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Dynamic Interactions between Gold-Backed and Conventional Cryptocurrencies:
A QVAR Network Approach

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Abstract
This study investigates the volatility and interconnectedness of gold-backed cryptocurrencies—HelloGold (Hello), Bitcoin, X8X, and PaxGold—within the framework of sustainable finance and its alignment with the Sustainable Development Goals (SDGs). Utilizing quantile vector-autoregressive (QVAR) approach, the research analyzes the contributions of both short-run and long-run volatility in pairwise comparisons among these assets. The findings reveal that Bitcoin demonstrates significantly higher volatility compared to the other cryptocurrencies, especially when paired with HelloGold and PaxGold, where short-term fluctuations are particularly pronounced. In contrast, X8X exhibits greater stability, maintaining consistently low volatility across all its pairings and showing minimal contributions from both the short- and long-term horizons. These results suggest that while Bitcoin remains a highly volatile option in the cryptocurrency market, X8X and PaxGold offer more stable investment alternatives, making them potentially safer choices for portfolio diversification. Ultimately, this study provides valuable insights into the varying volatility characteristics of these digital assets, assisting investors in optimizing their portfolios amid market uncertainty.

Keywords
Risk spillover, A QVAR network Approach, Sustainability, Contagion, Gold-backed cryptocurrency

1. Introduction
The world is facing increasing challenges due to rising conflicts, the lasting effects of COVID-19, the looming threat of climate change, and environmental disruptions. The combination of extreme climate events and the ongoing consequences of the pandemic has significantly impacted people's well-being (Jiang, 2020; Whiteside and Klabbers,2025). This confluence has led to disruptions in social and economic realms, exacerbating energy and food shortages while intensifying environmental threats. In response to the urgent need for sustainable economic and financial practices, Islamic finance presents itself as a model of ethical and responsible financial conduct. Grounded in Shariah law, the principles of Islamic finance naturally align with broader sustainability goals. This economic framework emphasizes risk-sharing, ethical behavior, and the prohibition of exploitative practices, including interest-based transactions. As the world confronts pressing global challenges such as climate change, social inequality, and ethical shortcomings within the financial sector, the integration of Islamic finance and sustainability holds the potential to drive significant and transformative change (Rabbani et al., 2021). In an era marked by rapid technological advancements and an increasing urgency to tackle global challenges, a significant convergence has emerged at the intersection of Islamic finance, digital innovation, and the pursuit of sustainable development (Mnif & Jarboui, 2021). Within this dynamic framework, the rise of Gold-backed cryptocurrency technology offers a unique opportunity to further the principles of the United Nations' Sustainable Development Goals (SDGs) and address the complexities of climate risk with renewed energy and creativity. Islamic finance, rooted in principles of equity, inclusivity, and ethical economic conduct, has gained significant recognition for its alignment with sustainable development goals (Hassan et al., 2021, Raimi et al., 2024). These principles, deeply embedded in Islamic teachings, provide a solid foundation for the exploration of digital currencies that

embody these values in the rapidly advancing technological landscape (Said et al., 2019). As we delve into the realm of Gold-backed cryptocurrency technology, it becomes increasingly clear that its potential extends beyond mere financial empowerment; it offers the promise of reshaping the global economic framework in line with the aspirations of the Sustainable Development Goals (SDGs).

In an era of technological innovation and shifting financial paradigms, a new concept has emerged at the crossroads of Islamic principles and digital advancements. These digital assets, designed to adhere to the ethical tenets of Islamic finance, not only have the potential to revolutionize the financial sector but also to act as catalysts for achieving the SDGs, particularly in areas such as Decent Work and Economic Growth, and Reduced Inequalities. By integrating risk-sharing principles and ethical financial practices, Gold-backed cryptocurrencies can foster stable and resilient economies, thereby advancing the global agenda for sustainable development (Koeswandana & Sugino, 2023; Mnif el al 2024). The framework of Gold-backed cryptocurrencies, which emphasizes the collective sharing of gains and losses, could mitigate the destabilizing effects of speculative bubbles and sudden market shocks. This resilience could significantly contribute to sustained economic growth and the creation of employment opportunities, key objectives of the SDGs.

Moreover, the ethical foundations of Islamic finance extend to the creation and utilization of these digital assets. In a world where economic stability is crucial, the innovative fusion of Islamic finance principles with cutting-edge blockchain technology offers a path toward resilient economies. By leveraging the potential of Gold-backed cryptocurrencies, policymakers, financial institutions, and stakeholders can cultivate an ecosystem that aligns with Islamic values and substantially contributes to the realization of the SDGs. As we navigate the evolving landscape of finance and development, exploring Gold-backed cryptocurrency risk spillover as a tool for economic stability emerges as a promising endeavor with far-reaching implications for portfolio management.

The COVID-19 pandemic has led investors to seek out new avenues that provide enhanced hedging options for their diversified portfolios. Traditionally, Islamic financial markets have been viewed as safe-haven assets, frequently remaining uncorrelated with conventional markets in times of crisis. However, both Gold-backed and conventional markets faced challenges during the pandemic and the associated social distancing measures. In this context, cryptocurrencies have gained traction among portfolio managers, although their compliance with Sharia law is a significant concern. Recently, the emergence of gold-backed cryptocurrencies has provided additional diversification options for Gold-backed portfolio managers, as these assets align with Sharia principles and are linked to the value of gold. This Sharia-compliant aspect minimizes speculative risks, allowing these assets to be exchanged for a predetermined amount of physical gold, which offers intrinsic value and helps to reduce price volatility and speculation (Aloui et al., 2021).

Historically, during times of crisis, there has been a notable trend of flight-to-safety behavior, leading to increased investments in gold and gold-backed cryptocurrencies. In the realm of Islamic finance, incorporating gold into Islamic equity portfolios has been recommended to enhance portfolio diversification (Maghyereh et al., 2018). Research indicates that gold has effectively acted as a safe haven for Gold-backed financial markets during the global financial crisis, although its effectiveness was not as significant during the COVID-19 pandemic (Hassan et al., 2021). Nonetheless, the role of traditional Sharia-compliant assets, such as gold and Sukuk, has primarily been explored only in relation to Sharia-compliant equity portfolios, leaving the potential of Gold-backed cryptocurrencies as a new Sharia-compliant asset largely unexamined. This paper aims to address this gap in the existing literature.

In recent years, cryptocurrency markets have garnered considerable attention from a diverse range of stakeholders, including retail and institutional investors, regulators, policymakers, Big Tech companies, and the media. The COVID-19 pandemic has further heightened this interest. While some researchers have raised concerns about the appropriateness of cryptocurrencies as money from an Islamic perspective, others have pointed out their potential contributions to Islamic finance (Shaikh et al., 2020; Siswantoro et al., 2020; Mnif et al., 2024). Additionally, several recent studies have examined the integration of non-Sharia-compliant cryptocurrencies, such as Bitcoin, into Islamic Sharia-compliant portfolios.

This paper contributes to the literature by investigating the diversification benefits of Gold-backed digital assets within Islamic equity portfolios, particularly during periods of heightened uncertainty. The onset of the COVID-19 pandemic has prompted a surge in studies examining the impact of this global health crisis on risk contagion and the transmission of return and volatility spillovers between Gold-backed and conventional cryptocurrency markets. A common approach employed in these studies is the DY connectedness framework, which utilizes the VAR-based Generalized Forecast Error Variance Decomposition (GFEVD) method developed by Diebold & Yilmaz (2012, 2014) and its extended applications in various domains.

This study analyzes the volatility spillover effects between Gold-backed and conventional cryptocurrencies using the novel Quantile time-frequency connectedness approach. This approach builds on the methodologies of Baruník & Křehlík (2018) and Antonakakis et al. (2020), enabling the decomposition of volatility connectedness into short-term and long-term components. The method effectively captures the time-varying nature of coefficients and the variance-covariance structure without losing data points or relying on arbitrary rolling windows. This study analyzes the volatility spillover effects between Gold-backed and conventional cryptocurrencies using a novel Quantile time-frequency connectedness approach. This innovative methodology builds on the work of Baruník & Křehlík (2018) and Antonakakis

et al. (2020), allowing for the decomposition of volatility connectedness into short-term and long-term components. By employing a time-varying vector auto regression model, the approach captures the dynamic relationships between the two markets without the loss of data points or the reliance on arbitrary rolling windows. This framework effectively addresses the time-varying nature of volatility spillovers, providing a more comprehensive understanding of how shocks in one cryptocurrency market influence the other over different market conditions. The implications of these findings are significant for investors and policymakers, as they shed light on the interconnectedness of these two categories of cryptocurrencies, thus facilitating more informed risk management and decision-making strategies in a rapidly evolving financial landscape.

The structure of the paper is as follows: Section 2 outlines the preliminary data analysis and methodology. Section 3 presents the empirical results, and Section 4 concludes with a discussion of the study's findings and their implications.

2. Data Descriptions and Methodology

2.1 Data

This study utilizes an extensive daily dataset that covers various cryptocurrency markets, with a specific focus on gold-backed cryptocurrencies, including HelloGold (HGT) and X8X, as well as the conventional gold-backed cryptocurrency PaxGold and the leading cryptocurrency Bitcoin (BTC). The data, sourced from the Yahoo Finance website, spans the period from December 31, 2020, to July 28, 2024.

2.2 Preliminary Analysis

In this section, we analyze the summary statistics derived from the first log differences of the cryptocurrency price series, utilizing the ERS unit root test as proposed by Elliott et al. (1996). These statistics provide insights into various characteristics of the cryptocurrency series, including volatility, distribution properties, potential non-normalities, and the presence of unit roots.

The mean return represents the average change in value for each cryptocurrency's price series. For instance, Bitcoin (BTC) exhibits a mean return of -0.0004, indicating a slight average decline over the period. This is coupled with a relatively high standard deviation of approximately 0.016, highlighting BTC's inherent volatility compared to other cryptocurrencies in our dataset. Skewness and kurtosis values further explore the shape and distribution characteristics of returns. A skewness of 1.595 for BTC suggests a positively skewed distribution, indicating more frequent significant positive returns. Meanwhile, a kurtosis value of 21.519 suggests that BTC's distribution has heavier tails than a normal distribution, implying an increased likelihood of extreme price movements. The Jarque-Bera test, with a notably high value of 25,751.574 for BTC, indicates a significant deviation from normality.

Similarly, other cryptocurrency series in the dataset exhibit comparable non-normality characteristics and potential outliers. The concept of time series stationarity underpins the application of the TVP-VAR frequency connectedness approach in time series analysis. To ensure stationarity, we conducted two categories of unit root tests: linear and nonlinear. This approach acknowledges that linear unit root tests may fail to detect mean reversion when the data-generating processes exhibit nonlinear characteristics. Consequently, we employed two linear unit root tests—the Jarque-Bera test (1980) and the ERS unit root test of Elliott et al. (1996)—to assess serial correlation. The results of these tests indicate that the variables are statistically stationary at the 1% significance level.

Table 1 Descriptive statistics results for the daily series data

	Mean	SD	Skewness	Kurtosis	Jarque-Bera	ERS
BTC	-0.0004	0.016	1.595***	21.519***	25751.574***	-10.949***
PaxGold	0.0002	0.0042	-0.190***	7.313***	2917.764***	-12.365***
HelloGold	-0.0005	0.0504	1.924***	25.502***	36196.104***	-8.749***
X8X	-0.0004	0.0522	-0.458***	27.115***	40055.106***	-5.277***

a/ Quantile time frequency connectedness approach

We utilize the quantile connectedness framework proposed by Chatziantoniou, Gabauer, and Stenfors (2021) to investigate the dynamics of shock transmission across clean energy, dirty energy, technology markets, and geopolitical uncertainties. This innovative approach offers a comprehensive lens to study how shocks are transmitted across different segments of the distribution, emphasizing extreme conditions such as market booms or crises. Unlike traditional methods that focus on average effects, this framework allows us to capture heterogeneous responses across varying market states, providing a deeper understanding of interconnectedness under normal, stressed, and extreme conditions.

The first step in our analysis involves estimating a quantile vector autoregression (QVAR) model with ppp lags. This model extends the conventional vector autoregression (VAR) framework by analyzing the relationships among variables at different quantiles of their distributions, rather than just their mean. This feature is particularly advantageous for examining how shocks originating in one sector, such as clean energy, can cascade to others, like dirty energy or technology markets, during periods of high volatility or uncertainty.

By focusing on quantile-specific dynamics, the QVAR(ppp) model uncovers how the magnitude and direction of these interdependencies vary across the distribution. For instance, the transmission of a shock may be minimal under normal

conditions but become pronounced during periods of heightened market stress. This nuanced approach not only highlights the asymmetric nature of shock propagation but also sheds light on the vulnerability of certain markets or sectors to extreme events.

Furthermore, this framework allows us to incorporate the role of geopolitical uncertainties, a critical factor influencing global markets. Geopolitical risks often exacerbate volatility, and their interaction with energy and technology markets creates complex spillover effects. The QVAR model captures these interactions by examining their influence across the entire distribution, offering insights into how geopolitical events amplify or mitigate the transmission of shocks. The quantile connectedness framework provides a robust tool for analyzing the dynamic interplay between markets, particularly during turbulent periods. This method enhances our understanding of systemic risks and offers valuable insights for policymakers, investors, and market participants aiming to navigate interconnected global markets effectively.

The first step in our analysis is to estimate a quantile vector autoregression model QVAR(p). referred to as which can be outlined as follows:

In the given context, we consider two N × 1 dimensional endogenous variable vectors, denoted by xt and xt−i, where i ranges from 1 to p. The parameter r lies within the interval [0, 1] represents the quantile of interest. The variable p denotes the lag length of the quantile vector autoregression model. The vector μ(r) is N × 1 dimensional and symbolizes the conditional mean at this quantile. Φj (r) refers to an N × N-dimensional QVAR coefficient matrix, and ut(r) characterizes the N × 1 dimensional error vector, which exhibits a variance-covariance matrix of N × N dimensions, denoted as Σ(r). Using Wold's decomposition theorem the QVAR(p) is transformrd into its QVMA(∞) representation, in which xt = Ψ(L)εt and Φ(L) = [Ψ(L)]−1. Since Ψ(L) contains infinite lags, it is by approximated by calculating Ψi at i = 1, …, H horizons.

We then aggregate all frequencies falling within a specified range of interest.

$$\tilde{\theta}_{ij}(d) = \int_a^b \tilde{\theta}_{ij}(\omega)\, d\omega$$

where d = (a, b): a, b ∈ (− π, π), a < b, Subsequently, we calculate various frequency connectedness events, which provide valuable perceptions into the transmission of effects within specific frequency ranges, represented by 'd'.

$$NPDC_{ij}(d) = \tilde{\theta}_{ij}(d) - \tilde{\theta}_{ji}(d) \quad \text{(Equation 1)}$$

$$TO_i(d) = \sum_{i=1, i\neq j}^{N} \tilde{\theta}_{ji}(d) \quad \text{(Equation 2)}$$

$$FROM_{it}(d) = \sum_{i=1, i\neq j}^{N} \tilde{\theta}_{ij}(d) \quad \text{(Equation 3)}$$

$$NET_i(d) = TO_i(d) - FROM_i(d) \quad \text{(Equation 4)}$$

Therefore,

$$TCI(d) = N^{-1} \sum_{i=1}^{N} TO_i(d) = N^{-1} \sum_{i=1}^{N} FROM_i(d) \quad \text{(Equation 5)}$$

3. Empirical Results and Discussion

3.1 Empirical Results

The stacked area chart in Figure 1 illustrates the cumulative contribution of different components over a sequential variable, likely representing time. The chart is divided into three distinct areas: "Total" (black), "1-5" (one to five days indicating the short horizon with red color), and "5-Inf" (over 5 days showing the long term with green color). The "Total" area, represented by the black uppermost layer, shows the overall cumulative value, which is the sum of the underlying components. The "1-5" component (red area) makes up the majority of the total, indicating it significantly influences the overall trend. It fluctuates moderately over the sequence, with noticeable peaks and troughs. The "5-Inf" component (green area) contributes a smaller, relatively stable portion to the total, remaining consistently low throughout the period. The chart effectively demonstrates how the "1-5" category dominates the total, while the "5-Inf" category, though present, has a minimal impact on the cumulative total. The variability in the total is primarily driven by the changes in the "1-5" category, as the "5-Inf" component remains steady.

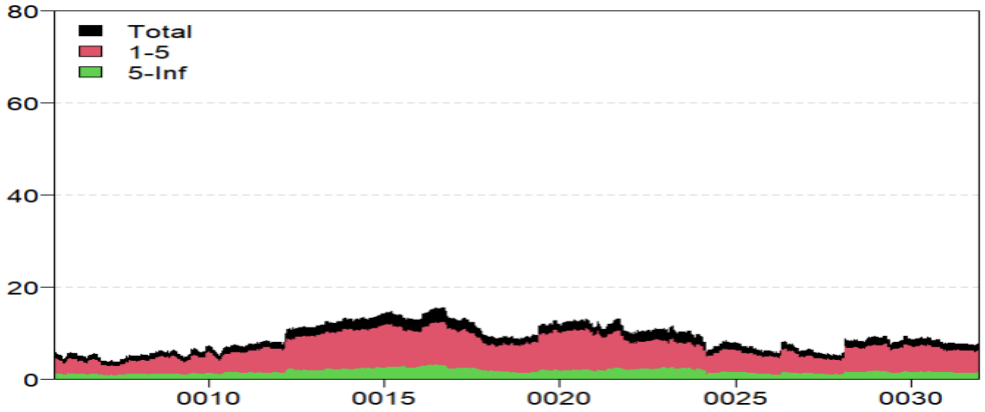

Fig. 1 Dynamic Total Connectedness

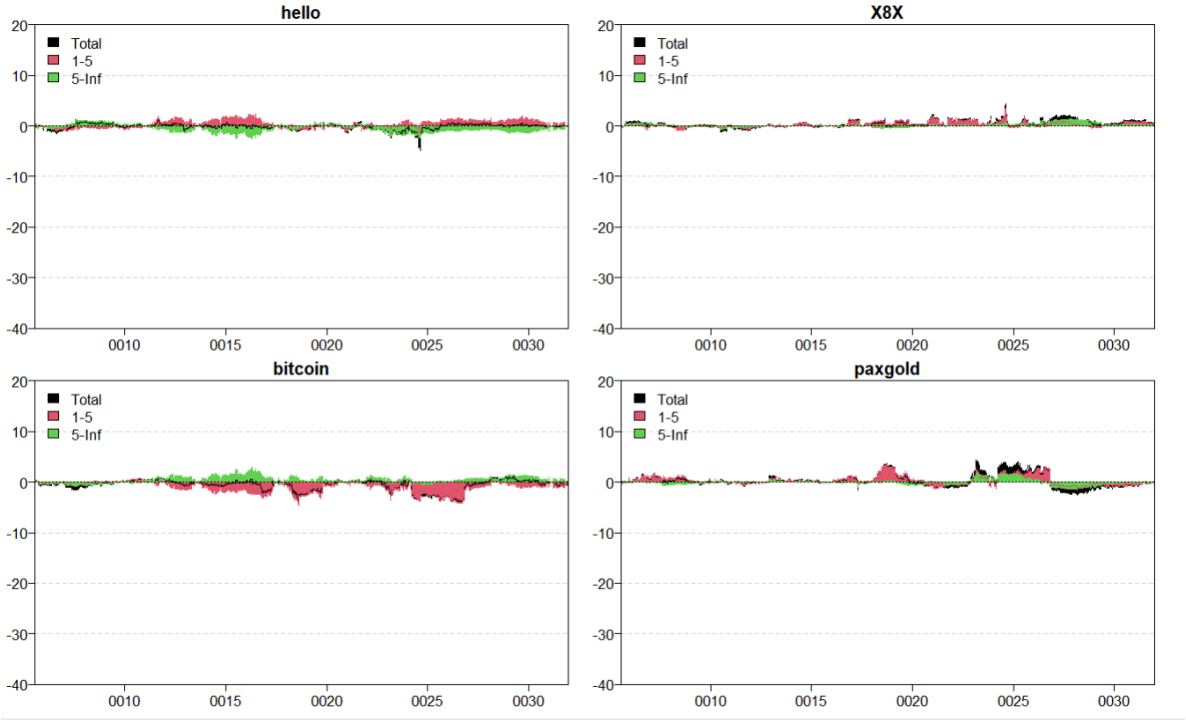

Fig. 2 Net Total Directional Connectedness

Figure 2 visualizes four separate stacked area charts, each corresponding to a different cryptocurrency: HelloGold (Hello), X8X, Bitcoin, and PaxGold. Each chart shows the cumulative contributions of two components labeled "1-5" (red area) and "5-Inf" (green area) to the total value (black area) over a specified period.

The chart for HelloGold shows relatively low overall volatility, with the "1-5" and "5-Inf" components contributing minimally to the total value. The fluctuations are small, and the total value remains close to zero throughout the observed period. X8X is Similar to HelloGold, the X8X chart also exhibits minimal fluctuations with low contributions from both the "1-5" and "5-Inf" components. The total value remains stable, with very few spikes, indicating low volatility. However, Bitcoin shows more pronounced variability compared to HelloGold and X8X. The "1-5" component contributes significantly to the total value, especially with some noticeable dips and peaks. The "5-Inf" component also shows variability but to a lesser extent. Overall, Bitcoin demonstrates higher volatility, with the total value fluctuating more prominently than in the other cryptocurrencies. PaxGold's market displays moderate volatility, with the "1-5" component having a visible impact on the total value, similar to Bitcoin but with slightly less intensity. The "5-Inf" component contributes relatively less but shows some movement, indicating that both components are influencing the total value. PaxGold's total value shows some notable fluctuations, reflecting moderate volatility. Overall, Bitcoin shows the highest volatility with significant fluctuations in the total value, followed by PaxGold. HelloGold and X8X exhibit much lower volatility, with their total values remaining relatively stable throughout the period. The charts provide a comparative view of how different components contribute to the overall volatility of each cryptocurrency. The analysis reveals distinct volatility patterns among Bitcoin, PaxGold, HelloGold, and X8X. Bitcoin exhibits the highest volatility, characterized by significant price fluctuations influenced by market sentiment, regulatory developments, and macroeconomic factors. This can attract traders seeking quick gains but may deter risk-averse investors. PaxGold follows with notable volatility, as its price is affected by both the cryptocurrency market and the price of physical gold, presenting a somewhat safer alternative. In contrast, HelloGold and X8X demonstrate much lower volatility, maintaining relatively stable values throughout the observed period, which may appeal to risk-averse investors looking for less exposure to market fluctuations. The comparative charts further illustrate how different cryptocurrencies respond to market dynamics, highlighting the varying degrees of risk involved. This underscores the importance of understanding volatility in investment decisions, encouraging investors to consider a diversified portfolio to balance high-risk assets like Bitcoin with the stability offered by HelloGold and X8X.

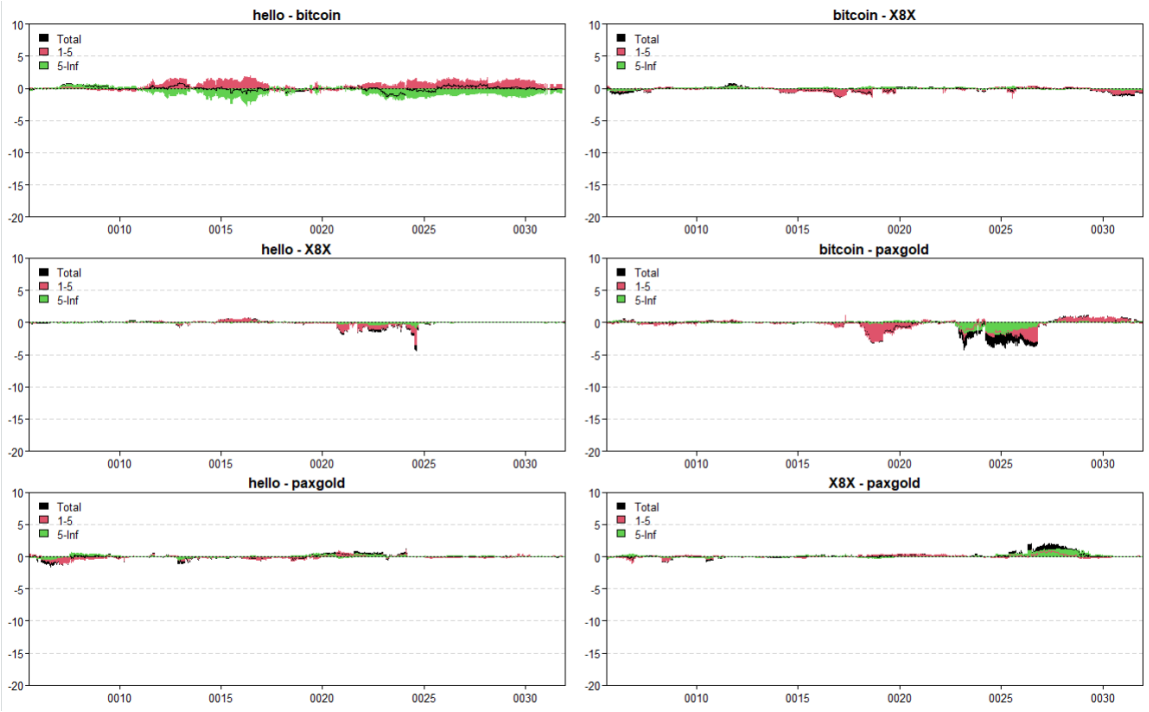

Fig. 3 Net Pairwise Directional Connectedness

The six stacked area charts in Figure 3 compare the volatility and component contributions between different cryptocurrency pairs: HelloGold (Hello) vs. Bitcoin, Bitcoin vs. X8X, Hello vs. X8X, Bitcoin vs. PaxGold, Hello vs. PaxGold, and X8X vs. PaxGold. The charts reveal varying degrees of volatility across these pairings. Notably, the Hello vs. Bitcoin and Bitcoin vs. PaxGold pairs exhibit more significant fluctuations, particularly in the "1-5" component (red area), indicating periods of increased volatility, especially in the middle and later stages of the time series. In contrast, pairings involving X8X, such as Bitcoin vs. X8X and Hello vs. X8X, show much lower volatility, with minimal contributions from both "1-5" and "5-Inf" components (green area), suggesting stability in these relationships. Bitcoin appears to be the more volatile asset when compared with the others, while X8X demonstrates greater stability, contributing to more consistent and lower total volatility in its pairings. The Hello vs. PaxGold and X8X vs. PaxGold pairs also show low volatility, reinforcing the stability of these particular assets relative to Bitcoin. Bitcoin emerges as the most volatile asset among the cryptocurrencies analyzed, with its price experiencing significant fluctuations driven by a variety of factors, including market sentiment, regulatory changes, and macroeconomic trends. This high volatility can attract speculative traders looking for short-term gains, but it may also raise concerns for investors seeking more stable investment options.

In contrast, X8X showcases greater stability, contributing to a more consistent and lower total volatility in its pairings. This stability positions X8X as an attractive option for risk-averse investors, as it tends to resist drastic price swings, allowing for a more predictable investment environment. The comparative analysis highlights how X8X can provide a reliable alternative in a volatile market, reinforcing its role as a stabilizing asset.

The pairs involving HelloGold versus PaxGold and X8X versus PaxGold further emphasize low volatility, indicating that these assets maintain their values relatively well in comparison to Bitcoin. The consistent performance of HelloGold and X8X against PaxGold suggests that they are less affected by extreme market movements and are more resilient during periods of volatility. This stability reinforces the notion that investing in assets like HelloGold and X8X can offer a hedge against the unpredictable nature of Bitcoin, appealing to investors looking for safer options within the cryptocurrency landscape. The analysis indicates that while Bitcoin remains a highly volatile and potentially lucrative asset, the greater stability offered by X8X, along with the low volatility of HelloGold and PaxGold pairings, presents a compelling case for diversification. Investors may benefit from incorporating these more stable assets into their portfolios to balance risk and enhance overall investment performance.

3.2 Discussion

The findings from this study provide valuable insights into the volatility dynamics and interconnectedness of various cryptocurrencies, specifically HelloGold (Hello), Bitcoin, X8X, and PaxGold. The analysis, using a TVP-VAR frequency connectedness approach, highlights significant differences in the behavior of these digital assets, which carry important implications for investors and policymakers.

Bitcoin, as indicated by the results, is characterized by substantial volatility, particularly when compared with other cryptocurrencies such as HelloGold and PaxGold. The pronounced fluctuations in the "1-5" component suggest that Bitcoin's market behavior is more sensitive to short-term shocks, making it a riskier asset. This high volatility is consistent with Bitcoin's reputation as a speculative asset, often subject to rapid price swings driven by market sentiment, regulatory news, and macroeconomic factors. The implications for investors are clear: while Bitcoin may offer high

returns, it also carries significant risk, making it less suitable for risk-averse investors or those seeking stable, long-term investment options.

In contrast, X8X consistently exhibits low volatility across all pairings, with minimal contributions from both the "1-5" and "5-Inf" components. This stability suggests that X8X is less affected by short-term market shocks and may offer a safer harbor for investors during periods of heightened market uncertainty. The stability of X8X could be attributed to its underlying asset backing, technological attributes, or market positioning, which buffers it against the kinds of speculative pressures that affect Bitcoin. For investors, X8X could serve as a stabilizing element in a diversified portfolio, potentially reducing overall portfolio risk while maintaining exposure to the cryptocurrency market.

PaxGold, which is backed by physical gold, also shows moderate volatility, particularly in its pairing with Bitcoin. This behavior aligns with the nature of gold as a traditional safe-haven asset, which tends to attract investment during periods of economic instability. However, PaxGold's volatility suggests that while it benefits from gold's stability, it is not immune to the broader market dynamics affecting cryptocurrencies. This dual characteristic makes PaxGold an interesting asset for investors looking to hedge against both market and currency risks.

The relatively low volatility observed in the pairings involving HelloGold and X8X reinforces the notion that certain cryptocurrencies can provide more stable investment opportunities. This stability is particularly valuable in the context of portfolio diversification, where the goal is often to balance high-risk, high-reward assets like Bitcoin with more stable assets that can cushion against market downturns.

These findings underscore the importance of understanding the unique characteristics of each cryptocurrency when making investment decisions. While the allure of high returns from volatile assets like Bitcoin is strong, the risk associated with such investments cannot be overlooked. On the other hand, assets like X8X and PaxGold offer a different value proposition, focusing on stability and risk mitigation, which can be particularly appealing in uncertain economic climates.

For policymakers, these results highlight the need to consider the distinct behaviors of various digital assets when crafting regulations. The high volatility of Bitcoin, for example, may necessitate different regulatory approaches compared to the more stable X8X or PaxGold. Understanding these nuances can help in designing frameworks that protect investors while fostering innovation and growth in the cryptocurrency market.

In conclusion, this study provides a comprehensive analysis of the volatility and connectedness of different cryptocurrencies, revealing the diverse risk profiles and potential roles these assets can play in an investment portfolio. As the cryptocurrency market continues to evolve, these insights will be crucial for both investors and policymakers in navigating the complex landscape of digital assets.

4. Conclusion

This study provides a detailed examination of the volatility dynamics and interconnectedness among several key cryptocurrencies, including HelloGold (Hello), Bitcoin, X8X, and PaxGold. Through the application of a TVP-VAR frequency connectedness approach, the analysis reveals distinct volatility profiles for each cryptocurrency, offering valuable insights for both investors and policymakers.

Bitcoin emerges as the most volatile asset among the studied cryptocurrencies, driven largely by short-term market shocks. Its significant fluctuations underscore the high-risk, high-reward nature of Bitcoin investments, making it a potentially lucrative but risky option for investors. In contrast, X8X exhibits a much lower volatility profile, indicating its potential as a stable asset within a diversified portfolio, particularly in times of market uncertainty. PaxGold, while generally stable due to its backing by physical gold, shows moderate volatility, highlighting its dual nature as both a safe-haven asset and a participant in the broader cryptocurrency market dynamics.

The study's findings emphasize the importance of understanding the unique characteristics of each cryptocurrency when making investment decisions. The contrast between the high volatility of Bitcoin and the stability of X8X and PaxGold illustrates the diverse opportunities and risks present in the cryptocurrency market. For investors, these insights can inform more balanced and strategic portfolio management, where the choice of assets is aligned with individual risk tolerance and investment goals.

For policymakers, the varying behaviors of these digital assets suggest that a one-size-fits-all regulatory approach may not be appropriate. Instead, regulations should be tailored to account for the specific risks and characteristics of different cryptocurrencies, ensuring both investor protection and market stability.

In conclusion, this study contributes to the growing body of literature on cryptocurrency markets by providing a nuanced understanding of the volatility and interconnectedness among different digital assets. As the market for cryptocurrencies continues to expand and evolve, these insights will be crucial for guiding both investment strategies and regulatory frameworks.

5. Implications and Recommendations

5.1 Implications

The findings of this study carry several important implications for investors, portfolio managers, and policymakers.

1. **Investment Strategy and Portfolio Diversification**: The clear differences in volatility among the cryptocurrencies analyzed—Bitcoin, HelloGold, X8X, and PaxGold—underscore the need for diversified

investment strategies. Bitcoin's high volatility suggests that it should be approached with caution by risk-averse investors. On the other hand, X8X and PaxGold offer more stable investment options, which could be strategically incorporated into portfolios to mitigate risk, particularly in volatile market conditions. The stability of X8X, in particular, makes it an attractive option for inclusion in diversified portfolios, serving as a counterbalance to more volatile assets.

2. **Risk Management**: The study highlights the importance of understanding the unique risk profiles of different cryptocurrencies. Investors and portfolio managers can use these insights to develop more nuanced risk management strategies. For instance, by balancing investments in high-volatility assets like Bitcoin with more stable ones like X8X or PaxGold, investors can achieve a more stable overall portfolio performance, even during periods of market turbulence.
3. **Policy and Regulation**: The varying behaviors of the cryptocurrencies studied suggest that a differentiated regulatory approach is necessary. Bitcoin's high volatility and speculative nature may require stricter regulatory oversight to protect investors and ensure market stability. Conversely, more stable assets like X8X and PaxGold might benefit from a regulatory environment that encourages their use as safe-haven assets within the broader cryptocurrency ecosystem. Policymakers need to consider these differences when crafting regulations, ensuring that they address the specific risks associated with each type of cryptocurrency while also promoting innovation and growth in the sector.
4. **Market Development**: The findings also have implications for the development of the cryptocurrency market itself. The demonstrated stability of certain cryptocurrencies like X8X suggests a potential role for these assets in broader financial markets, perhaps as alternatives to traditional safe-haven assets like gold. As the market for digital assets continues to mature, these stable cryptocurrencies could become integral to financial strategies that traditionally rely on physical commodities.

5.2 Recommandations

1. **For Investors and Portfolio Managers**: It is recommended that investors diversify their cryptocurrency portfolios by including a mix of volatile and stable digital assets. While Bitcoin may offer higher returns, its inclusion should be balanced with more stable assets like X8X or PaxGold to mitigate overall portfolio risk. Investors should also consider their individual risk tolerance and investment horizon when selecting cryptocurrencies, leaning towards stable assets if they are risk-averse or seeking long-term stability.
2. **For Policymakers**: Regulators should consider implementing a tiered regulatory framework that reflects the different risk profiles of various cryptocurrencies. High-volatility assets like Bitcoin may need more stringent regulations to curb speculative excesses and protect investors, while stable assets like X8X could benefit from regulatory support that encourages their adoption in traditional financial markets. Additionally, regulators should focus on promoting transparency and investor education to ensure that market participants are well-informed about the risks and benefits of different cryptocurrencies.
3. **For Cryptocurrency Developers**: Developers of new cryptocurrencies should take into account the findings of this study, particularly the demand for stable digital assets. Creating cryptocurrencies that prioritize stability and risk management could appeal to a broader range of investors, including institutional investors who are traditionally more conservative. Developers should also work closely with regulators to ensure that their products meet compliance requirements while offering innovative financial solutions.
4. **For Further Research**: This study highlights the need for ongoing research into the volatility and connectedness of cryptocurrencies. Future research should explore a broader range of digital assets, including newer and emerging cryptocurrencies, to provide a more comprehensive understanding of the market. Additionally, examining the impact of macroeconomic factors on cryptocurrency volatility could offer valuable insights for investors and policymakers alike.

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