Journal of Central Banking Theory and Practice, 2026, 3, pp. 125-162 *UDC: 339.738:004.7*

Received: 10 February 2026; accepted: 18 June 2026 *DOI: 10.2478/jcbtp-2026-0024*

Financial Technologies and Market Volatility: Dynamic Connectedness between FinTech and Traditional Markets

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Abstract: This study examines the dynamic volatility spillover between financial technologies and traditional and alternative financial markets. The analysis utilizes daily data covering the period from January 2018 to March 2026 for FinTech ETFs, the Nasdaq, Bitcoin, and gold markets. Interconnectivity among financial markets was analyzed using the time-varying parameter VAR (TVP-VAR) connectedness approach. The findings indicate the presence of a moderate and time-varying connectivity structure among the markets. In particular, a strong interaction was observed between the FinTech and Nasdaq markets, while Bitcoin was found to play a significant role as a volatility transmitter during certain periods. The gold market, on the other hand, generally exhibited more stable and limited interactions. Additionally, the study found that financial market linkages increase during periods of crisis and uncertainty. These results highlight that the transmission of volatility across financial markets has a dynamic structure and that portfolio diversification strategies should be evaluated accordingly. By examining FinTech markets alongside other major asset classes, the study provides a timely and comprehensive contribution to the literature.

Keywords: FinTech, Volatility Spread, TVP-VAR, Connectedness, Bitcoin, Gold.

JEL Classification: G10, G15, C32, C58.

1. Introduction

The financial system has undergone a marked transformation in recent years, driven by digitalisation, data-intensive decision-making processes, platform economies and the proliferation of new forms of financial intermediation. One of the most visible aspects of this transformation is the growing influence of financial technologies—or FinTech—on the production and distribution of financial services. FinTech is no longer merely an innovation sector limited to payment systems, digital lending, robo-advisory or blockchain-based solutions; it is also regarded as an axis of financial transformation that influences the structure of the banking sector, capital markets and the alternative investment ecosystem. Evidence is growing that FinTech is reshaping financial intermediation, simultaneously fostering both competitive and complementary relationships with traditional financial institutions, and that its impact on financial stability is not one-sided (Thakor, 2020; Boot et al., 2021; Fung et al., 2020; Daud et al., 2022; Nguyen & Dang, 2022; Elsayed et al., 2024).

The growth of FinTech is accelerating the spread of financial innovations across real and financial markets, whilst also amplifying the influence of technology-driven expectations and investor sentiment on asset price formation. Consequently, FinTech is now viewed not merely as a sector-specific technological phenomenon, but also in terms of cross-market information flows, risk transmission and the propagation of volatility. In particular, the blurring of boundaries between technology-focused equity markets, digital assets, commodities viewed as safe havens, and traditional financial sectors necessitates evaluating FinTech within a broader market network. Indeed, recent studies indicating increased investor interest in FinTech and growing interactions between thematic technology indices, artificial intelligence and robotic assets, energy transition themes, and new blockchain-based markets suggest that this transformation is systemic rather than merely sectoral in nature (Adekoya et al., 2022; Abakah et al., 2023; Gunay et al., 2023; Assaf et al., 2024; Ha et al., 2024; Su & He, 2024).

In modern literature, the role of FinTech in market stability is examined from two main perspectives. On the one hand, it is argued that FinTech enhances financial resilience by decentralising and diversifying financial services (Çevik, 2024). For example, there is empirical evidence that traditional banks' adoption of digital payment solutions such as BIZUM has reduced stock market volatility (Arenas et al., 2023). Furthermore, it has been observed that the development of FinTech reduces the risk of sudden stock price crashes by increasing information transparency (Zou & Zhang, 2025). On the other hand, the proliferation of digital finance can fuel market sensitivity and, consequently, volatility, particularly by increasing the participation of inexperienced investors in the market via trading apps (Ioannou et al., 2024). Indeed, it has been found that FinTech firms are more vulnerable to systemic shocks and have higher idiosyncratic risks compared to traditional financial institutions (Saklain, 2024).

This transformation in the financial system has made it necessary to assess risk and volatility not only within individual markets but also within the network of interconnections between markets. In this context, the connectedness approach has become one of the fundamental frameworks for analysing shock transmission, directional propagation and systemic risk channels between financial assets. In particular, modelling connectedness measures within a time-varying structure is important as it demonstrates that financial relationships do not remain static during crises, periods of uncertainty and regime shifts. The widespread acceptance of the TVP-VAR-based approach in the connectedness literature is also linked to this need. This is because, whilst mitigating limitations such as the choice of moving windows, this approach allows for a more flexible tracking of how market linkages evolve over time (Antonakakis et al., 2020). Furthermore, studies showing that connectedness levels rise during the pandemic, geopolitical shocks and periods of financial stress confirm that volatility contagion can intensify sharply on a cyclical basis (Sharif et al., 2020; Bouri et al., 2021; Wang et al., 2022; Sadorsky, 2025).

Similarly, the maturing of cryptocurrency markets and the increasing incorporation of alternative investment instruments into institutional portfolios have made it imperative to consider digital assets alongside traditional markets. The relationship between Bitcoin and equity markets, and that between gold and both equities and crypto assets, have reshaped discussions on hedging, safe-haven assets and portfolio diversification. There is strong empirical evidence, particularly in the post-COVID-19 period, that the correlation between Bitcoin and global equity markets, as well as the connectedness structure between crypto assets and other financial assets, has become more apparent, whereas gold has assumed different hedging roles depending on the circumstances (Bouri et al., 2020; Goodell & Goutte, 2021; Huang et al., 2023; Ugolini et al., 2023; Zhao & Zhang, 2023). These developments demonstrate that multi-market frameworks, which assess FinTech not only in relation to traditional finance but also alongside digital assets and safe-haven assets, have become more meaningful.

However, it appears that there is still no full consensus on the findings regarding the impact of FinTech on financial stability. On the one hand, it is argued that FinTech can strengthen the financial system by enhancing competition, efficiency and inclusivity; on the other hand, it is argued that it can deepen fragility and contagion by creating new channels of transmission. Moreover, it is understood that this effect can vary depending on the country, market structure, regulatory environment and asset class. Studies showing that FinTech supports financial stability in some cases, whilst conversely increasing fragility in others, are significant precisely for this reason (Fung et al., 2020; Daud et al., 2022; Nguyen & Dang, 2022; Elsayed et al., 2024; Wang & Ni, 2025). This picture makes it more accurate to assess FinTech not simply as a standalone ‘stability-enhancing’ or ‘risk-increasing’ factor, but rather through the connections it establishes with other financial markets.

Although the existing literature has made significant progress, two key gaps remain. Firstly, whilst studies examining the relationships between FinTech and the traditional financial sector are on the rise, frameworks that simultaneously consider FinTech indices alongside technology-heavy equity markets, cryptocurrency markets and safe-haven assets such as gold remain limited. Secondly, whilst most studies examine these relationships through specific bilateral links or sector pairings, it is evident that in the current financial structure, risk is distributed across multi-market networks. A study examining the spillovers between FinTech ETFs and traditional finance ETFs has shown that FinTech can often act as a net buyer; more recent studies, however, reveal that there are systemic links between FinTech shares and the banking, insurance and private equity markets that change over time, and that these links become more pronounced during periods of crisis (Chen et al., 2022; Henriques et al., 2025). The fact that research into FinTech’s links with NFTs, DeFi, thematic technology indices and other innovative assets has also begun during the same period indicates that FinTech needs to be analysed within a broader network (Gunay et al., 2023; Yousaf et al., 2023; Assaf et al., 2024; Henriques & Sadorsky, 2024).

Volatility spillover between FinTech indices and traditional asset classes exhibits an asymmetric and time-varying structure, particularly during periods of macro-financial uncertainty (Ha et al., 2024). Research has shown that periods such as the COVID-19 pandemic and geopolitical crises have intensified risk transmission between the FinTech and traditional finance sectors (Mino & Williamson, 2025; Sharma et al., 2024; Zhou & Li, 2022). During these periods, FinTech indices often act as 'receivers' of market shocks, whilst at the peak of crises they can assume the role of 'transmitters' of volatility to traditional markets (Jede & Teuteberg, 2025). Furthermore, the dynamic link between FinTech venture capital funding, bank credit flows and equity market movements presents a complex risk-return relationship from a global perspective (Bhatnagar et al., 2022; Golder & Barua, 2025).

This study is situated precisely within this gap. The primary objective of the study is to examine the volatility-based interaction between FinTech markets and traditional and alternative financial markets from a dynamic connectedness perspective. In this context, the FinTech index, Nasdaq, Bitcoin, and gold are analyzed jointly, integrating the technology-finance axis, the digital asset axis, and the safe-haven axis within a unified framework. The study focuses on the extent to which FinTech absorbs shocks from other markets or transmits shocks to them, how these relationships evolve over time, and how the connectedness network is reshaped during periods of heightened uncertainty. Accordingly, the study seeks to answer two central research questions: (i) whether FinTech functions primarily as a transmitter, receiver, or intermediary of volatility shocks within the broader financial system, and (ii) how the connectedness structure among FinTech, Nasdaq, Bitcoin, and gold evolves across different market conditions and uncertainty regimes. More broadly, the study aims to provide a systematic assessment of whether FinTech represents merely a technology-oriented market proxy or an active node within a broader volatility transmission network. More specifically, the study investigates whether FinTech behaves merely as a proxy for technology-oriented equity markets or constitutes a distinct financial node with its own volatility transmission characteristics. The selection of the TVP-VAR approach is motivated by evidence suggesting that connectedness structures are inherently dynamic and may change substantially during periods of pandemics, geopolitical tensions, monetary policy shocks, and financial stress (Antonakakis et al., 2020; Bouri et al., 2021; Zhao & Zhang, 2023; Henriques et al., 2025; Sadorsky, 2025). In particular, escalating geopolitical tensions in the Middle East, including the military confrontations involving the United States, Israel, and Iran, have been accompanied by heightened volatility across energy, commodity, cryptocurrency, and equity markets. Therefore, the sample period provides an opportunity to examine not only post-pandemic market dynamics but also changes in financial market connectedness during episodes characterized by elevated geopolitical uncertainty.

In this regard, the study aims to contribute to the literature on three levels. First, it establishes a more comprehensive market framework by evaluating FinTech not only in relation to the traditional financial sector but also alongside technology-intensive stock markets, cryptocurrencies, and gold. Second, by focusing on the time-dependent nature of the connectedness structure, it goes beyond static correlations. Third, it generates more direct insights regarding portfolio diversification and risk management for investors, and the systemic dimension of digital finance for policymakers. In this context, the remainder of the study is organized as follows: the second chapter systematically reviews the relevant literature; the third chapter describes the dataset and methodology; the fourth chapter presents the empirical findings; and the final chapter provides an overall evaluation of the results and discusses policy and investment implications.

2. Literature Review

The rapid rise of financial technologies has fundamentally disrupted traditional market dynamics, sparking extensive debate in the literature. While FinTech innovations promote financial inclusion through their potential to enhance operational efficiency and reduce costs (Afjal, 2023), they also have unpredictable effects on market volatility (Kubler & Schmedders, 2012). Current studies paint a dual-sided picture, suggesting that these technologies can serve as both a “stabilizer” and a “new source of risk” for the financial system (Çevik, 2024; Ioannou et al., 2024). In particular, the integration of digital assets and algorithmic trading into mainstream markets has altered asset pricing mechanisms, taking the interconnectedness between traditional and digital markets to a new level (Azar et al., 2022; Wang & Ni, 2025).

2.1. The Relationship Between FinTech and Financial Stability

The impact of FinTech on the financial system has been the subject of increasing research in the financial literature in recent years. Financial technologies refer to the use of digital technologies in the provision of financial services and are leading to significant structural changes in the financial system. FinTech companies operate in many areas, such as payment systems, digital credit platforms, investment applications, and blockchain-based services. These developments are transforming financial intermediation processes and giving rise to new competitive and collaborative relationships between traditional financial institutions and FinTech firms (Lee & Shin, 2018).

A significant portion of the literature focuses on the impact of FinTech on the stability of financial institutions. Çevik (2024) describes this situation as the “dark side of the moon,” highlighting the potential negative effects of FinTech development on financial stability. Similarly, Ioannou et al. (2024) question whether FinTech-induced instability differs from that of previous crises. Empirical findings indicate that FinTech credit expansion strains macroprudential frameworks and, in some cases, increases financial fragility (Sikalao-Lekobane, 2024; Sulehri & Ali, 2024). However, it has also been reported that banks’ digital transformation processes may have dampening effects on stock volatility (Arenas et al., 2023). Studies focused on emerging markets, meanwhile, reveal that FinTech’s impact on systemic risk and bank performance is asymmetric, and that it can manipulate institutions’ risk-taking behavior (Bamia & Bamia, 2025; Elekdağ et al., 2024).

The effects of FinTech on the financial system are intensely debated, particularly in terms of financial stability. While some studies argue that FinTech innovations can enhance the efficiency of the financial system by increasing the efficiency of financial services, others suggest that FinTech development may create new risk channels. For example, Haddad and Hornuf (2019) examined the effects of FinTech startups on global financial markets, demonstrating that the FinTech ecosystem is growing rapidly. Similarly, Vives (2019) noted that FinTech innovations are transforming the structure of financial intermediation and creating new competitive dynamics within the financial system.

Empirical studies on the relationship between FinTech markets and financial markets are also on the rise. For example, Alshater et al. (2022) examined the effects of FinTech development on volatility dynamics in financial markets and demonstrated that FinTech innovations can influence the behavior of financial markets. Additionally, some studies have shown that the performance of FinTech companies is strongly correlated with technology-focused stock markets (Gomber et al., 2018).

2.2. Intermarket Volatility Spillover and Interconnectedness

Interdependence among financial markets and volatility spillover have long been central topics in the financial literature. With the increasing global financial integration, it has become evident that shocks arising in different markets can spread rapidly to other markets. Consequently, understanding the risk transmission mechanisms between financial markets has become a critical area of research for financial stability, portfolio diversification, and risk management. The connectedness approach is recognized as one of the most significant methodological frameworks developed to measure interactions among financial markets in this context. In particular, connectedness measures based on variance decomposition enable the analysis of directional volatility spillover between financial markets (Diebold & Yilmaz, 2012).

Risk transfer between FinTech and traditional markets is examined within the framework of a "volatility spillover" that intensifies particularly during crisis periods (Arenas & Gil-Lafuente, 2020). Wang et al. (2022) identified a dynamic risk interaction between the FinTech and traditional financial sectors in the case of China. The COVID-19 pandemic has made this interaction more visible; during the pandemic, the interconnectedness of FinTech indices with traditional asset classes (energy, stocks, etc.) increased dramatically (Hà et al., 2024; Sharma et al., 2024; Zhou & Li, 2022). While Arnell et al. (2023) argue that structural breaks and uncertainty in technology sector markets trigger volatility spillovers, Saklain (2024) analyzed the effects of FinTech on systemic risk and bank market power from an Australian perspective. In emerging markets such as India, the dynamic relationship between risk and return has also been validated using advanced econometric models such as GARCH-M (Bhatnagar et al., 2022).

2.3. Investor Sentiment and the Role of Digital Factors

A significant portion of the FinTech literature focuses on examining the relationships between FinTech markets and cryptocurrency markets as well as alternative asset classes. In particular, the rapid rise of Bitcoin and other crypto assets has led to a reassessment of the interactions among financial markets. Studies on the relationship between cryptocurrency markets and traditional financial markets indicate that these markets are becoming increasingly integrated (Urquhart, 2017; Kyriazis, 2019).

The relationship between cryptocurrency markets and traditional financial assets becomes particularly evident during periods of crisis. For example, Katsiampa et al. (2019) examined the volatility dynamics of cryptocurrency markets and demonstrated that these markets possess distinct characteristics from traditional financial markets. However, some studies suggest that Bitcoin may be beneficial for portfolio diversification (Baur et al., 2018).

Gold also holds a significant place in the financial literature among alternative asset classes. Gold has long been regarded as a safe-haven asset and is particularly favored by investors during financial crises. Baur and McDermott (2010) demonstrated that gold can serve as a safe haven during financial crises. More recent studies, however, have examined the relationship between gold and cryptocurrency markets, comparing the roles of these two asset classes in financial markets.

Recent literature has thoroughly examined the role of investor sentiment—measured through social media and digital proxies—on FinTech volatility (Fang et al., 2021; Yang et al., 2024). It is argued that social media interactions and AI-based investment strategies fuel asymmetric shocks and price bubbles in the market. Yang et al. (2024) emphasize the central role of social media in the spillover effect between sentiment and volatility; meanwhile, Heydari and

Roubaud (2024) demonstrate that asymmetric interactions between advanced technologies and crypto assets manifest as “good” and “bad” volatility. Additionally, there are findings suggesting that FinTech development could reduce the risk of stock market crashes by enhancing information transparency (Zou & Zhang, 2025) or improve the pricing efficiency of data assets (Wang & Ni, 2025).

2.4. Literature Review and Contribution of the Study

Upon a general review, it is observed that the literature is largely confined to regional analyses (particularly China and the U.S.) or specific crisis periods (Wang et al., 2022; Zhang & Sun, 2024; Zhou & Li, 2022). Furthermore, most studies on the impact of FinTech on traditional markets employ static methods and overlook “spatial” or “time-frequency” based dynamic transitions between markets (Hà et al., 2024; Koranteng & You, 2024). While some existing studies view FinTech as a stabilizing factor, others define it as a source of systemic risk, presenting conflicting results (Çevik, 2024; Siddik et al., 2026).

Overall, while the existing literature has extensively examined the relationships between volatility spillovers and connectedness across financial markets, studies that address the dynamic linkages of FinTech markets with cryptocurrency markets, technology-heavy equity markets, and safe-haven assets within the same framework are quite limited. In particular, studies that examine FinTech indices alongside digital assets such as Bitcoin and traditional safe-haven assets like gold are relatively scarce in the literature. This study aims to fill this gap. The study analyzes the dynamic connectedness structure among FinTech markets, the Nasdaq stock market, the Bitcoin market, and the gold market using the time-varying parameterized VAR (TVP-VAR) method. In this regard, the study provides a more comprehensive framework for understanding how volatility spreads across different asset classes.

Unlike previous studies that primarily focus on bilateral relationships between FinTech and specific financial sectors, this study investigates whether FinTech constitutes an independent source of volatility transmission within a broader financial ecosystem that includes technology-intensive equity markets, cryptocurrencies, and safe-haven assets. Rather than merely documenting interconnectedness, the analysis seeks to identify the relative position of FinTech within the volatility transmission network, distinguishing whether FinTech predominantly acts as a transmitter, receiver, or intermediary of shocks. This perspective provides a deeper understanding of the evolving role of financial technologies in the architecture of modern financial markets.

This study aims to address the gaps in the literature in three key areas. First, rather than focusing on a single country or region, the study adopts a holistic approach to examine the interaction between global FinTech indices and a wide range of traditional asset classes (stocks, energy, foreign exchange). Second, by utilizing the most up-to-date data (including projections for 2025–2026), it analyzes the new generation of systemic risks created by geopolitical crises and technological monopolies. In particular, the escalating military tensions between the U.S., Israel, and Iran in the Middle East have had significant impacts on global financial markets and led to a marked increase in volatility in energy, commodity, crypto-asset, and stock markets. For this reason, the period covered by this study offers the opportunity to examine not only post-pandemic financial market dynamics but also changes in financial market connectedness during episodes characterized by heightened geopolitical uncertainty. Finally, by integrating asymmetric volatility spillovers and digital sensitivity factors within the same model framework, our study provides a clear set of evidence that resolves the existing empirical uncertainty in the literature for policymakers and portfolio managers.

3. Hypothesis Development

Interdependence among financial markets and the propagation of volatility are major research topics in the financial literature. Globalization, financial innovation, and technological advancements have led to shocks in one market spreading more rapidly to others. Therefore, examining the propagation of volatility and risk transmission among financial assets provides important insights for financial stability and portfolio management. The connectedness approach is one of the widely used methods for measuring this interaction among financial markets and enables the analysis of directional volatility spillover between financial assets (Diebold & Yilmaz, 2012).

The rise of FinTech markets has made this structure of interaction in financial markets more complex. As innovative firms representing the use of digital technologies in financial services, FinTech companies are transforming the structure of the financial system. FinTech innovations have led to the emergence of new business models in areas such as payment systems, digital credit platforms, and investment services (Thakor, 2020). These developments have strengthened the relationship between FinTech markets and traditional financial markets. In particular, the fact that a large portion of FinTech companies is traded on technology-heavy stock markets indicates that there may be a strong interaction between FinTech markets and stock markets.

The performance of technology-focused financial companies is generally closely linked to the technology sector and the broader stock market. Since the business activities of FinTech companies are often connected to digital platforms and data-driven financial services, their market performance is influenced by macroeconomic conditions, investor sentiment, and dynamics within the technology sector. Therefore, volatility spillover is expected between FinTech markets and technology-heavy stock markets. There are numerous studies in the financial literature demonstrating a strong interaction between the technology sector and the financial sector (Boot et al., 2021). In this context, a meaningful volatility link is expected between FinTech markets and stock markets.

The relationship between FinTech markets and cryptocurrency markets has also become a significant research topic in the financial literature in recent years. Cryptocurrency markets have emerged as a key component of financial innovations such as blockchain technology. Bitcoin and other crypto assets are closely associated with FinTech as a key component of the digital finance ecosystem. Studies on the role of cryptocurrency markets in financial markets indicate that these markets are increasingly interacting with traditional financial markets (Corbet et al., 2018). Therefore, volatility spillover between FinTech markets and cryptocurrency markets is expected.

Gold, which is among alternative investment instruments, has long been recognized in the financial literature as a safe-haven asset. In particular, investors' risk-aversion behavior during financial crises can increase demand for gold. Studies on the role of the gold market in financial markets indicate that gold can serve as a hedging instrument against stock markets during certain periods (Baur & McDermott, 2010). However, recent studies have revealed that the relationships between gold and other financial assets may change over time (Bouri et al., 2020). This suggests that the gold market's relationships with FinTech and other financial markets may have a dynamic structure.

Volatility spillovers across financial markets typically exhibit a structure that changes over time. Economic crises, geopolitical risks, and macroeconomic shocks can significantly affect market linkages. Therefore, it is important to use methods that account for the fact that linkages between financial markets can change over time. The TVP-VAR approach offers a suitable method for examining changes in the structure of connectedness among financial markets over time (Antonakakis et al., 2020). Within this framework, it is expected that the volatility spillover between FinTech markets and other asset classes exhibits a dynamic structure.

In line with this theoretical framework, the following hypotheses are tested in this study.

H1: There is a significant volatility link between FinTech markets and stock markets.

H2: There is a significant volatility link between FinTech markets and cryptocurrency markets.

H3: There is a significant volatility link between FinTech markets and the gold market.

H4: The volatility relationship among FinTech, stock, cryptocurrency, and gold markets exhibits a structure that changes over time.

Testing these hypotheses will contribute to a better understanding of the role of FinTech markets within the financial system. Additionally, determining the volatility spillover across different asset classes will provide important insights for investors' portfolio diversification strategies.

Beyond the existence of interconnectedness, the present study also seeks to understand the relative position of FinTech within the volatility transmission network. Given the close relationship between FinTech firms and technology-oriented equity markets, FinTech may behave either as an extension of the technology sector or as an independent source of volatility transmission. Similarly, the role of Bitcoin may vary across market conditions, acting as a volatility absorber during stable periods and as a volatility transmitter during episodes of heightened uncertainty and market stress.

4. Data Set and Methodology

4.1. Data Set

This study uses four different financial assets to examine the dynamic interconnections between financial technologies and traditional and alternative financial markets. The variables used in the analysis are, in order, the FinTech index representing the FinTech market, the Nasdaq index representing the stock market, the Bitcoin price representing the cryptocurrency market, and the gold price, which is considered a safe-haven asset. Since these assets represent different segments of financial markets, they provide a suitable framework for examining the propagation of volatility within the financial system.

To represent the FinTech market, the FinTech ETF index, which reflects the performance of FinTech companies, is used. FinTech market performance is represented by the Global X FinTech ETF (FINX), one of the most widely recognized exchange-traded funds tracking companies operating in the financial technology sector. The ETF includes firms engaged in digital payments, financial software, online lending, blockchain-related services, and other technology-driven financial activities. Due to its diversified exposure to major publicly traded FinTech companies across different segments of the industry, FINX provides a representative benchmark for the broader FinTech ecosystem. Therefore, it is employed in this study as a proxy for the FinTech market. The Nasdaq index, which includes technology-heavy companies, was chosen to represent the stock market. Bitcoin prices were used to represent the cryptocurrency market. Bitcoin is considered the primary indicator representing this market because it is the asset with the largest market capitalization in the cryptocurrency markets. Finally, gold prices have been included in the analysis as a safe-haven asset. In financial literature, gold is regarded as an asset that investors use as a hedging tool, particularly during periods of financial uncertainty (Baur & McDermott, 2010).

Table 1: Variables and Data Sources

Variable	Proxy	Frequency	Source
FinTech	FinTech ETF	Daily	Investing
Stock Market	Nasdaq Composite	Daily	Investing
Cryptocurrency	Bitcoin	Daily	CoinMarketCap
Safe Haven	Gold	Daily	Investing

Extending the analysis period through March 2026 represents a significant advantage of this study. This period encompasses significant uncertainties, including the post-pandemic recovery of global financial markets, rising geopolitical risks, and, in particular, the U.S.-Israel-Iran tensions in the Middle East. Therefore, the analysis period offers an important opportunity to examine how volatility linkages between financial markets change during periods of crisis and uncertainty.

4.2. Methodology

The connectedness approach is widely used to analyze volatility spillovers across financial markets. This approach was first developed by Diebold and Yilmaz (2012) and has been used to measure directional volatility spillovers across financial markets. However, traditional connectedness measures are based on fixed-parameter VAR models. This may not fully reflect the fact that relationships between financial markets can change over time.

To address this issue, the time-varying parameter (TVP-VAR) connectedness approach developed by Antonakakis et al. (2020) is employed. The TVP-VAR model features a flexible structure that allows for changes in the connections between financial markets over time. Thus, market linkages can vary depending on factors such as periods of crisis, macroeconomic shocks, or geopolitical developments.

In financial time series, price data typically exhibit non-stationary processes containing unit roots. For this reason, return series are generally used instead of price series in empirical finance studies. In this study, daily logarithmic return series were calculated for each asset.

The logarithmic return is defined as follows:

$$r = \ln\left(\frac{P_t}{P_{t-1}}\right) \tag{1}$$

Here, P_t represents the closing price of the relevant financial asset in period t, and P_{t-1} represents the closing price in the previous period.

The framework for the TVP-VAR model is provided below (Antonakakis et al., 2020):

$$x_t = \beta_t x_{t-1} + u_t \qquad u_t \sim \mathrm{N}(0, \Sigma_t) \tag{2}$$

$$vec(\beta_t) = vec(\beta_{t-1}) + v_t \qquad v_t \sim \mathrm{N}(0, R_t) \tag{3}$$

Equality “(2) and (3) represent the vectors "$x_t, x_{t-1}\ ve\ u_t$"of dimension $N\ x\ 1$. "$\beta_t\ ve\ \Sigma_t$" , represent matrices of dimension $N\ x\ N$. Furthermore, "$vec(\beta_t)$"and "v_t" are $N^2 x\ 1$ dimensional vectors, and the "R_t" matrix is $N^2 x\ N^2$ dimensional. After estimating the time-varying coefficients, the TVP-VAR model is transformed into the TVP-VMA model in Equation (3) using Wold decomposition theory.”

The VMA representation allows shocks originating in one market to be traced through the entire system over time. This transformation is essential for evaluating how volatility innovations are transmitted across FinTech, equity, cryptocurrency, and gold markets.

$$x_t = \sum_{i=1}^{p} \beta_{it}\, x_{t-1} + u_t = \sum_{j=1}^{\infty} \Lambda_{jt}\, u_t - u_t \tag{4}$$

In the next step, the TVP-VMA coefficients are obtained, the generalised forecast error variance decomposition (GFEVD) is calculated, and the dynamic cointegration framework is built upon this decomposition (Koop et al. 1996; Pesaran & Shin, 1998). The unscaled GFEVD, "$\phi_{ij,t}^{g}(\mathrm{J})$", represents variable j's effect on variable i, i.e., j's contribution to the variance of i's estimation error, and is defined as follows (Antonakakis et al. 2020,)”:

$$\phi_{ij,t}^{g}(\mathrm{J}) = \frac{\Sigma_{ii,t}^{-1}\sum_{t=1}^{J-1}(\iota_i' \Lambda_t \Sigma_t \iota_j)^2}{\sum_{j=1}^{N}\sum_{t=1}^{J-1}(\iota_i \Lambda_t \Sigma_t \Lambda_i' \iota_i)} \qquad \tilde{\phi}_{ij,t}^{g}(\mathrm{J}) = \frac{\phi_{ij,t}^{g}(\mathrm{J})}{\sum_{j=1}^{N}\phi_{ij,t}^{g}(\mathrm{J})} \tag{5}$$

The GFEVD framework quantifies the proportion of forecast error variance in a given market that can be attributed to shocks arising from other markets. Therefore, it provides a direct measure of cross-market volatility transmission and interconnectedness.

Equation (5) holds, where $\sum_{j=1}^{N}\tilde{\phi}_{ij,t}^{g}(\mathrm{J}) = 1$ and $\sum_{i,j=1}^{N}\tilde{\phi}_{ij,t}^{g}(\mathrm{J}) = N$, where J denotes the prediction horizon and ι_j is a vector with the i^(th) element equal to 1 and all others equal to 0. Using the GFEVD values obtained from this, the total connectivity index is calculated as follows:

$$C_t^{g}(\mathrm{J}) = 1 - N^{-1}\sum_{i=1}^{N}\tilde{\phi}_{ii,t}^{g}(\mathrm{J}) \tag{6}$$

This connectivity approach “shows how a shock in one variable spreads to other variables.

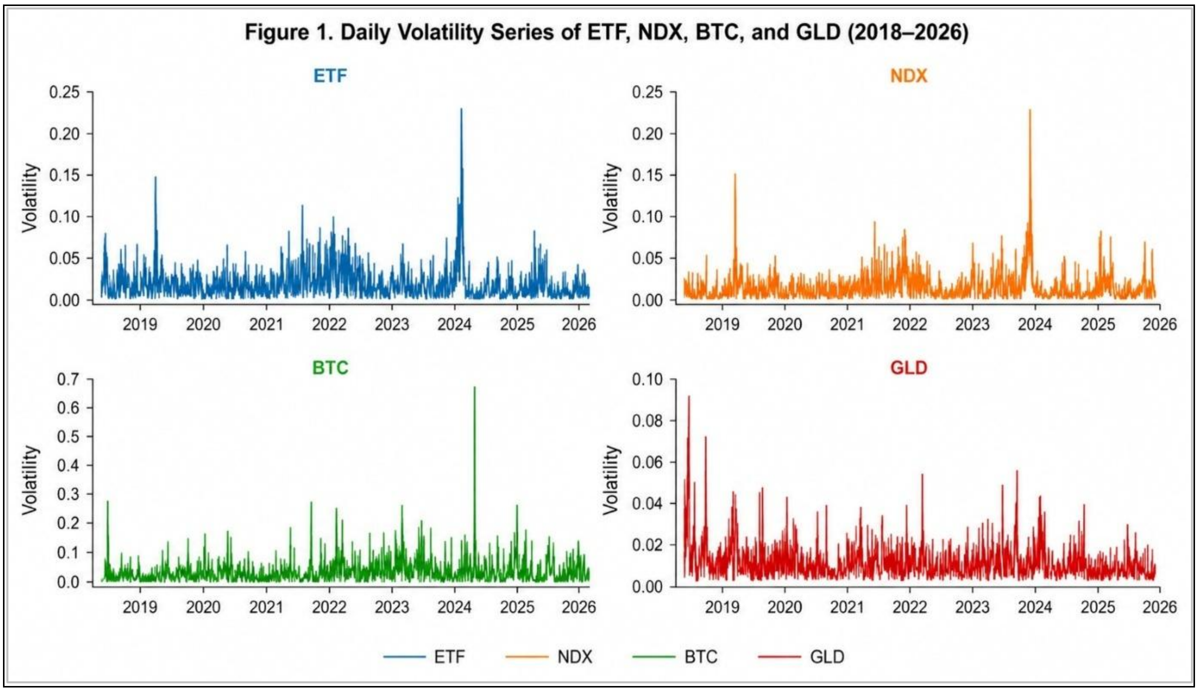
- Total Directional Connectivity to Others: $C_{i\to j,t}^{g}(\mathrm{J}) = \sum_{j=1,i\neq j}^{N}\tilde{\phi}_{ji,t}^{g}(\mathrm{J})$ (7)
- Total Directional Connectivity from Others:” $C_{i\leftarrow j,t}^{g}(\mathrm{J}) = \sum_{j=1,i\neq j}^{N}\tilde{\phi}_{ij,t}^{g}(\mathrm{J})$ (8)
- Net Total Directional Connectivity: $C_{i,t}^{g} = C_{i\to j,t}^{g}(\mathrm{J}) - C_{i\leftarrow j,t}^{g}(\mathrm{J})$ (9)
- Clear Bidirectional Connectivity: $NPDC_{ij}(\mathrm{J}) = \tilde{\phi}_{ji,t}(\mathrm{J}) - \tilde{\phi}_{ij,t}(\mathrm{J})$ (10)

The resulting connectedness measures enable the identification of net transmitters and net receivers of volatility, thereby revealing the relative position of each market within the broader financial system. If variable i's net total direct connectivity is positive, variable ‘i’ is a net volatility emitter in the system; if negative, it is a net volatility absorber. Similarly, if $NPDC_{ij}(\mathrm{J}) > 0$, variable i is a net volatility transmitter to variable j. However, if $NPDC_{ij}(\mathrm{J}) < 0$, variable i is a net volatility absorber from variable j (Antonakakis et al., 2020).

5. Findings

This section presents the empirical findings related to the dataset used in the study and evaluates the results obtained. First, descriptive statistics and key characteristics of the variables used in the analysis are examined, followed by tests of the stationarity properties of the time series. Subsequently, the dynamic interconnectedness structure among FinTech, stock, Bitcoin, and gold markets is analyzed using the TVP-VAR connectedness approach. The findings are evaluated within the framework of the total connectedness index, directional connectedness measures, and net volatility spillover; in particular, the study reveals which asset classes market shocks are concentrated in and how this pattern changes over time. Additionally, the analysis results are interpreted to demonstrate how interactions among financial markets differ under crisis periods and geopolitical uncertainties.

Figure 1: Volatility Charts of the Variables



When examining the time-series trends of the volatility series for the FinTech ETF, Nasdaq, Bitcoin, and gold variables in Figure 1, fluctuations concentrated in specific periods are observed across all series, indicating volatility clustering—a characteristic feature of financial time series. It is observed that FinTech ETFs and Nasdaq volatility structures move largely in tandem and exhibit simultaneous increases, particularly during certain periods, indicating that FinTech markets are closely correlated with technology-heavy stock markets. Bitcoin volatility, however, follows a higher and more erratic trajectory compared to other variables, occasionally featuring sharp spikes; this reflects the more speculative and high-risk nature of cryptocurrency markets. Gold volatility, on the other hand, generally exhibits a lower and more stable pattern, though it tends to increase during periods of global uncertainty. Overall, the graph reveals that volatility varies over time across all markets examined and that simultaneous increases occur during specific periods, pointing to the existence of dynamic interconnectivity among financial markets.

Table 2: Descriptive Statistics

	ETF	NDX	BTC	GLD
Mean	0.019	0.016	0.04	0.01
Variance	0	0	0.002	0
Skewness	2.939***	3.826***	3.773***	2.589***
	(0.000)	(0.000)	(0.000)	(0.000)
Ex.Kurtosis	17.192***	29.455***	34.635***	12.825***
	(0.000)	(0.000)	(0.000)	(0.000)
JB	28197.457***	79111.037***	107330.175***	16339.460***
	(0.000)	(0.000)	(0.000)	(0.000)
ERS	-11.819***	-10.398***	-8.777***	-12.637***
	(0.000)	(0.000)	(0.000)	(0.000)
Q(10)	1145.328***	1578.331***	652.454***	798.006***
	(0.000)	(0.000)	(0.000)	(0.000)
Q2(10)	1654.878***	1631.438***	596.178***	955.880***
	(0.000)	(0.000)	(0.000)	(0.000)

*Note: The symbols ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.*

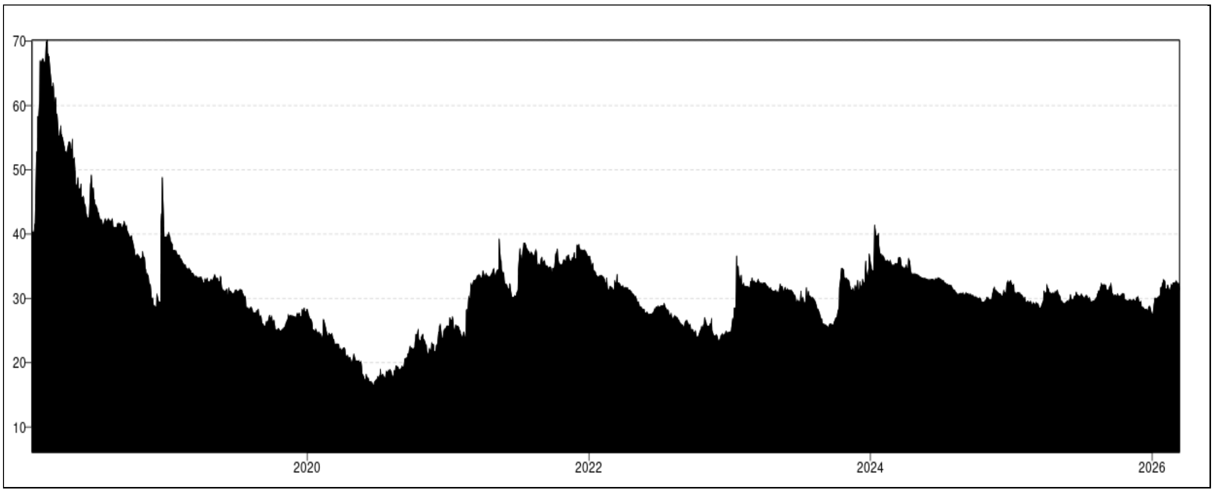
Upon examining Table 2, it is observed that the average returns for all variables are positive, with the highest average return observed for Bitcoin (0.04) and the lowest average returns observed for gold (0.01) and the Nasdaq (0.016). The variance values are significantly higher for Bitcoin, indicating that the cryptocurrency market involves higher risk and volatility compared to other assets. The fact that the skewness values are positive and statistically significant for all series reveals that returns are right-skewed, making large positive returns more likely. The fact that excess kurtosis values are quite high and significant indicates that the series exhibit fat-tailed distributions and that extreme values occur more frequently compared to a normal distribution. The fact that the Jarque-Bera test statistics are high and significant for all variables confirms that the series reject the assumption of a normal distribution. According to the ERS unit root test results, all series are stationary and are statistically suitable for use in the analysis. When these findings are evaluated together, it is concluded that the financial time series under examination exhibit characteristics specific to financial time series, such as high volatility, fat tails, autocorrelation, and heteroskedasticity, and that the use of dynamic and flexible models such as TVP-VAR is therefore appropriate.

Table 3: Average Dynamic Connectivity Table

	ETF	NDX	BTC	GLD	FROM
ETF	63.71	31.57	2.24	2.49	36.29
NDX	29.14	65.25	2.71	2.90	34.75
BTC	2.87	4.82	86.75	5.56	13.25
GLD	3.02	3.40	3.98	89.61	10.39
TO	35.02	39.78	8.93	10.95	94.68
NET	-1.27	5.03	-4.32	0.56	31.56/23.67

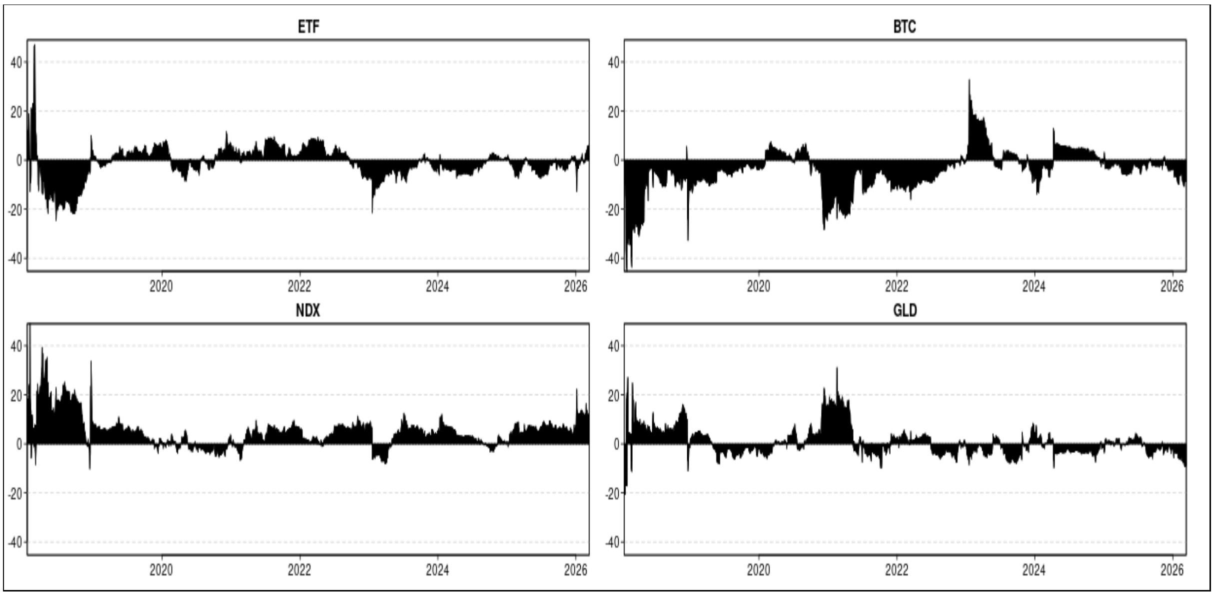
An examination of the average dynamic connectivity results presented in Table 3 reveals that the total connectivity level in the system is 31.56%, indicating a moderate level of volatility spillover among financial markets. The high diagonal values indicate that each market is significantly affected by its own shocks; this ratio is particularly high for Bitcoin (86.75%) and gold (89.61%). It is noteworthy that the FinTech ETF and Nasdaq markets are in a strong reciprocal interaction; the spillovers from the ETF to Nasdaq (31.57%) and from Nasdaq to the ETF (29.14%) highlight the close relationship between these two markets. When examining the “TO” and “NET” values, it is observed that the Nasdaq is a net volatility transmitter (NET: 5.03), whereas Bitcoin is the most prominent net volatility receiver (NET: -4.32). While the FinTech ETF market stands out as a slight net buyer (-1.27), the gold market appears to have a relatively balanced yet slightly net-selling structure (0.56). Overall, the results indicate that technology-heavy stock markets play a dominant role in the system, FinTech markets are more significantly affected within this structure, and Bitcoin and gold markets are relatively more isolated yet still influenced by the system.

Figure 2: Volatility Charts of Variables



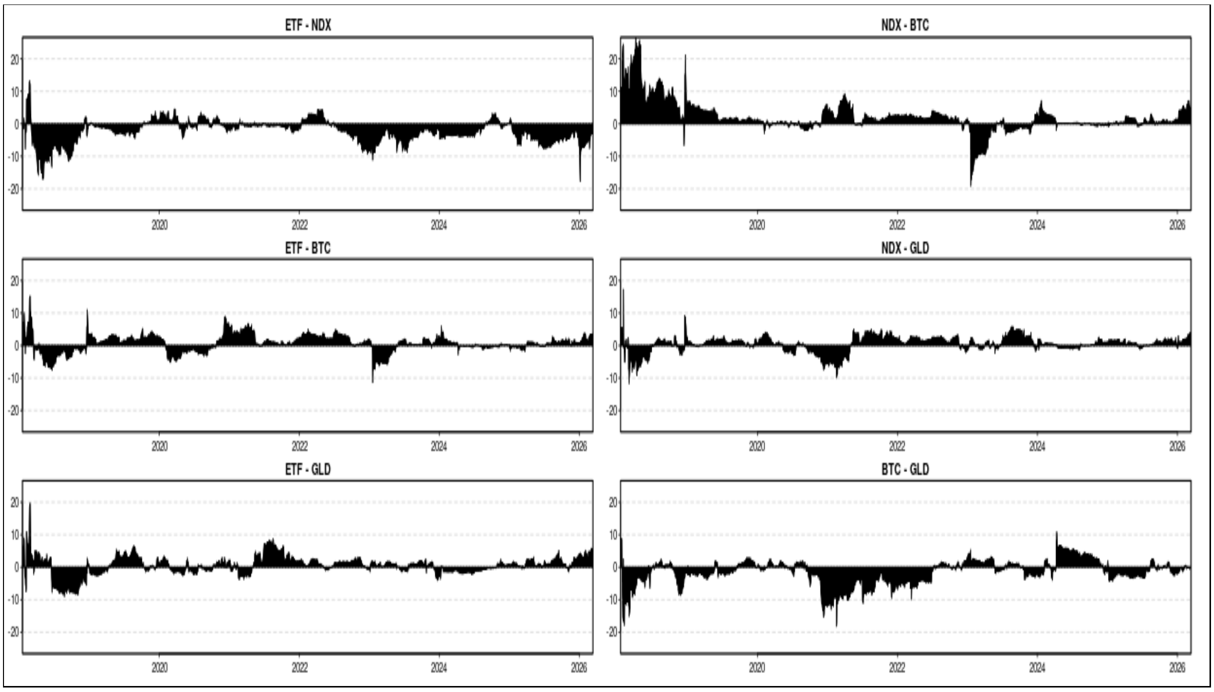
Upon examining Figure 2, it is observed that the overall level of dynamic connectedness exhibits significant fluctuations over time. Notably, the connectedness level was quite high at the beginning of the sample period (approximately in the 60–70% range) and subsequently entered a distinct downward trend. Around 2020, connectedness declined to low levels, then resumed an upward trend, fluctuating at moderate levels during the 2021–2022 period. In 2023 and the subsequent periods, the connectedness level appears to exhibit a relatively more stable structure, albeit with periodic spikes. Sudden spikes observed particularly during certain periods indicate that macroeconomic and geopolitical shocks in financial markets temporarily increase market linkages. Overall, the graph reveals that the spread of volatility across financial markets is not static; rather, it exhibits a dynamic structure that changes over time and increases particularly during periods of uncertainty.

Figure 3: Directional Correlation Charts



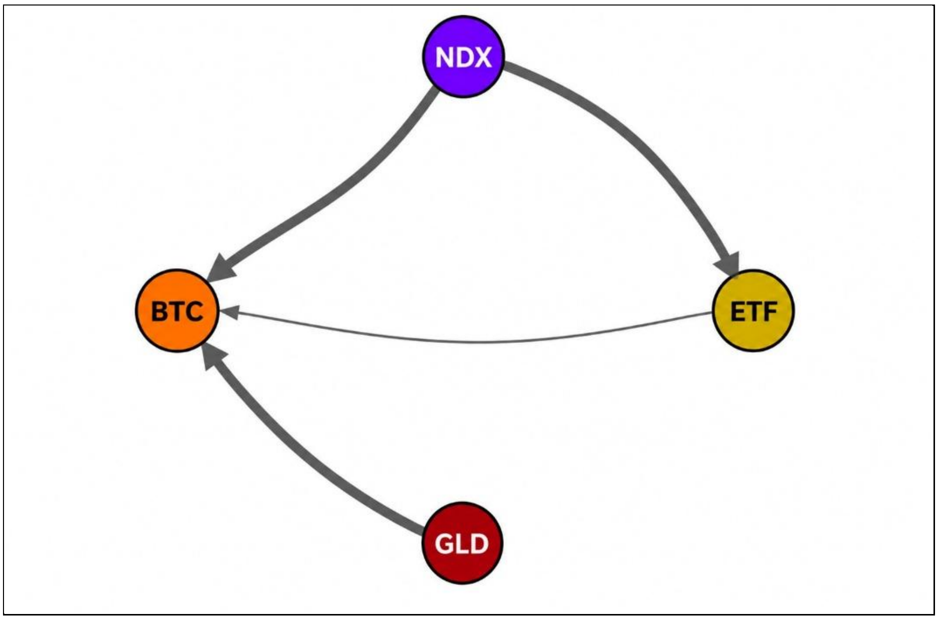
An examination of the directional correlation results in Figure 3 reveals that the markets under study shift between the roles of volatility transmitter and receiver over time. It is noteworthy that the FinTech ETF series was a net volatility absorber, particularly at the beginning of the sample period, and exhibited a more balanced structure in subsequent periods. The Bitcoin market, on the other hand, periodically assumed both strong volatility-spreading and absorbing roles, and notably became a significant source of shock in the system with sharp positive spikes during specific periods. It is understood that the Nasdaq index generally exhibits a more stable structure and is mostly in a limited volatility-spreading position. The gold market, on the other hand, largely follows a neutral trend, though it has been observed to assume a volatility-spreading role during certain periods, particularly when uncertainty increases. Overall, Figure 4 demonstrates that the directional interconnectivity between markets changes over time and that shocks in the financial system spread across different asset classes during different periods.

Figure 4: Net Bidirectional Correlation Plots



The net bidirectional correlation results presented in Figure 4 clearly demonstrate that both the direction and magnitude of volatility transmission between the examined market pairs have changed significantly over time. When examining the ETF–NDX relationship, a strong and occasionally shifting interaction between these two markets is observed; in some periods, the Nasdaq acts as the dominant volatility transmitter, while in others, the FinTech market becomes relatively more influential. The NDX–BTC relationship is particularly noteworthy: while the Nasdaq exerts a strong influence on Bitcoin during certain periods, in other segments, Bitcoin is observed to become a source of volatility through sudden and sharp movements. In the ETF–BTC and BTC–GLD pairs, Bitcoin occasionally shifts into a clearly dominant volatility-driving role; however, this effect is not consistent and exhibits a highly fluctuating pattern. This confirms that cryptocurrency markets, by their very nature, are characterized by high volatility. In the ETF–GLD and NDX–GLD relationships, it is observed that gold generally behaves as a more stable asset with limited interaction, though it can temporarily act as a source of volatility, particularly during periods of uncertainty and risk aversion. Overall, the graph indicates that the connections between market pairs do not have a fixed structure; rather, they constantly shift direction in response to macroeconomic developments, financial shocks, and geopolitical risks. These findings reveal that the risk transmission mechanism in the financial system is not one-way but rather two-way and dynamic, and that different markets can play a dominant role in the system during different periods.

Figure 5: Network Analysis of Volatility Propagation



Upon examining the network structure related to volatility propagation presented in Figure 5, it is observed that the relationships between financial markets exhibit a directed and asymmetric character. In the network structure, nodes represent the relevant markets, while arrows indicate the direction of volatility propagation and their thicknesses indicate the intensity of the propagation. In this context, it is noteworthy that the Nasdaq (NDX) and FinTech ETF markets occupy a central position within the network. In particular, a strong flow of volatility is observed from the Nasdaq to FinTech ETFs, indicating that technology-heavy stock markets have a decisive influence on FinTech markets. Similarly, there is a bidirectional relationship between FinTech ETFs and Bitcoin, though this relationship appears to be relatively weaker.

Bitcoin appears to serve as a key hub within its network structure and exhibits a mechanism that absorbs volatility originating from other markets. The observed flow of volatility from the gold (GLD) market toward Bitcoin suggests that safe-haven assets may interact with cryptocurrency markets during certain periods. In contrast, it is noteworthy that the gold market occupies a more peripheral position within the overall network structure and plays a limited role in volatility propagation. In general, network analysis reveals that volatility spillover in the financial system is concentrated around specific hubs, with the Nasdaq and FinTech markets playing a dominant role in this system; it also shows that Bitcoin functions more as a conduit that absorbs volatility and, at times, redistributes it.

6. Discussion

The findings of this study reveal a significant and time-varying volatility spillover between FinTech markets and traditional and alternative financial markets. In particular, the strong mutual interaction between the FinTech ETF and the Nasdaq index indicates that technology-focused financial assets are highly integrated. This finding suggests that, since FinTech companies operate largely within the technology ecosystem, these markets behave more as an extension of technology-heavy stock markets rather than as independent entities. This result is consistent with theoretical expectations that financial innovation enhances market integration.

An important contribution of this study is that it moves beyond the conventional question of whether financial markets are interconnected. While previous research has already documented various forms of connectedness among financial assets, the present study focuses on the specific role played by FinTech within this network. The findings suggest that FinTech should not be viewed merely as a technological subsegment of equity markets; rather, it functions as an active component of the broader financial system whose connectedness characteristics evolve across market regimes and periods of uncertainty.

From the perspective of the study’s hypotheses, the empirical findings provide substantial support for the proposed expectations. H1, which predicts significant volatility connectedness between FinTech and equity markets, is strongly supported by the results reported in Table 3 and further illustrated in Figures 4 and 5, where FinTech and Nasdaq exhibit pronounced volatility transmission patterns. H2, concerning the interaction between FinTech and Bitcoin markets, is also supported, as evidenced by the connectedness measures presented in Table

3 and the time-varying directional spillovers shown in Figures 4 and 5. In contrast, H3, which proposes a volatility linkage between FinTech and gold markets, receives only partial support. Although the results indicate a statistically meaningful relationship, the magnitude of the spillovers remains relatively limited compared with those observed between FinTech, Nasdaq, and Bitcoin. Finally, H4 is strongly confirmed by the dynamic connectedness patterns displayed in Figure 3, which demonstrate that volatility transmission evolves considerably over time and responds to changing market conditions. Overall, the evidence presented in the tables and figures provides consistent answers to the study's research questions regarding the position of FinTech within the connectedness network and the changing role of Bitcoin across different market environments.

The findings are largely consistent with the existing literature. In particular, results are consistent with the connectedness framework developed by Diebold and Yılmaz (2012, 2014) and Antonakakis et al. (2020), which demonstrates that volatility spillover has a directional and time-varying structure. Findings regarding the interaction between FinTech and traditional financial markets are consistent with the results presented by Chen et al., (2022) and Henriques et al., (2025). The fact that Bitcoin is a source of strong volatility from time to time supports the high volatility and potential for systemic impact highlighted by Corbet et al., (2018). The fact that the gold market exhibits more stable and limited interactions is consistent with the findings of Baur and McDermott (2010) and Bouri et al. (2020).

However, the results suggest that the structure of financial market connectedness is not fixed and evolves in response to changing market conditions. Rather than merely confirming the existence of interconnectedness, the findings identify Nasdaq as the dominant node within the volatility transmission network, reflecting its central role in shaping risk dynamics across FinTech, cryptocurrency, and gold markets. In contrast, Bitcoin exhibits a conditional role, alternating between volatility transmitter and receiver depending on prevailing market conditions and uncertainty regimes. These patterns indicate that the connectedness structure is influenced not only by overall market integration but also by the changing functions of individual assets within the financial system. Furthermore, the fluctuations observed during the latter part of the sample period suggest that episodes of elevated uncertainty strengthen cross-market linkages. Although geopolitical risk is not explicitly included as a separate variable in the model, the sample period encompasses several major geopolitical events, allowing the analysis to capture changes in market connectedness during periods of heightened uncertainty.

From an investment perspective, the time-varying nature of connectedness suggests that diversification benefits are not constant over time. During periods of heightened uncertainty, the strengthening of cross-market linkages may reduce the effectiveness of portfolio diversification as asset classes become more synchronized. Similarly, assets that are often considered hedging instruments, such as gold and, to some extent, Bitcoin, may exhibit changing roles depending on prevailing market conditions. Consequently, investors should adopt dynamic portfolio management strategies rather than relying on static assumptions regarding diversification and hedging effectiveness.

7. Conclusions and Policy Recommendations

This study has revealed important findings regarding the structure of interconnectedness within the financial system by analyzing the dynamic volatility spillover between FinTech markets and traditional and alternative financial markets. The results indicate that there is a significant interaction among FinTech, stock, Bitcoin, and gold markets, and that this interaction changes over time. In particular, the strong link between FinTech and Nasdaq markets highlights that technology-focused financial assets tend to move in tandem, while Bitcoin has emerged as a significant source of volatility at certain times, and gold has assumed a more limited yet stable role.

This study makes three key contributions to the literature. First, by examining FinTech markets alongside stock, cryptocurrency, and gold markets, it offers a more comprehensive analytical framework. Second, by employing the TVP-VAR approach, it reveals the dynamic structure of volatility propagation over time, moving beyond static analyses. Third, by extending the analysis period through March 2026, the study also covers the post-pandemic period and the effects of rising geopolitical risks on financial markets. In this regard, the study expands upon existing research in the literature using an updated dataset. The study also contributes conceptually by identifying the position of FinTech within the volatility transmission network rather than merely documenting the existence of market connectedness.

The findings provide important implications for investors. The time-varying nature of connectedness suggests that portfolio diversification strategies should be designed dynamically rather than relying on static assumptions. The findings indicate that diversification benefits may diminish during periods of elevated connectedness, particularly when Nasdaq-driven volatility propagates across the financial system. Therefore, assets traditionally regarded as hedges should not be assumed to provide constant protection across all market environments. In this context, investors should carefully monitor changes in market connectedness when constructing portfolios and managing risk. While Bitcoin may act as a transmitter or receiver of volatility depending on market conditions, gold appears to offer relatively more stable diversification benefits, although its effectiveness is not uniform across all periods.

From the perspective of policymakers, the increasing interconnectedness of financial markets stands out as a factor that could accelerate the spread of systemic risk. In particular, the increasing integration of FinTech markets into the financial system enhances these markets' capacity to transmit potential shocks to other markets. Therefore, regulatory authorities must assess the FinTech ecosystem not only from an innovation perspective but also within the framework of financial stability. Furthermore, the strengthening of the links between cryptocurrency markets and the financial system underscores the importance of regulations targeting these markets. Monitoring the spread of volatility across financial markets and developing early warning systems are of critical importance for managing systemic risks.

This study has certain limitations. The fact that the analysis is limited to only four specific financial assets may restrict the generalizability of the findings. Furthermore, the method used is based on linear relationships and may not fully reflect the nonlinear interactions between financial markets. In addition, the analysis is limited to daily data, and data at different frequencies may yield different results.

Future research may extend the analysis by incorporating additional asset classes and employing nonlinear methodologies to capture more complex patterns of financial connectedness. Furthermore, the inclusion of investor sentiment indicators, geopolitical risk measures, and macroeconomic variables may provide a deeper understanding of the factors driving volatility transmission across markets. Future studies may also assess the robustness of the findings using alternative FinTech proxies, different model specifications, and complementary connectedness frameworks, thereby enhancing the stability, generalizability, and policy relevance of the results.

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