

Time-Varying Dependence and Contagion Between Bitcoin and Major Equity Indices: Evidence from DCC-GARCH Models

التبعية المتغيرة بمرور الوقت والعدوى بين البيتكوين ومؤشرات الأسهم الرئيسية:

أدلة من نماذج DCC-GARCH

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Received: 19/01/2026

Accepted: 10/06/2026

Published: 12/06/2026

Abstract:

This study examines the time-varying dependence and contagion dynamics between Bitcoin and major equity indices (S&P 500, FTSE 100, DAX 40, and Nikkei 225) over the period 2014–2025. Using daily return data, a Dynamic Conditional Correlation GARCH (DCC-GARCH) framework is employed to jointly model conditional volatility and evolving correlations across different market regimes. The results show that Bitcoin exhibits exceptionally high volatility and strong persistence, consistent with an IGARCH-type process. Dynamic correlations between Bitcoin and equity markets are highly unstable, remaining low or occasionally negative during tranquil periods, but increasing markedly during episodes of financial stress, particularly during the COVID-19 crisis and the 2022 monetary tightening cycle. However, heteroskedasticity-adjusted contagion tests following Forbes and Rigobon (2002) indicate that the rise in correlations during crises reflects increased market interdependence rather than pure contagion. Overall, the findings suggest that Bitcoin may offer diversification benefits in normal times, but fails to serve as a hedge or safe haven during periods of systemic turmoil, with important implications for portfolio management and financial stability.

Keywords: Bitcoin; DCC-GARCH; Dynamic Correlation; Financial Contagion; Equity Markets

JEL Classification: C58, G11, G15, G17, C32

المخلص:

تهدف هذه الدراسة إلى تحليل الاعتماد الديناميكي وآليات العدوى المالية بين عملة البيتكوين وعدد من المؤشرات البورصية العالمية الرئيسية، وهي S&P 500 و FTSE 100 و DAX 40 و Nikkei 225، خلال الفترة 2014–2025. باستخدام نموذج الارتباط الشرطي الديناميكي مع نماذج GARCH (DCC-GARCH) لنمذجة التقلبات الشرطية والارتباطات المتغيرة زمنياً بين الأسواق. تشير النتائج إلى أن البيتكوين يتميز بتقلب مرتفع جداً مع استمرارية قوية للتقلب، بما يتوافق مع عملية من نوع IGARCH. كما تُظهر النتائج أن الارتباط بين البيتكوين وأسواق الأسهم غير ثابت، إذ يكون ضعيفاً في فترات الاستقرار، بينما يرتفع بشكل ملحوظ خلال فترات الأزمات المالية، خاصة خلال أزمة كوفيد-19 والتشديد النقدي في عام 2022. غير أن اختبارات العدوى المعدلة لأثر التغيرات غير المتجانسة تشير إلى أن هذا الارتفاع يعكس زيادة في الترابط بين الأسواق وليس عدوى مالية صرفة. وتخلص الدراسة إلى أن البيتكوين يوفر مزايا تنوع في الظروف العادية، لكنه لا يمثل أداة تحوط أو ملاذاً آمناً خلال فترات الاضطراب الشديد.

الكلمات المفتاحية: البيتكوين؛ نموذج DCC-GARCH؛ الارتباط الديناميكي؛ العدوى المالية؛ أسواق الأسهم

تصنيفات JEL: C32, G17, G15, G11, C58

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INTRODUCTION

Since its launch in 2009, Bitcoin has driven a shift in crypto-assets from peripheral technological curiosities to investable instruments embedded in global portfolios. Once regarded as largely detached from conventional asset classes, Bitcoin is now actively traded by institutional and retail investors alike, which has intensified its connections with major equity markets. This deepening integration compels a reassessment of Bitcoin's position within the international financial architecture, notably its contribution to diversification and its ramifications for financial stability and systemic risk (Panyagometh, 2024; Wu et al., 2025).

Over the same period, financial markets have been repeatedly struck by large shocks, including the COVID-19 pandemic, rising geopolitical conflict, and bouts of monetary policy strain. These episodes have heightened equity market volatility and renewed interest in alternative assets that could buffer systemic disturbances. In this environment, an expanding literature documents stronger co-movements between Bitcoin and stock indices, especially during crisis regimes, thereby challenging the assumption that crypto-assets are structurally independent from traditional markets (Ali and Khurram, 2025; Dimitriadis et al., 2025).

Assessing these interdependencies requires econometric methods that capture conditional heteroskedasticity and the time variation of cross-market dependence. GARCH-type models, particularly the Dynamic Conditional Correlation specification, offer a coherent framework for tracing correlation dynamics and the transmission of shocks across assets (Engle, 2002). Applying DCC-GARCH to crypto-asset data enables a rigorous evaluation of how the link between Bitcoin and equity markets evolves over time and whether it remains stable across different market conditions..

The scholarly record reports conflicting evidence on the linkage between Bitcoin and equity markets. One body of work finds low comovement during tranquil regimes, consistent with diversification benefits, whereas another documents pronounced correlation spikes under financial turmoil, indicative of contagion dynamics (Moni & Sankararaman, 2025; Yi, 2025). A plausible source of these inconsistencies is the widespread reliance on static correlation frameworks, which impose time-invariant dependence and disregard regime transitions.

Uncertainty likewise surrounds Bitcoin's status as a hedge or safe-haven instrument. While some analyses identify context-specific, partial protection, other studies depict Bitcoin as a risk-sensitive asset that becomes strongly synchronized with equities during systemic crises (Dimitriadis et al., 2025; Lamine, 2025). Taken together, these results argue for a dynamic, state-contingent perspective that differentiates Bitcoin's behavior across market phases.

1.3 Research gap

Despite substantial recent contributions, significant gaps remain. Only a limited number of studies jointly model conditional volatility, time-varying dependence, and contagion between Bitcoin and a representative panel of major equity indices over extended horizons that include multiple crisis regimes. Empirical evidence on Bitcoin's diversification and safe-haven properties is still markedly heterogeneous, largely owing to methodological divergence and truncated sample periods. Moreover, the transmission channels of shocks between crypto-asset

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and equity markets are not yet rigorously characterized within a unified DCC-GARCH framework..

Research objectives and questions

This study aims to characterize the time-varying interdependence and contagion channels between Bitcoin and leading global equity indices using a DCC-GARCH framework. Specifically, it traces the evolution of conditional correlations over time, isolates intervals of intensified cross-market transmission, and evaluates whether Bitcoin serves as an effective diversifier or hedge in the presence of equity market shocks.

Contributions of the study

This work advances the literature along three dimensions:

- 1) Methodological: it deploys a coherent DCC-GARCH specification that jointly models volatility dynamics and time-varying dependence, ensuring internal consistency in estimation and inference.
- 2) Empirical: it offers up-to-date evidence spanning multiple major crisis episodes, allowing for a comparative assessment across distinct stress regimes.
- 3) Conceptual: it clarifies Bitcoin's economic function by rigorously assessing its diversification and hedging properties in a volatile and uncertain financial environment..

1. LITERATURE REVIEW

1.1 Bitcoin and traditional financial markets

2.1 Integration of crypto-assets with conventional markets Early empirical work generally portrayed Bitcoin as largely segmented from traditional financial systems. More recent studies, however, document a gradual strengthening of comovements, especially with major US and European equity indices (Wu et al., 2025; Yi, 2025). This pattern is consistent with increasing financialization of Bitcoin and the rising footprint of institutional investors.

1.2 Financial volatility and GARCH models for crypto-assets

Bitcoin exhibits markedly higher volatility than standard asset classes, together with pronounced persistence over time. To capture these features, researchers frequently employ GARCH specifications and asymmetric variants that accommodate leverage-type effects (Ali & Khurram, 2025; Panyagometh, 2024). A recurrent result is that adverse shocks tend to amplify conditional volatility more than positive shocks of comparable magnitude.

1.3 Dynamic dependence and DCC-GARCH frameworks

DCC-GARCH models are designed to track the time-varying structure of conditional correlations. A growing body of evidence reveals substantive dynamic dependence between Bitcoin and equity markets, with correlations intensifying in turbulent phases (Moni & Sankararaman, 2025; Pereira, 2025). These findings underscore the superiority of dynamic correlation models over static measures for characterizing cross-market linkages.

1.4 Financial contagion and crisis episodes

Contagion is typically reflected in a statistically significant surge in cross-asset correlations during stress periods. Recent analyses indicate that shocks associated with the COVID-19 pandemic and geopolitical turmoil have strengthened volatility transmission between Bitcoin and stock markets (Gençyürek, 2025; Dimitriadis et al., 2025). This propagation mechanism heightens the vulnerability of diversified portfolios that incorporate crypto-assets.

2.5 Bitcoin as a diversifier, hedge, or safe haven

Evidence on Bitcoin's portfolio role remains mixed. Some contributions report short-horizon diversification gains, whereas others find that such benefits dissipate in severe crises (Lamine, 2025; Kamal & Bouri, 2025). Taken together, the results point to a state-dependent profile in which the asset's function varies with market conditions.

1.6 Critical synthesis

Overall, the literature does not support classifying Bitcoin as a consistently reliable safe haven across market regimes. The heterogeneity of empirical outcomes and the paucity of unified frameworks motivate a comprehensive reassessment based on DCC-GARCH models over a long sample.

2. Methodology

This section sets out the econometric framework used to investigate time-varying interdependence and contagion between Bitcoin and major equity benchmarks. It outlines the data, preliminary diagnostic procedures, and the univariate GARCH and multivariate DCC-GARCH specifications implemented.

2.1 Data and description of variables

The empirical analysis relies on daily closing prices for five assets: Bitcoin (BTC) and four flagship stock indices spanning the US, European, and Asian markets. The equity indices are the Standard & Poor's 500 (S&P 500) for the United States, the FTSE 100 for the United Kingdom, the DAX 40 for Germany, and the Nikkei 225 for Japan. These assets are selected for their systemic relevance and their capacity to capture broad global market dynamics, which enables an assessment of whether Bitcoin is integrated with, or remains segmented from, traditional financial markets.

The sample period extends from September 18, 2014, to May 30, 2025, yielding a horizon of more than ten years that traverses multiple market regimes, including high-volatility episodes, bull and bear phases, and major systemic events such as the COVID-19 pandemic, the Russian-Ukrainian conflict, and the 2023 banking crisis. The dataset comprises 2,438 daily observations. All data are sourced from Yahoo Finance.

For the empirical analysis, raw price series are converted into logarithmic returns (log-returns), computed as follows:

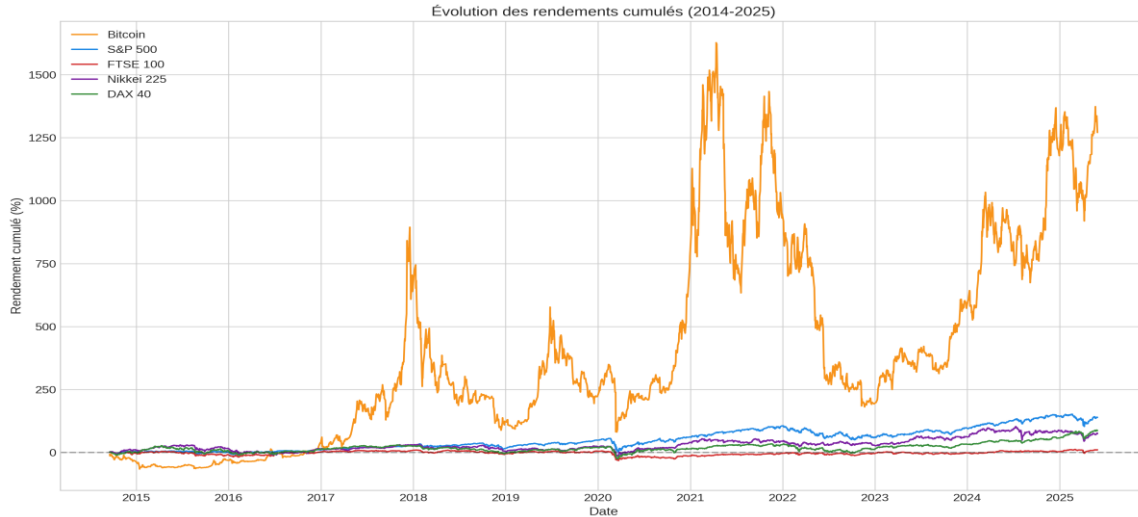
$$r_t = \ln(P_t / P_{t-1})$$

Let r_t denote the logarithmic return at time t , and P_t the corresponding closing price. In financial econometrics, log-returns are routinely employed because their statistical properties are more

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tractable; in particular, they tend to be stationary and their empirical distributions are typically closer to Gaussian than those of raw price levels.

Figure 1: Cumulative returns (2014-2025)



Note: The figure illustrates the cumulative performance of the five assets over the study period. Bitcoin shows exceptional growth despite significant volatility.

2.2 Preliminary statistical analysis

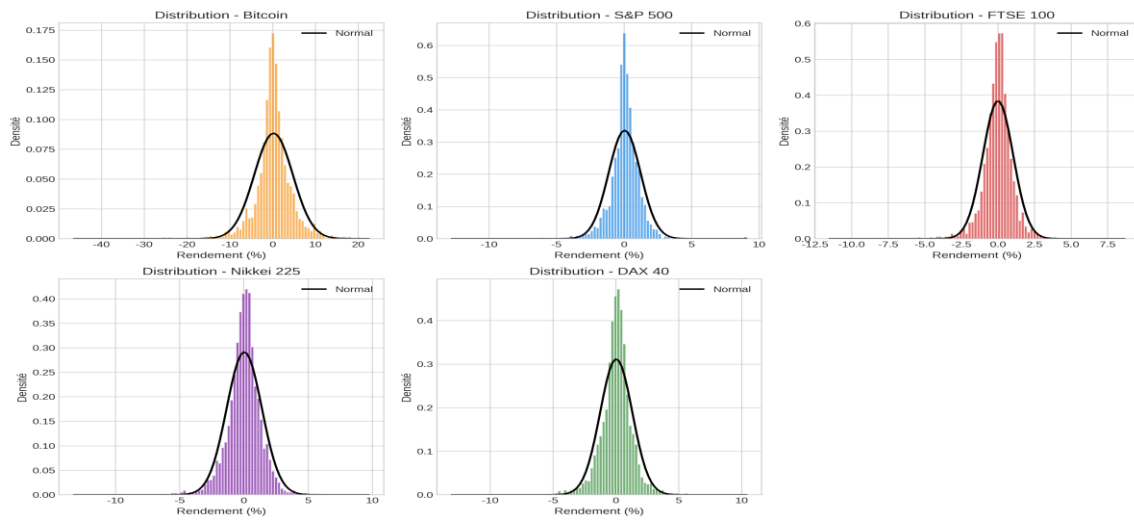
A preliminary analysis was conducted to examine the statistical properties of the return series. Table 1 presents the descriptive statistics for each asset.

Table 1: Descriptive statistics for daily returns (%)

Statistic	Bitcoin	S&P 500	FTSE 100	Nikkei 225	DAX 40
Average	0.2124	0.0429	0.0094	0.0322	0.0339
Median	0.1935	0.0699	0.0550	0.0767	0.0911
Maximum	22.5119	9.0895	8.6664	9.7366	10.4143
Minimum	-46.4730	-12.7652	-11.5117	-13.2341	-13.0549
Standard deviation	4.5116	1.1866	1.0375	1.3689	1.2804
Asymmetry	-0.6400	-0.7779	-0.8760	-0.3189	-0.5959
Kurtosis (excess)	8.9967	15.4141	11.9939	8.6405	9.2900
Jarque-Bera	8388.72	24381.40	14,924.92	7625.29	8911.27
p-value (JB)	0.0000	0.0000	0.0000	0.0000	0.0000

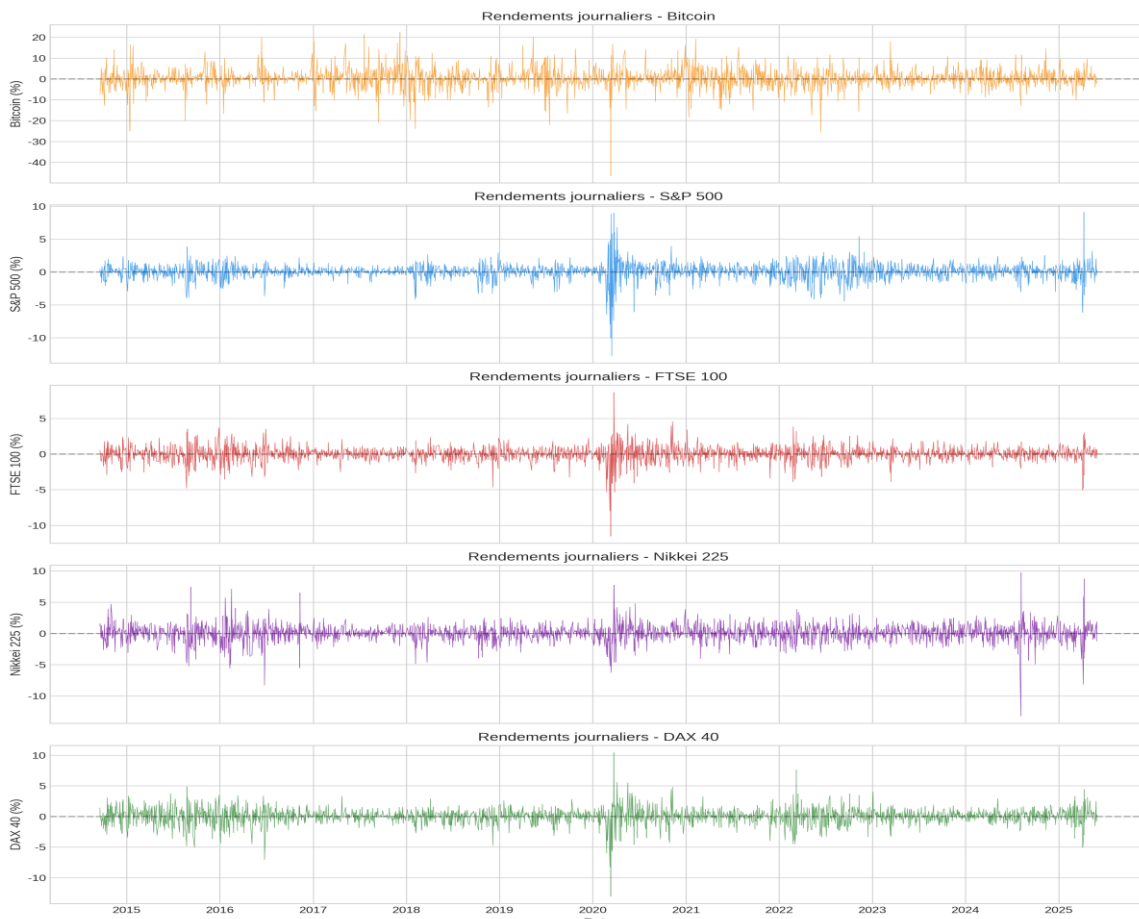
The findings are consistent with established stylized facts in financial time-series analysis. Relative to broad equity indices, Bitcoin exhibits markedly higher mean daily returns together with a substantially larger standard deviation, reflecting a more pronounced risk-return profile. All return distributions display negative skewness, which implies an elevated likelihood of extreme downside realizations. Moreover, kurtosis is well above three for every asset, indicating leptokurtic behavior with heavy tails..

Figure 2: Distribution of daily returns



Note: The histograms show the density of returns compared to a normal distribution (black line). The deviation from normality is visible, particularly at the tails of the distribution.

Figure 3: Evolution of daily returns (2014-2025)



Note: The figure shows periods of high and low volatility that cluster together, a phenomenon known as volatility clustering.

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Unit root diagnostics based on the Augmented Dickey-Fuller and KPSS tests jointly indicate that all log-return series are stationary in levels, $I(0)$, thereby satisfying the fundamental requirement for GARCH estimation. The presence of autoregressive conditional heteroskedasticity is substantiated by Engle's ARCH-LM test, with p-values below 0.001 for every series.

2.3 Volatility modeling: univariate GARCH specifications To characterize the evolution of conditional variance for each return series, we adopt the GARCH(1,1) framework of Bollerslev (1986). This benchmark model is widely employed for its parsimony and its capacity to capture pronounced volatility persistence. The specification is given by the following formulation.:

$$\text{Mean equation: } r_t = \mu + \varepsilon_t$$

$$\text{Variance equation: } \sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

In this specification, r_t denotes the asset return, μ the conditional expectation, ε_t the innovation, and σ_t^2 the conditional variance. To accommodate leptokurtic behavior in empirical returns, the standardized shock z_t is modeled as an i.i.d. white-noise process following a Student's t distribution. The degree of volatility persistence is summarized by the coefficient sum $\alpha_1 + \beta_1$.

2.4 DCC-GARCH model

To examine time-varying dependence between Bitcoin and the selected indices, we adopt Engle's Dynamic Conditional Correlation framework (2002). The DCC-GARCH specification captures the evolution of cross-asset correlations over time, offering a far more informative representation than static correlation measures.

Estimation follows the standard two-stage procedure:

- 1) Univariate modeling. Each return series is fitted with a GARCH(1,1) model estimated separately. From these models, we extract the conditional variances and the standardized innovations.
- 2) Correlation dynamics. The standardized residuals are then used to estimate the DCC parameters governing the time variation in correlations. The conditional correlation matrix R_t is specified as follows:

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

where $\bar{Q}$ is the unconditional correlation matrix of standardized residuals. The scalars a and b are the DCC parameters, capturing respectively the effect of past shocks (news) and the persistence of the correlation (decay). The condition $a + b < 1$ ensures the stationarity of the correlation process.

2.5 Identification of crisis periods and contagion testing

To test for financial contagion, we compare the average conditional correlations during "normal" periods and "crisis" periods. A statistically significant increase in correlation during a crisis is interpreted as potential evidence of contagion.

However, as Forbes and Rigobon (2002) point out, an increase in correlation during a crisis may be an artifact of increased volatility (heteroscedasticity) rather than evidence of pure

contagion. To correct for this bias, we apply the Forbes-Rigobon adjustment, which calculates an adjusted crisis correlation that takes into account the increase in market variance.

3. Empirical results

This section presents the empirical results obtained from applying the econometric models described in the previous section.

3.1 Descriptive results

Preliminary statistical analysis of daily returns highlights the stylized facts characteristic of financial assets. Bitcoin stands out with an annualized volatility of **71.62%**, which is approximately 3 to 4 times higher than that of stock market indices (between 16.47% and 21.73%). This high volatility is associated with an average annualized return of **53.53%**, far exceeding that of the stock markets.

Table 2: Annualized return statistics

Asset	Annual return (%)	Annual volatility (%)	Sharpe ratio
Bitcoin	53.53	71.62	0.75
S&P 500	10.81	18.84	0.57
FTSE 100	2.37	16.47	0.14
Nikkei 225	8.13	21.73	0.37
DAX 40	8.54	20.33	0.42

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Figure 4: Static correlation matrix of returns



Note: The matrix shows static correlations over the entire period. Bitcoin has weak correlations with stock market indices.

3.2 GARCH model results

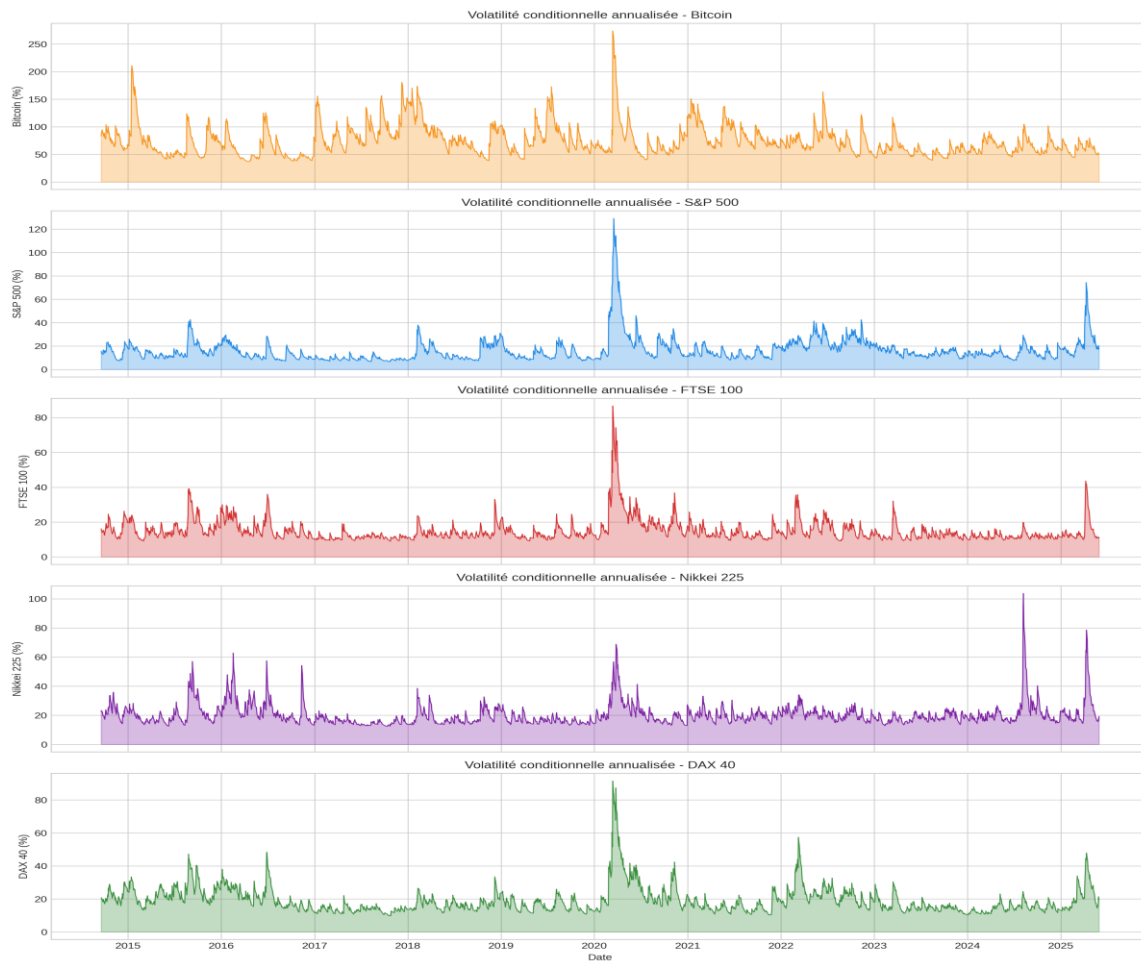
The estimates of the GARCH(1,1) models for each asset are summarized in Table 3. All estimated parameters are statistically significant at the 1% level.

Table 3: Results of GARCH(1,1) model estimation

Asset	ω	α (ARCH)	β (GARCH)	$\alpha + \beta$	ν (Student)
Bitcoin	0.6051	0.1251	0.8749	1.0000	2.87
S&P 500	0.0267	0.1858	0.8104	0.9963	5.35
FTSE 100	0.0658	0.1692	0.7707	0.9399	5.03
Nikkei 225	0.1268	0.1620	0.7748	0.9368	5.36
DAX 40	0.0529	0.1411	0.8366	0.9777	4.84

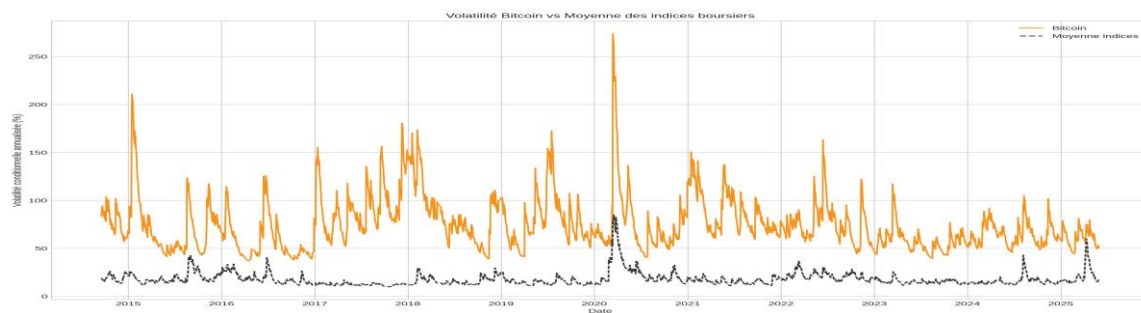
For all assets, the sum of the ARCH (α) and GARCH (β) coefficients is very close to 1, indicating **high volatility persistence**. For Bitcoin, persistence is equal to 1, suggesting an IGARCH (Integrated GARCH) type process, where shocks have a permanent effect on future variance.

Figure 5: Annualized conditional volatilities GARCH(1,1)



Note: The figure shows the evolution of annualized conditional volatilities for each asset. Bitcoin displays significantly higher and more erratic volatility.

Figure 6: Comparison of Bitcoin volatility vs. average indices



Note: The figure compares the annualized conditional volatility of Bitcoin (in orange) with the average of the four stock market indices (in black).

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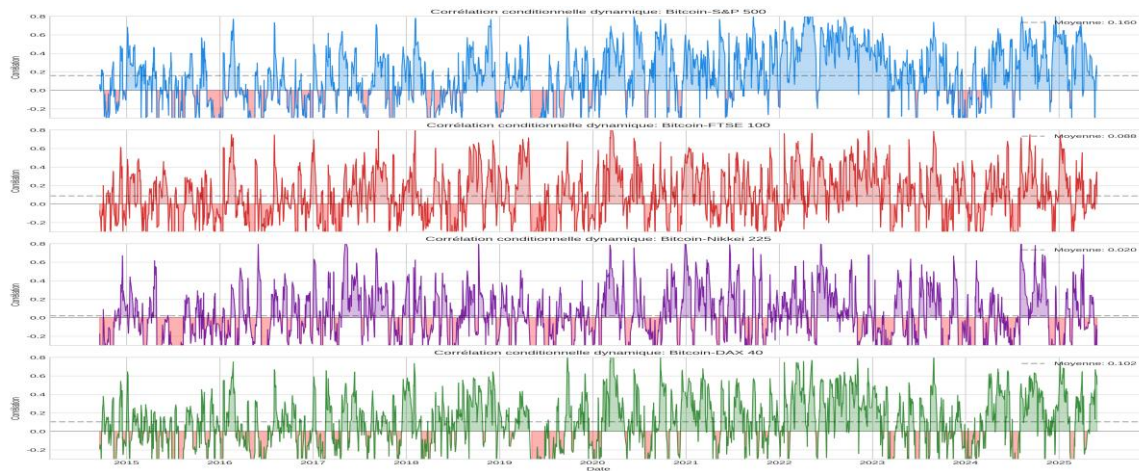
3.3 Dynamic conditional correlations (DCC-GARCH)

The DCC-GARCH model estimation produced the following parameters: **a = 0.206** and **b = 0.769**. The sum ($a + b = 0.975$), close to 1, indicates that the correlation process itself is very persistent.

Table 4: Dynamic conditional correlation statistics

Pair	Mean	Standard deviation	Minimum	Maximum	Median
Bitcoin-S&P 500	0.160	0.316	-0.850	0.856	0.168
Bitcoin-FTSE 100	0.088	0.296	-0.773	0.865	0.093
Bitcoin-Nikkei 225	0.020	0.301	-0.820	0.863	0.013
Bitcoin-DAX 40	0.102	0.296	-0.787	0.897	0.110

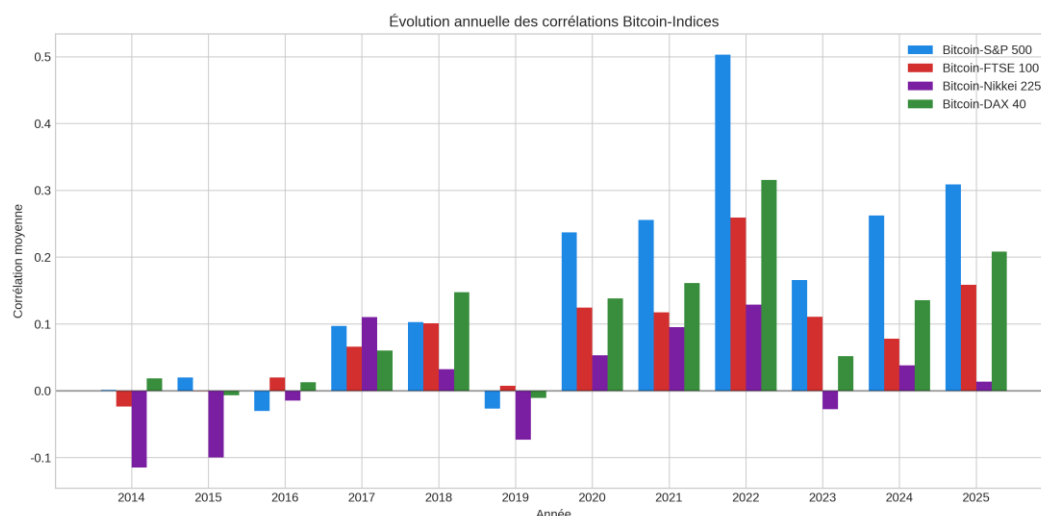
Figure 7: Dynamic conditional correlations between Bitcoin and indices (DCC-GARCH)



Note: The figure shows the evolution over time of conditional correlations between Bitcoin and each stock market index. The dotted line indicates the average correlation.

A systematic examination of the correlation structure yields two principal conclusions. Correlations are nonstationary, varying substantially over time and spanning a wide range from negative association to pronounced positive co-movement. They also intensify during stress regimes, with sharp increases evident in the March 2020 COVID-19 crash and again throughout the monetary tightening episodes of 2022

Figure 8: Annual evolution of average Bitcoin-Index correlations



Note: The year 2022 stands out for its exceptionally high correlations, reflecting Bitcoin's growing integration into the traditional financial system.

3.4 Contagion test results

To determine whether the increase in correlations during periods of crisis constitutes evidence of contagion, we conducted formal tests. Table 5 compares average correlations during normal periods and periods of crisis.

Figure 9: DCC correlations with periods of crisis (shaded areas)



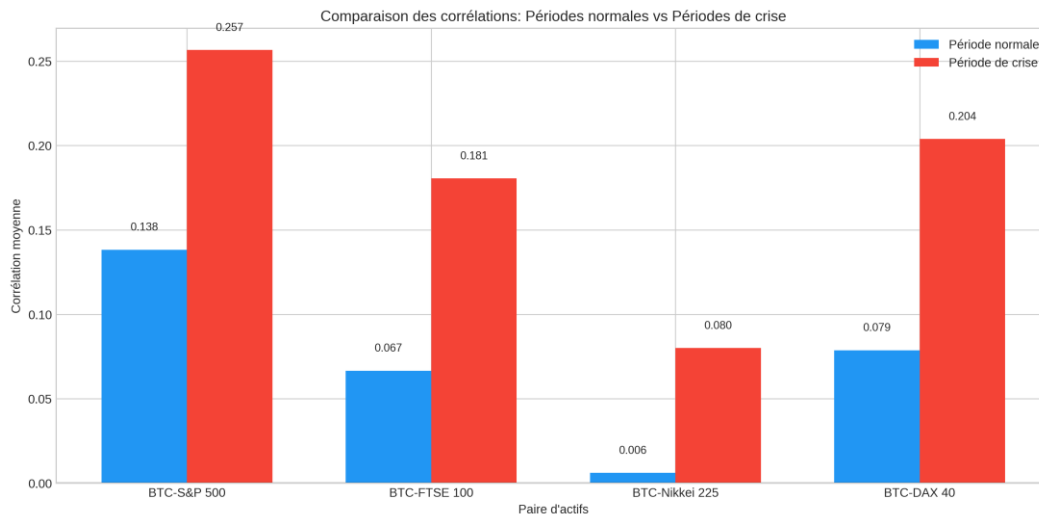
Note: The shaded areas represent identified periods of crisis (COVID-19, war in Ukraine, etc.). An increase in correlations can be observed during these episodes.

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Table 5: Contagion test – Comparison of correlations (Normal vs. Crisis)

Pair	Normal Corr.	Crisis Corr.	Difference	p-value	Conclusion
Bitcoin-S&P 500	0.138	0.257	+0.118	< 0.001	Significant
Bitcoin-FTSE 100	0.067	0.181	+0.114	< 0.001	Significant
Bitcoin-Nikkei 225	0.006	0.080	+0.074	< 0.001	Significant
Bitcoin-DAX 40	0.079	0.204	+0.125	< 0.001	Significant

Figure 10: Comparison of average correlations (normal periods vs. crisis periods)



Note: The blue bars represent correlations during normal periods, while the red bars represent correlations during crisis periods. The increase is visible for all pairs.

The results show a statistically significant increase in correlations for all pairs during crises. However, the **Forbes-Rigobon test**, which corrects for heteroscedasticity bias, gives different results (Table 6).

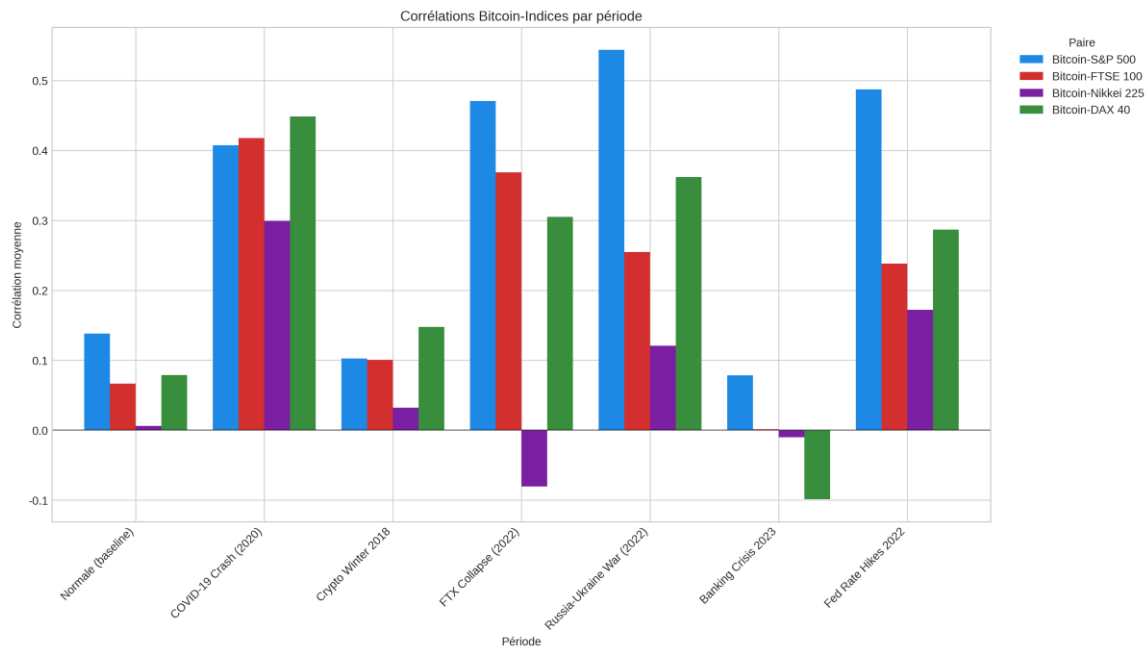
Table 6: Forbes-Rigobon contagion test (adjusted for heteroscedasticity)

Pair	Normal Corr.	Crisis Corr.	Adjusted Corr.	p-value	Conclusion
Bitcoin-S&P 500	0.138	0.257	0.119	0.645	No contagion
Bitcoin-FTSE 100	0.067	0.181	0.098	0.274	No contagion
Bitcoin-Nikkei 225	0.006	0.080	0.054	0.179	No contagion

Bitcoin-DAX 40	0.079	0.204	0.116	0.234	No contagion
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After adjusting for heteroscedasticity, the adjusted crisis correlation is no longer statistically different from the correlation in normal times. This key finding suggests that the observed increase in co-movements is a manifestation of increased **interdependence** due to general market volatility, rather than **pure contagion** (structural change in dependence). In other words, in times of panic, all risky assets tend to move together, and Bitcoin is no exception.

Figure 11: Average correlations by specific crisis period



Note: The highest correlations were observed during the COVID-19 crash and the turmoil of 2022 (war in Ukraine, rising interest rates, collapse of FTX).

4. Discussion

This section interprets the empirical results, positions them in relation to the existing literature, and discusses their implications for investors and regulators.

4.1 Economic interpretation of the results

Our econometric investigation uncovers several salient stylized facts about Bitcoin's dynamics relative to benchmark equity indices. First, Bitcoin exhibits extremely elevated unconditional volatility, measured at 71.6% on an annualized basis, and its conditional variance follows an IGARCH-type process with persistence at the unit boundary ($\alpha + \beta = 1$). This configuration indicates that volatility shocks are effectively permanent, consistent with a highly speculative asset that is acutely sensitive to information arrivals. In contrast to mature equity markets, where volatility innovations typically decay over time, disturbances to Bitcoin's volatility do not mean-revert, which reflects persistent structural uncertainty and a continuous price discovery mechanism.

Second, the central result of the study concerns the state dependence of cross-market comovements. Estimates from a DCC-GARCH framework reveal that the conditional correlation between Bitcoin and equities is strongly time varying, oscillating from near zero or

mildly negative in tranquil regimes to substantially positive during stress episodes, reaching up to 0.50 with the S&P 500. This evidence rejects the assumption of constant correlation and implies regime-contingent behavior. In low-volatility environments Bitcoin functions largely as an uncorrelated, potentially diversifying asset, whereas during crises it tends to align with traditional risky assets and co-move with them.

Finally, the most striking result is the distinction between **interdependence** and **contagion**. While a naive mean difference test concludes that correlations increase significantly in times of crisis (suggesting contagion), the Forbes and Rigobon (2002) test, which corrects for the bias induced by heteroscedasticity, refutes this conclusion. Our results (p -values > 0.05) indicate that there is **no pure contagion** from the stock market to Bitcoin. The increase in co-movements is a manifestation of interdependence: in the face of a global macroeconomic shock (e.g., COVID-19, monetary tightening), all risky assets, including Bitcoin, react in concert, leading to a mechanical increase in correlations. Bitcoin is therefore not a source of contagion, but rather a recipient of global systemic shocks, just like other risky assets.

4.2 Discussion of results in light of the research gap

This study contributes to the literature in several ways. First, it fills a gap by applying a rigorous methodology to distinguish interdependence from contagion. Many studies, such as those by Conlon et al. (2020) and Yousaf and Ali (2021), document an increase in correlations during the COVID-19 crisis but do not formally qualify it using volatility-adjusted tests. Our approach, based on the DCC-GARCH model and the Forbes and Rigobon (2002) test, provides a more nuanced and econometrically robust response.

Second, our methodological contribution consists in integrating a Dynamic Conditional Correlation framework with a formal contagion testing procedure, estimated on a large and up-to-date dataset extending to 2025. This design captures time-varying interdependence across markets and mitigates the risk of biased inference that arises when one relies on static correlations or naive testing strategies. Whereas studies such as Gil-Alana et al. (2020) emphasize long-run comovement, our dynamic specification uncovers short- and medium-horizon regime shifts, which are central to portfolio management and asset allocation.

Empirically, our main contribution is to demonstrate that, despite its growing integration into the financial system, Bitcoin does not act as a vector of contagion from equity markets. Rather, it behaves as a "barometer" of global risk sentiment. This result refines the conclusions of studies such as that by Qiu et al. (2026), which analyze contagion networks, by clarifying the nature of the link: it is a common reaction to a global risk factor rather than a transmission of bilateral shocks.

4.3 Comparison with existing literature

Our results resonate with part of the literature while qualifying the conclusions of another.

Convergence: In line with a large body of literature (Bouri et al., 2020; Shahzad et al., 2020; Cocco et al., 2022), we find that the Bitcoin-equity correlation increases in times of crisis. Our analysis confirms that Bitcoin loses its diversification properties when markets are prone to risk aversion. The idea that Bitcoin is not a reliable safe haven is consistent with the findings of Conlon et al. (2020) and Kumar (2020) during the COVID-19 crisis.

Points of divergence and nuance. Our primary departure lies in how the observed rise in correlations is characterized. Although much of the literature loosely invokes contagion or spillover (Caferra, 2022; Qiu et al., 2026), applying the Forbes and Rigobon (2002) correction leads us to reject the hypothesis of pure contagion. This distinction is crucial. It implies that Bitcoin is not a vulnerable conduit that imports and amplifies shocks from traditional markets, but an asset that comoves with others because of exposure to a shared systematic factor. This interpretation is consistent with Forbes and Rigobon's (2002) original argument of no contagion, only interdependence.

Sources of discrepancy. Divergent conclusions largely reflect methodological choices. VAR and network frameworks (e.g., Qiu et al., 2026) extract forward-looking variance spillovers, yet they do not correct for the heteroskedasticity-induced bias highlighted by Forbes and Rigobon. Copula-based studies (e.g., Yan, 2026) emphasize tail dependence, but they do not implement a formal contagion test in the Forbes and Rigobon sense. In contrast, our DCC-GARCH combined with the FR test is explicitly tailored to address this identification problem.

4.4 Implications for investors and portfolio construction

The practical consequences for investors are direct.

- Bitcoin as a diversifier. In tranquil market regimes, Bitcoin's correlations with equity indices are low and at times negative, which yields substantive diversification benefits. Incorporating it into a standard portfolio can improve the risk–return trade-off. This property is not constant and varies with market conditions.
- Bitcoin as hedge or safe haven. The evidence indicates that Bitcoin does not function as a hedge against equity drawdowns, nor as a safe haven. By definition, a safe haven remains uncorrelated or negatively correlated during crises. We instead find that Bitcoin's correlation turns strongly positive precisely in such periods. Investors holding Bitcoin to offset a stock market crash should anticipate co-movement and concurrent losses in crypto positions. This result accords with Bouri et al. (2017, 2020) and contradicts the popular notion of Bitcoin as digital gold.
- Operational guidance. A tactical, state-dependent allocation is warranted. Use Bitcoin for diversification when volatility is subdued, but reduce or hedge exposure as stress indicators rise. Volatility-based signals, such as movements in the VIX, provide a useful basis for dynamically adjusting the Bitcoin weight.

4.5 Limitations and robustness

This study has several limitations that point to avenues for further research.

- Data coverage. Our analysis relies on daily closing observations. High-frequency intraday data could uncover finer contagion and information transmission mechanisms, especially around macroeconomic announcement windows.

Model limitations: The DCC-GARCH model, although robust, imposes a common correlation dynamic on all asset pairs. More flexible models such as ADCC (Asymmetric DCC) or dynamic copula models (e.g., based on Student's t or SJC) could better capture asymmetric dependencies and extreme tail dependencies, as suggested by Yan (2026).

Sensitivity to methodological choices: The definition of crisis periods is exogenous and may influence the results of contagion tests. Although we used the dates of recognized major events, an endogenous approach to detecting structural breaks could refine the analysis.

4.6 Prospects for future research

Several extensions of this work can be considered.

Methodological extensions: The use of dynamic copula-vine models would allow for more flexible modeling of the pair-wise dependence structure. Wavelet analysis, as in Caferra (2022), could decompose correlations by frequency (short, medium, long term) to better understand investment horizons.

Other assets and markets: It would be relevant to extend the analysis to other crypto-assets (such as Ethereum, which according to Qiu et al. (2026) is becoming a risk transmitter) and other asset classes (commodities, bonds, real estate) to gain a comprehensive view of diversification opportunities.

Implications for regulation: The fact that Bitcoin is integrated into global systemic risk, even as a receiver, has implications for financial stability. Regulators need to monitor the growing exposure of institutional and retail investors to this asset class, as a crisis in the cryptocurrency market could have repercussions on the balance sheets of economic agents and amplify financial shocks.

5. Conclusion

This study analyzed the dynamic dependence and contagion between Bitcoin and four major stock indices (S&P 500, FTSE 100, Nikkei 225, DAX 40) over a period of more than ten years (2014-2025) using a DCC-GARCH model and robust contagion tests.

5.1 Summary of main results

The main econometric results are as follows: (i) The correlation between Bitcoin and equity markets is highly dynamic and dependent on market conditions, ranging from low in calm periods to high in times of crisis. (ii) Bitcoin volatility is extremely persistent, following an IGARCH process, which means that shocks have permanent effects. (iii) The increase in co-movements during periods of crisis is not due to pure contagion, but to increased interdependence, as shown by the Forbes and Rigobon (2002) test. Bitcoin reacts to global systemic shocks in the same way as other risky assets.

5.2 Contributions of the study

Our contribution is threefold. **Theoretically**, we clarify the nature of the link between crypto-assets and traditional markets by distinguishing between interdependence and contagion. **Empirically**, we show, using a recent and long sample, that Bitcoin fails in its role as a safe haven precisely when investors need it most. **Methodologically**, we illustrate the importance of using robust contagion tests to avoid erroneous conclusions about the nature of financial shocks.

5.3 Final implications

For investors, the evidence supports a more discriminating view of Bitcoin. It enhances portfolio diversification under tranquil market conditions, yet provides limited hedging effectiveness during periods of acute stress. This asymmetry argues for tactical, state-contingent exposure and dynamic risk management. For policymakers and regulators, Bitcoin's deeper integration with conventional financial markets, even if chiefly as a buffer to idiosyncratic disturbances, warrants heightened surveillance and prudential oversight to uphold systemic stability.

6.4 Final limitations and future avenues

This study is constrained by its reliance on daily observations and by the structural assumptions inherent in the DCC framework, both of which motivate additional research. Valuable extensions include high-frequency empirical designs, asymmetric copula models to capture tail dependence and regime effects, and a broader coverage of asset classes and cryptoassets. These directions would refine inference and advance our understanding of an evolving and fast-moving financial ecosystem.

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