

Volatility Spillover in Gold Asset Classes: Time-varying parameter vector autoregression (TVP-VAR) Approach

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INTRODUCTION



Gold has been a fundamental element of India's economic and cultural landscape. India's status as one of the world's foremost gold consumers is deeply rooted in its socio-economic fabric, making it an attractive avenue for investment and financial innovation (Bouri et al, 2017).



Although the physical gold spot market remains widely used, contemporary financial products such as gold futures, exchange-traded funds (ETFs), and shares in gold mining firms have become increasingly popular. These new options provide investors with enhanced flexibility, transparency, and liquidity (Baur & McDermott, 2010).



Financial market interconnectedness describes how changes in price and volatility in one market or financial instrument can affect others. In the realm of gold investments, this interconnectedness is influenced by various elements, including worldwide market patterns, national economic strategies, and investor conduct.



The relationship between gold investment options in India is further intricate due to the global nature of gold market. Local instruments, such as gold spot prices and Deccan Gold Mining Corporation shares, interact with international entities like global gold ETFs.

LITERATURE REVIEW

The interconnectedness of financial instruments is a central theme in the study of market dynamics. For gold, a multifaceted asset class, understanding the interlinkages among its various investment alternatives is particularly critical.

Relevance of gold in institutional portfolios has varied over time. Emmrich and McGroarty (2013) observes that while gold investment fell out of favour in the 1980s and 1990s, it has experienced a resurgence since the 2000s, particularly following the 2007 financial crisis. Their study revealed that incorporating gold, especially gold bullion, often enhances portfolio risk-adjusted returns.

Historically, gold has functioned as a safeguard against inflation, currency volatility, and geopolitical instability (Baur and McDermott, 2010 & Wang et al., 2011). Baur and Lucey (2010) further differentiate these roles, contending that gold serves as a hedge during periods of stability and as a safe haven during times of crisis.

Literature indicates that volatility is impacted by numerous elements, such as worldwide events, market modifications, and investor attitudes (Bekaert & Harvey, 1997; Uddin et al., 2021). Gold-related financial instruments demonstrate intricate volatility patterns, offering significant insights into their risk profiles and market conduct (Cai et al., 2001; Tadorava, 2016; Zhang et al., 2021).

LITERATURE REVIEW

Gold Instruments:

Gold Spot Prices	<ul style="list-style-type: none">• The immediate delivery price of physical gold is reflected in gold spot prices.• Research conducted by Hammoudeh and Yuan (2008) highlights that during times of economic instability, gold spot prices demonstrate considerable volatility. The researchers note that gold's function as a safe-haven asset becomes more evident amidst global crises, resulting in increased price fluctuations.• In India, the volatility patterns of gold spot prices are uniquely shaped by factors such as currency exchange rates, global gold prices, and international oil prices (Bouri et al., 2017; Mishra et al., 2021).
Gold Futures	<ul style="list-style-type: none">• Investors use gold futures to mitigate price risks and speculate on future price fluctuations.• Ghosh et al. (2004) assert that arbitrage opportunities between gold spot and futures prices contribute to their interconnected relationship and shared volatility patterns.• The long-term equilibrium connection between spot and futures gold prices in the Indian commodity market (Pradhan et al., 2020) underscores the importance of understanding these dynamics for effective risk management and investment strategies in India.• Literature suggests gold futures volatility is influenced by factors including macroeconomic variables, market sentiment, and global economic uncertainty (Fang et al., 2018; Ma et al., 2021; Wen et al., 2020).

LITERATURE REVIEW

Gold Instruments:

Gold ETFs	<ul style="list-style-type: none">• Gold ETFs have transformed the landscape of gold investments, providing investors with exposure to gold price movements without the necessity of possessing physical gold.• Research conducted by Baur and McDermott (2010) indicates that gold ETFs demonstrate volatility patterns akin to those of spot prices, albeit with heightened responsiveness to market liquidity and fund-specific elements.• As a contemporary investment instrument, gold ETFs have risen to prominence. The advent of this financial product has bolstered gold's significance in financial markets emerging as an impactful market in terms of return transmission across various ETF markets (Lau et al., 2017).
Gold Mining Equities	<ul style="list-style-type: none">• Shares in gold mining companies, exemplified by Deccan Gold Mining Corporation, offer amplified exposure to gold price fluctuations. Bloise and Shieh (1995) contend that mining stocks inherently possess greater volatility than physical gold due to the operational and financial risks intrinsic to mining operations.• Gold mining equities typically demonstrate considerable sensitivity to gold price movements. For instance, Twite (2002) notes that Australian gold-mining stocks, on average, shift by 0.76% for every 1% change in gold prices denominated in Australian dollars. Similarly, Tufano (1998) observes that North American gold mining stocks move 2% for each 1% alteration in gold prices, although these exposures vary across time and companies.• Notably, the correlation between gold prices and mining stock values is not always linear. This dual exposure renders mining stocks a high-risk, high-potential-return investment option. However, there is a paucity of research examining Deccan Gold Mines Ltd. within the Indian context.

LITERATURE REVIEW

Gold Instruments:

Global Gold ETFs	<ul style="list-style-type: none">• Global gold ETFs represent a significant segment of the gold investment landscape, offering diversified exposure to international markets. Studies by Ji et al. (2018) highlight the interconnectedness of global gold ETFs with other financial markets, noting their sensitivity to macroeconomic indicators such as interest rates and inflation expectations.• The SPDR Gold Trust, often referred to by its ticker symbol GLD, is one of the largest and most popular gold ETFs worldwide. It aims to track the price of gold bullion, providing investors with a cost-effective and liquid means of gaining exposure to gold (Lettau & Madhavan, 2018).• While gold ETFs are designed to track the price of gold closely, they may exhibit some tracking errors. Research on emerging markets ETFs has shown that tracking errors can be substantial, especially during periods of high cross-sectional dispersion in stock returns (Blitz & Huij, 2012).
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LITERATURE REVIEW

Volatility Spillover & Interconnectedness:

- The concept of interconnectedness pertains to the propagation of disruptions across financial instruments or markets. Diebold and Yilmaz (2009) were pioneers in examining spillover effects, establishing frameworks to measure directional spillovers between assets.
- The intricate nature of financial interconnections necessitates advanced econometric methodologies. Conventional techniques, such as correlation and regression analyses, are insufficient for capturing the evolving and time-dependent characteristics of these connections. Consequently, researchers have adopted sophisticated models, including vector autoregression (VAR), generalised autoregressive conditional heteroskedasticity (GARCH), and copula models.
- VAR models provide a flexible framework for examining multivariable time series data, enabling the investigation of complex relationships and interdependencies among variables across time (Sato et al., 2007). However, standard VAR models assume constant parameters, which limits their applicability in dynamic markets. Time-varying parameter VAR (TVP-VAR) models address the limitations of static VAR by allowing parameters to change over time. Primiceri (2005) demonstrates the effectiveness of TVP-VAR in analysing monetary policy dynamics.

LITERATURE REVIEW

Volatility Spillover in gold markets:

In gold markets, interconnectedness is evident in various ways. Ghosh et al. (2004) emphasize the robust connections between gold spot and futures prices, driven by arbitrage opportunities.

Similarly, Ji et al. (2018) extend this analysis to encompass global gold ETFs, highlighting the impact of international market dynamics on domestic instruments.

Emerging markets, including India, present distinct challenges when studying interconnectedness. Narayan et al. (2010) argue that increased volatility and vulnerability to external shocks intensify the interconnectedness of financial instruments in these markets.



LITERATURE REVIEW

Research Gaps

A major portion of existing studies treat gold as a homogeneous asset, overlooking the distinct dynamics of its investment alternatives and neglecting the interconnectedness and collective volatility of such alternatives.

Limited discussion on interconnectedness in gold market with focus on emerging economies such as India.

Limited application of advanced econometric methods, such as TVP-VAR, to capture the temporal evolution of interconnectedness in gold markets.

Lack of studies exploring gold mining equities as an alternative gold investment.

AIM OF THE STUDY

To explore the interconnectedness between gold investment options

- The study specifically examines the dynamic connections among gold spot prices, futures contracts, exchange-traded funds (ETFs), shares of Deccan Gold Mining Corporation, and global gold ETF (SPDR Gold Trust).

To capture the temporal evolution of relationships between gold investment options

- The study employs a time-varying parameter vector autoregression (TVP-VAR) approach enabling the identification of changing relationships over time

To identify risk transmission pathways for gold investment options

- Through the examination of dynamic linkages across these assets, the study provides insights for portfolio management, risk diversification, and market efficiency.

METHODOLOGY

'To' and 'From' Spillover

The connectedness approach depicts transfer of volatility from variable i to all other variables j and is known as total directional connectedness to others

$$TO_{ij} = \sum_{n=1}^k C_{ij \cdot nm}$$

The directional volatility that can be explained by variable 'i' due to spillover of risk from all other variables j is known as total directional connectedness from others

$$FROM_{ij} = \sum_{m=1}^k C_{ji \cdot nm}$$

METHODOLOGY

'Net' Spillover

The deduction of total directional connectedness to others from total directional connectedness from others results in the net total directional connectedness:

$$NET_{ij} = TO_{ij} - FROM_{ij}$$

NET_{ij} illuminates the difference between "TO" and "FROM,". Net transmitter of shocks (risk) to the system is denoted by a positive net value while a net receiver of shocks (risk) from other markets in the system is denoted by a negative net value.

METHODOLOGY

Data and Descriptive Statistics

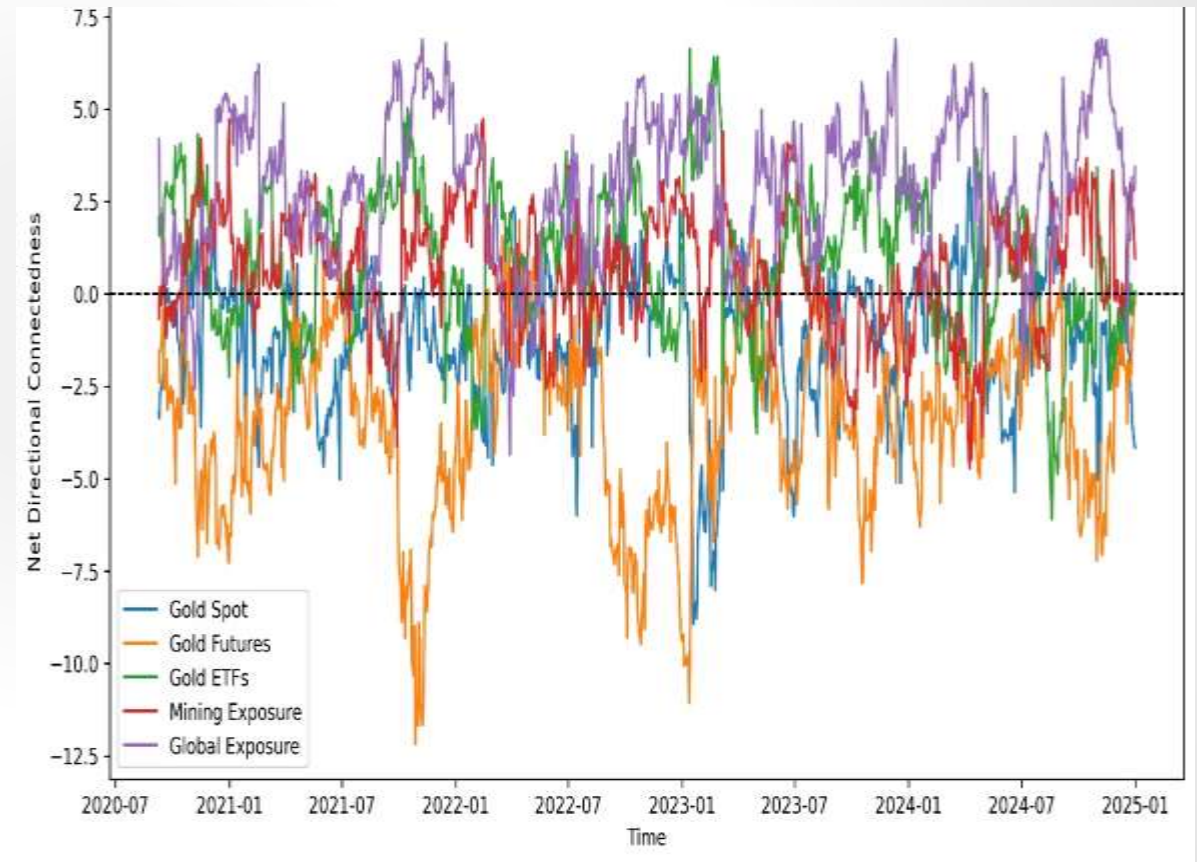
Time Frame: 1 January 2020 to 10 January 2025

Number of Observations: 1313 daily observations

Variables Considered and Data Sources:

- Gold Spot: Multi Commodity Exchange (MCX) Gold Spot, extracted from Bloomberg
- Gold Futures Index: Multi Commodity Exchange (MCX) Gold Futures iComdex, extracted from Bloomberg
- Gold ETF: Nippon India ETF Gold (BeES) unit prices, extracted from Investing.com
- Global Gold ETF: SPDR® Gold Shares, extracted from spdrgoldshares.com
- Gold Mining Exposure: Deccan Gold Mines Ltd. (DGML) share prices , extracted from Bloomberg

Figure 1: Return Time Series of the Network



METHODOLOGY

Descriptive Statistics

Table 1 presents the descriptive statistics, revealing that variance is highest in Gold ETFs and Mining Exposure, while Global exposure and have the lowest. The skewness statistics confirm an asymmetric price distribution.

Table 1 : Descriptive Statistics

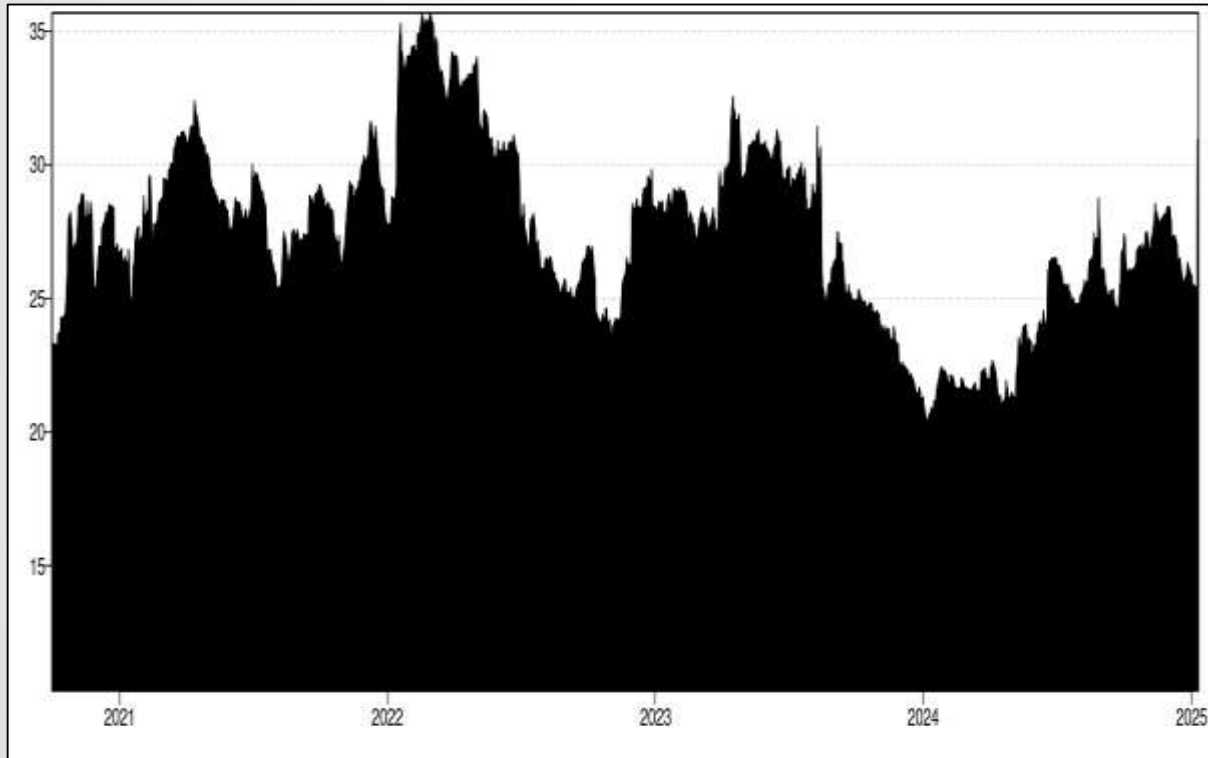
	Global Exposure	Mining Exposure	Gold.ETFs	Futures	Gold.Spot
Mean	182.081	54.713	47.894	17579.073	55137.500
Variance	0.498	1.629	1.849	0.527	3.232
Skewness	0.027 -0.688	0.128* -0.058	0.108 -0.108	0.063 -0.35	-0.453*** 0
Ex.Kurtosis	1.787*** 0	25.879*** 0	13.396*** 0	1.413*** 0	15.766*** 0
JB	174.658*** 0	36615.910*** 0	9813.103*** 0	109.997*** 0	13634.081*** 0
ERS	-9.856*** 0	-7.408*** 0	-22.118*** 0	-4.844*** 0	-7.115*** 0
Q(10)	314.837*** 0	295.790*** 0	248.038*** 0	310.510*** 0	254.253*** 0
Q2(10)	172.610*** 0	313.401*** 0	257.033*** 0	142.164*** 0	140.368*** 0

Note: *, **, *** represents the null hypothesis of normality is rejected at the 10%, 5% and 1% level, respectively.

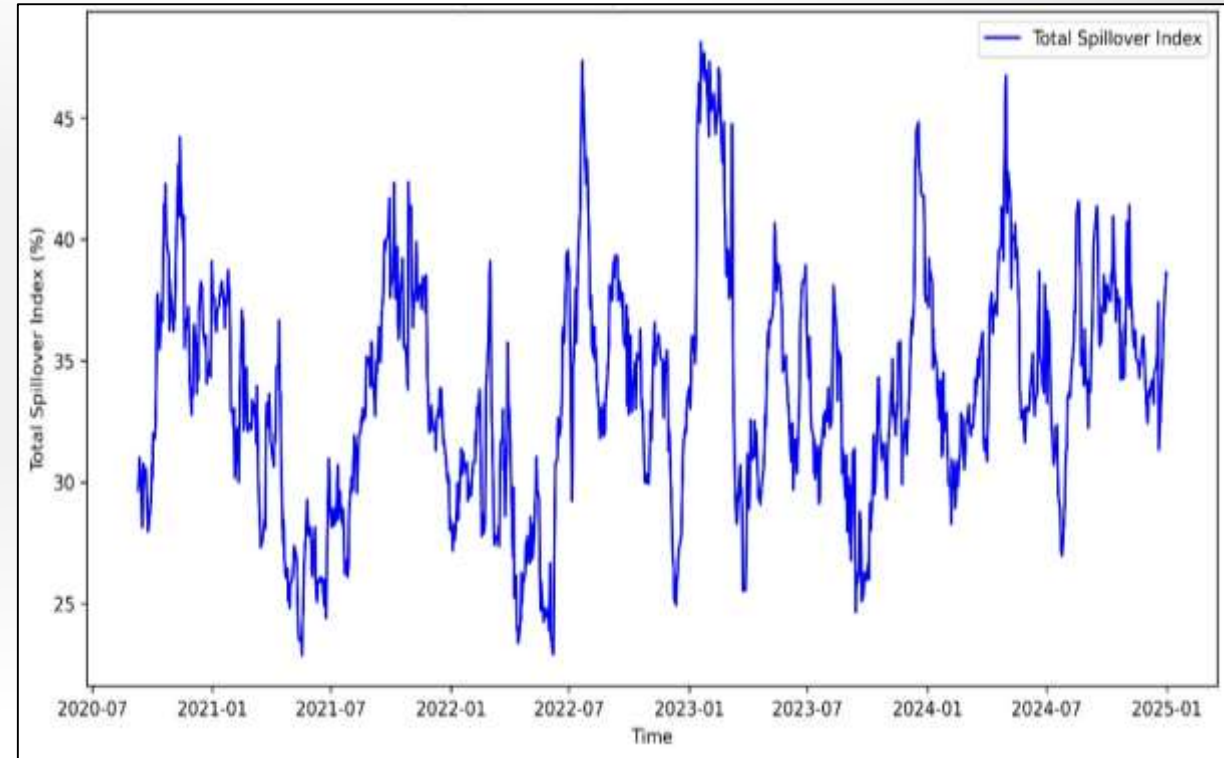
RESULTS & DISCUSSION

Figure 4: Dynamic total connectedness.

Panel A: Total Spillover Index Over Time



Panel B: Dynamic Total Spillover Index Over Time



Time connectedness TCI (Diebold and Yilmaz, 2012) using a 200 days rolling-window VAR & 10 step ahead forecast

RESULTS & DISCUSSION



Dynamic Total Connectedness plot : 35%

Demonstrates the linkage patterns between the considered variables

Range of fluctuation is time varying between (4.76) to 3.10.

Signs of time variation can be observed from the net directional connectedness. Interlinkages between the market systems is captured and quantified in the joint spillover index. The results are consistent with Baruník & Křehlík (2018) as well as Diebold & Yilmaz (2012).

RESULTS & DISCUSSION

Table 2: Average Dynamic connectedness table

	Global Exposure	Mining Exposure	Gold ETFs	Futures	Gold. Spot	FROM
Global Exposure	81.08	3.48	2.90	10.64	1.90	18.92
Mining Exposure	5.53	83.80	2.67	5.05	2.96	16.20
Gold.ETFs	3.40	1.63	85.64	3.90	5.42	14.36
Futures	10.56	3.83	3.24	79.70	2.66	20.30
Gold.Spot	2.16	2.50	5.22	3.81	86.32	13.68
TO	21.65	11.44	14.03	23.40	12.94	83.47
Inc.Own	102.73	95.24	99.67	103.10	99.26	cTCI/TCI
NET	2.73	(4.76)	(0.33)	3.10	(0.74)	20.87/16.69

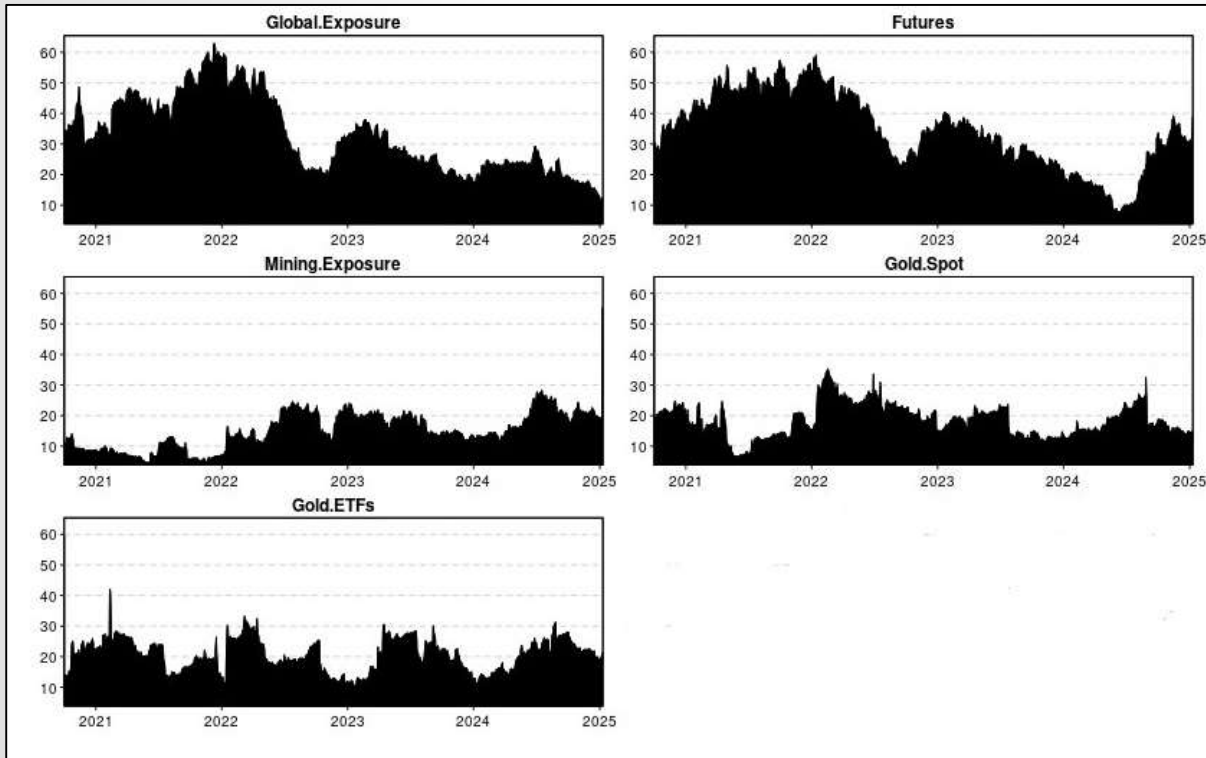
Gold futures emerge as prominent net transmitters of shocks within the system, with a NET connectedness of 3.10, indicating their active role in propagating market dynamics. This reflects their heightened responsiveness to market liquidity and fund-specific factors

Global ETFs exhibit strong connections, as evidenced by their contribution to the variance of other variables, although their NET connectedness is nearly balanced at -0.33, suggesting they are both influencers and influenced.

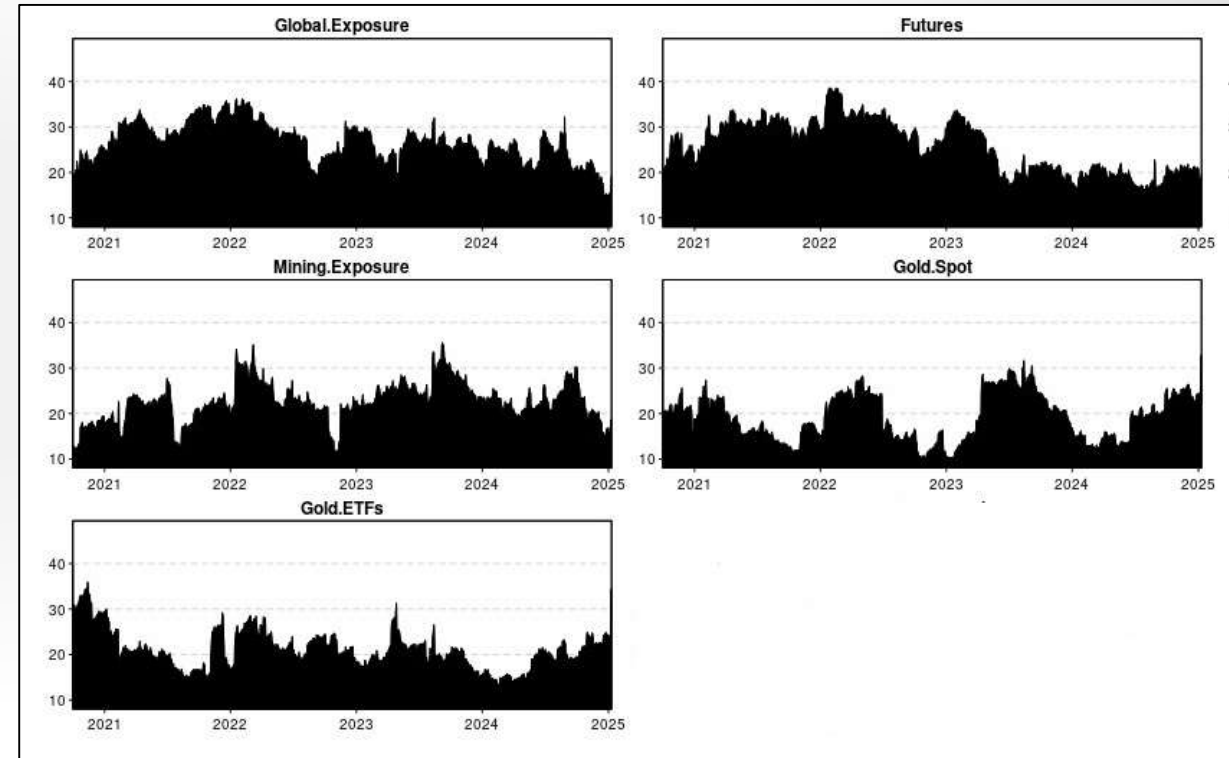
RESULTS & DISCUSSION

Figure 03: dynamic net pairwise directional connectedness

Panel B: 'To Others' Connectedness

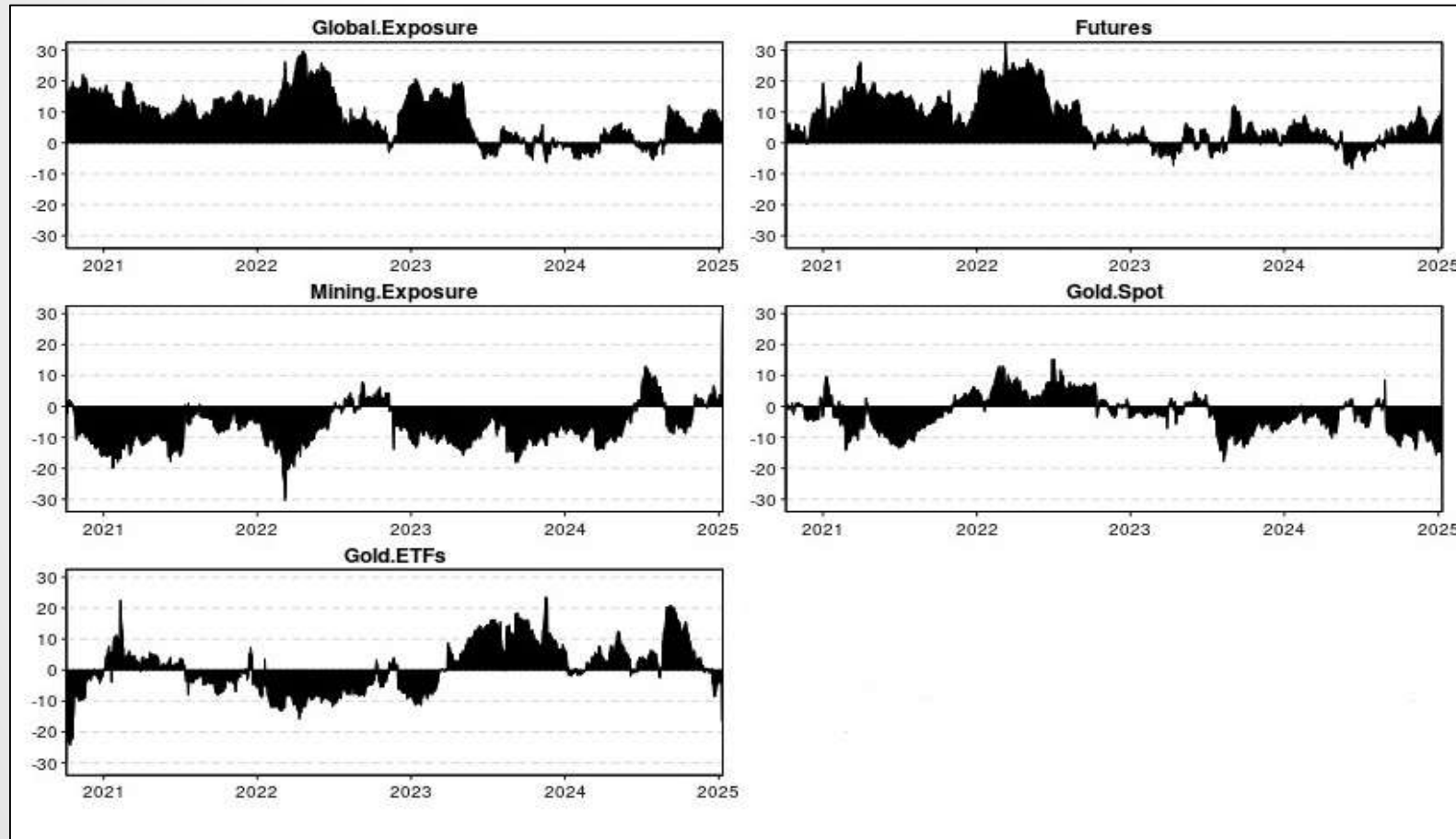


Panel C: 'From Others' Connectedness



RESULTS & DISCUSSION

Figure 03: dynamic net pairwise directional connectedness
Panel A: Net Connectedness



Dynamic Net connectedness of each futures series is analyzed as volatility induced in the system minus the volatility shocks received from the system.

RESULTS & DISCUSSION



- Total Connectedness Index – 16.69



- Net pairwise indices are ranging from 11.44 to 23.40




- Volatility contagion scale peaked during February 2022 as the directional connectedness for each set of asset classes.



- The highest magnitude of spillover from Global Exposure was to Mining Spillover.

RESULTS & DISCUSSION



- A positive value in the plot showcases that the asset class acts as transmitter of volatility at that point of time and the same holds true vice versa.




- Dynamic net directional connectedness is majorly through the gold futures market as it is the largest transmitter of volatility and the largest receiver of volatility.



- Directional volatility spillovers are from Gold Futures and Gold Exposure time series. The quantum of spillover is generally small

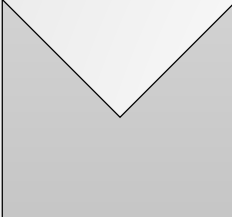


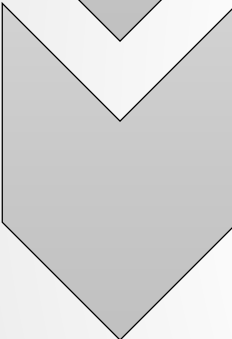
- Connectedness between the sample commodities increases with occurrence of the events such as the starting period of Russia Ukraine War in February 2022.

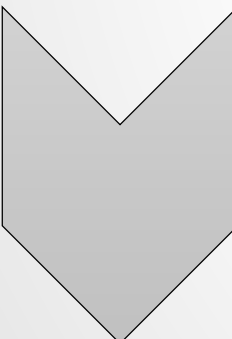


- The assessment allows us to investigate the reasons behind market changes and infer if an asset class acts as a net shock transmitter or a net shock receiver.

RESULTS & DISCUSSION

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- Gold mining equities, with a FROM connectedness of 16.20%, show substantial exposure to shocks from other market segments, particularly from gold spot prices and futures, due to inherent operational and financial risks associated with mining activities. Their NET connectedness of -4.76% underscores their vulnerability as net receivers of shocks.

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- Critical influence of global exposure (TO connectedness of 21.65%) on domestic instruments, demonstrating the sensitivity of the Indian gold market to global market dynamics. Conversely, gold spot prices, with a high Inc. Own value of 99.26, underscore their role as a relatively self-contained segment within the interconnected system.

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- Results emphasize the importance of considering both domestic and international factors when evaluating the Indian gold market. For investors, the findings offer valuable insights for optimizing portfolio diversification strategies, particularly by leveraging the shock-transmission roles of futures and global exposure. For policymakers, understanding these interconnected dynamics can inform strategies to enhance market efficiency and stability.

CONCLUSION AND IMPLICATIONS



Gold futures emerge as crucial transmitters of shocks, reflecting their significant influence on market dynamics. Global ETFs demonstrate a dual role, both influencing and being influenced by various factors, further emphasizing the interconnected nature of the system.



Gold mining equities exhibit heightened susceptibility to shocks from gold spot prices and futures, attributable to their inherent operational and financial risks, which may amplify their sensitivity to price fluctuations.



The profound impact of global market dynamics on domestic instruments underscores the importance of adopting a comprehensive approach that incorporates both domestic and international factors when assessing market behavior. This approach is vital for anticipating systemic vulnerabilities and formulating effective intervention strategies.



For investors, these insights provide valuable guidance on optimizing portfolio diversification by capitalizing on the varying shock transmission and absorption capacities of different gold market segments. For policymakers, the findings reveal opportunities to strengthen regulatory frameworks, enhance market resilience, promote transparency, and mitigate systemic risks.

CONCLUSION AND IMPLICATIONS

Policy Implications

Optimizing Risk Management Protocols for Gold Mining Securities	<ul style="list-style-type: none">• The substantial susceptibility of gold mining securities to fluctuations in other sectors, particularly gold spot prices, underscores the necessity for policies that mitigate operational and financial vulnerabilities.
Enhancing the Stability of ETFs as Investment Vehicles	<ul style="list-style-type: none">• Global ETFs exhibit reciprocal tendencies of influencing and being influenced by other market segments, indicative of their interconnectedness.• Transparency in ETF operations, ensure adequate liquidity provisions, and encourage mechanisms to reduce tracking discrepancies.• Fortification of ETFs against systemic shocks and bolster investor confidence in their efficacy as diversification instruments.
Fostering Portfolio Diversification and Strengthening Investor Protection	<ul style="list-style-type: none">• The interconnectedness and varied shock transmission capacities of different gold market segments offer portfolio diversification opportunities. Policymakers should prioritize financial literacy programs to educate investors on leveraging these opportunities in gold instruments as the markets are resilient

**THANK
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