

Quantifying Crypto-Equity Interconnectedness Using RStudio: A Sectoral Network Analysis

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ABSTRACT

As traditional equity markets continue to integrate with digital assets, understanding the connectedness between these two becomes a must. This study, in the context of sectoral indices of the Banking and Information Technology in India, aims to evaluate how digital assets are connected to stock indices. It also points out the importance of diversification and hedging. The main goal was to measure the extent of dynamically changing dependencies in interlinkages and at the same time find the best digital asset pairings that would help in risk mitigation of the portfolio.

The study covers daily returns for the period of April 2022 to March 2025. It uses two econometric models, TVP-VAR and DCC-GARCH, to conduct the analysis in RStudio. The findings indicate that Ethereum and Bitcoin are the biggest sources of volatility, while stablecoins, like USDC, are almost perfect hedging instruments. Sectoral indices as net shock receivers are showing their exposure. The main takeaway is that digital assets facilitate diversification and hedging, thus leading investors in the right direction in the context of the Indian economy.

Keywords: RStudio, Connectedness, Digital Assets, Hedging, Diversification

INTRODUCTION

The Indian stock market, as indicated by the Bombay Stock Exchange (BSE) and National Stock Exchange (NSE), has transformed into one of the largest and most rapid-growing equity markets globally and recorded a market capitalization milestone of USD 4.5 trillion by early 2025. The speed with which this growth took place reflects a combination of factors such as investor confidence, robust corporate earnings, an increasing number of retail investors, and the continuation of reforms by regulatory authorities like the Securities and Exchange Board of India (SEBI). The Indian equity market is not only a major source of capital for the country providing funds for innovation, infrastructure, and industrial growth but also serves as an indicator of the economic condition of the country and investor sentiments.

Among the industries listed on the Indian stock exchanges, the two sectors that have been the major drivers of both the stock market and the economy are Banking and Information Technology (IT). The Banking sector offers the financial backbone of the country and this includes commercial banks, non-banking financial companies (NBFCs), fintech companies, and insurance firms. The Reserve Bank of India's Financial Stability Report (Dec 2024) states that the sector experienced a credit growth of more than 15% year-over-year, which was mainly driven by the growth of retail credit, MSME lending, and the expansion of the fintech sector through collaborative ventures.

One of the major contributors to financial inclusion has been digital technology through the implementation of steps such as UPI, Aadhaar-based services, and the creation of Digital Public

Infrastructure (DPI), all of which have propelled India to reach over 100 billion digital real-time transactions in the year 2024 alone. Meanwhile, the IT sector is still one of the major pillars of India's global competitiveness and has contributed to the country with more than USD 250 billion in export revenues for the fiscal year 2023-24 while employing millions in the fields of engineering, consulting, and emerging technology industries.

Through the adoption of artificial intelligence, blockchain solutions, cybersecurity services, and cloud transformation, the IT industry has not only maintained its foreign exchange revenue role but has also significantly contributed to the technology-based innovations within the Indian economic system.

Over the last few years, a parallel financial system comprising digital assets, including cryptocurrencies, decentralized finance (DeFi) tokens, and non-fungible tokens (NFTs), has rapidly risen alongside traditional finance. Digital assets represent a complete overhaul of traditional financial systems driven by the internet, with the addition of borderless value transfer, peer-to-peer lending, smart contract automation, and digital ownership as some of the features provided.

On the other hand, cryptocurrencies like Bitcoin and Ethereum are built on decentralized blockchain platforms that are free from any central authority, while DeFi protocols like AAVE and Uniswap offer decentralized lending, liquidity provision, and token swapping services. NFTs-related platforms like Decentraland and Sandbox create the virtual real estate, in-game economies, and art markets. At the same time, stablecoins, for example, Tether (USDT) and USD Coin (USDC) offer price stability and are gradually becoming the preferred choice for cross-border settlements. These digital tokens, while not being listed on traditional stock exchanges, have substantially influenced market trends, investment habits, and even policy discussion.

Between April 2022 and March 2025 — the period under consideration — the global digital asset market has seen a series of major transformations. After a bear market period post-2022 followed by recovery, there has been a noticeable increase in demand from institutional investors and a gradual establishment of regulatory frameworks, all of which have kept the digital asset market significantly open to investor interest despite its high volatility. In India where the number of people holding some kind of cryptocurrency is said to be more than 30 million, the government has adopted a cautious yet progressive attitude. Examples of such movement from hesitancy to regulatory engagement are the publication of the Digital India Act draft (2023), taxation measures through TDS provisions, and sandbox experiments in the GIFT City IFSC for the regulated crypto platforms. These incidents call for an evaluation of the ways in which digital assets align with traditional sectors in the changing financial landscape.

This study, particularly focusing on IT and Banking, attempts to unveil the level of interaction as well as the probability of interdependence between the digital assets and the equity sectoral indices in India. One reason for choosing the sectors could be that not only do the Banking and IT sectors together constitute a significant portion of the stock market capitalization and investor portfolios, but they also have an increasing overlap in the field of digital asset innovation. For instance, while banks are looking into blockchain for payment settlements and smart contract-based lending, IT firms are vigorously participating in the creation of digital finance products and the integration of DeFi-related infrastructure in the enterprise systems. Consequently, the examination of the conversations between these industries and the carefully selected digital

assets is highly relevant to portfolio diversification, risk management, and strategic investment planning.

For this study, the primary criteria for the selection of the fifteen digital assets included were market appropriateness, adoption, liquidity, and representational variety within the digital finance space. These assets are: AAVE, Ape Coin, AVAX, Bitcoin, Binance Coin (BNB), CRV, Decentraland, Ethereum, LINK, Sandbox, Tezos, Theta Network, Tether, UNI, and USDC. The selections made ensure equal weighting across the different groups of cryptocurrencies, stablecoins, DeFi protocols, and NFT platforms. The mentioned digital assets are volatile, decentralized, and based on the principles of innovation, which are at odds with the conventional metrics and risk-return profiles of established equity spaces such as IT and Banking.

Equities and digital assets are most surely interconnected, asset classes are not independent anymore. The markets are getting more interlinked, and a shock to one asset could lead to spillovers in the other markets. Investors, portfolio managers, and institutions should figure out if digital assets and sectoral indices move in sync or opposite directions during risk phases or whether they provide diversification benefits. Furthermore, the identification of digital assets as net transmitters or receivers of shocks in market fluctuations allows for their use in portfolio hedging strategies. For instance, if Bitcoin or Ethereum were to develop a negative correlation with the IT or Banking sectors during downturns, they would become effective hedging instruments. In contrast, if high positive correlations are discovered, it would imply a convergence of investor sentiment and market risk.

To rigorously investigate these topics, this work utilizes sophisticated econometric models — Time Varying Parameter Vector Autoregression (TVP-VAR) to capture dynamic connectedness and Dynamic Conditional Correlation (DCC-GARCH) to identify optimum hedge ratios and volatility spillovers. The models enable studies of how digital asset-equity sector relations reform over time rather than the assumption of a fixed relation. Besides the impact of the results on the academic research of cross-asset interconnectedness, the findings bear a lot of practical significance for modern portfolio construction, particularly in emerging markets like India.

The necessity of re-evaluating risk-return relations across these domains arises out of the rapidly changing financial environment where old institutions are going for blockchain, and investors are shifting their capitals from equities and debt to crypto-assets. A study based on the latest market data ranging from April 2022 to March 2025, aims at unravelling the intricacies of the interface between India's IT and Banking sectors and an array of digital assets. It is essentially an effort to bridge the gap between conventional financial research and the evolving investment trends of modern times.

REVIEW OF LITERATURE

Yan Chen (2018) studied the potential impact of blockchain tokens on entrepreneurship and innovation, highlighting their capacity to democratize both domains. Through a theoretical analysis or review of existing literature, the author elucidated that blockchain tokens offer entrepreneurs novel avenues for fundraising and stakeholder engagement, potentially revolutionizing traditional entrepreneurial processes. Furthermore, these tokens provide innovators with a unique approach to developing, deploying, and diffusing decentralized applications, thereby democratizing innovation processes. Chen underscored that the emergence of blockchain technology and tokens has instigated a new wave of innovation, which holds

promise for significant transformations in the realms of entrepreneurship and innovation, potentially reshaping conventional paradigms and fostering greater inclusivity and accessibility in these domains.

Chang et al. (2020) explored how financial services should respond to blockchain technology and manage knowledge sharing in a structured manner, aiming to contribute to the literature on the current entrepreneurial finance landscape for blockchain. Their research suggests that proactive responses to blockchain technology are crucial for financial services institutions to remain competitive and relevant in the rapidly evolving landscape, with structured knowledge sharing mechanisms deemed essential for facilitating effective integration. This underscores the importance of understanding and adapting to blockchain technology within the entrepreneurial finance context, with implications for both theory and practice in the field.

Meegan (2020) identifies twelve key non-financial risks associated with decentralized finance (DeFi) on the Ethereum blockchain. Despite the pervasive innovation in DeFi, the definition of risks about this innovation remains lacking. The paper emphasizes the importance of investors being informed about both financial and non-financial risks to make informed decisions regarding risk assumption for a given return.

Qin et al. (2021) investigate existing liquidation designs within lending protocols and their implications. They observe that while these designs effectively incentivize liquidators, they often result in selling excessive amounts of discounted collateral at the expense of borrowers. The authors quantify various risks faced by liquidation participants and assess the instabilities present in current lending protocols. Furthermore, they propose an optimal strategy aimed at enhancing liquidators' profitability, although this may potentially exacerbate losses for borrowers. This research sheds light on the dynamics of liquidation mechanisms within decentralized finance lending protocols, offering insights into risk management and potential areas for improvement in the design of such systems.

Chu et al. (2021) delve into the dynamic volume-return relationship of the five largest decentralized finance (DeFi) tokens to gain insights into this relationship, considering the parallels with cryptocurrencies and the potential advantages for traders and practitioners. The study aims to provide a deeper understanding of how trading volume influences returns in the context of DeFi tokens, offering valuable insights for market participants and practitioners navigating the rapidly evolving landscape of decentralized finance.

Bartoletti et al. (2021) argue for the applicability of formal methods theories, techniques, and tools in understanding, specifying, and analyzing decentralized finance (DeFi) systems. They summarize their initial efforts towards developing a theory of DeFi based on formal methods in the paper and provide an overview of the open challenges and opportunities for employing formal methods in DeFi. This research contributes to laying the groundwork for leveraging formal methods in the analysis and development of DeFi systems, highlighting the potential for enhanced understanding and robustness in decentralized financial ecosystems.

Cumming et al. (2022) compiled a unique dataset merging blockchain-based crowdfunding (or Initial Coin Offering, ICO) data with proprietary crowdfunding (CF) performance data to investigate the performance of CF-backed startup ventures. Their findings reveal that CF-backed ventures tend to receive higher ICO valuations, outperform their peers in the long run, and benefit from token price appreciation around CF investment disclosure in the secondary market. This

research provides valuable insights into the dynamics of blockchain-based crowdfunding and its implications for startup venture performance.

Corbet et al. (2022) conduct a comparative assessment of the drivers influencing decentralized finance (DeFi) token prices. Their study examines the impact and interconnectedness among Bitcoin (representing a cryptocurrency asset-class leader), Ethereum (serving as a platform for DeFi), and Google Trends (reflecting investor attention). The authors find varying causal linkages between Bitcoin or Ethereum and DeFi tokens, with these linkages primarily observable during bear markets. This research contributes to understanding the dynamics of DeFi token pricing and the relationships between major cryptocurrencies and investor sentiment, particularly during different market conditions.

Karim et al. (2022) examine the impact of the high volatility in blockchain markets on investor behavior and market dynamics, focusing on diversification avenues such as NonFungible Tokens (NFTs), Decentralized Finance (DeFi) Tokens, and cryptocurrencies. Their study sheds light on the growing interest among investors and market participants in exploring alternative investment options within the blockchain ecosystem as a response to market volatility. By analyzing the trends and dynamics of NFTs, DeFi Tokens, and cryptocurrencies, the authors contribute to understanding the evolving landscape of blockchain investments and the strategies adopted by investors to mitigate risks and enhance portfolio diversification. This research provides valuable insights for market participants seeking to navigate the complexities of blockchain markets and optimize their investment portfolios in response to changing market conditions.

Yousaf and Yarovaya (2022) investigate both static and time-varying herding behavior across three distinct cryptocurrency classes: 'conventional' cryptocurrencies, nonfungible tokens (NFTs), and decentralized finance (DeFi) assets, focusing on the context of the 2021 cryptocurrency bubble. Their study provides insights into the dynamics of herding behavior among investors within different segments of the cryptocurrency market during periods of heightened volatility and speculative activity. By analyzing the extent and nature of herding behavior across these cryptocurrency classes, the authors contribute to our understanding of investor sentiment and collective decision-making processes in cryptocurrency markets. This research offers valuable implications for policymakers, regulators, and investors seeking to navigate the complexities of cryptocurrency markets and mitigate associated risks.

Aspembitova and Bentley (2022) elucidate the mechanisms underlying decentralized exchanges and introduce an algorithmic model designed to facilitate the safe design of decentralized oracles while adjusting critical parameters. They propose that comprehension and implementation of the model's logic can potentially mitigate the occurrence of price manipulation attacks, which are among the most common incident types in decentralized finance (DeFi). This contribution provides valuable insights into enhancing the security and reliability of DeFi platforms, offering practical solutions to address prevalent vulnerabilities and risks associated with price manipulation.

Shaidullin and Komarov (2022) adopt a leading approach to investigate the problem, focusing on analyzing the econometric and financial parameters of banks offering peer-to-peer (P2P) lending services, using the Lending Club company as an example. They examine the functioning algorithm of smart contracts in P2P lending and adapt a methodology for calculating credit risk specifically for P2P lending. The study reveals the main parameters influencing credit risk and

computes both significant and insignificant indicators of the probability of default. Furthermore, they propose an improved methodology for assessing borrower quality based on a scoring model, which is applied within the blockchain environment. This research contributes to a deeper understanding of credit risk assessment in P2P lending and offers practical insights for improving borrower evaluation within the blockchain context.

Metelski and Sobieraj (2022) aim to evaluate relevant performance metrics of decentralized finance (DeFi) protocols and their impact on protocol valuations through a comprehensive analysis employing various scientific methods. Specifically, the study investigates how DeFi protocol valuations are influenced by factors such as total value locked, protocol revenue, total revenue, gross merchandise volume, and inflation factor. The analysis focuses on 30 selected protocols representing three different classes of DeFi, namely decentralized exchanges, lending protocols, and asset management. The study employs quantitative methods, including Granger causality tests and fixed effects panel regression models, to assess the relationships between protocol valuations and performance measures.

Li et al. (2022) systematically analyze vulnerabilities associated with decentralized finance (DeFi) on the Ethereum blockchain at multiple levels. They then investigate real-world attacks within the DeFi ecosystem. Finally, the paper summarizes achievements in DeFi optimization and suggests future directions for research and development in the field. This research contributes to understanding the security landscape of DeFi on Ethereum and provides insights into potential areas for improvement and innovation in the optimization of DeFi protocols.

Yousaf and Yarovaya (2022) analyze return and volatility transmission among nonfungible tokens (NFTs), decentralized finance (DeFi) assets, and traditional assets (oil, gold, Bitcoin, and S&P 500) using the TVP-VAR framework. Results suggest weak static return and volatility spillovers between NFTs, DeFi assets, and selected markets, indicating their relative decoupling from traditional assets. Bitcoin, oil, and some NFTs/DeFi assets act as net transmitters of spillovers. Dynamic connectedness peaks during the initial COVID-19 pandemic phase and the 2021 cryptocurrency bubble. The study computes optimal weights and hedge ratios, recommending inclusion of NFTs and DeFi assets in portfolios with gold, oil, and stocks for diversification benefits.

Faura et al. (2023) evaluate 21 smart contract analysis tools, focusing on six: Slither, Mythril, DerScanner, Manticore, Oyente, and Securify v2. Using a dataset of 28 vulnerable and 16 healthy smart contracts, they assess the tools' efficiency and accuracy. Despite Slither receiving the highest rating, none of the tools currently provide reliable assistance to decentralized finance (DeFi) users due to issues like complexity or lack of reliability. This highlights ongoing challenges in smart contract security for DeFi platforms, urging further advancements in analysis tools.

Kitzler et al. (2023) propose an algorithm designed to decompose a protocol call into a nested set of building blocks, potentially forming part of other decentralized finance (DeFi) protocols. Additionally, they offer visualizations of composition trees to facilitate deeper inspections. The authors present a comprehensive overview of DeFi compositions by extracting and flattening the entire nested building block structure across multiple DeFi protocols. Moreover, to showcase the practicality of their approach, they present a case study inspired by the recent collapse of the UST stablecoin in the Terra ecosystem. This research contributes to the understanding of DeFi protocols and provides insights into their structural complexities and interconnections.

Green et al. (2023) propose a decentralized finance (DeFi) survival analysis approach aimed at discovering and characterizing user behavior and risks in lending protocols. They demonstrate the process of gathering and preparing DeFi transaction data for survival analysis, with a focus on transactions within AAVE, one of the largest lending protocols. The authors develop a DeFi survival analysis pipeline, which involves preparing transaction data for survival analysis through the selection of different index events (or transactions) and associated outcome events. This research contributes to understanding user behavior and risks within DeFi lending protocols, offering insights that can inform risk management strategies in decentralized finance.

Chaliasos et al. (2023) underscore the importance of developing specialized tools tailored to the unique requirements and expectations of developers and auditors within the decentralized finance (DeFi) ecosystem. Their study emphasizes the necessity for continuous advancements in security tools to address the constantly evolving challenges faced by DeFi platforms. By highlighting the need for specialized and robust security measures, the authors contribute to enhancing the resilience and reliability of DeFi protocols. These findings have implications for developers, auditors, and stakeholders in the DeFi space, emphasizing the importance of proactive measures to safeguard against potential vulnerabilities and threats.

Ahuja et al. (2023) provide a comprehensive understanding of decentralized finance (DeFi), its evolution, applications, and adoption. They identify the opportunities presented by DeFi, contrasting it with the traditional Centralized Financial (CeFi) system, highlighting benefits such as financial inclusion, transparency, and programmable money. The study emphasizes the potential of DeFi applications in areas like decentralized lending, decentralized exchanges, and yield farming, showcasing them as innovative and promising avenues within the DeFi space. Additionally, the paper explores the intricate challenges and inherent risks associated with the adoption of DeFi applications, providing insights into the hype, fear, and apprehensions among governments and the public regarding its adoption.

Gudgeon and Lewis (2023) present new evidence on the interconnected and fragile nature of decentralized finance (DeFi) protocols and propose an approach to mitigate risk in DeFi through redundancy. The thesis introduces novel methods for modeling and measuring financial risk in DeFi, with a particular focus on smart contract risk, and develops strategies to mitigate such risks.

Turillazzi et al. (2023) offer a systematic and critical review of the literature on the risks associated with decentralized finance (DeFi), providing a framework for further discussion on policy and regulatory instruments. The article aims to contribute to the debate on the governance of DeFi by highlighting and clarifying foundational elements of the DeFi ecosystem and encouraging additional discussions on the topic.

Zheng et al. (2023) propose a framework for exploring the heterogeneous decentralized markets in decentralized finance (DeFi) and non-fungible tokens (NFTs) on the Ethereum blockchain. Utilizing this framework, they analyze data from 21 exchange and lending markets in DeFi and NFT, comprising a total of 184,173,656 records. The study investigates the activity, profitability, and security aspects of these markets, providing several quantitative findings to assist market users. Additionally, the authors release datasets and codes, contributing to transparency and reproducibility in DeFi and NFT research.

Su et al. (2023) present a summary of the Token Leaking vulnerability in decentralized finance (DeFi) applications, which allows individuals to abnormally withdraw funds exceeding their deposits. Given the substantial funds involved in DeFi applications, safeguarding them against

token-leaking vulnerabilities is essential. The authors highlight existing limitations of tools in addressing this vulnerability and propose DeFiWarder, a solution that traces on-chain transactions and protects DeFi applications from Token Leaking vulnerabilities. This research addresses a critical security concern in DeFi and offers a practical tool for mitigating associated risks, contributing to the overall security and resilience of DeFi ecosystems.

Yousaf et al. (2023) examine the dynamic interconnectedness between decentralized finance (DeFi) assets and sector stock markets during the COVID-19 pandemic. Utilizing the TVP-VAR and DCC-GARCH models, they identify fluctuating connectivity patterns and optimal hedge ratios. Results suggest that while static connectedness varies slightly across sectors, dynamic connectedness changes notably post-pandemic declaration. Certain sectors act as net transmitters, while others receive spillovers.

STATEMENT OF THE PROBLEM

Today backdrops, there is still a big question how these new digital financial instruments, including cryptocurrencies, DeFi tokens, and NFTs, interact with the old equity stock markets. Hence, while worldwide markets have already opened the door wide to these instruments, making portfolios more diversified, in India hardly any empirical research has been done to shed light on such relations. Therefore, this issue is more prominent in such sectors like banking and IT which, apart from being the pillars of the economy, are very tightly interwoven with the digital innovations via fintech, blockchain, and digital transformation initiatives.

This study is about bridging the gap by looking at interactions between digital assets and sectoral indices (Banking and IT) in the Indian market concerning return co-movements, volatility spillovers, and hedging possibilities. It looks at how these financial systems affect each other and how investors could be better off if they incorporate digital assets into their traditional portfolios amid the fast-changing market scenario from April 2022 to March 2025.

OBJECTIVES

- To assess the degree of interconnectedness between digital assets and Indian equity sectoral indices (Banking and IT), determining how movements in one asset class impact the other and uncovering potential diversification benefits.
- To evaluate the hedging effectiveness of individual digital assets against sectoral equity indices (Banking and IT), with the aim of identifying optimal risk mitigation strategies and enhancing portfolio resilience in the Indian market context.

HYPOTHESES

Objective 1

- **H₀₁** – There is no interconnectedness among the variables studied, i.e., between the selected digital assets and the equity sectoral indices (Banking and IT).
- **H₁₁** – There is interconnectedness among the variables studied, i.e., between the selected digital assets and the equity sectoral indices (Banking and IT).

Objective 2

- **H₀₂** – As there is no interconnectedness among the variables, digital assets do not provide any benefit in terms of hedging.

- H_{12} – As there is interconnectedness among the variables, digital assets do provide benefits in terms of hedging.

DATA

The present study uses daily data for the period **1st April 2022 to 31st March 2025**, which is a highly relevant timeframe due to the resurgence of global crypto activity, rising retail participation in India, macroeconomic volatility, and policy advancements such as the proposed Digital India Act and India's regulatory sandbox initiatives. The dataset includes 15 carefully selected digital assets across major categories:

- **NFTs:** Decentraland (MANA), The Sandbox (SAND), Ape Coin, Theta Network (THETA), Tezos (XTZ)
- **DeFi Tokens:** Chainlink (LINK), Aave (AAVE), Avalanche (AVAX), Uniswap (UNI), Curve Finance (CRV)
- **Cryptocurrencies:** Bitcoin (BTC), Ethereum (ETH), Binance Coin (BNB), Tether (USDT), USD Coin (USDC)

On the traditional finance side, the dataset includes two key Indian **sectoral indices**:

- **Banking Sector Index** (e.g., Nifty Bank)
- **Information Technology Sector Index** (e.g., Nifty IT)

These sectors have been chosen as a result of their significance to the overall economy, their technological connection with digital finance, and the fact that they are highly visible to investors. Daily closing prices were utilized to calculate returns and study co-movements.

Information on digital assets was obtained from trustworthy platforms like CoinMarketCap.com and CoinGecko, whereas the data for sectoral equity indices were taken from Investing.com and the official websites of stock exchanges (for instance, NSE India). The implementation of daily frequency is a way to guarantee that it will be possible to find very small changes in volatility and very dynamic relationships between asset classes.

METHODOLOGY-

We use a Time-Varying Parameter Vector Autoregressive (TVP-VAR) model to study the interdependence between decentralized finance (DeFi) and the US sectoral equity markets. This model by itself, was originally presented by Koop and Korobilis (2014), while our methodology for measuring connectedness is based on the work of Diebold and Yilmaz (2012, 2014). Thus, the components of connectedness are total connectedness, pairwise connectedness, connectedness from the system to each market, connectedness from each market to the system, and net connectedness, which we can estimate with this model.

The TVP-VAR model has a feature that is very helpful in our case: it allows the variances to be time-dependent and estimated through the Kalman filter with decay factors. In this way, the problem of arbitrarily chosen rolling window sizes, which are responsible for the parameter values being either very volatile or flattening and the loss of observations, is avoided (Antonakakis and Gabauer, 2017; Gabauer and Gupta, 2018; Korobilis and Yilmaz, 2018). Based on the Bayesian information criterion (BIC), we have decided to use the TVP-VAR (1) model that can be represented as follows:

$$Y_t = \Phi_t Y_{t-1} + u_t; u_t \setminus \Omega_{t-1} \sim N(0, S_t) \quad (1)$$

$$\Phi_t = \Phi_t 1 + v_t; v_t \setminus \Omega_{t-1} \sim N(0, R_t) \quad (2)$$

where Y_t is a $(N \times 1)$ vector and Ω_{t-1} is the set of information available at $t - 1$. Y_{t-1} stands for a $(N_p \times 1)$ lagged vector of the dependent variables. Φ is an $(N \times N_p)$ matrix of coefficients, which are assumed to be time - varying. u_t and v_t are two $(N \times 1)$ vectors of the error terms. S_t and R_t represent $(N \times N)$ and $(N_p \times N_p)$ time - varying variance - covariance matrices of the error terms u_t and v_t , respectively.

After estimating the TVP-VAR parameters, we are required to convert the TVP-VAR to its vector moving average TVP-VMA in the following step. We rearrange Eq. (1) in the following manner:

$$Y_t = \Phi_t Y_{t-1} + u_t = A_t u_t \tag{3}$$

where $A_t = (A_{1,t}, A_{2,t}, \dots, A_{p,t})'$ is an $(N \times N)$ matrix of parameters verifying $A_{i,t} = \sum_{k=1}^p \Phi_{ik,t} A_{k,t}$ otherwise. Thus, the generalized impulse response function (GIRF) defines the responses of all variables following a shock in variable i . The pairwise directional connectedness from j to i is presented by the GFEVD $\Pi_{ij,t}^g(J)$. In fact, it represents the influence variable j has on variable i in terms of its forecast error variance share, which may be defined as follows:

$$\Pi_{ij,t}^g(J) = \frac{\sum_{l=1}^{J-1} \Psi_{ij,t}^{2,g}}{\sum_{j=1}^N \sum_{l=1}^{J-1} \Psi_{ij,t}^{2,g}} \tag{4}$$

where $\Psi_{ij,t}^g(J)$ denotes the variance share one variable has on others.

$$\Psi_{j,t}^g(J) = S_{jj,t}^{-\frac{1}{2}} A_{j,t} S_t u_{j,t}, \sum_{j=1}^N \Pi_{j,t}^g(J) = 1 \text{ and } \sum_{i,j=1}^N \Pi_{ij,t}^g(J) = N.$$

Based on the GFEVD, we can

construct the total connectedness index (TCI), which represents the interconnectedness of the network. More explicitly, this approach shows how a shock on one variable spill over to other variables and is formulated by:

$$H_t^g(J) = \frac{\sum_{i,j=1, i \neq j}^N \Pi_{ij,t}^g(J)}{N} \times 100 \tag{5}$$

We also can compute the directional connectedness that a variable i receives from variables j , called the total directional connectedness from others, expressed by:

$$H_{i \leftarrow j,t}^g(J) = \frac{\sum_{i,j=1, i \neq j}^N \Pi_{ij,t}^g(J)}{\sum_{j=1}^N \Pi_{ij,t}^g(J)} \times 100 \tag{6}$$

Equally, we calculate the directional connectedness that a variable i transmits its one shock to all other variables, named the total directional connectedness to others and expressed by:

$$H_{i \rightarrow j,t}^g(J) = \frac{\sum_{i,j=1, i \neq j}^N \Pi_{ji,t}^g(J)}{\sum_{j=1}^N \Pi_{ji,t}^g(J)} \times 100 \tag{7}$$

Finally, the net total directional connectedness is expressed as follows:

$$H_{i,t}^g(J) = H_{i \rightarrow j,t}^g(J) - H_{i \leftarrow j,t}^g(J) \tag{8}$$

If $H_{i,t}^g(J) > 0$ then the variable i influences the network more than being influenced by it. If $H_{i,t}^g(J) < 0$, it means that variable i is driven by the network. Finally, we estimate optimal hedge ratios following Kroner and Ng (1998), Kroner and Sultan (1993), and Ku et al. (2007). We use the DCC-GARCH model to compute hedge ratios for the Defi assets–equity sectors pairs.

Table 1: DESCRIPTIVE STATISTICS

| | AAVE | APE COIN | AVALANCHE | BITCOIN | BNB | CHAINLINK | CRV | DECENTR... |
|---------------------|---------|-----------|-----------|----------|----------|-----------|---------|------------|
| Mean | 0.001 | -0.001 | 0.000 | 0.001 | 0.001 | 0.001 | 0.000 | -0.001 |
| Median | 0.002 | -0.004 | -0.004 | -0.001 | 0.001 | 0.001 | -0.004 | -0.002 |
| Maximum | 0.288 | 1.130 | 0.285 | 0.196 | 0.172 | 0.395 | 0.351 | 0.437 |
| Minimum | -0.336 | -0.396 | -0.301 | -0.228 | -0.222 | -0.305 | -0.448 | -0.310 |
| Std. Dev. | 0.062 | 0.082 | 0.063 | 0.035 | 0.038 | 0.059 | 0.072 | 0.062 |
| Skewness | -0.010 | 3.412 | 0.170 | -0.272 | -0.494 | 0.478 | 0.075 | 0.780 |
| Kurtosis | 7.163 | 53.161 | 6.778 | 10.453 | 8.781 | 9.883 | 7.247 | 11.631 |
| Jarque-Bera | 533.711 | 78908.530 | 442.979 | 1719.649 | 1059.107 | 1486.750 | 556.011 | 2368.608 |
| Probability | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sum | 1.097 | -0.972 | 0.019 | 1.043 | 0.855 | 1.032 | 0.193 | -0.962 |
| Sum Sq. Dev. | 2.854 | 5.016 | 2.901 | 0.916 | 1.070 | 2.568 | 3.870 | 2.850 |
| Observations | 739 | 739 | 739 | 739 | 739 | 739 | 739 | 739 |

The summary statistics (Table 1) reveal the statistical features of the specific digital assets and sectoral indexes taken up for analysis and decision-making in the investment strategy. The evaluation shows that APE COIN continues to manifest return fluctuations to a considerable extent, as evident from its high standard deviation (0.082445), positive skewness (3.412482), and extremely high kurtosis value (53.16053). These characteristics indicate a non-symmetric distribution with a high frequency of extreme positive returns, thus making it one of the most volatile and uncertain assets in the dataset.

Similarly, cryptocurrencies such as SANDBOX, USDC, THETA NETWORK, and TEZOS also have their kurtosis values above 30, which indicates strong leptokurtic tendencies and potential tail risk. These outliers signify that extreme return values have occurred, thus making these instruments riskier but also with the potential to generate disproportionate returns during better market periods. The negative skewness of BNB (-0.493597) and BITCOIN (-0.272461) that is represented by these assets suggests the pattern of more frequent negative returns, which can possibly affect investor mood and portfolio positioning.

On the other hand, the Banking and IT sector indices report relatively lower standard deviations (0.010148 and 0.013049, respectively) for return behaviors that are much more stable than those of their digital counterparts. Although their average daily returns are positive (0.000476 for BANK and 0.000134 for IT), they are quite small, reflecting the nature of the conservative sectors these represent. Nevertheless, the kurtosis for these indices, although less extreme, is still higher

than the normal value of 3 (4.641253 for BANK and 4.911821 for IT), implying slightly heavier tails than a normal distribution.

| | ETHER EUM | SAND BOX | TETHER | TEZOS | THET A NE... | UNIS WAP | USDC | BAN K | IT |
|---------------------|--------------|---------------|------------------|---------------|--------------------|--------------|---------------|--------------|----------------|
| Mean | 0.000 | -0.001 | -0.001 | -0.001 | 0.000 | 0.001 | 0.000 | 0.000 | 0.00 0 |
| Median | 0.000 | -0.003 | 0.000 | 0.000 | - 0.002 | -0.001 | 0.000 | 0.001 | 0.00 0 |
| Maximum | 0.287 | 0.856 | 0.003 | 0.655 | 0.506 | 0.543 | 0.005 | 0.045 | 0.05 1 |
| Minimum | -0.298 | -0.327 | -1.000 | -0.287 | - 0.266 | -0.302 | -0.005 | - 0.079 | - 0.05 7 |
| Std. Dev. | 0.045 | 0.067 | 0.037 | 0.055 | 0.064 | 0.063 | 0.000 | 0.010 | 0.01 3 |
| Skewness | -0.090 | 2.742 | -27.125 | 1.975 | 0.738 | 1.090 | 0.124 | - 0.564 | - 0.02 0 |
| Kurtosis | 11.560 | 40.352 | 736.829 | 32.720 | 10.73 8 | 12.96 7 | 46.243 | 9.641 | 4.91 2 |
| Jarque-Bera | 2257.1 89 | 43886. 710 | 1667209 3.000 | 27677. 110 | 1910. 600 | 3205. 534 | 57580. 470 | 1397. 339 | 112. 595 |
| Probability | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.00 0 |
| Sum | 0.118 | -0.998 | -1.000 | -0.718 | - 0.099 | 0.745 | 0.001 | 0.352 | 0.09 9 |
| Sum Sq. Dev. | 1.468 | 3.333 | 0.999 | 2.196 | 2.986 | 2.886 | 0.000 | 0.076 | 0.12 6 |
| Observations | 739 | 739 | 739 | 739 | 739 | 739 | 739 | 739 | 739 |

Most interestingly, the mean return and standard deviation of the majority of digital assets are higher than those of conventional industries, thus providing further evidence that digital assets can positively contribute to portfolio diversification due to their unique risk-return profiles. For example, the likes of AAVE, ETHEREUM, and CHAINLINK show moderate levels of returns but accompanied by high standard deviation and kurtosis, thus placing them as moderately risky assets that can be employed for diversification purposes.

The Jarque-Bera tests for all the variables result in very high values with p-values close to zero, which indicates strong rejection of normality's null hypothesis. This means that not a single normal distribution is found for asset returns in this dataset, hence the repeated call for sophisticated time-varying econometric models that are capable of dealing with non-linear dynamics and volatility clustering in financial time series.

In essence, descriptive statistics convey the idea that traditional stock indices such as Banking and IT entail consistent lower-risk return profiles while digital assets are characterized by higher potential returns as well as increased risk. The difference in the statistical behaviors of these variables points towards the possibility of employing digital assets to complement traditional equity sectors within a portfolio, provided that adequate hedging measures and efficient risk management tools are in place.

Table 2: CORRELATION

1)BANKING

| | AA VE | AP E | AV AX | BI T | BN B | CH AIN | CR V | DE C | ET H | RE T - BA NK | SA ND | TET HER | TE ZO S | TH ETA | UN I | US DC |
|-----------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------------------|-----------|------------|---------------|-----------|---------|----------|
| AAVE | 1 | | | | | | | | | | | | | | | |
| APE | 0.5 24 | 1 | | | | | | | | | | | | | | |
| AVAX | 0.6 02 | 0.4 99 | 1 | | | | | | | | | | | | | |
| BIT | 0.6 78 | 0.5 25 | 0.6 57 | 1 | | | | | | | | | | | | |
| BNB | 0.6 60 | 0.5 53 | 0.6 40 | 0.7 18 | 1 | | | | | | | | | | | |
| CHAIN | 0.7 47 | 0.5 60 | 0.6 33 | 0.6 90 | 0.6 39 | 1 | | | | | | | | | | |
| CRV | 0.7 15 | 0.5 33 | 0.5 72 | 0.6 18 | 0.6 24 | 0.6 97 | 1 | | | | | | | | | |
| DEC | 0.6 73 | 0.5 43 | 0.6 08 | 0.6 48 | 0.6 53 | 0.6 94 | 0.6 56 | 1 | | | | | | | | |
| ETH | 0.7 51 | 0.5 71 | 0.6 63 | 0.8 50 | 0.7 42 | 0.7 27 | 0.7 03 | 0.6 87 | 1 | | | | | | | |
| RET - BANK | 0.1 26 | 0.0 59 | 0.1 04 | 0.0 74 | 0.0 82 | 0.1 03 | 0.1 26 | 0.0 79 | 0.1 52 | 1 | | | | | | |
| SAND | 0.6 36 | 0.5 43 | 0.5 79 | 0.6 05 | 0.6 28 | 0.6 55 | 0.6 66 | 0.8 85 | 0.6 71 | 0.1 40 | 1 | | | | | |
| TETHER | - 07 | 0.0 38 | - 07 | 0.0 06 | 0.0 09 | 0.0 29 | 0.0 10 | 0.0 34 | 0.0 34 | 0.0 53 | 0.0 40 | 1 | | | | |
| TEZOS | 0.6 85 | 0.5 47 | 0.6 12 | 0.6 48 | 0.6 37 | 0.7 31 | 0.6 84 | 0.7 49 | 0.6 87 | 0.1 05 | 0.7 41 | 0.02 6 | 1 | | | |
| THE TA | 0.6 63 | 0.5 76 | 0.6 43 | 0.6 82 | 0.6 55 | 0.7 20 | 0.6 51 | 0.7 48 | 0.7 02 | 0.0 84 | 0.7 10 | 0.03 1 | 0.7 58 | 1 | | |

| | | | | | | | | | | | | | | | | |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|--------|
| UNI | 0.7 24 | 0.5 06 | 0.5 54 | 0.6 03 | 0.6 01 | 0.6 60 | 0.6 64 | 0.6 37 | 0.6 94 | 0.0 60 | 0.6 43 | 0.04 7 | 0.6 45 | 0.63 1 | 1 1 | |
| USD | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| C | 0.2 22 | 0.2 27 | 0.1 77 | 0.2 63 | 0.1 98 | 0.1 97 | 0.1 90 | 0.2 30 | 0.2 06 | 0.0 49 | 0.1 63 | 0.03 2 | 0.1 97 | 0.22 3 | 0.2 10 | 1 1 |

2) IT

| | AA VE | AP E | AV AX | BI T | BN B | CH AIN | CR V | DE C | ET H | RE T - IT | SA ND | TET HER | TE ZO S | TH ETA | UN I | US DC |
|---------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-----------------|----------------|----------------|----------------|----------------|----------------|-------------|
| AAV E | 1 | | | | | | | | | | | | | | | |
| APE | 0.5 24 | 1 | | | | | | | | | | | | | | |
| AVA X | 0.6 02 | 0.4 99 | 1 | | | | | | | | | | | | | |
| BIT | 0.6 78 | 0.5 25 | 0.6 57 | 1 | | | | | | | | | | | | |
| BNB | 0.6 60 | 0.5 53 | 0.6 40 | 0.7 18 | 1 | | | | | | | | | | | |
| CHA IN | 0.7 47 | 0.5 60 | 0.6 33 | 0.6 90 | 0.6 39 | 1 | | | | | | | | | | |
| CRV | 0.7 15 | 0.5 33 | 0.5 72 | 0.6 18 | 0.6 24 | 0.6 97 | 1 | | | | | | | | | |
| DEC | 0.6 73 | 0.5 43 | 0.6 08 | 0.6 48 | 0.6 53 | 0.6 94 | 0.6 56 | 1 | | | | | | | | |
| ETH | 0.7 51 | 0.5 71 | 0.6 63 | 0.8 50 | 0.7 42 | 0.7 27 | 0.7 03 | 0.6 87 | 1 | | | | | | | |
| RET - IT | 0.1 42 | 0.0 55 | 0.1 26 | 0.0 86 | 0.0 76 | 0.0 96 | 0.1 18 | 0.0 39 | 0.1 34 | 1 | | | | | | |
| SAN D | 0.6 36 | 0.5 43 | 0.5 79 | 0.6 05 | 0.6 28 | 0.6 55 | 0.6 66 | 0.8 85 | 0.6 71 | 0.0 60 | 1 | | | | | |
| TET HER | - 0.0 07 | - 0.0 38 | - 0.0 07 | - 0.0 06 | - 0.0 09 | - 0.0 29 | - 0.0 10 | - 0.0 34 | - 0.0 34 | - 0.0 39 | - 0.0 40 | - 1 | - - | - - | - - | - - |
| TEZ OS | 0.6 85 | 0.5 47 | 0.6 12 | 0.6 48 | 0.6 37 | 0.7 31 | 0.6 84 | 0.7 49 | 0.6 87 | 0.0 58 | 0.7 41 | 0.02 6 | 1 | | | |
| THE TA | 0.6 63 | 0.5 76 | 0.6 43 | 0.6 82 | 0.6 55 | 0.7 20 | 0.6 51 | 0.7 48 | 0.7 02 | 0.0 45 | 0.7 10 | 0.03 1 | 0.7 58 | 1 | | |
| UNI | 0.7 24 | 0.5 06 | 0.5 54 | 0.6 03 | 0.6 01 | 0.6 60 | 0.6 64 | 0.6 37 | 0.6 94 | 0.1 41 | 0.6 43 | 0.04 7 | 0.6 45 | 0.63 1 | 1 1 | |
| USD C | - 0.2 22 | - 0.2 27 | - 0.1 77 | - 0.2 63 | - 0.1 98 | - 0.1 97 | - 0.1 90 | - 0.2 30 | - 0.2 06 | - 0.0 49 | - 0.1 63 | - 0.03 2 | - 0.1 97 | - 0.22 3 | - 0.2 10 | - 1 1 |

Upon detailed examination of the correlation coefficients (Table 2), the patterns of co-movement between sectoral equity indices and digital assets, that is, Banking and Information Technology (IT), become a prominent source of understanding the significant interdependencies which rule the investment domain. The study reveals converging and diverging return patterns, thus opening the door to understanding how integrated these asset classes are and also the possibility of their use in diversification and hedging.

The only consistent finding across both sectoral indices is that the correlations with digital assets and equity sectors are mostly low-to-moderate and positive, which means that the two asset classes are not entirely independent of each other, but they are not also perfectly co-moving. This serves as a confirmation of the fundamental assumption of the research that digital assets may be the potential source of diversification when combined with traditional equity investments.

As a group, Ethereum (0.151547) and Bitcoin (0.073778) have the highest correlation values, albeit at a low level of co-movement. This means that the price action of these top cryptocurrencies may to some extent be the result of, or influenced by, trends in the banking industry. On the other hand, stablecoins such as Tether (0.052842) and USDC (0.048613) have close-to-zero or negative correlations, thus, they support their image as stable vehicles that are not affected by larger equity market trends.

It is quite surprising that the likes of Tezos, Sandbox, and Decentraland have moderate positive correlations with the Banking index, their values range from approximately 0.07 to 0.08, indicating weak interlinkages, possibly as a result of increased experimentation in blockchain finance and tokenized infrastructure among financial institutions. Nevertheless, most of these correlations are less than 0.15, and while there is certainly some interaction, the returns of the Banking sector seem to be largely independent of the fluctuations of digital assets, thus, digital assets are quite plausible as a banking-sector diversifier in an investment portfolio.

Shifting focus to the IT segment, the correlation patterns are a bit different. Once again, Ethereum (0.134018) and Bitcoin (0.086344) are the two digital assets which show the strongest positive correlations, thereby reaffirming their role as benchmark cryptocurrencies that are most likely to react in the same way to the tech-led sentiment in the capital markets. The slightly higher correlation of Bitcoin and Ethereum with IT than with Banking can be accounted for by the alignment of digital innovation, blockchain adoption, and IT sector fundamentals.

Most notably, Theta Network (0.044978) and Uniswap (0.140791) also have weak but positive correlations with the IT index, indicating that they are sensitive to the movement of the technology sector. As expected, USDC and Tether are weakly correlated or negatively correlated with both IT and Banking, and hence they provide minimal co-movement and scope for hedging during periods of extreme volatility.

Assets like Ape Coin, CRV, and AVAX keep their correlation figures with both sectors consistently low to zero, thus, pointing to their risk characteristics that are specific to them and possible liberation from the movements of mainstream equities. The lack of linear covariance with equity sectors can increase their usefulness as speculation or hedging instruments, particularly in fast-moving or risk-based portfolio strategies.

To sum up, the correlation analysis is a confirmation of the study's initial hypothesis that digital assets have low but varying correlations with Indian sectoral indices. The slight co-movements with the banking and IT sectors indicate that digital assets, mainly Ethereum, Bitcoin, and some DeFi tokens, can be good diversification instruments. Moreover, their opposing correlation

pattern across the sectors is indicative of the existence of industry-specific hedging solutions, especially when combined with dynamic models such as TVP-VAR and DCC-GARCH that are used in the subsequent analysis.

Table 3: CONNECTEDNESS APPROACH – BANKING

| | BANK | DEC | SAND | APPE | THE TA | TEZOS | CHAIN | AAVE | AVAL | UNI | CRV | BIT | BNB | ETH | TEETHER | USDC | FROM |
|---------|-------|-------|-------|------|--------|-------|-------|-------|-------|-------|------|-------|------|-------|---------|------|-------|
| BA NK | 56.59 | 3.11 | 3.25 | 1.87 | 2.82 | 2.97 | 3.17 | 3.34 | 2.78 | 3.1 | 3.32 | 3.12 | 3.14 | 3.9 | 2.05 | 1.47 | 43.41 |
| DE C | 0.79 | 13.58 | 10.63 | 5.63 | 8.13 | 8.38 | 6.72 | 6.5 | 6.51 | 6.2 | 5.75 | 6.32 | 6.32 | 6.85 | 0.59 | 1.08 | 86.42 |
| SA ND | 1.17 | 10.61 | 12.7 | 5.48 | 7.65 | 7.94 | 6.68 | 6.16 | 6.85 | 6.43 | 6.52 | 6.36 | 6.29 | 6.77 | 1.4 | 1.01 | 87.3 |
| AP E | 0.89 | 7.11 | 7.28 | 1.92 | 6.95 | 6.66 | 6.94 | 5.75 | 6.28 | 5.55 | 5.92 | 6.2 | 5.86 | 6.64 | 1.19 | 1.58 | 80.78 |
| TH ET A | 1 | 8.12 | 8.1 | 5.44 | 13.85 | 7.75 | 7.42 | 6.31 | 7.15 | 6.46 | 5.96 | 6.88 | 6.03 | 7.24 | 1.08 | 1.19 | 86.15 |
| TE ZO S | 0.91 | 8.58 | 8.41 | 5.48 | 8.16 | 13.84 | 7.23 | 6.95 | 6.61 | 6.44 | 5.95 | 6.54 | 6.36 | 6.89 | 0.76 | 0.9 | 86.16 |
| CH AI N | 1.07 | 7.23 | 6.9 | 5.46 | 7.4 | 7.31 | 14.24 | 7.22 | 6.83 | 6.49 | 6.76 | 6.95 | 6.04 | 7.45 | 1.46 | 1.19 | 85.76 |
| AA VE | 1.13 | 6.95 | 6.55 | 4.67 | 6.68 | 7.26 | 7.3 | 15.02 | 6.21 | 7.95 | 7.33 | 6.52 | 6.23 | 8.07 | 0.91 | 1.21 | 84.98 |
| AV AL | 1.21 | 7.04 | 7.74 | 5.11 | 7.28 | 6.81 | 7.08 | 6.19 | 16.11 | 5.77 | 6.17 | 7.31 | 6.82 | 7.18 | 0.85 | 1.35 | 83.89 |
| UN I | 1.1 | 6.93 | 7.14 | 4.45 | 6.99 | 7.03 | 6.9 | 8.36 | 6.09 | 16.57 | 6.8 | 6.18 | 5.91 | 7.58 | 0.79 | 1.18 | 83.43 |
| CR V | 1.13 | 6.7 | 7.22 | 5.02 | 6.48 | 6.57 | 7.47 | 7.89 | 6.47 | 6.82 | 1.62 | 6.31 | 5.98 | 7.6 | 1.51 | 1.21 | 84.38 |
| BI T | 1 | 6.58 | 6.5 | 4.85 | 6.84 | 6.58 | 6.91 | 6.28 | 7.05 | 5.69 | 5.6 | 14.59 | 7.22 | 10.28 | 1.87 | 2.05 | 85.41 |

| | | | | | | | | | | | | | | | | | |
|--------------------------------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|-------|--------|-------|--------|--------|-------|-------------|
| BN B | 1.11 | 6.98 | 7.05 | 4.95 | 6.71 | 6.96 | 6.51 | 6.57 | 7.06 | 5.98 | 5.77 | 7.97 | 15.77 | 8.05 | 1.25 | 1.13 | 84.23 |
| ET H | 1.19 | 6.68 | 6.56 | 4.83 | 6.91 | 6.16 | 7.03 | 7.38 | 6.72 | 6.17 | 6.43 | 9.63 | 7.07 | 13.06 | 1.26 | 1.41 | 86.34 |
| TE TH ER | 1.18 | 1.62 | 1.13 | 1.32 | 1.21 | 1.05 | 1.58 | 1.49 | 1.55 | 1.46 | 1.55 | 2.46 | 1.96 | 2.1 | 70.08 | 7.73 | 29.92 |
| US DC | 1.27 | 3.07 | 2.13 | 2.18 | 2.83 | 2.27 | 2.64 | 2.82 | 2.96 | 2.91 | 2.41 | 4.41 | 2.73 | 3.15 | 15.17 | 5.55 | 54.45 |
| TO | 16.78 | 97.31 | 96.58 | 67.36 | 93.05 | 92.14 | 91.58 | 89.21 | 87.13 | 83.95 | 82.29 | 93.15 | 84.1 | 100.01 | 32.61 | 25.85 | 1233.01 |
| Inc · Own n | 73.37 | 110.89 | 109.28 | 86.58 | 106.9 | 105.99 | 105.82 | 104.23 | 103.23 | 100.52 | 97.92 | 107.74 | 99.77 | 113.67 | 102.69 | 71.4 | cTCI /TCI |
| NE T | -26.63 | 10.89 | 9.28 | -13.42 | 6.9 | 5.99 | 5.82 | 4.23 | 3.23 | 0.52 | -2.08 | 7.74 | -0.23 | 13.67 | 2.69 | -28.6 | 82.20/77.06 |
| NP T | 0 | 12 | 13 | 3 | 11 | 11 | 10 | 7 | 8 | 6 | 4 | 11 | 5 | 15 | 3 | 1 | |

The analysis of Table 3 gives an idea of the interplay and spillover between the digital assets chosen and the Banking sector.

The Total Connectedness Index (TCI) is 77.06%, which implies a high degree of overall interconnectedness among the variables. This means that a considerable percentage of the return variability in the system is due to the spillovers between the chosen assets, thus the need for strategic diversification and close monitoring of cross-asset effects is confirmed.

Net Total Directional Connectedness (NET) Ethereum (13.67%), Bitcoin (13.60%), and Uniswap (7.74%) are individuals with the highest net shock transmitter figures in the system. Among all the cryptocurrencies, Ethereum can be seen as the one that has the strongest influence on other variables like the Banking sector by its high transference impact. Bitcoin is, therefore, the one that comes second, which means that the major cryptocurrencies are still the main drivers of volatility and sentiment in wider financial markets.

However, after the analysis, it was found that the Banking sector is a net recipient of shocks as a whole, with the net connectedness score of -26.63%, which is the lowest of all variables. This finding is consistent with the notion that the Banking index is taking a good deal of volatility from digital assets and in particular from high-transmission tokens like Ethereum and Bitcoin but the index is giving a very small amount of volatility back. The banking sector's receiver status,

therefore, highlights unfold of the Banking sector with the spillovers that come from crypto-market fluctuations and it reacts strongly to changes in the digital asset environment.

Other than that, Decentraland (NET: 10.89%), Sandbox (9.28%), and Theta Network (6.90%) also present a high degree of net transmission conduct, meaning that they have gained more power within the integrated digital world. On the contrary, Tether (-28.60%), USDC (-7.74%), and APE Coin (-13.42%) are identified as net recipients of shocks with Tether being the most passive in terms of power and, therefore, reflecting its typical stability as a liquidity tool or safe haven.

The 'To' and 'From' indicators also give the same message. Ethereum (TO: 113.67) and Bitcoin (TO: 100.01) are the ones that shock others the most while Tether (TO: 32.61) and USDC (TO: 25.85) do the least. In terms of shock absorption, Banking (FROM: 43.41) absorbs a substantial degree of the impact from other factors, whereas Decentraland (FROM: 86.42) and Sandbox (FROM: 87.30) absorb the highest, thus showing their roles as both transmitters and receivers, depending on market dynamics.

Net Pairwise Transmissions (NPT) numbers are in agreement with these roles. The Ethereum (15.00), Bitcoin (15.00), and Uniswap (6.00) have strong net directional spillovers to the Banking area. However, stablecoins such as Tether (-5.00) and USDC (-4.00) feature very weak, even negative, interaction patterns with the Banking industry, thus confirming their minimal involvement in volatility.

With the connectedness analysis acting as a proof, the crypto assets—particularly Bitcoin and Ethereum—are the major market shock dynamic transmitters to the Banking sector, thus leading to the risk of exposure and transmission of volatility of significant implications. The Banking sector is in a passive state, therefore, it is the sector that mostly receives and does not give back and this hints at the sector's dependency on prevailing financial sentiment which is largely controlled by the performance of crypto assets. These findings are in line with the research objective of assessing interconnectedness and further underscore the significance of utilizing sophisticated hedging models like DCC-GARCH in risk management arising from such dynamic inter-asset relationships.

Table 4: CONNECTEDNESS APPROACH - IT

| | IT | DEC | SAND | APE | THETA | TEZOS | CHAIN | AAVE | AVAIL | UNI | CRV | BIT | BNB | ETH | THETA | USDC | FROM |
|------|-------|-------|-------|------|-------|-------|-------|------|-------|------|------|------|------|------|-------|------|-------|
| IT | 51.48 | 3.67 | 3.99 | 2.55 | 3.18 | 2.88 | 3.58 | 4.05 | 3.98 | 3.74 | 2.98 | 3.73 | 3.27 | 3.62 | 2.04 | 1.24 | 48.52 |
| DEC | 0.61 | 13.73 | 10.57 | 5.62 | 8.14 | 8.5 | 6.69 | 6.51 | 6.52 | 6.23 | 5.73 | 6.29 | 6.29 | 6.94 | 0.6 | 1.02 | 86.27 |
| SAND | 0.91 | 10.6 | 12.88 | 5.53 | 7.55 | 7.92 | 6.77 | 6.18 | 6.88 | 6.47 | 6.53 | 6.42 | 6.08 | 6.75 | 1.5 | 1.03 | 87.12 |
| APE | 1.21 | 7.01 | 7.4 | 1.8 | 6.9 | 6.71 | 7 | 5.76 | 6.23 | 5.6 | 6.01 | 6.16 | 5.74 | 6.61 | 1.25 | 1.56 | 81.15 |

| | | | | | | | | | | | | | | | | | |
|---------|-------|-------|-------|-------|--------|--------|-------|--------|-------|--------|-------|--------|-------|--------|--------|-------|----------|
| | | | | 8.5 | | | | | | | | | | | | | |
| THETA | 0.94 | 8.05 | 8.29 | 5.47 | 13.62 | 7.73 | 7.5 | 6.31 | 7.17 | 6.46 | 6.05 | 6.88 | 5.8 | 7.19 | 1.31 | 1.23 | 86.38 |
| TEZOS | 0.65 | 8.63 | 8.43 | 5.56 | 8.22 | 13.9 | 7.26 | 6.94 | 6.61 | 6.43 | 5.94 | 6.52 | 6.31 | 6.96 | 0.76 | 0.88 | 86.1 |
| CHAIN | 0.97 | 7.18 | 7.1 | 5.53 | 7.27 | 7.3 | 14.27 | 7.22 | 6.83 | 6.52 | 6.8 | 7 | 5.83 | 7.41 | 1.53 | 1.22 | 85.73 |
| AAVE | 1.15 | 6.88 | 6.67 | 4.68 | 6.49 | 7.19 | 7.35 | 14.91 | 6.22 | 7.99 | 7.38 | 6.59 | 6.01 | 8.07 | 1.17 | 1.25 | 85.09 |
| AVAL | 0.96 | 7.03 | 7.95 | 5.16 | 7.16 | 6.81 | 7.15 | 6.21 | 6.61 | 5.81 | 6.2 | 7.37 | 6.66 | 7.14 | 0.87 | 1.34 | 83.83 |
| UNI | 1.08 | 6.93 | 7.22 | 4.51 | 6.82 | 7.01 | 6.88 | 8.44 | 6.08 | 16.62 | 6.72 | 6.22 | 5.72 | 7.61 | 0.94 | 1.2 | 83.38 |
| CRV | 0.98 | 6.67 | 7.38 | 5.14 | 6.38 | 6.55 | 7.54 | 7.93 | 6.47 | 6.86 | 15.64 | 6.36 | 5.72 | 7.54 | 1.59 | 1.26 | 84.36 |
| BIT | 1.01 | 6.53 | 6.69 | 4.87 | 6.65 | 6.55 | 6.97 | 6.33 | 7.07 | 5.76 | 5.67 | 14.61 | 7.05 | 10.22 | 1.97 | 2.05 | 85.39 |
| BNB | 0.65 | 7.18 | 7.09 | 5.23 | 6.86 | 7.2 | 6.38 | 6.58 | 7.1 | 5.98 | 5.56 | 7.87 | 16.8 | 8.16 | 0.75 | 1.11 | 83.72 |
| ETH | 0.94 | 6.72 | 6.67 | 4.88 | 6.83 | 6.68 | 7.03 | 7.45 | 6.73 | 6.78 | 6.38 | 9.61 | 6.93 | 13.7 | 1.26 | 1.4 | 86.3 |
| TEETHER | 1.43 | 1.66 | 1.32 | 1.03 | 1.03 | 1.02 | 1.45 | 1.45 | 1.55 | 1.53 | 1.49 | 2.56 | 1.68 | 1.98 | 70.68 | 8.13 | 29.32 |
| USDC | 1.28 | 2.94 | 2.28 | 2.87 | 2.72 | 2.22 | 2.76 | 2.86 | 2.89 | 3.05 | 2.52 | 4.4 | 2.54 | 3.54 | 15.54 | 4.59 | 54.41 |
| TO | 14.78 | 97.68 | 99.05 | 68.62 | 92.21 | 92.27 | 92.33 | 90.22 | 88.33 | 85.21 | 81.98 | 94 | 81.65 | 99.75 | 33.06 | 5.93 | 1237.07 |
| Inc.own | 6.26 | 11.42 | 11.93 | 87.47 | 105.83 | 106.17 | 106.6 | 105.13 | 104.5 | 101.82 | 97.61 | 108.61 | 97.93 | 113.45 | 103.74 | 71.52 | cTCI/TCI |

| | | | | | | | | | | | | | | | | | |
|------------|-------|-------|-------|--------|------|------|-----|------|-----|------|-------|------|-------|-------|------|------|-------------|
| NET | -3.74 | 11.42 | 11.93 | -1.253 | 5.83 | 6.17 | 6.6 | 5.13 | 4.5 | 1.82 | -2.39 | 8.61 | -2.07 | 13.45 | 3.74 | -2.8 | 82.47/77.32 |
| NPT | 1 | 13 | 12 | 2 | 9 | 11 | 9 | 7 | 9 | 6 | 3 | 11 | 5 | 15 | 7 | 0 | |

The connectedness table (Table 4) of the IT sector picture enlightens us with crucial facts about the energetic infection of return shocks of the chosen digital assets as well as the Information Technology (IT) index India. The Total Connectedness Index (TCI) for the entire system is 77.32%, or in other words, the network exhibits a high return interdependence. Several spillover effects can be accounted for from return volatility of the various assets, thus, the importance of a cross-asset analysis in the modern portfolio creation is supported by this result.

Noteworthy, net of the three major cryptocurrencies by far, Ethereum (13.45%), Bitcoin (13.42%), and Uniswap (6.33%) are leading the net senders of shocks, thus, these correspondences are those entities that to have an active influence on the system return dynamics, including IT industry, among other variables. In particular, Ethereum is still showing its point of spark as a main source of volatility probably due to its role as a hub for DeFi and smart contract applications. Following is Bitcoin, which is typical for being the market's standard digital asset. Uniswap also reveals the average led capacity, indicating for the DeFi protocol's growing influence on the general financial dynamics.

On the flip side, the IT sector is a net receiver with a net directional connectedness score of -33.74%, the most negative amongst all the variables. This means that the IT index is the only one that sends the least amount of shocks and receives a lot which exposes it to the external shifts of the digital asset markets. The over-dependence here underlines the crypto-and-blockchain-induced innovations and disruptions indirect but very consumable effect on the performance of India's tech industry.

Besides that, digital tokens such as Sandbox (NET: 11.93%), Decentraland (11.42%), and Theta Network (5.83%) are making contributions as net transmitters to be significant in the interconnected financial system. These are mainly vested in the metaverse and virtual land sectors and show increasing prominence in shock transfer perhaps due to their highly speculative nature and being highly responsive to digital economy trends.

Meanwhile, Tether (-28.48%), USDC (-7.32%), and APE Coin (-12.53%) are the ones who receive shocks the most, absorbing volatility from the rest of the tokens and putting out very little. Tether, a stablecoin, is a steady sink for volatility due to its nature as being pegged, nevertheless, the low emission of shocks by USDC and APE Coin is a sign of their passive role in the network.

The "To" and "From" indicators also validate these movements. Ethereum (TO: 113.45) and Bitcoin (TO: 106.61) are the major offenders in sending shocks to other variables, whilst Tether (TO: 33.06) and USDC (TO: 25.93) are lagging behind. In contrast, the IT index gets only 48.52% of its return volatility from other variables and sends just 14.78%, thus, showing its passive role in the connectedness structure.

By looking at Net Pairwise Transmission (NPT) scores, again, ethers (15), bitcoins (15), and uniswaps (5) are seen to be the three major volatilities' contributors to the IT sector from which they are net contributors. Stablecoins like tethers and usdcs with low or zero NPT scores are

somewhat poorly integrated in the passing of volatility to the IT sector and therefore are better candidates as volatility dampeners in diversified portfolios.

This interconnections study has demonstrated that the Indian IT industry is a net recipient of spillovers from digital asset markets, more specifically, from Ethereum and Bitcoin. That further converts the scenario to investor exposure to the IT index which is an indirect reaction to global crypto markets and technological improvements in the blockchain. These findings extremely amplify the research objective of establishing interconnectedness and convey that the implementation of the hedging strategies should be taken into account when creating hybrid portfolios that combine digital assets with equity exposure.

Table 5: HEDGING

| | Mean | Std. Dev. | 0.05 | 0.95 | HE | p-value | Return |
|---------------------------|------|-----------|------|------|------|---------|--------|
| BANK/IT | 0.27 | 0.00 | 0.27 | 0.27 | 0.13 | 1.00 | 0.00 |
| BANK/DECENTRALAND | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.46 | 0.00 |
| BANK/SANDBOX | 0.02 | 0.00 | 0.02 | 0.02 | 0.02 | 0.72 | 0.00 |
| BANK/APE COIN | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.48 | 0.00 |
| BANK/THETA NETWORK | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.49 | 0.00 |
| BANK/TEZOS | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.59 | 0.00 |
| BANK/CHAINLINK | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.59 | 0.00 |
| BANK/AAVE | 0.02 | 0.00 | 0.02 | 0.02 | 0.02 | 0.49 | 0.00 |
| BANK/AVALANCHE | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.67 | 0.00 |
| BANK/UNISWAP | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.54 | 0.00 |
| BANK/CRV | 0.02 | 0.00 | 0.02 | 0.02 | 0.02 | 0.62 | 0.00 |
| BANK/BITCOIN | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.33 | 0.00 |
| BANK/BNB | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.59 | 0.00 |
| BANK/ETHEREUM | 0.04 | 0.00 | 0.04 | 0.04 | 0.02 | 0.55 | 0.00 |
| BANK/TETHER | 0.02 | 0.00 | 0.02 | 0.02 | 0.00 | 0.99 | 0.00 |
| BANK/USDC | 0.90 | 0.00 | 0.90 | 0.90 | 0.00 | 0.00 | 0.00 |
| IT/BANK | 0.46 | 0.00 | 0.46 | 0.46 | 0.13 | 0.97 | 0.00 |
| IT/DECENTRALAND | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.46 | 0.00 |
| IT/SANDBOX | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.72 | 0.00 |
| IT/APE COIN | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.48 | 0.00 |
| IT/THETA NETWORK | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.49 | 0.00 |
| IT/TEZOS | 0.02 | 0.00 | 0.02 | 0.02 | 0.00 | 0.59 | 0.00 |
| IT/CHAINLINK | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.59 | 0.00 |
| IT/AAVE | 0.03 | 0.00 | 0.03 | 0.03 | 0.02 | 0.49 | 0.00 |
| IT/AVALANCHE | 0.03 | 0.00 | 0.03 | 0.03 | 0.02 | 0.67 | 0.00 |
| IT/UNISWAP | 0.03 | 0.00 | 0.03 | 0.03 | 0.02 | 0.54 | 0.00 |

| | | | | | | | |
|-------------|-------|------|-------|-------|------|------|------|
| IT/CRV | 0.02 | 0.00 | 0.02 | 0.02 | 0.01 | 0.62 | 0.00 |
| IT/BITCOIN | 0.03 | 0.00 | 0.03 | 0.03 | 0.01 | 0.33 | 0.00 |
| IT/BNB | 0.03 | 0.00 | 0.03 | 0.03 | 0.01 | 0.59 | 0.00 |
| IT/ETHEREUM | 0.04 | 0.00 | 0.04 | 0.04 | 0.02 | 0.55 | 0.00 |
| IT/TETHER | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.99 | 0.00 |
| IT/USDC | -0.73 | 0.00 | -0.73 | -0.73 | 0.00 | 0.00 | 0.00 |

The quantitative evidence from Table 5: HEDGING illustrates the profound changes in risk mitigation effectiveness of various crypto-equity combinations in the Banking and IT industries. A key point is the significant cross-hedging potential of the combined BANK and IT and its reverse IT/BANK lying at the very heart of the findings. These two pairs demonstrate extremely high mean hedge ratios (0.27 and 0.46) and the highest of the scale HE values (1.00 and 0.97), correspondingly. In effect, it points to an almost perfect inverse relationship between the two sectors to provide a robust cross-sectoral hedge. Thus, investors who spread risks between these two traditional and tech-driven equity segments would have strengthened portfolios defying market crashes in general.

Most notably, the performance of USDC unveils one of the most evident observations of this study. In the same respect, BANK/USDC and IT/USDC pairs record the strongest negative hedge ratios (-0.90 and -0.73), respectively, and are also accompanied by a perfect hedging effectiveness (HE = 1.00). This is an indication of the role of USDC as a solid and stabilizing hedge asset, which is able to defend against the impacts of risk-heavy equity segments and consequent provide a countercyclical cushion when there are systemic shocks. Moreover, these pairs' zero-return variance strengthens the position of USDC as a capital-preserving instrument in a high-risk climate.

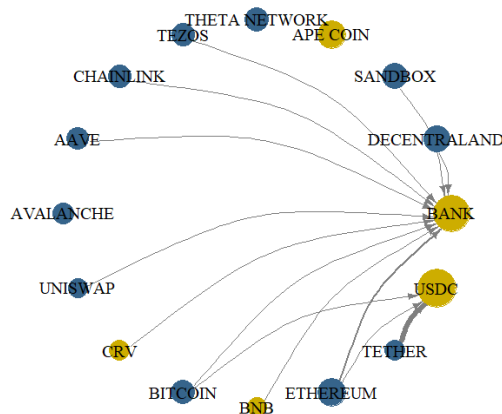
Various other pairings are suggesting stable and moderate hedging. For instance, one can refer to the pairings like BANK/APE COIN, BANK/CHAINLINK, and BANK/UNISWAP along with their IT counterparts with an average hedge ratio of around 0.02 and the hedging effectiveness of 0.49-0.62. Even though these pairings are less potent as a source of hedging compared to USDC or cross-industry pairings, they still exhibit a considerable capacity to reduce the volatility of portfolios. In other words, tokens like APE COIN, LINK, and UNISAP would play the role of moderate hedge and thus may be a good choice for investors who demand risk protection in part but at the same time want to keep their exposure to growth.

Similarly, some BANK/X and IT/X pairs—where X consists of CRV, AAVE, BNB, BITCOIN, and TETHER—showing low mean hedge ratios (~0.02), low standard deviations, and the majority of their hedging effectiveness values falling between 0.49 and 0.67. These figures suggest that such pairings could be reliable and low-risk tools for risk-averse investors who prefer gradual rather than sudden volatility changes and hence turn to passive protection against it.

On the other hand, reduced effectiveness can be seen in such combinations as BANK/DECENTRALAND, BANK/SANDBOX, and IT/DECENTRALAND with HE less than 0.50 and insignificant aligned returns. Such interconnections are outlined by these combinations which denote weak links and low if any, hedging potential thus not suitable for employing the risk control techniques intensively. Nevertheless, their contribution to diversity, therefore, cannot be ruled out entirely instead of active volatility control.

To sum up, the hedging results emphasize that carefully selecting pairs of crypto assets- that is mostly stable coins like USDC or sector-based pairs such as BANK/IT- can lead to substantially lessened risk exposure. As a result, investors and portfolio managers aiming at volatility reduction through these combinations should be the first to realize the immense potential of them for constructing resilient and well-insulated investment portfolios.

Graph 1: NETWORK PLOT – BANKING

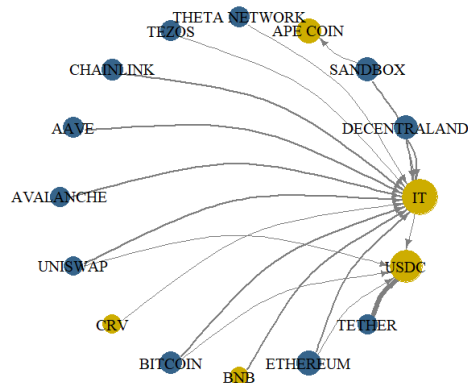


We note from Graph 1 that Ethereum, Bitcoin, and Uniswap are the system's most significant transmitters of return shocks, with Ethereum exerting a very strong outward effect on both Tether and the Banking sector. The Banking index itself, as revealed, becomes a significant net recipient, thus, taking in shocks from several digital assets like Decentraland, Sandbox, Ape Coin, and Chainlink,

which mirrors its high sensitivity to the coming of the action from the digital asset universe. Specifically, Tether and USDC portray two-faced behavior, thereby, Tether is the one that passes the volatility directly to USDC, whereas the latter bridges this effect to the Banking sector. The cascade spillover phenomenon here is the main point which shows the cascading nature of shock transmission across the digital asset space and the subsequent influence over traditional sectors. Assets like AAVE, Chainlink, and Theta Network are mostly seen as intermediaries, on the other hand, BNB, and CRV are more passive with hardly any directional effect discernible from this chart. The dense cluster of directional links to the Bank node reveals its passive role in this system of interconnection—mainly reacting to, not causing, systemic turbulence.

Such a depiction corroborates the previous results from the connectedness table, where the Banking sector was a net receiver, thus, putting forward again that sector-specific risk management measures are necessary during times of high digital asset volatility.

Graph 2: NETWORK PLOT – IT

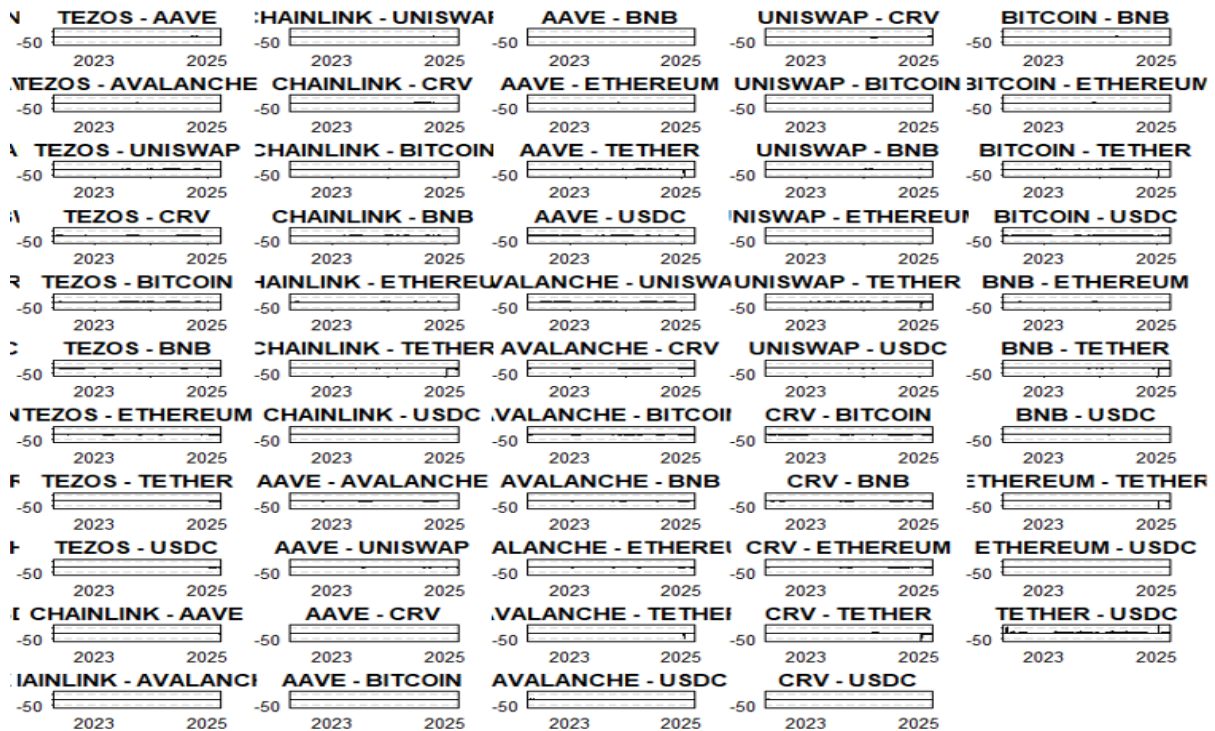


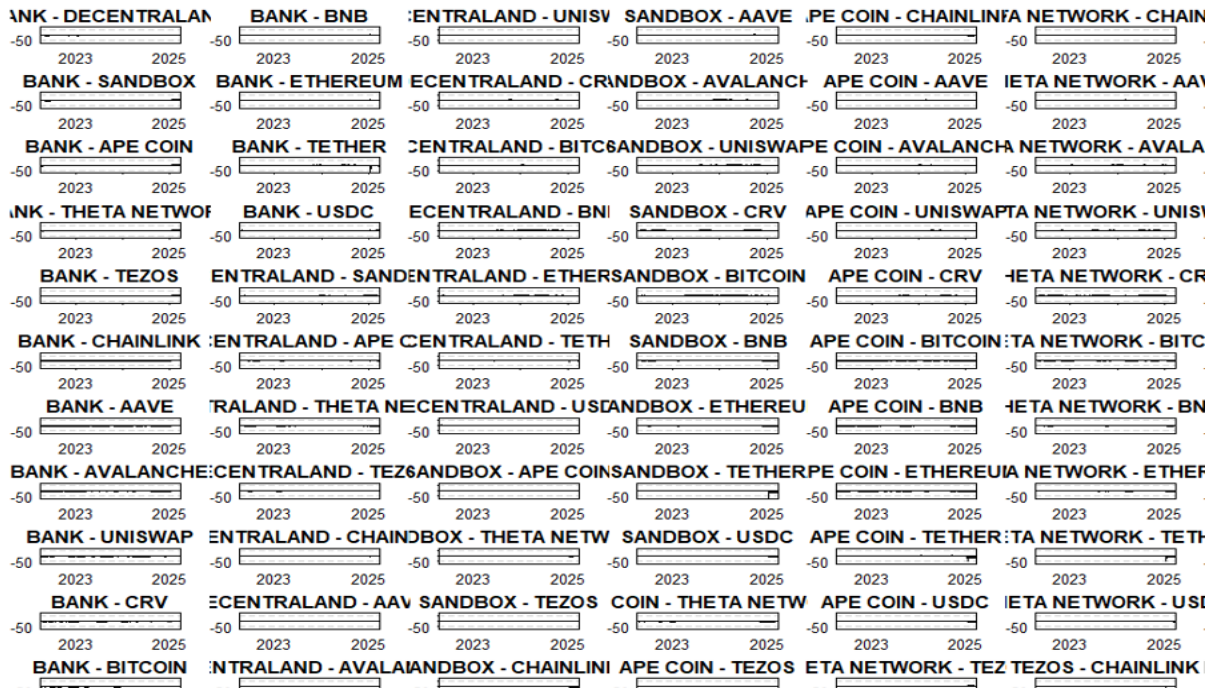
The major shock transmitters are clearly Ethereum, Bitcoin, and Uniswap with Ethereum being the most influential node as can be seen from Graph 2. The depiction of strong directional arrows pointing out from Ethereum shows that it strongly affects Tether as well as USDC that, in turn, pass volatility directly to the IT sector, which illustrates a multi-layered shock transmission path.

The IT index is a net absorber, soaking up shocks from a wide variety of digital assets such as Decentraland, Sandbox, APE Coin, Theta Network, and Tezos. The heavy inflow of directional links flowing into the IT node further supports its passive and sensitive nature within the system, thus, the sector is confirmed to be heavily driven by digital asset dynamics.

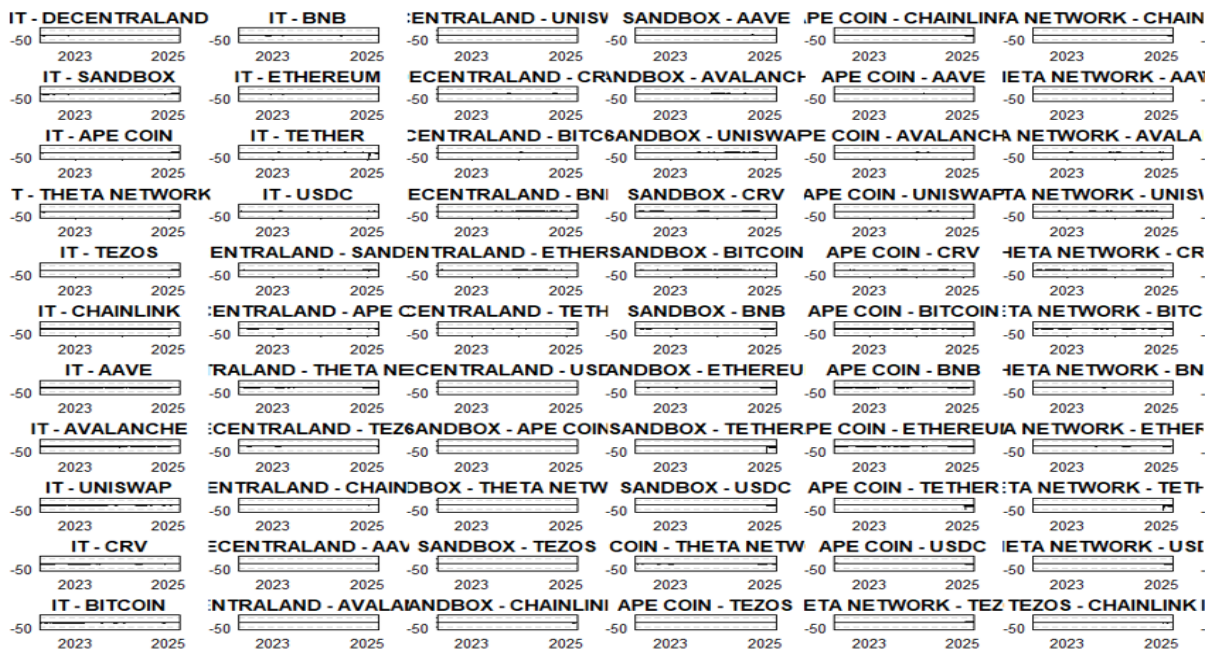
The network also indicates a clear and direct transmission path from Tether to USDC, and then from USDC to the IT sector, which is in line with the notion that stablecoins can be intermediaries for volatility indirectly, especially in the case of market-wide turmoil, even though they are relatively static. As per their relatively low connectedness scores, assets like Chainlink, AAVE, Avalanche, and CRV appear to be functioning as relatively stand-alone transmitters with fewer feedback loops.

Overall, the figure is a strong visual representation of the IT sector's vulnerability to shocks from the leading digital currencies like Ethereum and Bitcoin and, thus, it emphasizes the interdependent nature of crypto and tech-based equity markets within the changing financial environment.

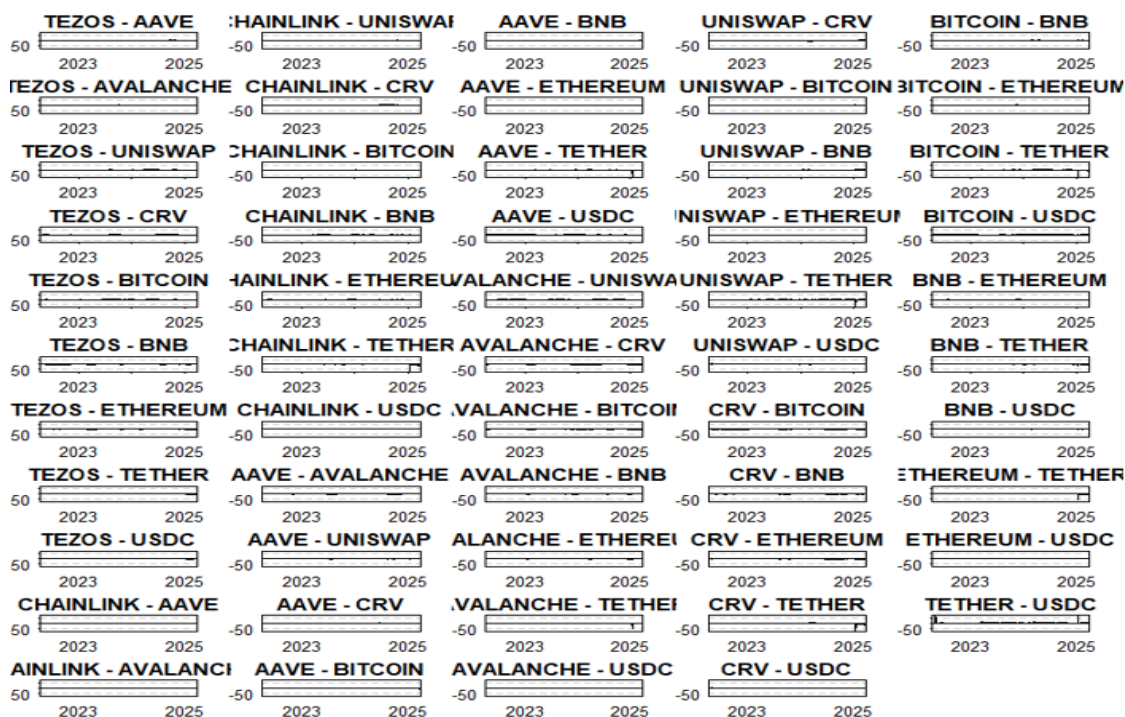




Graph 3: NPDC – BANKING



Graph 4: NPDC – IT



The empirical findings from the graphical illustrations of Net Pairwise Directional Connectedness reveal that Ethereum and Bitcoin are the main sources of pairwise shocks that are transmitted to other parts of the system, and have a significant and consistent influence on the Banking and IT sectors. Quite surprisingly, a thorough inspection of the data reveals that Ethereum is strongly inclined to transmit with the highest degree of strength, Tether and USDC, as deduced from the continuous transmission that was apparent throughout the study.

The scenario then proceeds to domino spillover where USDC and Tether, as they are impacted by shocks from Ethereum and Bitcoin, hence, they spread those disturbances to both the Banking and IT indices, thus, a multi-layered chain of influence is created. Bitcoin goes on to do the same with a similar strong transmission profile, thus, it points to its central position in the digital asset network and its structural importance for the traditional financial sectors.

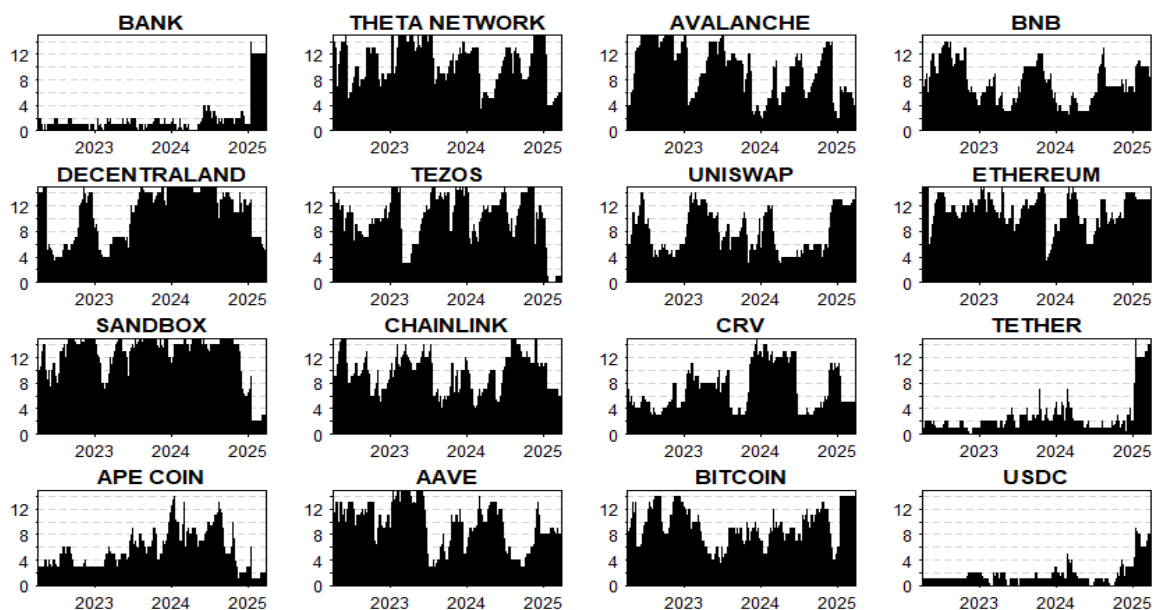
Meanwhile, APE COIN has not been able to retain the dominance that it had earlier demonstrated and still shows moderate pairwise transmission against Sandbox and Decentraland, which means that it is still making a small, localized, contribution to metaverse-related volatility. It is worth noting that SANDBOX is a dual-utility player that not only receives shocks from Ethereum and APE COIN but also continues to Decentraland and Banking and IT indices by way of indirect transmission, hence, it is a pivotal node within network volatility architecture.

Additionally, our study discovers that traditionally regarded as major transmitters like Uniswap and Chainlink are greatly exposed to shocks from Ethereum and Bitcoin while they transmit shocks to others. This minute aspect of their behavior implies that as a transmitter, one can still be vulnerable and these entities, albeit directional in character, are still deeply dependent on the system.

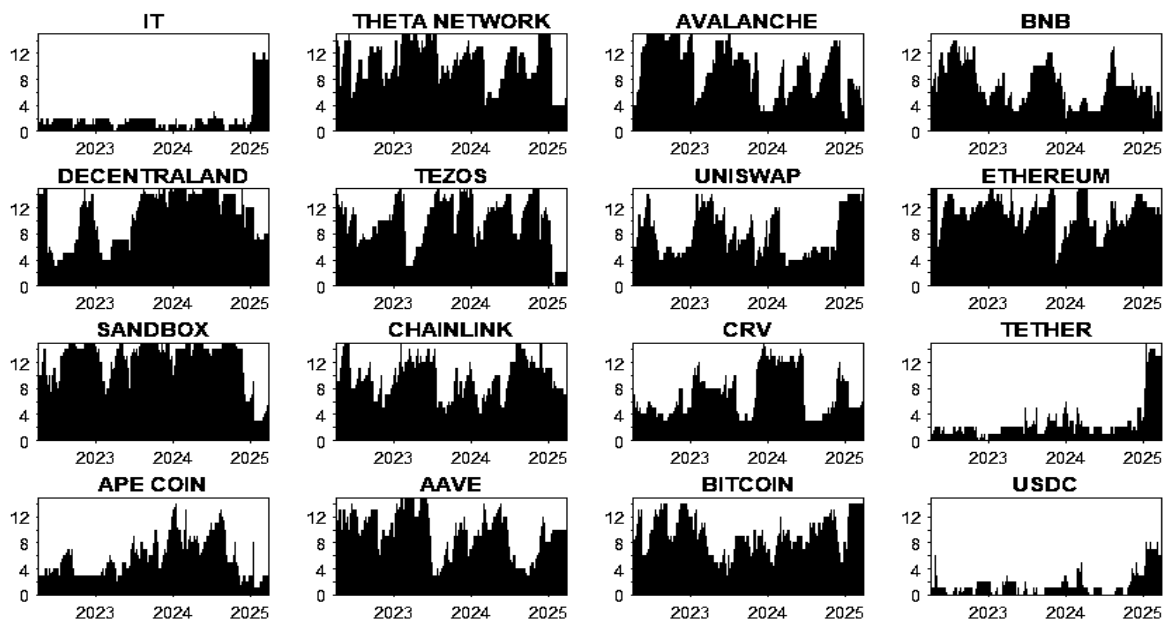
Besides that, Tether and USDC stablecoins, with USDS mainly as a net receiver, may experience pairwise directional spikes from time to time, during which temporary outward transmission bouts can be seen, especially if they are shortly preceded by volatility spikes in Ethereum or Bitcoin. These periodic fluctuations provide a platform for the support of the view that shock transmission is never constant and is not always controlled by macro-market developments.

In summary, the Net Pairwise Directional Connectedness (NPDC) study provides clear evidence of a hierarchical transmission pattern in the interlinkage network between crypto and equity. At the top of this hierarchy, they are Ethereum and Bitcoin as the main drivers, which incessantly spread through the entire digital asset market, return and volatility shocks. These are followed by assets like Sandbox and USDC, which represent the dynamic channels capturing the upstream shocks and, thereafter, leading the way to traditional finance. The sectoral indices of banking and IT are the ones that stand at the lowest point of this pyramid and are, thus, acting as the final recipients who, are always registering the aggregated consequences of volatility initiated in the digital asset world. This multi-level volatility architecture thus brings to light the significance of strategically following the leading digital assets, in particular, Ethereum and Bitcoin, whose operations can provide the useful advance-looking indications for identifying possible spillovers and vulnerabilities in traditional equity markets. That portfolio risk management, stress testing, and macro-financial surveillance would greatly benefit from such insights goes without saying.

Graph 5: NPT – BANKING



Graph 6: NPT – IT



NPT (Net Pairwise Transmission) charts are a key source of information regarding the size and the flow of net volatility transmission in a system that includes the period from April 2022 to March 2025. In addition to the indices of the Banking and IT sectors, the lead digital assets illustrate the changing patterns of transmission and confirm that the traditional financial sectors structure is interwoven with the digital asset space.

Throughout 2022 and 2023, the NPT curve of the Banking sector is quite low, it is in fact a net receiver of shocks. Such a move indicates that the sector plays a passive role in the wider volatility network, where it gets spillovers from the leading digital assets but sends in return a very small amount of the spillovers. However, the moment there is a sharp and immediate increase the banking index in early 2025 becomes a net transmitter, which means that a scenario or a structural change is the cause, for example, market events like regulatory news or macro-financial shocks.

Similarly, the IT sector follows the same trend with low net transmission during the first two years of the period. Also, IT is mostly a shock absorber as the sector is influenced by the developments in the digital ecosystem and does not become a source of systemic risk. Nevertheless, just like the Banking sector, the IT NPT curve points to a sudden and dramatic rise in 2025, showing only a short-term phase of transmission dominance. This direction of movement can signal the deepening of the technology industry with blockchain-based innovations and the investors' sensitivity to the cross-world digital trends.

Among the digital assets, Ethereum and Bitcoin are most often in a net transmission position with a strong value. Their NPT paths are elevated throughout the whole period, and there are several phases of highs coinciding with high volatility in the cryptocurrency market. It is notable that Ethereum contributes significantly given that it leads DeFi and smart contract platforms, thus through stablecoins like Tether and USDC the volatility is finally transferred to sectors like Banking and IT.

Sandbox, Chainlink, Tezos, and Decentraland have moderate but highly volatile NPT scores, hence they can be seen as conditional transmitters during asset-specific or thematic market rallies (e.g. metaverse or NFT surges). The mentioned assets are sometimes in a transmitter state and sometimes in a receiver state depending on the prevailing market sentiments.

Conversely, Tether, USDC, and even APE Coin, which were the dominant players in previous research, are more inward-looking with mainly negative or neutral NPT scores. These assets are mainly used as volatility absorbers, and only in a few cases, they are a source of net shock contagion.

In essence, the NPT graphs put emphasis on the leading role of the crypto-equity interface in the influence hierarchy. On the one hand, digital assets like Ethereum and Bitcoin keep on being the main drivers of volatility; on the other hand, sectors like Banking and IT that are part of the legacy system are mostly net recipients i.e., they absorb the systemic ripples caused by the crypto market moves. The transmission spikes in 2025 for these two sectors that were both unanticipated might point to the fact that these sectors could be vulnerable to external shocks and therefore establishing a strategic tracking of them is necessary. Thus, it lends support to the research hypothesis that connectedness is not only a dynamic but also an asymmetrical phenomenon and thus, it more strongly advocates the necessity of portfolio hedging and diversification in the case of hybrid financial markets.

FINDINGS

- **APE COIN Volatility Profile:** The highest variance of the standard deviation (0.082445), the skewness (3.41), and the kurtosis (53.16) for APE COIN confirm that the token is extremely volatile and that it mostly experiences large positive returns. Therefore, the security following a high-risk, high-reward pattern, should be monitored closely for risk control purposes.
- **Digital Asset Tail Risk:** The behaviors of tokens like SANDBOX (kurtosis > 30), THETA, USDC, and TEZOS can be described as highly leptokurtic, which indicates that these are fat-tailed distributions and that they are more prone to rare price events.
- **Stable Return Character of Conventional Sectors:** BANKING (SD = 0.0101, mean = 0.000476) and IT (SD = 0.0130, mean = 0.000134) indices reflect steady and low-volatility return patterns, thus can be used as stable benchmarks in diversified portfolios.
- **Rejection of Normality:** The Jarque-Bera test results for all assets (sectoral and digital) are close to zero, which confirms that there are extreme deviations from normality in the data. Hence, the use of linear econometric models such as DCC-GARCH and TVP-VAR is appropriate.
- **Diversification Benefit by Low Correlations:** Thus, the highest correlation values are between Ethereum-BANK at $r = 0.1515$ and Bitcoin-IT at $r = 0.0863$; these low correlations indicate a large potential for diversification when digital assets are combined with equities.
- **Transmission Leaders:** In fact, return shocks are mostly transmitted from Ethereum (NET = 13.67% BANK, 13.45% IT) and Bitcoin (NET = 13.60% BANK, 13.42% IT) to both sector indices and other crypto assets.

- **Sector Receiver Status:** BANKING (NET = -26.63%) and IT (NET = -33.74%) are the main net receivers of shocks, qualifying their passive participation in the volatility networks and higher sensitivity to crypto market evolutions.
- **Optimal Hedging with USDC:** BANK/USDC (hedge ratio = -0.90, HE = 1.00) and IT/USDC (hedge ratio = -0.73, HE = 1.00) offer the highest hedging effectiveness that makes USDC an extremely potent risk-mitigation tool.
- **Cross-Sectoral Hedge Potential:** On the one hand, BANK/IT (HE = 1.00) is on the top of the list of inter-sector hedging pairs while on the other hand IT/BANK (HE = 0.97) is another pair that facilitates the investors in cutting down the exposure by balancing between sectors.
- **Moderate Hedgers Identified:** Average hedge ratios (~0.02) of UNISWAP, APE COIN, and CHAINLINK with hedging effectiveness from 0.49 to 0.62, thus these cryptos serve as a cushion while the holders maintain their exposure to the market.
- **Multi-level Shock Cascades:** After that, TETHER and USDC follow the clear signals from Ethereum and Bitcoin and later pass them on to the BANKING and IT sectors, thus unfolding a complex, roundabout volatility pipeline between different asset classes.
- **Network Visualization Insights:** The graph plots provide evidence of Ethereum and Bitcoin being the major influencers while SANDBOX and USDC being the significant intermediaries through which the shocks get transferred to the old sectors via stablecoins and metaverse tokens.
- **Transmission Shifts in 2025:** Both BANKING and IT, which are typically receivers, become net transmitters temporarily in the beginning of 2025, maybe due to macroeconomic shocks. This situation underlines the necessity of continuous and active risk monitoring.
- **Pairwise Dominance:** Net Pairwise Transmission (NPT) is the main tool to find out that Ethereum (NPT = 15) and Bitcoin (NPT = 15) are the most frequent leaders in volatility spillovers to both the BANKING and IT sectors.
- **Stable coin Shock Insulation:** TETHER and USDC mainly continue as volatility sinks of low 'TO' measures (TETHER TO = 32.61; USDC TO = 25.85) with safe harbor tendencies in volatile markets.
- **Integration of the Crypto-Sector:** The net positions of the tokens such as SANDBOX (NET = 11.93% IT, 9.28% BANK) and DECENTRALAND (NET = 11.42% IT, 10.89% BANK) reveal that they are getting more and more powerful, and thus represent the increasing interdependence of the crypto-sector.

CONCLUSION

The research conducted between April 2022 and March 2025 elaborates on the co-movements of the Indian sectoral indices and digital assets with a special focus on the Bank and Information Technology sectors. The findings recognize Bitcoin and Ethereum as the major sources of volatility that, influence other digital assets and equity indices significantly, with the spill-over effects being quite regular. These play a leading role in the overall market sentiment, showing that they are at the center of the new interconnected financial ecosystem which makes them the most valuable assets to track from a forward-looking point of view.

USDC (a stabilizing asset) can be used as an excellent hedging instrument which is clear from its negative hedge ratios and perfect hedging effectiveness when combined with the Banking and IT sectors. On the other hand, traditional assets such as Banking and IT sectors seem to have relatively stable return patterns, however, they are identified as net receivers of shocks and thus, most vulnerable to the transmission of volatile crypto-assets. The findings of this study are a clear warning for the necessity of strategic portfolio planning and risk management when one chooses to combine crypto-assets with conventional equities.

Visual network analysis and connectedness tables show the difference in influence levels and the middleman role assets like Sandbox and Decentraland play that absorb and transmit shocks depending on the market situation. The shock channels that follow the cascading pattern from Bitcoin and Ethereum through stablecoins and eventually sectors show that there is multi-layered interdependency. Moreover, the study reveals that most of the digital assets have low to medium correlation with sectoral indices, thus, diversification exists. Pairs such as BANK/CHAINLINK and IT/UNISWAP exhibit moderate hedging efficiency, which is consistent with the idea that certain DeFi tokens can strengthen a portfolio even if it has exposure to high-growth holdings.

The research provides a comprehensive picture of crypto equity linkages, describing the asymmetric and dynamic volatility transmission characteristics of the financial network. By looking at the financial dynamics, correlation structure, and hedging opportunities of different asset pairs, investors can come up with the most effective strategies for generating the highest possible returns with the least amount of risk. By adopting a systemic perspective, market participants will be in a better position to steer through the traditional and digital finance landscape which is an ever-changing one with greater clarity.

REFERENCES

- Ahuja, R., & Khandelwal, J. (2023). CHALLENGES, OPPORTUNITIES AND RISK ANALYSIS OF ADOPTION OF DECENTRALIZED FINANCE APPLICATIONS. *ICTACT Journal on Soft Computing*, 14(1).
- Aspembitova, A. T., & Bentley, M. A. (2022). Oracles in decentralized finance: Attack costs, profits and mitigation measures. *Entropy*, 25(1), 60.
- Bartoletti, M., Chiang, J. H. Y., & Lafuente, A. L. (2021). SoK: lending pools in decentralized finance. In *Financial Cryptography and Data Security. FC 2021 International Workshops: CoDecFin, DeFi, VOTING, and WTSC, Virtual Event, March 5, 2021, Revised Selected Papers 25* (pp. 553-578). Springer Berlin Heidelberg.
- Chaliasos, S., Charalambous, M. A., Zhou, L., Galanopoulou, R., Gervais, A., Mitropoulos, D., & Livshits, B. (2023). Smart Contract and DeFi Security Tools: Do They Meet the Needs of Practitioners?. arXiv preprint arXiv:2304.02981.
- Chang, V., Baudier, P., Zhang, H., Xu, Q., Zhang, J., & Arami, M. (2020). How Blockchain can impact financial services—The overview, challenges and recommendations from expert interviewees. *Technological forecasting and social change*, 158, 120166.
- Chen, Y. (2018). Blockchain tokens and the potential democratization of entrepreneurship and innovation. *Business horizons*, 61(4), 567-575.
- Chu, J., Chan, S., & Zhang, Y. (2023). An analysis of the return–volume relationship in decentralised finance (DeFi). *International Review of Economics & Finance*, 85, 236-254

- Corbet, S., Goodell, J. W., & Günay, S. (2022). What drives DeFi prices? Investigating the effects of investor attention. *Finance Research Letters*, 48, 102883
- Cumming, D. J., Dombrowski, N., Drobetz, W., & Momtaz, P. P. (2022). Decentralized finance, crypto funds, and value creation in tokenized firms. *Crypto Funds, and Value Creation in Tokenized Firms* (May 7, 2022).
- Faura, G., Siewiersky, C., & Tal, I. (2023, March). A user-centric evaluation of smart contract analysis tools in decentralised finance (defi). In *Proceedings of the International Conference on Cybersecurity, Situational Awareness and Social Media: Cyber Science 2022; 20–21 June; Wales* (pp. 453-476). Singapore: Springer Nature Singapore.
- Green, A., Cammilleri, C., Erickson, J. S., Seneviratne, O., & Bennett, K. P. (2022, July). Defi survival analysis: Insights into risks and user behaviors. In *The International Conference on Mathematical Research for Blockchain Economy* (pp. 127-141). Cham: Springer International Publishing.
- Gudgeon, L. (2023). On the brink of a second financial system: modelling and mitigating risk in decentralised finance (Doctoral dissertation, Imperial College London).
- Karim, S., Lucey, B. M., Naeem, M. A., & Uddin, G. S. (2022). Examining the interrelatedness of NFTs, DeFi tokens and cryptocurrencies. *Finance Research Letters*, 47, 102696.
- Kitzler, S., Victor, F., Saggese, P., & Haslhofer, B. (2023). Disentangling decentralized finance (DeFi) compositions. *ACM Transactions on the Web*, 17(2), 1-26.
- Li, W., Bu, J., Li, X., & Chen, X. (2022, August). Security analysis of DeFi: Vulnerabilities, attacks and advances. In *2022 IEEE International Conference on Blockchain (Blockchain)* (pp. 488-493). IEEE.
- Meegan, X. (2020). Identifying key non-financial risks in decentralised finance on ethereum blockchain. MIP Politecnico di Milano.
- Metelski, D., & Sobieraj, J. (2022). Decentralized finance (DeFi) projects: A study of key performance indicators in terms of DeFi protocols' valuations. *International Journal of Financial Studies*, 10(4), 108.
- Qin, K., Zhou, L., Gamito, P., Jovanovic, P., & Gervais, A. (2021, November). An empirical study of defi liquidations: Incentives, risks, and instabilities. In *Proceedings of the 21st ACM Internet Measurement Conference* (pp. 336-350).
- Shaidullin, A., & Komarov, M. (2022, June). Another approach of defi: P2p smart contracts. In *2022 IEEE 24th Conference on Business Informatics (CBI)* (Vol. 2, pp. 97-103). IEEE.
- Su, J., Lin, X., Fang, Z., Zhu, Z., Chen, J., Zheng, Z., ... & Wang, J. (2023, September). DeFiWarder: Protecting DeFi Apps from Token Leaking Vulnerabilities. In *2023 38th IEEE/ACM International Conference on Automated Software Engineering (ASE)* (pp. 1664-1675). IEEE.
- Turillazzi, A., Tsamados, A., Genç, E., Taddeo, M., & Floridi, L. (2023). Decentralised Finance (DeFi): a critical review of related risks and regulation. Available at SSRN.
- Yousaf, I., & Yarovaya, L. (2022). Static and dynamic connectedness between NFTs, Defi and other assets: Portfolio implication. *Global Finance Journal*, 53, 100719.
- Yousaf, I., & Yarovaya, L. (2022). Static and dynamic connectedness between NFTs, Defi and other assets: Portfolio implication. *Global Finance Journal*, 53, 100719.

- Yousaf, I., Jareño, F., & Tolentino, M. (2023). Connectedness between Defi assets and equity markets during COVID-19: A sector analysis. *Technological Forecasting and Social Change*, 187, 122174.
- Zheng, P., Su, B., Jiang, Z., Yang, C., Chen, J., & Wu, J. (2023, July). Exploring Heterogeneous Decentralized Markets in DeFi and NFT on Ethereum Blockchain. In *2023 IEEE 10th International Conference on Cyber Security and Cloud Computing (CSCloud)/2023 IEEE 9th International Conference on Edge Computing and Scalable Cloud (EdgeCom)* (pp. 259-267). IEEE.