Climate-Aware Renewable Energy Portfolio Optimisation under Quantile Connectedness: Evidence from Energy and Financial Markets

Chiraz Hmercha[1,2], Christian de Peretti[1,3], Manel Kacem[2], and Lotfi Belkacem[2]

[1]Laboratory of Actuarial and Financial Sciences (LSAF), University of Claude Bernard Lyon 1, 50 Av. Tony Garnier, 69007 Lyon, France
[2]Laboratory Research for Economy, Management and Quantitative Finance, University of Sousse, Route de la ceinture Sahloul 3 - 4054 Sousse, Tunisia
[3]Ecole Centrale de Lyon, University of Lyon, 36 avenue Guy de Collongue, 69134 Ecully, France
[@]Emails: hmercha.chiraz@gmail.com

Abstract

This study investigates the diversification efficiency and risk management properties of climate-aware portfolio strategies in renewable energy markets, and examines the state-dependent volatility spillovers that underpin them. Using a Quantile Vector Autoregression (QVAR) framework applied to GARCH-filtered conditional volatilities of renewable energy, conventional energy, and financial market indices over the period 2013–2023, we capture nonlinear and tail-dependent interconnections that vary across different quantiles of the volatility distribution, distinguishing between periods of financial distress, normal market conditions, and market exuberance. Weather-related influences are incorporated through Principal Component Analysis applied to climate variables linked to a French Renewable Energy Index (REFI), followed by a Threshold Autoregressive specification to account for regime shifts, yielding a weather-adjusted index (REFIweather), which is integrated for the first time into a multi-market quantile connectedness setting. The empirical results confirm that market interdependencies intensify significantly during extreme market conditions, reflecting the state-dependent nature of volatility spillovers. Across all market regimes, portfolios integrating clean energy indices and the weather-adjusted REFIweather construct, under Minimum Connectedness and Minimum Correlation strategies, systematically deliver superior risk management and diversification efficiency compared to alternative allocations. Conversely, under the Minimum Variance framework, optimal risk-adjusted performance is achieved through heavy concentration in low-volatility assets rather than through genuine climate-oriented diversification.

These findings highlight the critical role of portfolio construction criteria in assessing the diversification value of renewable energy assets, and demonstrate that climate-aware connectedness-based strategies yield more efficient and resilient portfolio allocations in the context of the global energy transition.
Keywords: Renewable energy markets, Weather risk, Financial stock market, Quantile connectedness, Portfolio optimization, Energy transition.