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The impact of ECB's Quantitative Easing on cryptocurrency markets during times of crisis

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A B S T R A C T

In this paper, we investigate non-linear linkages between Bitcoin and the unconventional monetary policies of the European Central Bank (ECB). In particular, we examine whether a low-interest rate environment resulting from QE indirectly encourages investors to move towards Bitcoin. Using a Bayesian VAR model with time-varying coefficients and stochastic volatility (TVP-BVAR-SV model), we compare Bitcoin's responses to the shadow rate shocks during the pre- and post-COVID-19 periods. Moreover, despite the high uncertainty and the low-interest rate environment, Bitcoin's response during the COVID-19 period reveals a steeper drop compared to the pre-COVID-19 period. That said, investors did not resort to Bitcoin for safety and higher returns. Our findings can be attributed to the unprecedented nature of the crisis, the investor reluctance and pessimism, and the changing behavior of Bitcoin, which is no longer perceived as a safe haven.

1. Introduction

Financial markets are very sensitive to information spread through the macroeconomic environment. For example, the central bank's statements could have a direct impact on market participants' expectations, and this, in turn, would affect their investment choices (Bekaert et al., 2013; Galariotis et al., 2018; Kurov, 2010). The rational expectations theory states that economic agents forecast future returns on financial assets through information disseminated by the central bank. Based on their forecasts, they buy and sell in a way that maximizes their future profits (Altavilla et al., 2016; Bernanke and Kuttner, 2005; Sun and Liu, 2016). For instance, Bernanke and Kuttner (2005) find that the monetary shocks have a significant impact on investors' expectations indicating the sensitivity of investors' behavior to the central bank's decisions. López-Penabad et al. (2022) showcased the impact of negative interest rate policies on the profitability and risk-taking behavior of European banks. In a related vein, Neaime and Gaysset (2022) delved into a discussion on the suitable monetary policy responses to regional and oil price shocks in MENA countries after COVID-19.

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Following the COVID-19 crisis, the European Central Bank (ECB) resumed its unconventional monetary policy called Quantitative easing (QE). Through the massive asset purchase programs, the European monetary authorities attempt to support financial market and revive economic activity. To do so, the ECB's QE should positively influence economic players' expectations and restore investor confidence.

Among others, the objectives of central banks are to ensure financial stability and the protection of investors, lower exchange rates and stimulate the stock market. According to the ECB (2022), approximately 10% of the European households had purchased crypto-assets, including Bitcoin. The ECB considers this phenomenon as a threat to both financial stability and the safety of investors. In fact, potential disruptions in the market for cryptocurrencies like Bitcoin could introduce unexpected risks to the financial system, which can harm financial stability. In addition, investing in the cryptocurrency market can expose investors to unforeseen losses and high risks. This could lead to uncertainty in financial markets. Moreover, higher demand for cryptocurrencies may influence the stock and exchange rate behaviors. In such a scenario, it could harm the effectiveness of monetary policy transmission. The massive asset purchase of sovereign debt, perceived as the most secure financial asset, increases their prices and brings down their yields. Therefore, it would be interesting to examine whether the reduction of interest rates through QE indirectly prompts investors to move towards Bitcoin to seek higher returns.

The literature that investigates the cryptocurrency responses to monetary policy interventions is limited. A few studies that investigate this relation focus on the FED's interventions and associated news (e.g., Demir et al., 2018; Dyhrberg, 2016; Corbet et al., 2020). Some studies exhibit a positive relationship between central bank policy rates and cryptocurrency returns, explained by the capital flight from stock markets to the cryptocurrency market (e.g., Demir et al., 2018; Dyhrberg, 2016). For instance, Dyhrberg (2016) shows that a high FED's policy rate is associated with an increase in Bitcoin returns. His findings are consistent with the hypothesis asserting that Bitcoin is an effective asset for portfolio diversification (Corbet et al., 2018; López et al., 2019). Corbet et al. (2017) show that the FED's communication related to the QE significantly affects the Bitcoin returns volatility. In the same vein, Corbet et al. (2020) argue the existence of a volatility spillover transfer from the FED's announcements to the cryptocurrency market. Recently, Xin and Jiang (2023) argued that a central bank digital currency (CBDC) can address the limitations of a negative interest rate policy (NIRP) in the traditional fiat system, overcoming the zero lower bound constraint and enabling more effective economic stabilization and policy implementation.

Another strand of the literature defends the hypothesis that economic decisions do not affect the Bitcoin market. Vidal-Tomás and Ibañez (2018) find that Bitcoin does not respond to the monetary decisions of the Federal Reserve System, the European Central Bank, the Bank of Japan, and the Bank of England. Similar results found by Lyócsa et al. (2020) indicate that Bitcoin's volatility is not influenced by most US macroeconomic news and announcements, such as government budget deficits, inflation, and even monetary policy announcements.

Some studies show that cryptocurrencies can act as a safe haven to guard against economic policy uncertainty (EPU) (e.g., Demir et al., 2018; Paule-Vianez et al., 2020; Wu et al., 2019). For instance, Wu et al. (2019) indicate that Bitcoin is more sensitive to EPU shocks than gold shocks. Paule-Vianez et al. (2020) highlight the investment attractiveness of Bitcoin as a hedging tool against uncertainty shocks in US economic policy. Their results reveal a significant relationship between the EPU Economic Uncertainty Index and the Bitcoin returns and volatility. Lucey et al. (2021) introduced new measure of cryptocurrency uncertainty – Cryptocurrency Uncertainty Index (UCRY) that can capture the uncertainty beyond Bitcoin. UCRY Policy specifically reflect policy-related uncertainty while UCRY Price capture uncertainty associated with price volatility. Both indices have demonstrated a high level of variability around the key event in cryptocurrency space. In their following work, Wang et al. (2022) introduced the Central Bank Digital Currency (CBDC) indices: CBDC Uncertainty Index (CBDCUI) and CBDC Attention Index (CBDCAI), that have a significant negative relationship with the volatilities of the MSCI World Banks Index, USEPU, and the FTSE All-World Index, and positive with the volatilities of cryptocurrency markets and VIX.

Recently, the onset of the COVID-19 crisis prompted researchers to understand the effects of this unprecedented and unexpected event on investor behavior in the cryptocurrency market. Several studies show that cryptocurrencies, especially Bitcoin, are considered safe havens for investors during the COVID-19 period. For example, Goodell and Goutte (2021a) (2021b) claim that the high number of deaths from COVID-19 has led to high bitcoin prices. Other researchers show that Bitcoin is no longer successful in attracting investors as a safe-haven asset in the financial market. For example, Wątorek et al. (2020) find that the cryptocurrency market does not show any cross-correlation with the traditional markets such as currencies, stock indices, and commodities during the pre-COVID-19 period. However, this property suddenly changed with the appearance of COVID-19. They highlight positive cross-correlations between Bitcoin and the risky assets. As a result, they conclude that the cryptocurrency market has ceased to be considered a "safe haven" and has instead become part of the global financial network. Chen et al. (2020) deduce the same conclusion using a new proxy that measures the feeling of fear of COVID-19. The results suggest that Bitcoin is failing to act as a safe haven during the COVID-19 pandemic. In the same context, Raheem (2021) documents the COVID-19 pandemic is harming Bitcoin's safe-haven property.

Le et al. (2021) document that COVID-19 has changed patterns of connectedness between Fintech and other asset classes. Yarovaya et al. (2022a) further explained why COVID-19 can be considered a 'black-swan' event specifically for cryptocurrency markets, that due to their short existence have never faced such a high global shock before. Even such innovations, like stablecoins, that supposed to have in-built stability mechanism and low volatility, failed to demonstrate safe haven properties during the COVID-19 (Jalan et al., 2021), and their volatility was comparable to Bitcoin. Recently, Katsiampa et al. (2022) offered in-depth analysis of co-movements among Bitcoin and other cryptocurrencies in pre- and during COVID-19 periods and show the shift in influential power from Bitcoin to Ethereum during the pandemic period. This could be explained by the boom of the decentralized finance (DeFi) assets that often built on Ethereum blockchain. While other cryptocurrency markets are getting increasingly influential, Bitcoin still receive attention from practitioners and academic communities.

The research on the changing patterns of connectedness during the COVID-19 is vary vast (see Yarovaya et al., 2022b), however, no study examined Bitcoin's response to the ECB's Quantitative Easing shocks during COVID-19, and our research fills this gap in the literature. Our paper extends a still-underdeveloped research area, namely the cryptocurrency market under unconventional monetary policies in times of crisis. It contributes to the literature on several aspects. First, this is the one of the first studies to examine the transmission of the ECB's QE to Bitcoin and the investor sentiment during the pre-and post-COVID-19 pandemic. Second, our study uses an approach that takes into account possible non-linear relations between Bitcoin and ECB's monetary policy. In particular, we use a BVAR model with time-varying coefficients and stochastic volatility (TVP-BVAR-SV model) developed by Primiceri (2005) and Del Negro and Primiceri (2015). Third, we investigate the stochastic volatility of Bitcoin and the investor sentiment index over the period 2012–2022 to identify the degree of the severity of the COVID-19 crisis contributing to growing cryptocurrency research.

The remainder of this chapter is structured as follows: Section 2 presents the methodology. Section 3 describes the data. Section 4 discusses the empirical results. Section 5 concludes.

2. Methodology

Our methodology employs the BVAR model with time-varying coefficients and stochastic volatility (TVP-BVAR-SV model) developed by Primiceri (2005) and incorporates the corrigendum recommended by Del Negro and Primiceri (2015). This model is employed in the context of the COVID-19 crisis to detect possible modifications in the behavior of financial and economic components (e.g., Aloui, 2021; Adekoya et al., 2021). The TVP-BVAR allows us to capture any potential change in the transmission of shadow rate shocks to the investor sentiment index and Bitcoin in a flexible and robust manner. The model is expressed as follows:

$$Y_t = c_t + b_{1,t}Y_{t-1} + \ldots + b_{p,t}Y_{t-p} + u_t \quad t = 1, \ldots., T \tag{1}$$

where Y_t denotes a vector containing the shadow rate, Bitcoin and the investor sentiment index, p is the lags' number, c_t is an $(n \times 1)$ vector that contains the constants, $b_{p,t}$ is an $(n \times n)$ matrix representing the matrix of coefficients and u_t is an $(n \times 1)$ denoting by the vector of the innovations. The variance covariance matrix of u_t can be presented as follows:

$$\Omega_t = A_t^{-1}H_t\left(A_t^{-1}\right)' \tag{2}$$

$$H_t = \sum_t \sum_t' \tag{3}$$

$$\sum_t = \begin{bmatrix} \sigma_{1,t} & 0 & \cdots & 0 \\ 0 & \sigma_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \ldots & 0 & \sigma_{n,t} \end{bmatrix} \tag{4}$$

where A_t is a lower triangular matrix:

$$A_t = \begin{bmatrix} 1 & 0 & \cdots & 0 \\ \alpha_{21,t} & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{n1,t} & \ldots & \alpha_{nn-1,t} & 1 \end{bmatrix} \tag{5}$$

The reduced form of the TVP-BVAR-SV is:

$$y_t = X_t'\widetilde{C}_t + A_t^{-1}\sum_t \varepsilon_t \tag{6}$$

where,

$$X'_t = I \otimes \left[1, y_{t-1}', \ldots, y_{t-p}'\right] \tag{7}$$

$$\widetilde{C}_t = vec(\left[c_t, b_{1,t}, \ldots, b_{p,t}\right] \tag{8}$$

and

$$VAR(\varepsilon_t) = I_n \tag{9}$$

The Primiceri (2005) approach assumes that the parameters (e.g., variance, mean…) are varying over time. Thus, the coefficients $\widetilde{C}_t, A_t$ et $\sum_t$ exhibit time-varying characteristics. These assumptions are crucial for capturing potential nonlinearity in the relations between Bitcoin and the monetary policy shocks. The estimation of the parameters is based on the approach of Primiceri (2005) and Del Negro and Primiceri (2015). The coefficients and the non-null and non-unitary elements of A_t evolve as random walks:

$$C_t = C_{t-1} + \omega_t \tag{10}$$

$$k_t = k_{t-1} + \varphi_t \tag{11}$$

where C_t is the vector of the coefficients presented as $C_t = (c_t; b_{1,t}\ldots, b_{p,t})'$ and k_t is the non-null and non-unitary elements of the A_t defined by $k_t = (a_{21,t}, \ldots, a_{n1,t}, \ldots, \alpha_{nn-1,t})'$.The stochastic volatility $h_t = (\sigma_{1,t}, \sigma_{2,t}, \ldots, \sigma_{n,t})'$ evolve as geometric random walks:

$$h_t = \ln(\sigma_t) = \ln(\sigma_{t-1}) + \mu_t \tag{12}$$

$$h_t = h_{t-1} + \mu_t \tag{13}$$

The residual vectors are normally distributed:

$$\begin{bmatrix} \varepsilon_t \\ \omega_t \\ \varphi_t \\ \mu_t \end{bmatrix} \sim N(0, V) \tag{14}$$

$$V = \begin{bmatrix} I_n & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & W \end{bmatrix} \tag{15}$$

Q, S, and W denote the hyper-parameters. We follow Primiceri (2005) and Del Negro and Primiceri (2015) to estimate the parameters and hyper-parameters. Thus, we opt for the Gibbs sampler with different blockings using the Markov Chain Monte Carlo (MCMC) algorithm. Primiceri's approach starts by specifying a prior distribution for the parameters of the model. We set priors of normal distributions whose mean and variance are selected based on the estimates of a constant parameter VAR model. These priors are updated based on the information contained in our data, which are extracted from the pre-sample period using the Ordinary Least Squares (OLS) estimation. In our study, the pre-sample represents the first 42 months that are used to draw the pre-calibration.

When examining the effects of monetary policy shocks using a VAR model, it is essential to assume that monetary policy shocks are independent of all other innovations (Primiceri, 2005). For the context of our study, it is important to start from the hypothesis that QE actions affect Bitcoin and investor sentiment. This identification assumption isolates the shadow rate shocks to allow for an accurate interpretation of their effects. While Cholesky's decomposition of the forecast error covariance matrix is typically recommended for obtaining a lower triangular matrix in VAR models, TVP-VAR already assumes that A_t is a lower triangular matrix, which allows a direct estimation from the Gibbs sampler's output (Primiceri, 2005; Del Negro and Primiceri, 2015; Lubik and Matthes, 2015).

3. Data

As stated above, the aim of this paper is to examine the transmission of the ECB's monetary policy to the cryptocurrency market. To do so, we use monthly data from August 2010 through August 2022. Due to the zero lower bound context, we opted for the shadow rate constructed by Wu and Xia (2016)[1] to measure the ECB's monetary interventions. Bitcoin and the Eurozone Investor Sentiment Index data are collected from Bloomberg. We have opted for the logarithm of Bitcoin prices.

4. Results

4.1. The stochastic volatility

Fig. 4 illustrates the stochastic volatility of the Shadow rates, Bitcoin, and the Eurozone Investor Sentiment Index from July 2012 to August 2022. Bitcoin reached its highest peak of volatility at the end of 2017. This volatility can be explained by the mistrust of investors towards the cryptocurrency market and the very strict control measures adopted by some countries to curb capital flight and better control money laundering and terrorist financing. Those measures have had a negative impact on the cryptocurrency market including Bitcoin. Bitcoin's volatility has gradually decreased, then, has remained at a low level since 2019. Bitcoin's volatility fell to its lowest level in 2019 just before the onset of the COVID-19 pandemic in 2020, the date from which we notice upward volatility. Subsequently, we notice a high volatility during 2020–2021. This instability can be explained by the huge uncertainty, the financial panic, and the economic recession that characterized the COVID-19 period. The volatility curve of the investors' sentiment index confirms the financial disturbance during the COVID-19 period over which it reached its highest level with a large volatility spike in the first half of 2021. In 2022, investor sentiment reached its highest peak of volatility, a surge likely attributed to the Russia-Ukraine war, the significant increase in natural resource prices, and the uncontrollable inflation that characterized this period.

4.2. The impulse responses

Fig. 1 shows the impulse responses of Bitcoin and the Investor Sentiment Index to shadow rate shocks on three different dates,

[1] Shadow rates data for the Euro area can be downloaded from Cynthia Wu's website: https://sites.google.com/view/jingcynthiawu/shadow-rates

namely: (i) in October 2014, before the implementation of the QE. (ii) In March 2016, which is characterized by the application of the QE, and (iii) in February 2021, which is characterized by the maintaining of the QE policy in the context of the COVID-19 pandemic. The shaded areas correspond to 68% confidence intervals. Figs. 2 and 3 present the pairwise differences between impulse responses at three different dates. First, it appears that the shape of the response curves to monetary policy shocks changes from one period to another, which suggests the variation in the link between the ECB's monetary policy, Bitcoin and the investor sentiment. This implies a nonlinear relation between the three variables.

Figs. 1 and 2 indicate that the ECB's monetary interventions restored investor confidence in the financial markets in 2014 and 2016. In fact, the aim of the monetary policy is to support the financial markets, thus encouraging investors to invest more in the stock market. By lowering interest rates, the central bank seeks to mitigate systemic risks, bolster business growth, and support the economic system. This, in turn, would have a positive impact on investors' perception of the economic environment, leading to an optimistic investor sentiment surrounding the financial market.

Furthermore, the dissemination of monetary decisions can shape how investors perceive the financial market. For instance, when the central bank announces significant measures like QE, it signals a commitment to stimulating economic activity and bolstering financial markets. The ECB's communication about its commitment to ensuring financial stability can lead investors to perceive the investment environment market as less risky. Positive signals emphasizing stability and reduced uncertainty encourage investors to invest more in the traditional financial market.

This can explain the decreasing shape of the bitcoin impulse responses diagrams, which indicates that QE shock leads to a drop in bitcoin prices. Bitcoin does not attract investors during periods of stability. In fact, the Bitcoin dynamics have often been explained by the speculators' behavior. One of the primary objectives of QE is to mitigate uncertainty and ensure stability in traditional financial markets. Thus, speculative investors would perceive less risk in conventional financial markets. This perception would lead them to allocate their funds to other assets instead of Bitcoin, potentially yielding higher returns.

In 2021, a QE shock brings down the confidence index more sharply compared to responses in 2016 and 2014, despite the drop in the investor confidence index. Our results can be explained by three main reasons, namely: (i) the sudden appearance of COVID-19 which has overturned investors' expectations, (ii) the global economic recession resulting from the containment measures, and (iii) the great uncertainty surrounding the global financial market. All those factors make the ECB's unconventional monetary shock

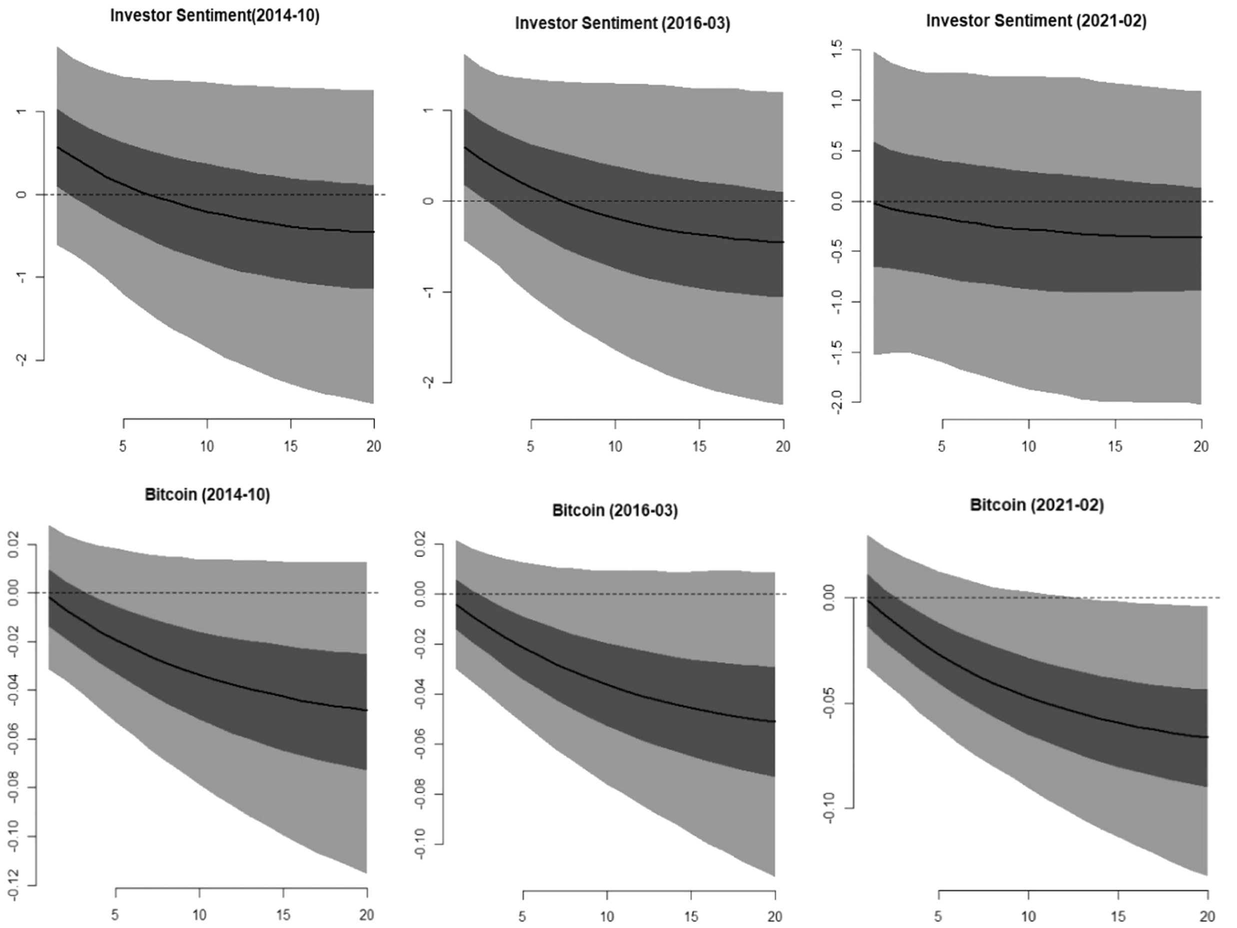

Fig. 1. Impulse responses of Bitcoin and the Eurozone Investor Sentiment Index to shadow rate shocks in 2014–10, 2016–03 and 2021–02.

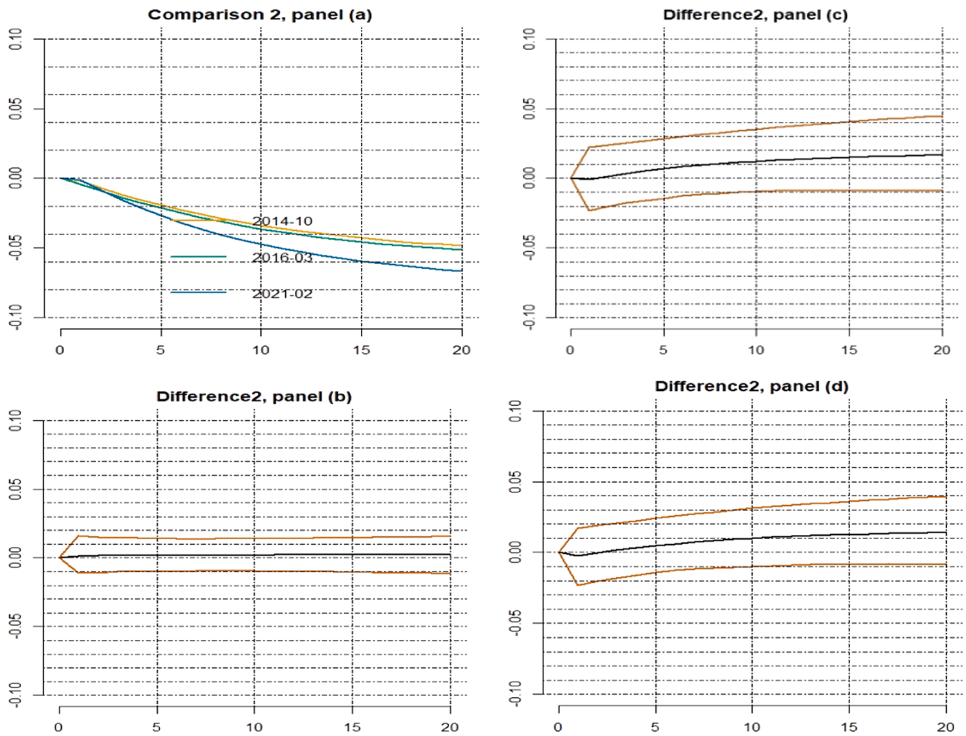

Fig. 2. Comparison: Bitcoin (a) Bitcoin's impulse responses to Shadow rate shocks in 2014–10, 2016–03 and 2021–02 (b) difference between Bitcoin's responses in 2014 and 2016 with the 16th and 84th percentiles, (c) difference between responses in 2014 and 2021 with 16th and 84th percentiles, (d) difference between responses in 2016 and 2021 with 16th and 84th percentiles.

incapable of restoring the confidence of market participants.

In times of economic uncertainty and reduced investor confidence, financial markets often experience a flight to safety, where investors gravitate toward secure and stable assets such as gold and government bonds. QE shocks reflect very low interest rates, including sovereign bonds, which are perceived as the most secure financial asset. Despite the extreme uncertainty characterizing the COVID-19 period and low government bond yields, Bitcoin's response reveals a steeper drop than the pre-COVID-19 period. This indicates that investors are not seeking out Bitcoin for safety and higher returns during this period. Three key factors contribute to the observed results. First, the unprecedented nature of the crisis caused by the COVID-19 pandemic. Second, investor reluctance led to a decline in financial trading, as market players were pessimistic about financial performance and the future evolution of the stock market. Third, the changing behavior of bitcoin, as shown by Chen et al. (2020), Wątorek et al. (2020), and Raheem (2021). They state that Bitcoin's behavior has changed during the COVID-19 period. Bitcoin is now primarily used as a speculative asset rather than a safe haven asset. This means that investors in the financial markets no longer perceive Bitcoin as a secure investment. Hence, Bitcoin is emerging as a component of the global financial system, making it sensitive to financial crises such as the COVID-19 crisis.

5. Robustness check

To assess the robustness of our findings, we employ the Bayesian VAR (BVAR) model. This section aims to evaluate whether the empirical results are sensitive to variations in prior calibration. To do so, we perform a shadow rate shock on Bitcoin and investor confidence index following the approach of Giannone et al. (2015). Their BVAR model integrates a hierarchical modeling strategy for prior selection (Kuschnig and Vashold, 2021). It incorporates the Minnesota priors, the sum of coefficient priors, and the priors related to the 'dummy-initial-observation' approach, as introduced by Litterman (1986) and Sims (1993).

The expression of the BVAR model is as follows:

$$Y_t = a_0 + a_1 Y_{t-1} + \ldots + a_p Y_{t-p} + u_t \quad t = 1, \ldots., T \tag{16}$$

where Y_t represents a vector of endogenous variables, a_0 is an intercept vector p signifies the number of lags, a_p stands as an m × m matrix of coefficients, and u_t denotes a vector of structural innovations (following a normal distribution). As the BVAR model operates under the assumption of a fixed variance-covariance matrix, we utilize the Augmented Dickey-Fuller test to assess the stationarity of each variable. The outcomes in Table 1 reveal that the time series Bitcoin and Investor Sentiment Index exhibit stationarity. However, we employ a first difference transformation on the shadow rates. The impulse responses of Bitcoin and investor sentiment index to a shadow rate shock, reported in Fig. 5, corroborate the declining trend of Bitcoin and investor sentiment index in response to the central

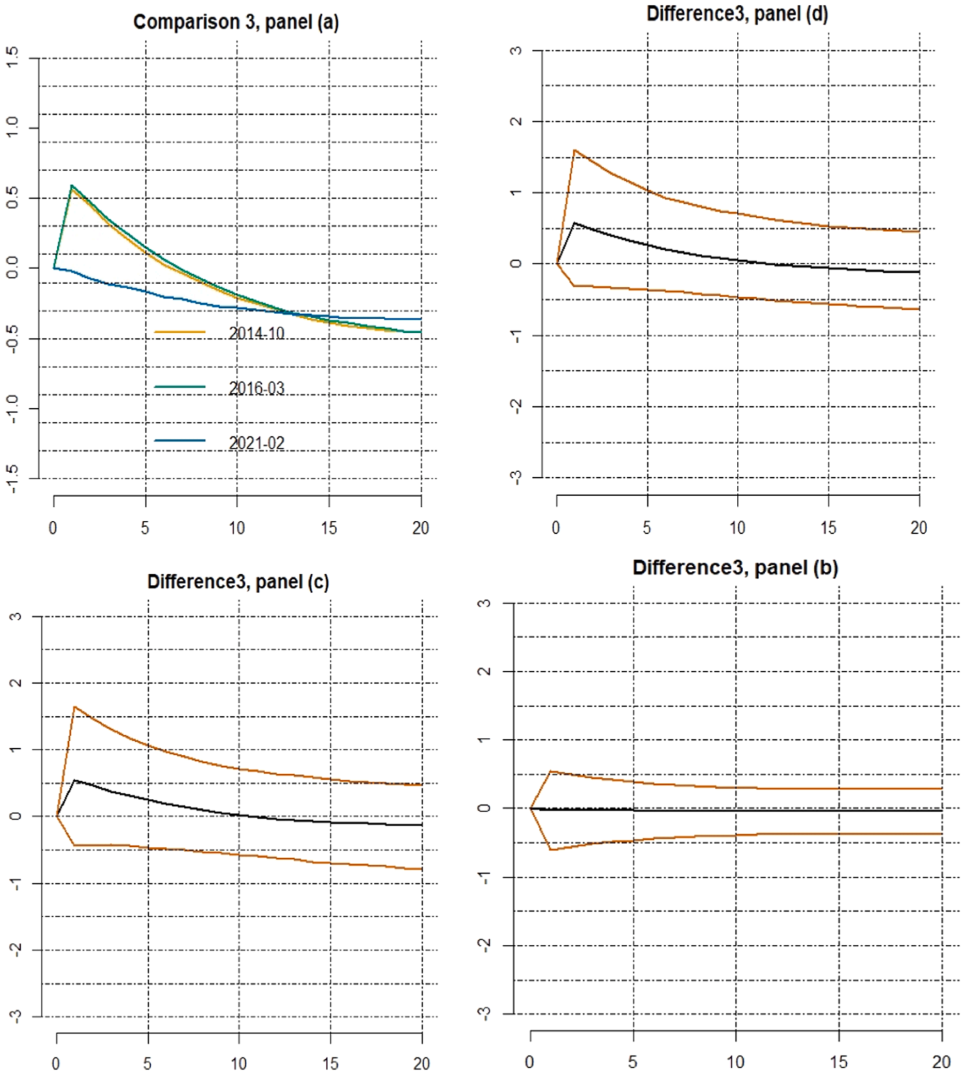

Fig. 3. Comparison: Investor Sentiment Index (a) impulse responses of the Investor Sentiment Index to Shadow rate shocks in 2014–10, 2016–03 and 2021–02 (b) difference between investor sentiment responses investors in 2014 and 2016 with 16th and 84th percentiles, (c) difference between responses in 2014 and 2021 with 16th and 84th percentiles, (d) difference between responses in 2016 and 2021 with 16th and 84th percentiles.

bank intervention. The BVAR model outputs support that QE failed to restore investor confidence during the post-COVID-19 period. They also confirm that a low-interest rate environment is not prompting investors to turn to the Bitcoin market in search for safety and higher yields.

6. Conclusion

We employed a BVAR model with time varying parameters and stochastic volatility (TVP-BVAR-SV) to examine the transmission of unconventional monetary policies to the cryptocurrency markets. We compared the responses of the pre-and post-COVID-19 pandemic to detect a possible change in the relation between the ECB's Quantitative Easing, the investor sentiment index, and Bitcoin. Our results show that a shadow rate shock led to a reduction in Bitcoin's prices and an increase in the confidence index in the European stock market during the pre-COVID-19 period. These results indicate that the ECB's monetary policy succeeded in supporting the financial market and restoring investor confidence during non-crisis periods. Thus, investor confidence, in a certain and stable environment, has reduced the capital flight to the Bitcoin market. On the other hand, it is important to regulators and policy-makers to know that the QE has failed to restore investor confidence during the COVID-19 pandemic. Our findings also reveal that Bitcoin has been affected by the uncertainty that characterizes the post-COVID-19 period and no longer preserves its safe-haven property.

Our results should be of great interest to regulators, policy-makers, and portfolio managers. In fact, there are hints of a looming geopolitical crisis on the European continent with the outbreak of the Russian-Ukrainian conflict in February 2022 (Yousaf et al.,

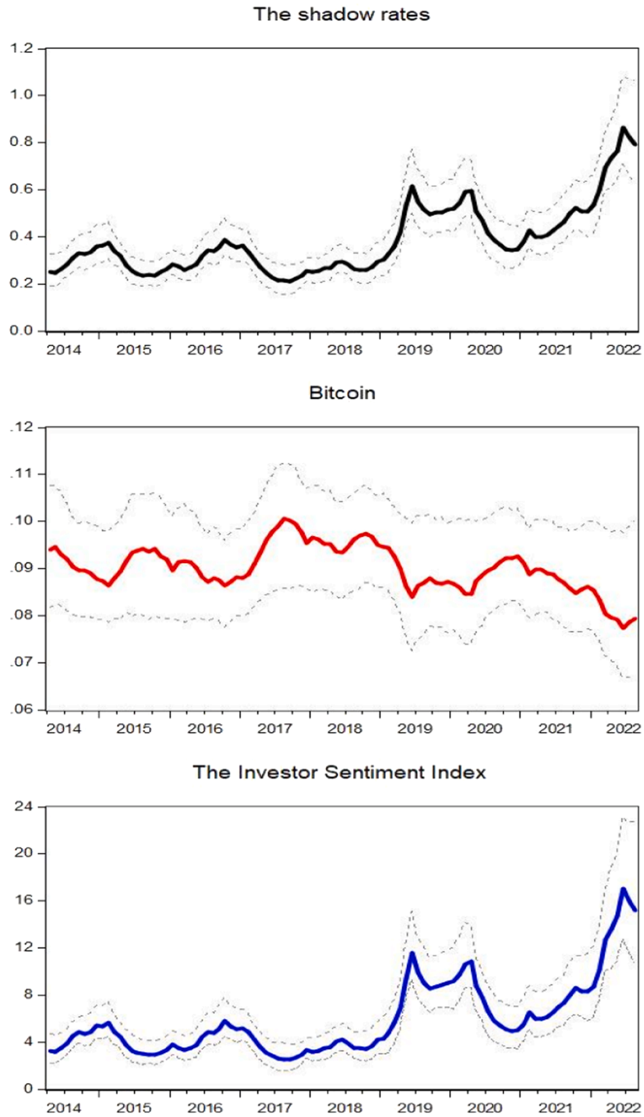

Fig. 4. The Standard deviations of residuals.

Table 1
Augmented Dickey-Fuller test.

		t-Statistic	Prob.*
Bitcoin		-3.246678	0.0193
Investor Sentiment Index		-2.887028	0.0494
Shadow Rates		-1.177438	0.6833
Shadow Rates (first difference)		-12.00817	0.0000
Test critical values:	1% level	-3.476143	
	5% level	-2.881541	
	10% level	-2.577514	

* MacKinnon (1996) one-sided p-values.

2022). According to Reuters, Bitcoin plunged to its lowest level in a month minutes after the beginning of the conflict. The Eurozone is about to face a new economic crisis. Thus, portfolio managers and policymakers should learn from the lessons of the COVID-19 crisis that has altered the relations between the financial system components. They should consider the possible non-effectiveness of QE to restore the confidence of economic actors during a possible future crisis. Moreover, investors should take into account the transmission of unconventional monetary policies to both the investor's expectations and the bitcoin prices in order to reallocate their portfolios to

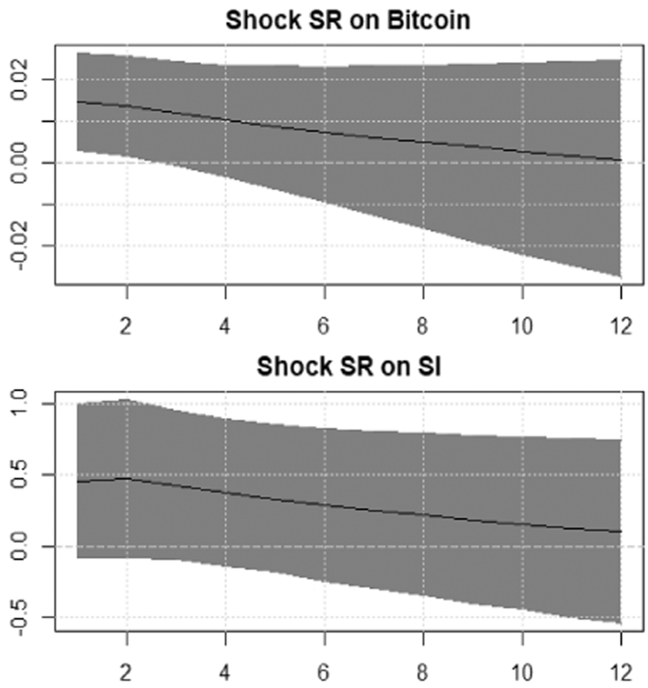

Fig. 5. Impulse responses of the Investor Sentiment, Bitcoin prices to a Shadow rate shock. Shaded areas refer to the 90% credible sets.

achieve risk diversification objectives during a potential future crisis.

CRediT authorship contribution statement

Aloui Donia: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft. **Yarovaya Larisa:** Conceptualization, Formal analysis, Supervision, Writing – review & editing. **Guesmi Khaled:** Conceptualization, Formal analysis, Supervision, Validation, Writing – review & editing. **Rachdi Houssem:** Data curation, Investigation, Methodology, Visualization, Writing – review & editing. **Zouaoui Riadh:** Methodology, Writing – original draft, Writing – review & editing.

Data Availability

Data will be made available on request.

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