Volatility in the Energy Transition Metals and Financial Markets: A Network Connectedness Approach

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EXTENDED ABSTRACT

In this study, we apply the network connectedness approach developed by Diebold and Yilmaz (2015, 2012) to analyse volatility spillovers between eight major financial markets and twelve Energy Transition Metals (ETMs), which are key components in the development of clean energy technologies. By analysing both static and dynamic network connectedness between financial indices and ETM markets, we estimate the volatility spillovers between these two market segments. To the best of our knowledge, this study is the first to extend the network connectedness framework between a broad set of global financial markets and the energy transition metals.

From an economic and financial perspective, understanding volatility spillovers between financial markets and ETMs is essential because they provide crucial insights into risk transmission, market interdependence, and systemic stability, thereby affecting capital allocation, production costs, and ultimately the pace and affordability of the green transition (Akadiri and Ozkan, 2025; Sohag et al., 2023). On the one hand, ETMs play a crucial role for the development of renewable energy technologies, battery storage systems, electric vehicles, and for the implementation of broader decarbonization initiatives (International Energy Agency, 2021). On the other hand, financial markets play a vital role in routing financial resources toward the green transition (Kedward et al., 2022). For this reason, it is important to study whether the spillovers of volatilities might hamper the green transition by impacting the future prices of these metals, generating higher costs to all those energy and manufacturing firms willing to pursue a low carbon transition.

The network connectedness approach allows us to identify the transmission of net volatility spillovers from one market to another (financial markets, ETMs markets, and cross-market interactions) as well as within a specific market. Furthermore, by adopting the same estimation strategy over a rolling window, we capture the time-varying behaviour of such measures of connectedness around major economic and financial events. Overall, our results provide detailed information on dependencies between different markets and offer actionable insights for portfolio managers seeking to design optimal investment strategies.

We focus on financial market indices for both developed (Germany, France, Spain, and Italy) and emerging economies (China, Russia, Japan, and Singapore) and on a large set of Industrial and Energy Transition Metals (Aluminium, Cobalt,

Copper, Lead, Nickel, Zinc, Tin, IronOre, Silver, Palladium, Platinum, and Lithium). We employ normalized real daily closing prices for all the series, and we then compute daily returns and monthly realized volatility. The final sample comprises a period spanning from January 2015 to December 2024, yielding a total of 119 monthly observations.

To estimate both static and dynamic connectedness measures, we implement a Generalized Forecast Error Variance Decomposition (GFEVD) derived from Vector Autoregressive (VAR) models to demonstrate total, directional, and net pairwise spillovers across our system of 20 time series. For the sake of addressing the overparametrization issue, we use an adaptive elastic-net penalization approach – as proposed by Zou and Zhang (2009). This method combines shrinkage and variable selection, effectively reducing dimensionality issues by eliminating insignificant coefficients. The optimal lags are then determined by the sparsity patterns of the estimated coefficient matrices. The GFEVD-based connectedness framework is widely used in the literature and offers important advantages. It measures spillovers from each market without requiring identification restrictions or imposing an arbitrary ordering of variables in the VAR.

Preliminary results suggest that the German market (7.91%) is the primary source of volatility spillover shocks to other markets, whereas the volatility shocks transmitted to other markets originate from the Singapore market (22.88%), making it the largest net transmitter in the system. Concerning the total spillovers from the ETMs markets, our results highlight the central role of Copper (6.73%) and Aluminium (5.94%) propagating volatility to the whole ETM network, while the IronOre (8.14%) is the largest net transmitter of volatility shocks.

Concerning the transmission of total and net volatility across the two markets, the overall return patterns remain broadly consistent. Copper (4.69%) and some major European stock markets – e.g., Italy (3.83%), and Germany (3.57%) – are transmitting volatility across the integrated network of financial and ETMs markets, whereas Platinum (17.3%) is the largest transmitter of volatility and Copper (-32.07%) is the largest receiver of volatility in net-pairwise terms. Our results indicate that investors who focus solely on ETM commodities may still experience negative return spillover shocks originating from most stock markets in the Europe-Asia region. Overall, our analysis suggests that stock market investments remain a key component for constructing an optimal portfolio, while diversification benefits from ETM commodities alone are relatively limited.

Our study has several important contributions to the existing literature. First, we identify the net transmitters and net recipients of return and volatility spillovers within a spillover network framework. Investors are not only concerned with the existence of spillovers but also with their direction and magnitude across various markets. By decomposing the total spillover index into directional spillovers, we calculate the net pairwise spillover index, which provides detailed information on the net contribution of each market. This methodological approach offers more precise perceptions for portfolio allocation and risk management decisions. Second, we emphasize the role of net pairwise network connectedness as a measure of shock transmission across markets. Specifically, we provide a visual representation of the complex network connectedness among stock indices, ETMs and cross-markets, enabling a clearer understanding of directional linkages both within and across market classes. From a practical perspective, these findings enhance the understanding of price discovery mechanisms and cross-market linkages, offering valuable implications for portfolio and fund managers. Third, we utilize a rolling-window estimation approach to capture the time-varying dynamics of spillovers. This approach allows us to examine how major financial and economic events such as Brexit, the COVID-19 outbreak, and the Russia-Ukraine War have influenced the intensity and direction of return and volatility spillovers. Unlike analyses based on arbitrarily defined sub-samples, the rolling framework captures the continuous evolution of risk transmission over time, providing a more comprehensive and realistic assessment of dynamic interconnectedness in financial and ETMs markets.

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