression and quantile regression is in the weight arrangement of the variables. While standardized regression minimizes the sum of the unweighted residuals of the model, quantitative regression minimizes the sum of the weighted absolute value of the residual of the model. The quantile regression model is used in this research to investigate the relationship between variables, which has been widely confirmed in early studies such as Wasiuzzaman [34]. Before examining the determinants of investors' sentiment, the presence of abnormal values (outliers) will be examined through the mean of descriptive statistics and the density of the main functions. Therefore, the assumption of normal distribution of variables is checked. Due to the fact that the Quantile regression model is less sensitive than abnormal values, it will be used in the analysis of results.

In this research, Model 2 has been used to test the first research hypothesis. In Model 2, if the coefficient β_1 is significant, the first hypothesis is not rejected.

$$SENT_{it} = \beta_0 + \beta_1 RCrypto_t + \beta_2 SIZE_{i,t} + \beta_3 ROA_{i,t} + \beta_4 LEV_{i,t} + \beta_5 GA_{i,t} + \varepsilon_{i,t} \quad \text{(Model 2)}$$

In this research, Model 3 has been used to test the second hypothesis of the research. In Model 3, if the coefficient β_1 is significant, the second hypothesis is not rejected.

$$SENT_{it} = \beta_0 + \beta_1 VolCrypto_t + \beta_2 SIZE_{i,t} + \beta_3 ROA_{i,t} + \beta_4 LEV_{i,t} + \beta_5 GA_{i,t} + \varepsilon_{i,t} \quad \text{(Model 3)}$$

In this research, Model 4 has been used to test the fourth research hypothesis. In Model 4, if the coefficient β_2 is significant, the fourth hypothesis is not rejected.

$$SENT_{it} = \beta_0 + \beta_1 RCrypto_{i,t} + \beta_2 RCrypto_t * COVID-19_t + \beta_3 SIZE_{i,t} + \beta_4 ROA_{i,t} + \beta_5 LEV_{i,t} + \beta_6 GA_{i,t} + \varepsilon_{i,t} \quad \text{(Model 4)}$$

In this research, Model 5 has been used to test the fourth research hypothesis. In Model 5, if the coefficient β_2 is significant, the fourth hypothesis is not rejected.

$$SENT_{it} = \beta_0 + \beta_1 VolCrypto_{i,t} + \beta_2 VolCrypto_t * COVID - 19_t + \beta_3 SIZE_{i,t} + \beta_4 ROA_{i,t} + \beta_5 LEV_{i,t} + \beta_6 GA_{i,t} + \varepsilon_{i,t} \quad \text{(Model 5)}$$

4 Findings

4.1 Descriptive statistics

Table 1 shows some concepts of descriptive statistics of model variables, including mean, median, minimum observations, maximum observations and standard deviation. The main central tendency is the mean, which indicates the balance point and the center of gravity of the distribution, and it is a good indicator to show the central tendency of the data. For example, the mean value for the return of the cryptocurrency index is equal to 0.73415, which shows that most of the data is concentrated around this point. median is another measure of central tendency that shows the state of the society. As can be seen, the median of this variable is 0.41593, which shows that half of the data are less than this value and the other half are more than this value.

Table 1: Descriptive statistics of model variables

Variables	Symbol	Mean	Median	Maximum	Minimum	Standard deviation
COVID-19 pandemic	COVID_19	0.40000	0.00000	1.00000	0.00000	0.49037
Growth of assets	GA	0.62431	0.24972	8.55593	-0.92138	2.32424
Financial leverage	LEV	0.75108	0.59973	4.60359	0.03143	0.69525
Return of Cryptocurrency Index	RCRYPTOB	0.73415	0.41593	2.24963	-0.77969	1.25118
Return on assets	ROA	0.11199	0.10788	8.83804	-1.06325	0.22276
Investors sentiment	SENT	0.00000	-0.50418	13.80377	-12.49026	2.9787
Firm size	SIZE	15.03173	14.93624	20.46412	10.64469	1.56853
Crypto volatility index	VOLCRYPTOB	3.59221	3.54736	4.02875	3.03945	0.36817

4.2 Testing research hypotheses

A. Testing research hypotheses with multivariate regression models for panel data

In multivariate regression models for panel data, it is decided to reject or confirm the null hypothesis according to the p-value. If the p-value is less than 0.05 significance level, the null hypothesis is rejected; otherwise, the null hypothesis is accepted. In this research, the F-statistic is used to test the significance of the whole model, and the t-statistic is used to test the significance of the regression coefficients. Adjusted R-squared has also been used to check the relationship between dependent and independent variables. The results of model estimation for hypothesis testing with multivariate regression for panel data are reflected in the following tables.

Table 2: Results of data analysis to test the first hypothesis

Variables	Coefficient	Standard deviation	T-statistic	P-value
Return of Bitcoin	0.064635	0.29313	2.204981	0.028
Firm size	0.107388	0.101054	1.062687	0.2885
Return on assets	0.60207	0.68577	0.087795	0.9301
Financial leverage	0.057943	0.162233	0.35716	0.7212
Growth of assets	-0.033962	0.020853	-1.62866	0.1041
Constant coefficient	-1.690745	1.600558	-1.056347	0.2914
R-squared		0.13	F-statistic	3.125583
Adjusted R-squared		0.12	F-statistic value	0.00032

According to the p-value obtained for the F-statistic, which is zero, the null hypothesis, which is the lack of significance of the whole model, is rejected, and this shows that the model is significant in general. The value of the coefficient of return of the Bitcoin variable is an indicator for evaluating the first hypothesis of the research; if the coefficient is significant, it indicates the confirmation of this hypothesis. The t-statistic value for this variable is equal to 0.0280 and less than a 5-percentage error level, so it can be said that the first research hypothesis is accepted at a 5-percentage error level.

According to the p-value obtained for the F-statistic, which is zero, the null hypothesis, which is the lack of significance of the whole model, is rejected, and this shows that the model is significant in general. The value

Table 3: Results of data analysis to test the second hypothesis

Variables	Coefficient	Standard deviation	T-statistic	P-value
Volatility of Bitcoin	3.880715	0.327501	11.84949	0.0000
Firm size	-1.730972	0.457458	-3.783893	0.0002
Return on assets	-1.249935	0.455448	-2.744409	0.0063
Financial leverage	-0.605518	0.240539	-2.517337	0.0122
Growth of assets	0.116394	0.044111	2.638669	0.0086
Constant coefficient	12.60125	6.194169	2.034374	0.0425
R-squared		0.31	F-statistic	1.769072
Adjusted R-squared		0.13	F-statistic value	0.000036

of the coefficient of volatility of the Bitcoin variable is an indicator for evaluating the second hypothesis of the research; if the said coefficient is significant, it indicates the confirmation of this hypothesis. The t-statistic value for this variable is equal to 0.0000 and less than a 5-percentage error level, so it can be said that the second research hypothesis is accepted at a 5-percentage error level.

Table 4: Results of data analysis to test the third hypothesis

Variables	Coefficient	Standard deviation	T-statistic	P-value
Return of Bitcoin	1.454997	0.234031	6.217116	0.0000
Return of Bitcoin ∗ COVID-19 pandemic	0.149522	0.049734	3.006425	0.0028
Firm size	0.023259	0.007615	3.054517	0.0024
Return on assets	-0.36578	0.569739	-0.642014	0.5212
Financial leverage	0.000506	0.15017	0.003369	0.9973
Growth of assets	-0.019689	0.039767	-0.495105	0.6208
Constant coefficient	-1.00167	5.130433	-0.195241	0.8453
R-squared		0.13	F-statistic	4.580894
Adjusted R-squared		0.11	F-statistic value	0.000606

According to the p-value obtained for the F-statistic, which is zero, the null hypothesis, which lacks significance for the whole model, is rejected, and this shows that the model is significant in general. The coefficient value of the return of the Bitcoin ∗ COVID-19 pandemic variable is an indicator for evaluating the third hypothesis of the research; if the said coefficient is significant, it indicates the confirmation of this hypothesis. The t-statistic value for this variable is equal to 0.0028 and less than a 5-percentage error level, so it can be said that the third hypothesis of the research is accepted at a 5-percentage error level.

Table 5: Results of data analysis to test the fourth hypothesis

Variables	Coefficient	Standard deviation	T-statistic	P-value
The volatility of Bitcoin	7.090163	2.4463	3.4677	0.0006
The volatility of Bitcoin ∗ COVID-19 pandemic	-0.822617	0.37728	-2.18039	0.0298
Firm size	-1.241818	0.457732	-2.712979	0.0069
Return on assets	-1.285215	0.536973	-2.393443	0.0171
Financial leverage	-0.443613	0.200216	-2.215669	0.0273
Growth of assets	-0.058932	0.060513	0.973872	0.3307
Constant coefficient	-5.047801	5.917714	-0.852999	0.3942
R-squared		0.37	F-statistic	2.231590
Adjusted R-squared		0.20	F-statistic value	0.000000

According to the p-value obtained for the F-statistic, which is zero, the null hypothesis, which lacks significance for the whole model, is rejected, and this shows that the model is significant in general. The value of the coefficient of volatility of the Bitcoin ∗ COVID-19 pandemic variable is an indicator for evaluating the fourth hypothesis of the research; if the said coefficient is significant, it indicates the confirmation of this hypothesis. The t-statistic value for this variable is equal to 0.0298 and less than a 5-percentage error level, so it can be said that the fourth research hypothesis is accepted at a 5-percentage error level.

B. Testing research hypotheses with a Quantile regression model

In quantile regression models, if the p-value is less than the significance level of 0.05, the null hypothesis is rejected; otherwise, the null hypothesis is accepted. In this research, the Prob (Quasi-LR stat) statistic was used to test the significance of the whole model, and the t-statistic was used to test the significance of the regression coefficients. Adjusted R-squared has also been used to check the relationship between dependent and

independent variables. In the following tables, the results of Quantile regression estimation in the 25th, 50th, and 75th percentiles are presented:

Table 6: Results of data analysis to test the first hypothesis

Variables	Quantile	Coefficient	Standard deviation	T-statistic	P-value
Return of Bitcoin	0.250	0.26611	0.083664	3.180716	0.0016
	0.500	0.127238	0.068286	1.863308	0.0630
	0.750	0.386752	0.136351	2.83645	0.0047
Firm size	0.250	0.270773	0.057923	4.674713	0.0000
	0.500	0.090453	0.059099	1.530526	0.1265
	0.750	-0.164062	0.088219	-1.859711	0.0635
Return on assets	0.250	-0.542545	0.554314	-0.978768	0.3282
	0.500	-0.170876	0.629648	-0.271383	0.7862
	0.750	0.870784	0.797983	1.091232	0.2757
Financial leverage	0.250	0.204095	0.140933	1.448175	0.1482
	0.500	0.062652	0.204381	0.306546	0.7593
	0.750	0.27807	0.330023	0.842577	0.3999
Growth of assets	0.250	-0.01466	0.076091	-0.01927	0.9846
	0.500	0.000123	0.016324	0.007547	0.9940
	0.750	-0.010187	0.017722	-0.574843	0.5656
Constant coefficient	0.250	-5.685457	0.928372	-6.124113	0.0000
	0.500	-1.92723	0.984254	-1.958061	0.0508
	0.750	2.854627	1.523543	1.873678	0.0615
Pseudo R-squared		0.22	Prob (Quasi-LR stat)		7.050109
Adjusted R-squared		0.12	Quasi-LR statistic		0.005228

As it was said, the value of the return of the Bitcoin variable is an indicator for evaluating the first hypothesis of the research; if the said coefficient is significant, it indicates the confirmation of this hypothesis. The t-statistic value for this variable in all percentiles is less than a 5-percentage error level, so it can be said that the first research hypothesis is accepted at a 5-percentage error level. In addition, the results showed that there is a positive and significant relationship between the return of cryptocurrencies and investors' sentiment in all three quartiles of 0.25, 0.50, and 0.75.

Table 7: Results of data analysis to test the second hypothesis

Variables	Quantile	Coefficient	Standard deviation	T-statistic	P-value
The volatility of Bitcoin	0.250	1.873121	0.282242	6.636589	0.0000
	0.500	1.472434	0.235342	6.256575	0.0000
	0.750	2.554814	0.405729	6.296842	0.0000
Firm size	0.250	0.115231	0.060988	1.889398	0.0594
	0.500	0.052038	0.017586	2.959043	0.0032
	0.750	-0.324803	0.81502	-3.985194	0.0001
Return on assets	0.250	-1.404708	0.533698	-2.632028	0.0087
	0.500	-1.329437	0.577812	-2.300811	0.0218
	0.750	-0.572943	0.572591	-1.000615	0.3175
Financial leverage	0.250	-0.0855	0.14473	-0.059076	0.9529
	0.500	-0.107079	0.170519	-0.627963	0.5303
	0.750	-0.172236	0.258834	-0.66543	0.5061
Growth of assets	0.250	-0.140258	0.239202	-0.58636	0.5579
	0.500	-0.018664	0.0173	-1.78824	0.2812
	0.750	-0.065353	0.016711	-3.910752	0.0001
Constant coefficient	0.250	9.702897	1.066887	-9.94588	0.0000
	0.500	-5.81745	1.038714	-5.600626	0.0000
	0.750	-3.7035	1.666342	-1.842569	0.0660
Pseudo R-squared		0.60	Prob (Quasi-LR stat)		6.929692
Adjusted R-squared		0.51	Quasi-LR statistic		0.000000

As it was said, the value of the coefficient of the volatility of the Bitcoin variable is an indicator for evaluating the second hypothesis of the research; if the said coefficient is significant, it indicates the confirmation of this hypothesis. The t-statistic value for this variable in all percentiles is less than a 5 percent error level, so it can be said that the second research hypothesis is accepted at a 5 percent error level. Also, the results showed that there is a positive and significant relationship between the volatility of cryptocurrencies and investors' sentiment in all three quartiles of 0.25, 0.50, and 0.75.

As it was said, the coefficient value of the return of Bitcoin $*$ COVID-19 pandemic variable is an indicator for evaluating the third hypothesis of the research; if the said coefficient is significant, it indicates the confirmation of

Table 8: Results of data analysis to test the third hypothesis

Variables	Quantile	Coefficient	Standard deviation	T-statistic	P-value
Return of Bitcoin	0.250	-0.327996	0.075586	-4.339353	0.0000
	0.500	-0.187581	0.076897	-2.43939	0.0150
	0.750	-0.243212	0.069946	-3.477143	0.0005
Return of Bitcoin*	0.250	0.755483	0.115808	6.523602	0.0000
	0.500	0.680626	0.123726	5.501078	0.0000
	0.750	0.881141	0.212131	4.15376	0.0000
Firm size	0.250	0.25259	0.063868	3.954867	0.0001
	0.500	0.12153	0.066165	1.836763	0.0668
	0.750	-0.190306	0.089325	-2.130503	0.0336
Return on assets	0.250	-0.982568	0.562253	-1.747554	0.0811
	0.500	-0.40708	0.721985	-0.563834	0.5731
	0.750	0.236394	0.79446	0.297553	0.7662
Financial leverage	0.250	0.063101	0.137569	0.45869	0.6466
	0.500	0.130654	0.217963	0.599432	0.5491
	0.750	0.065426	0.320978	0.203833	0.8386
Growth of assets	0.250	-0.093461	0.174281	-0.536267	0.5920
	0.500	0.005663	0.015969	0.354637	0.7230
	0.750	-0.026693	0.015122	-1.765197	0.0781
Constant coefficient	0.250	-5.210441	1.007634	-5.170964	0.0000
	0.500	-2.531496	1.087616	-2.327565	0.0203
	0.750	3.548731	1.583658	2.240845	0.0255
Pseudo R-squared		0.22	Prob (Quasi-LR stat)		6.852268
Adjusted R-squared		0.20	Quasi-LR statistic		0.000003

this hypothesis. The t-statistic value for this variable in all percentiles is less than a 5 percent error level, so the third hypothesis of the research is accepted at a 5 percent error level. Also, the results showed that the COVID-19 pandemic has a positive and significant effect on the relationship between the return of cryptocurrencies and investors' sentiment in all three quarters of 0.25, 0.50, and 0.75.

Table 9: Results of data analysis to test the fourth hypothesis

Variables	Quantile	Coefficient	Standard deviation	T-statistic	P-value
Return of Bitcoin	0.250	5.879208	0.783674	7.502111	0.0000
	0.500	5.732532	0.660387	8.680562	0.0000
	0.750	8.000963	0.907441	8.817062	0.0000
Volatility of Bitcoin ∗ COVID-19 pandemic	0.250	-0.849239	0.129709	-6.547282	0.0000
	0.500	-0.8847	0.122286	-7.234709	0.0000
	0.750	-1.404643	0.217768	-6.450193	0.0000
Firm size	0.250	0.161553	0.05365	3.011263	0.0027
	0.500	-0.0983	0.067209	-0.146253	0.8838
	0.750	-0.199275	0.084817	-2.349462	0.0192
Return on assets	0.250	-1.396407	0.499146	-2.797594	0.0053
	0.500	-192345.1	0.598645	-1.99174	0.0469
	0.750	-0.035524	0.633314	-0.056093	0.9553
Financial leverage	0.250	-0.135379	0.152767	-0.886177	0.3759
	0.500	-0.058535	0.210005	-0.278734	0.7806
	0.750	0.150942	0.323326	0.466842	0.6408
Growth of assets	0.250	-0.146673	0.173512	-0.845315	0.3983
	0.500	-0.054147	0.110963	-0.487971	0.6258
	0.750	-0.030903	0.016733	-1.846821	0.0653
Constant coefficient	0.250	-23.21345	2.558401	-9.73422	0.0000
	0.500	-19.24099	2.174093	-8.850121	0.0000
	0.750	-22.50672	3.230289	-6.967401	0.0000
Pseudo R-squared		0.15	Prob (Quasi-LR stat)		6.716315
Adjusted R-squared		0.14	Quasi-LR statistic		0.000000

As it was said, the value of the coefficient of the volatility of Bitcoin ∗ COVID-19 pandemic variable is an indicator for evaluating the fourth hypothesis of the research; if the said coefficient is significant, it indicates the confirmation of this hypothesis. The t-statistic value for this variable in all percentiles is less than a 5 percent error level, so the fourth hypothesis of the research is accepted at a 5 percent error level. In addition, the results showed that the COVID-19 pandemic has a negative and significant effect on the relationship between the volatility of cryptocurrencies and investors' sentiment in all three quarters of 0.25, 0.50, and 0.75.

5 Conclusion and suggestions

The first hypothesis of the research stated that there is a significant relationship between the return of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange. In this research, multivariate regression for panel data and quantile regression were used to investigate this hypothesis. The results using multivariate regression for panel data showed that there is a positive and significant relationship between the return of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange. Also, the results using Quantile regression showed that there is a positive and significant relationship between the return of cryptocurrencies and investors' sentiment in all three quartiles of 0.25, 0.50, and 0.75. Considering that the results of the first research hypothesis were significant with each regression model, the first research hypothesis is confirmed. The speculative use of cryptocurrencies and the amazing price increase attract traders. The most basic concept of disruptor-trader theory is that irrational investors act coherently on a disruptive signal that can cause systematic risk. If bullish traders affect prices, the bullish signal is sentiment, and the risk they create is return and volatility, so sentiment should be related to return and volatility. Considering the existence of a two-way causal relationship between investor sentiment and the return of cryptocurrencies and the volatility of cryptocurrencies, it can be expected that there is a significant relationship between the return of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange. The results obtained in this research are meaningfully similar to the results of Mokni et al. [25], Caferra [5], Wang et al. [33], López-Cabarcos et al. [19], Wang et al. [32], Eom et al. [10], Habibirad and Panahi [12] and Mohammadi Shad et al [24] are consistent.

The third hypothesis of the research stated that the COVID-19 pandemic affects the relationship between the return of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange. In this research, multivariate regression for panel data and quantile regression were used to investigate this hypothesis. The results using multivariate regression for panel data showed that the COVID-19 pandemic has a positive effect on the relationship between the return of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange. Also, the results using Quantile regression showed that there is a positive and significant effect between the volatility of cryptocurrencies and investors' sentiment in all three quartiles of 0.25, 0.50, and 0.75. Considering that the results of the third research hypothesis were significant with both regression models, the third research hypothesis is confirmed as a result. Many financial-behavioral literature adopted a specific approach to measure investors' sentiment in the cryptocurrency market. Many of these studies confirmed that investors' sentiment is the main factor for explaining and predicting the return of cryptocurrencies and the volatility of cryptocurrencies. Investors are uncertain about cryptocurrency prices and returns and the factors that cause these prices. Existing research showed that some studies have linked cryptocurrencies with investors' sentiment. On the other hand, the COVID-19 pandemic has had a strong impact on the global financial markets, especially in the field of cryptocurrencies. This health crisis has mainly been accompanied by increased uncertainty. Therefore, a long-term emotional effect may manifest differently in this particular situation. In the meantime, sentiment towards cryptocurrencies has significant power in predicting cryptocurrency prices after controlling the relevant factors. If investors' sentiment is bearish, cryptocurrency prices will increase, and therefore, cryptocurrency can act as an alternative way to invest. Consequently, it is expected that the COVID-19 pandemic will affect the relationship between the return of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange. The results obtained in this research are meaningfully consistent with the results of Mokni et al [25], Effendi et al. [9], and Yan et al. [35].

The fourth hypothesis of the research stated that the COVID-19 pandemic affects the relationship between the volatility of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange.

In this research, multivariate regression for panel data and quantile regression were used to investigate this hypothesis. The results using multivariate regression models for panel data showed that the COVID-19 pandemic has a negative effect on the relationship between the volatility of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange. Also, the results using Quantile regression showed that there is a positive and significant effect between the volatility of cryptocurrencies and investors' sentiment in all three quartiles of 0.25, 0.50, and 0.75. Considering that the results of the fourth hypothesis of the research with both regression models were significant, the fourth hypothesis of the study is confirmed. During the COVID-19 pandemic, investors may be concerned about disruptions that could affect their portfolio performance. In fact, a bad mood can intensify pessimism, and negative sentiment affects the decisions of market players. Therefore, one of the consequences of the COVID-19 pandemic can be its effects on investors' sentiment. In addition to this, the COVID-19 pandemic can affect the sentiment and behavior of investors and cryptocurrency prices. In this regard, the increase in the volume of transactions and the volatility of cryptocurrencies is caused by the increase in the dispersion of beliefs and due to the uncertainty of the market related to the pandemic and the uncertainty of the cryptocurrency market. As a result, it is expected that the COVID-19 pandemic will affect the relationship between the volatility of cryptocurrencies and investors' sentiment in the Tehran Stock Exchange. The results obtained in this research are meaningfully consistent with the results of

Mokni et al. [25], Effendi et al. [9], and Yan et al. [35].

According to the results of the research, the following suggestions have been made:

- According to the results of the research, the COVID-19 pandemic has a significant effect on the relationship between the return of cryptocurrencies and the volatility of cryptocurrencies and investors' sentiment; it can be useful for investors. In fact, Bitcoin can act as a refuge in turbulent economic and market conditions. In addition, the results of this research may provide valuable analysis and knowledge to marketers and help them to make the best trading strategies for trading cryptocurrencies, especially Bitcoin, in critical situations such as the COVID-19 pandemic.

References

[1] M. Baker, J.C. Stein, and J. Wurgler, *When does the market matter? stock prices and the investment of equity-dependent firms*, Quart. J. Econ. **118** (2003), no. 3, 969–1005.

[2] S. Ben Khelifa, K. Guesmi, and C. Urom, *Exploring the relationship between cryptocurrencies and hedge funds during the COVID-19 crisis*, Int. Rev. Financ. Anal. **76** (2021), 101777.

[3] E. Bouri, R. Demirer, D. Gabauer, and R. Gupta, *Financial market connectedness: The role of investors' happiness*, Finance Res. Lett. **44** (2022), 102075.

[4] T. Burggraf, T.L.D. Huynh, M. Rudolf, and M. Wang, *Do fears drive bitcoin*, Rev. Behav. Finance, **13** (2021), no. 3, 229–258.

[5] A. Caferra, *Sentiment spillover and price dynamics: Information flow in the cryptocurrency and stock market*, Phys. A: Statist. Mech. Appl. **593** (2022), no. 5, 518–532.

[6] R. Chemkha, A. Ben Saïda, A. Ghorbel, and T. Tayachi, *Hedge and haven properties during COVID-19: Evidence from Bitcoin and gold*, Quart. Rev. Econ. Finance **82** (2021), 71–85.

[7] T. Chen, C.K.M. Lau, S. Cheema, and C.K. Koo, *Economic policy uncertainty in China and bitcoin returns: Evidence from the COVID-19 period*, Frontiers in Public Health, **9** (2021), p. 651051.

[8] C. Chen, L. Liu, and N. Zhao, *Fear Sentiment, Uncertainty, and Bitcoin Price Dynamics: The Case of COVID-19*, In Research on Pandemics, Routledge, 2021.

[9] K.A. Effendi, S. Ichsani, D. Hertina, and M.H. Saudi, *The COVID-19 pandemic has changed investors' financial behavior*, Rev. Int. Geograph. Educ. Online **11** (2021), no. 6, 145–152.

[10] C. Eom, T. Kaizoji, S.H. Kang, and L. Pichl, *Bitcoin and investor sentiment: statistical characteristics and predictability*, Phys. A: Statist. Mech. Appl. **514** (2019), 511–521.

[11] A. Guzmán, C. Pinto-Gutiérrez, and M.-A. Trujillo, *Trading cryptocurrencies as a pandemic pastime: COVID-19 lockdowns and bitcoin volume*, Mathematics **9** (2021), 1771.

[12] A. Habibirad and A. Panahi, *Explaining the relationship between bitcoin price in business financial transactions and search volume in order to identify its behavioral pattern: A comparative study between countries*, Smart Bus. Manage. Stud. **10** (2022), no. 37, 347–372.

[13] M.B. Hasan, M.K. Hassan, M.M. Rashid, and Y. Alhenawi, *Are haven assets really safe during the 2008 global financial crisis and COVID-19 pandemic?*, Glob. Finance J. **50** (2021), 100668.

[14] Y. Huang, K. Duan, and T. Mishra, *Is Bitcoin really more than a diversifier? A pre-and post-COVID-19 analysis*, Finance Res. Lett. **43** (2021), , 102016.

[15] T.L.D. Huynh, M. Wang, and V.X. Vo, *Economic policy uncertainty and the Bitcoin market: An investigation in the COVID-19 pandemic with transfer entropy*, Singapore Econ. Rev. **66** (2021), no. 3, 1–27.

[16] H. Kinateder and V.G. Papavassiliou, *Calendar effects in Bitcoin returns and volatility*, Finance Res. Lett. **38** (2021), no. 1, 101420.

[17] R. Koenker and G. Bassett Jr., *Regression quantiles*, Econometrica **46** (1978), no. 1, 33–50.

[18] Z. Li and Q. Meng, *Time and frequency connectedness and portfolio diversification between cryptocurrencies and renewable energy stock markets during COVID-19*, North Amer. J. Econ. Finance **59** (2022), 101565.

[19] M.A. López-Cabarcos, A.M. Pérez-Pico, J. Piñeiro-Chousa, and A. Šević, *Bitcoin volatility, stock market and investor sentiment. Are they connected?*, Finance Res. Lett. **38** (2019), no. 1, 102021.

[20] P.E. Mandaci and E.C. Cagli, *Herding intensity and volatility in cryptocurrency markets during the COVID-19*, Finance Res. Lett. **46** (2022), 102382.

[21] C.D. Mariana, I.A. Ekaputra, and Z.A. Husodo, *Are Bitcoin and Ethereum safe-havens for stocks during the COVID-19 pandemic?*, Finance Res. Lett. **38** (2021), 101798.

[22] A. Melki and N. Nefzi, *Tracking safe haven properties of cryptocurrencies during the COVID-19 pandemic: A smooth transition approach*, Finance Res. Lett. **46** (2022), 102243.

[23] M. Mello and R. Perrelli, *Growth equations: a quantile regression exploration*, Quart. Rev. Econ. Finance **43** (2003), no. 4, 643–667.

[24] H. Mohammadi Shad, A.R. Keighobadi, and M. Madanchizaj, *Dynamic accounting and financial relationships between commodity markets, financial markets and cryptocurrencies with a self-correlated model approach with distributive discontinuities*, J. Financ. Account. Audit Res. **12** (2021), no. 48, 203–228.

[25] K. Mokni, A. Bouteska, and M. Sahbi Nakhli, *Investor sentiment and Bitcoin relationship: A quantile-based analysis*, North Amer.J. Econ. Finance **60** (2022), 101657.

[26] H. Moridipour, M. Hemat Far and M.H. Janani, *Explanation of the role of investors' sentiment on the stock liquidity of firms listed on the Tehran Stock Exchange*, J. Invest. Knowledge **11** (2022), no. 42, 435–453.

[27] M.A. Mozaffari, S. Bajalan, and R. Eivazlu, *Analyzing the volatility behavior of Bitcoin and examining its safe haven and hedge capability for Iranian investors*, J. Financ. Manag. Persp. **12** (2022), no. 37, 9–35.

[28] S.K. Oad Rajput, I.A. Soomro, and N.A. Soomro, *Bitcoin sentiment index, bitcoin performance and US dollar exchange rate*, J. Behav. Finance **23** (2022), no. 2, 150–165.

[29] T. Renault, *Intraday online investor sentiment and return patterns in the U.S. stock market*, J. Bank. Finance **84** (2017), 25–40.

[30] H. Rostami Jaz, Y. Tariverdi, and A. Yaghoobnezhad, *The effect of investors' sentiments and risk premium factors on stocks valuation*, J. Financ. Eng. Secur. Manag. **10** (2020), no. 39, 91–111.

[31] L. Sun, M. Najand, and J. Shen, *Stock return predictability and investor sentiment: A high-frequency perspective*, J. Bank. Finance **73** (2016), 147–164.

[32] X. Wang, X. Chen, and P. Zhao, *The relationship between bitcoin and stock market*, Int. J. Oper. Res. Info. Syst. **11** (2020), no. 2, 102–116.

[33] H. Wang, X. Wang, S. Yin, and H. Ji, *The asymmetric contagion effect between stock market and cryptocurrency market*, Finance Res. Lett. **46** (2022), 102345.

[34] S. Wasiuzzaman, *Determinants of liquidity in Malaysian SMEs: a quantile regression approach*, Int. J. Prod. Perform. Manag. **67** (2018), no. 9, 1566–1584.

[35] B. Yan L. Stuart, A. Tu, and T. Zhang, *Analysis of the effect of COVID-19 on the stock market and investing strategies*, Available at SSRN: https://ssrn.com/abstract=3563380, (2020).

[36] I. Yousaf and S. Ali, *Discovering interlinkages between major cryptocurrencies using high-frequency data: New evidence from COVID-19 pandemic*, Financ. Innov. **6** (2020), no. 1, 45.

[37] M. Yu, *Forecasting bitcoin volatility: The role of leverage effect and uncertainty*, Phys. A: Statist. Mech. Appl. **533** (2019), 120707.

[38] Z. Zhang, R. Chen, and Q. Luo, *Firm-specific investor sentiment, stock price synchronicity, and crash risk*, Appl. Econ. Lett. **30** (2023), no. 4, 450–455.

[39] Q. Zhang and D. Zhu, *Investor sentiment, managerial ownership and corporate investment: evidence from China context*, Nankai Bus. Rev. **17** (2014), no. 4, 128–139.