

Assessing Long-term Interdependence and Volatility Persistence in Cryptocurrencies: A DCC-GARCH Approach

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ABSTRACT

Cryptocurrency has significantly altered the way people invest today. Bit- coin has generated substantial returns over time, attracting numerous investors to the cryptocurrency market and driving a significant increase in cryptocurrency investment. Numerous cryptocurrencies have also been introduced to the market. Some of these have generated significant returns for investors, while others have incurred substantial losses. This article aims to evaluate the viability of cryptocurrencies as a long-term investment by analyzing historical data, examining the expansion of cryptocurrencies, and considering their future potential. This research paper aims to determine whether Cryptocurrency is a suitable long-term investment.

Keywords: Cryptocurrencies, Bitcoin, History, Long-Term Gains, Future Prospects



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1. INTRODUCTION

Over the last decade, the cryptocurrency market has experienced significant growth, marked by both substantial increases and substantial declines in value. Bitcoin, first proposed by Satoshi Nakamoto in 2008, has changed from a theoretical idea to a real asset class. In November 2021, it had a market cap of more than \$2.9 trillion, but by February 2023, it had dropped to about \$1.1 trillion (CoinMarketCap, 2023, as cited in Gordon, Li, & Marthinsen, 2023). This evolution has not only captivated investors globally but also propelled a parallel surge in academic inquiry, especially since 2018—the year when nearly three-quarters of all scholarly articles on Cryptocurrency were published, as revealed by topic modeling of peer-reviewed journals (Gordon et al., 2023). Cryptocurrencies are digital or virtual currencies that use cryptography for security and operate on decentralized networks, based on blockchain technology. Cryptocurrency emerged in the early 2000s, but it was not until the introduction of Bitcoin in 2009 by Satoshi Nakamoto that it started gaining widespread attention.

Both Cryptocurrencies and blockchain technology were new and gradually started gaining global attention as the cryptocurrencies continued to grow day by day. Bitcoin, often referred to as digital gold, was created as a peer-to-peer electronic cash system, aiming to bypass traditional financial institutions. Its decentralized nature means it operates

without a central authority, such as a government or a bank, making transactions more transparent and resistant to censorship. The decentralized nature of Bitcoin has led to its use in illegal activities, resulting in widespread negative opinions about the cryptocurrency. To this day, it poses a barrier to the legal adoption of cryptocurrencies. It has been estimated that thousands of alternative Cryptocurrencies have been created since the inception of Bitcoin.

These alternative cryptocurrencies, commonly referred to as altcoins, have their own unique features and purposes. With the launch of Ethereum in 2015 by Vitalik Buterin, developers can now create decentralized applications (dApps) and decentralized autonomous organizations (DAOs) on the Ethereum platform. Both positive and negative aspects characterize the cryptocurrency market. While cryptocurrencies have been beneficial for some and detrimental for others, their long-term investment outlook remains unclear.

1.1. Legality. Despite the popularity of cryptocurrencies, they continue to struggle to establish their legitimacy due to their illicit use. However, some countries have taken steps to accept cryptocurrencies and establish new frameworks, including the United States, the United Kingdom, Japan, Australia, and the European Union. Furthermore, countries such as Canada, Singapore, South Korea, India, and Brazil are

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not in favor of legalizing Cryptocurrencies, but they have not yet restricted their use. In contrast, China has effectively banned cryptocurrency enterprises from operating in the country. The regulation of Cryptocurrencies remains unclear, leading to uncertainty surrounding them. However, many countries have come forward to accept and legalize cryptocurrencies, which may contribute to their widespread adoption on a global scale in the future.

1.2. Cryptocurrency Growth. The growth of cryptocurrencies over the years has been nothing short of remarkable. With the introduction of Bitcoin, the reputation of Cryptocurrencies has skyrocketed in terms of market capitalization and adoption by the general public, thereby reshaping the financial landscape. Initially, cryptocurrencies were seen as niche assets, primarily used by technology enthusiasts and early adopters. Nevertheless, as awareness spread and technological advances improved usability and security, more people began to consider cryptocurrencies as viable alternatives to traditional forms of money. Gradually, people began investing and trading in the cryptocurrency market, although many remained skeptical about investing in cryptocurrencies due to the numerous negative factors surrounding them. As blockchain technology continued to evolve beyond currency applications, it accelerated the growth of cryptocurrencies. Projects that utilize blockchain technology for various purposes, such as supply chain management, identity verification, and decentralized finance, have demonstrated the potential of blockchain technology.

2. RESEARCH METHODOLOGY

This study uses a quantitative approach to analyze the long-term relationship between major cryptocurrencies and their dynamic correlations over time. Secondary data were obtained from Kaggle (2020–2025) for the top 100 cryptocurrencies, focusing on price series (Open, Close, High, Low) and market capitalization.

2.1. Return Calculation. The continuously compounded return for each cryptocurrency i at time t is computed as:

$$r_{i,t} = \ln \left(\frac{P_{i,t}^{\text{close}}}{P_{i,t}^{\text{open}}} \right)$$

Where P^{close} and P^{open} denote the closing and opening prices respectively.

2.2. Univariate GARCH(1,1) Model. To capture time-varying volatility, each return series is first modeled using a univariate GARCH(1,1) process as

proposed by Bollerslev (1986):

$$r_{i,t} = \mu_i + \epsilon_{i,t}, \quad \epsilon_{i,t} = \sigma_{i,t} z_{i,t}$$

$$\sigma_{i,t}^2 = \omega_i + \alpha_i \epsilon_{i,t-1}^2 + \beta_i \sigma_{i,t-1}^2$$

where σ^2 is the conditional variance, $\epsilon_{i,t}$ is the residual term, and $z_{i,t}$ is an i.i.d. standard normal variable. The parameters α_i and β_i capture the short-term and long-term persistence in volatility respectively.

2.3. Dynamic Conditional Correlation (DCC–GARCH) Model. After obtaining standardized residuals $\hat{z}_{i,t} = \epsilon_{i,t}/\hat{\sigma}_{i,t}$, the dynamic correlations between assets are modeled using the DCC specification of Engle (2002). The correlation dynamics are given by:

$$Q_t = (1 - a - b) \bar{Q} + a(z_{t-1} z'_{t-1}) + b Q_{t-1}$$

$$R_t = \text{diag}(Q_t)^{-1/2} Q_t \text{diag}(Q_t)^{-1/2}$$

where Q_t is the time-varying covariance matrix of standardized residuals, $\bar{Q}$ is the un-conditional covariance matrix, and R_t is the dynamic conditional correlation matrix. The parameters a and b control how quickly correlations respond to market shocks and how persistent they remain over time.

2.4. Interpretation. The DCC–GARCH output enables the study of evolving co-movements among cryptocurrencies. A rising correlation indicates convergence in market behavior, while declining correlation suggests diversification opportunities. By analyzing these dynamics over time, the study identifies whether cryptocurrency markets exhibit long-term integration or maintain independence in their volatility structures.

3. RESULTS AND DISCUSSION

This section presents the empirical findings from the Dynamic Conditional Correlation (DCC–GARCH) analysis conducted on three major cryptocurrencies: Bitcoin, Ethereum, and Solana. The study explores their return characteristics, volatility persistence, and evolving correlations from 2020 to 2025 to assess the degree of interdependence and potential diversification benefits.

3.1. Descriptive Statistics. Table 1 summarizes the descriptive statistics of daily log returns for the selected cryptocurrencies. Solana exhibits the highest mean return and standard deviation, indicating both higher potential gains and greater risk. Bitcoin displays the lowest volatility, reflecting its relative market stability compared to newer assets. All series are leptokurtic and non-normal, validating the use of GARCH-type models to capture volatility clustering.

TABLE 1. Descriptive Statistics of Daily Returns (2020–2025)

Cryptocurrency	Mean	Std. Dev.	Skewness	Kurtosis
Bitcoin	0.0013	0.0313	-0.1154	6.561
Ethereum	-0.0002	0.0430	-1.1646	10.0534
Solana	0.0022	0.0636	-0.225	10.5803

3.2. Univariate GARCH(1,1) Model Results. The GARCH(1,1) estimates, reported in Table 2, reveal strong volatility persistence across all assets. The persistence parameter ($\alpha_1 + \beta_1$) exceeds 0.97 for each cryptocurrency, indicating that large market

movements continue to influence volatility over extended periods. This behavior is consistent with the stylized facts of financial returns, where volatility shocks tend to decay slowly over time.

TABLE 2. Estimated GARCH(1,1) Parameters and Volatility Persistence

Cryptocurrency	μ	α_1	β_1	$\alpha_1 + \beta_1$
Bitcoin	0.0015	0.0690	0.9061	0.9751
Ethereum	-0.0003	0.0865	0.8877	0.9742
Solana	0.0015	0.1249	0.8473	0.9723

The statistically significant α_1 coefficients imply that new information is rapidly incorporated into market volatility, while the large β_1 values show high persistence of shocks. These findings highlight the speculative and information-sensitive nature of cryptocurrency markets.

The DCC–GARCH model captures time-varying correlations between the assets, as summarized in Table 3. The average correlations indicate a high level of interconnectedness among the three cryptocurrencies. Bitcoin and Ethereum display the strongest correlation, reflecting shared investor sentiment and synchronized trading patterns. Solana’s correlations are slightly lower, suggesting that it retains marginal diversification potential due to its distinct ecosystem.

3.3. Dynamic Conditional Correlation Analysis.

TABLE 3. Average Dynamic Conditional Correlations among Cryptocurrencies

Pair	Average Correlation
Bitcoin–Ethereum	0.77015
Bitcoin–Solana	1.77015
Ethereum–Solana	2.77015

3.4. Graphical Interpretation. The evolution of correlations over time is depicted in Figure 1. The DCC plot shows that correlations remained relatively high throughout the study period, with temporary

declines during market turbulence, such as mid-2021 and late 2022. These short-lived drops suggest partial decoupling during phases of heightened uncertainty or asset-specific events.

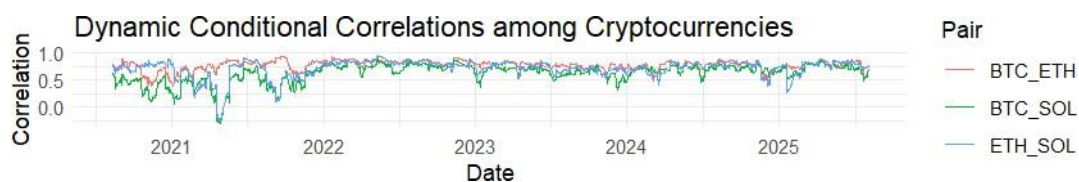


FIGURE 1. Dynamic Conditional Correlations among Cryptocurrencies (DCC Plot)

Periods of elevated correlation indicate synchronized market responses, reducing diversification benefits for investors. Conversely, lower correlation phases reflect transient opportunities for portfolio risk management. Overall, the results confirm that the cryptocurrency market exhibits both persistent interdependence and temporary volatility spillovers.

3.5. Discussion. The high persistence and strong dynamic correlations underscore that cryptocurrencies have evolved into a more integrated market segment. Bitcoin and Ethereum, in particular, behave as co-moving assets driven by similar economic and speculative forces. Solana, though newer, is gradually aligning with broader market trends. These findings suggest diminishing diversification advantages within cryptocurrency portfolios.

The results align with recent empirical evidence on digital asset convergence, where institutional adoption, cross-market arbitrage, and shared liquidity channels contribute to sustained co-movement. This dynamic structure implies that market shocks or regulatory developments can propagate rapidly across the ecosystem, amplifying volatility transmission and systemic risk.

CONCLUSION AND FUTURE RESEARCH SCOPE

The findings of this study provide clear evidence that the cryptocurrency market has become more integrated and less suitable for intra-market diversification. Bitcoin and Ethereum exhibit a high degree of co-movement, while Solana, although slightly less correlated, follows a similar volatility pattern. The GARCH(1,1) results demonstrate significant persistence in conditional variances, suggesting that volatility shocks have lasting effects and that market uncertainty remains elevated even in the long run. The DCC-GARCH analysis confirms that correlations between the major cryptocurrencies remain strong for most of the observed period, with only brief phases of weakening during episodes of market stress.

These results indicate that the cryptocurrency market is evolving toward greater maturity, shaped by broader participation from institutional investors, increasing transparency, and more standardized trading behavior. However, persistent volatility and clustered price movements point to ongoing speculative dynamics and sensitivity to policy or macroeconomic shocks. For investors, this implies that the potential for risk reduction through diversification among large-cap cryptocurrencies is limited, though cross-asset diversification with traditional instruments such as equities or commodities may still offer protection. Future research could extend this work in several directions. First, incorporating additional digital assets such as stable coins, decentralized finance tokens, or asset-backed cryptocurrencies could help compare the behavior of speculative and stable digital instruments. Second, examining the role of macroeconomic indicators, global liquidity, and monetary policy could clarify how external conditions influence volatility

spillovers across digital assets. Finally, applying advanced models such as regime-switching or copula-based DCC frameworks may uncover nonlinear relationships and asymmetries that standard approaches cannot capture.

Overall, the study contributes to understanding how the interconnected behavior of major Cryptocurrencies affects investment strategy and market stability. As the digital asset ecosystem continues to develop, insights into volatility transmission and dynamic correlation patterns will remain essential for both researchers and market participants seeking to manage risk and forecast long-term performance.

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