

Non-linear and Distributional Dynamics of Altcoin Returns : A NARDL-QNARDL Analysis of Energy, ESG, and Macro-Economic Factors

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Abstract

This study aims to assess the quantile, asymmetric and nonlinear impact of the economic indices and commodities on the price of Ethereum. We used NARDL to identify long-run and short-run asymmetry and QNARDL model on daily data from 2016 to 2024 to explain the unique or distributional asymmetry based on the location of the dependent variable within its own distribution. Findings reveal close connection of Ethereum with energy market and ESG index. Energy assets and environmental factors significantly influence the daily return of Ethereum. The coefficient of error term represents the fast speed (92.70%) of correction and achieving a capacity of the market to equilibrium explains the influence of the solar index and real estate price on the Ethereum price and indicates eliminating the arbitrage window. Outcome invites researchers and practitioners to explore the linkage of the cryptocurrency market with environmental factors and macro-financial development variables.

JEL Code : G15; C22; Q43; Q56

Keywords : Cryptocurrency; Ethereum; Bitcoin; Financial Assets; NARDL; QNARDL; ESG; Energy; Macro-economic;

I. Introduction

CRYPTOCURRENCIES HAVE GAINED a lot of attention in the financial markets due to the quick development of blockchain technology, and the belief held by some that they could represent a new class of investment assets. Most central banks including the RBI are bullish on the introduction of their own digital currency (Agarwal and Pandey, 2023). Even though the cryptocurrency market is operating in dichotomy, where the crypto assets are being actively traded in numerous countries and on contrary an outright ban in some countries including China, Iraq, Bangladesh, Nepal to name a few. This phenomenon of duality reflects the diverse economic priorities, apart

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Submitted October 2025; Accepted February 2026

References

- Adewuyi, A. O., B. A. Wahab, A. K. Tiwari, and H. X. Do, (2024), "Do bitcoin electricity consumption and carbon footprint exhibit random walk and bubbles? Analysis with policy implications", *Journal of Environmental Management*, Vol. 367, No. 121-958.
- Agarwal, J.D., Manju Agarwal, Aman Agarwal and Yamini Agarwal, (2018), "The Theory of Money, Wealth and Efficient Currency Market: Modeling M5 as Money Supply with Cryptocurrency", *Finance India*, Vol. 32, No. 2, June 2018
- Agarwal, J.D., Manju Agarwal, Aman Agarwal and Yamini Agarwal, (2023), "Trust as a Financial Value", *Finance India*, Vol. 37, No. 3, September 2023, pp. 665-678
- Agarwal, Aman and Krishna Nath Pandey, (2023), "Central Bank Digital Currency (Digital Rupee), M5 as Money Supply & Financial Inclusion for Economic Prosperity : Review of Literature", *Finance India*, Vol. 36, No. 4, December 2023, pp. 1105-1148
- Aharon, D. Y. and E. Demir, (2022), "NFTs and asset class spillovers: Lessons from the period around the COVID-19 pandemic", *Finance Research Letters*, Vol. 47, Article No. 102515.
- Aysan, A. F., A. U. I. Khan, and H. Topuz, (2021), "Bitcoin and altcoins price dependency: Resilience and portfolio allocation in COVID-19 outbreak", *Risks*, Vol. 9, No. 4, pp 1-74.
- Baum, A., (2009), "*Commercial real estate investment: A strategic approach*", Taylor & Francis, London, UK pp. 1-436.
- Baur, D. G. and T. K. McDermott, (2016), "Why is gold a safe haven?", *Journal of Behavioral and Experimental Finance*, Vol. 10, No. 3, pp. 63-71.
- Beck, R., C. Müller-Bloch, and J. L. King, (2018), "Governance in the blockchain economy: A framework and research agenda", *Journal of the Association for Information Systems*, Vol. 19, No. 10, pp. 1020-1034.
- Bose, R., J. Nagarkar, S. Malik, and N. Bharti, (2024), "Unveiling the interlinkage between Ethereum and Nifty indices: Impact of cryptocurrency on Indian equity markets post COVID-19", *Cogent Economics & Finance*, Vol. 12, No. 1, Article No. 2359599.
- Bouri, E., O. Cepni, D. Gabauer, and R. Gupta, (2021), "Return connectedness across asset classes around the COVID-19 outbreak", *International Review of Financial Analysis*, Vol. 73, No 3, Article No. 101646.
- Bouri, E., R. Gupta, A. Lahiani, and M. Shahbaz, (2018), "Testing for asymmetric nonlinear short- and long-run relationships between bitcoin, aggregate commodity and gold prices", *Resources Policy*, Vol. 57, pp. 224-235.
- Bouri, E., R. Gupta, and D. Roubaud, (2019), "Herding behaviour in cryptocurrencies", *Finance Research Letters*, Vol. 29, pp. 216-221.
- Brown, R. L., J. Durbin, and J. M. Evans, (1975), "Techniques for testing the constancy of regression relationships over time", *Journal of the Royal Statistical Society Series B: Statistical Methodology*, Vol. 37, No. 2, pp. 149-163.
- Caporale, G. M., L. Gil-Alana, and A. Plastun, (2018), "Persistence in the cryptocurrency market", *Research in International Business and Finance*, Vol. 46, pp. 141-148.

Chaim, P. and M. P. Laurini, (2019), "Is bitcoin a bubble?", *Physica A: Statistical Mechanics and its Applications*, Vol. 517, pp. 222-232.

Cheah, E.-T. and J. Fry, (2015), "Speculative bubbles in bitcoin markets? An empirical investigation into the fundamental value of bitcoin", *Economics Letters*, Vol. 130, pp. 32-36.

Cheah, E.-T., T. Mishra, M. Parhi, and Z. Zhang, (2018), "Long memory interdependency and inefficiency in bitcoin markets", *Economics Letters*, Vol. 167, pp. 18-25.

Cho, J. S., T-H. Kim, and Y. Shin, (2015), "Quantile cointegration in the autoregressive distributed-lag modeling framework", *Journal of Econometrics*, Vol. 188, No. 1, pp. 281-300.

Choudhury, T., U. N. Kayani, A. Gul, S. A. Haider, and S. Ahmad, (2023), "Carbon emissions, environmental distortions, and impact on growth", *Energy Economics*, Vol. 126, Article No. 107040.

Ciaian, P., M. Rajcaniova, and D. Kancs, (2016), "The economics of bitcoin price formation", *Applied Economics*, Vol. 48, No. 19, pp. 1799-1815.

De Vries, A., (2018), "Bitcoin's growing energy problem", *Joule*, Vol. 2, No. 5, pp. 801-805.

De Vries, A., (2023), "Cryptocurrencies on the road to sustainability: Ethereum paving the way for bitcoin", *Patterns*, Vol. 4, No. 1, Article No. 100633.

Fama, E. F., (1970), "Efficient capital markets", *Journal of Finance*, Vol. 25, No. 2, pp. 383-417.

Garcia-Monleon, F., I. Danvila-del Valle, and F. J. Lara, (2021), "Intrinsic value in cryptocurrencies", *Technological Forecasting and Social Change*, Vol. 162, Article No. 120393.

Ghaemi Asl, M., M. M. Rashidi, A. K. Tiwari, C.-C. Lee, and D. Roubaud, (2023), "Green bond vs. Islamic bond: Which one is more environmentally friendly?", *Journal of Environmental Management*, Vol. 345, Article No. 118580.

Gil-Alana, L. A., E. J. A. Abakah, and M. F. R. Rojo, (2020), "Cryptocurrencies and stock market indices: Are they related?", *Research in International Business and Finance*, Vol. 51, Article No. 101063.

Gkillas, K. and P. Katsiampa, (2018), "An application of extreme value theory to cryptocurrencies", *Economics Letters*, Vol. 164, No 3, pp. 109-111.

Grobys, K. and N. Sapkota, (2020), "Predicting cryptocurrency defaults", *Applied Economics*, Vol. 52, No. 46, pp. 5060-5076.

Hanif, W., J. A. Hernandez, V. Troster, S. H. Kang, and S. M. Yoon, (2022), "Nonlinear dependence and spillovers between cryptocurrency and global/regional equity markets", *Pacific-Basin Finance Journal*, Vol. 74, Article No. 101822.

Harb, E., C. Bassil, T. Kassamany, and R. Baz, (2024), "Volatility interdependence between cryptocurrencies, equity, and bond markets", *Computational Economics*, Vol. 63, No. 3, pp. 951-981.

Isah, K. O. and P. C., Ekeocha, (2023), "Testing the forecasting prowess of bitcoin uncertainty in the predictability of stock returns", *FIIA Business Review*, Article No. 23197145231210343.

Jareño, F., M. D. L. O. González, M. Tolentino, and K. Sierra, (2020), "Bitcoin and gold price returns: A quantile regression and NARDL analysis", *Resources Policy*, Vol. 67, Article No. 101666.

Jena, S. K., A. Lahiani, A. K. Tiwari, and D. Roubaud, (2021), "Uncovering the complex asymmetric relationship between trading activity and commodity futures price: Evidenced from QNARDL study", *Resources Policy*, Vol. 74, Article No. 102277.

Kartal, C. and Ü. Ö. Can, (2022), "Analysis of the correlation between cryptocurrencies, S&P 500 and US 10-year treasury bond index with Granger causality test", *Journal of Management and Economics Research*, Vol. 20, No. 2, pp. 274-291.

Verma, R., D. Sharma, and S. Sam, (2023), "Cryptocurrency market anomaly: The day-of-the-week-effect", *Finance India*, Vol. 37, No. 1, pp. 301-316.

Wang, Y., B. Lucey, S. A. Vigne, and L. Yarovaya, (2022), "An index of cryptocurrency environmental attention (ICEA)", *China Finance Review International*, Vol. 12, No. 3, pp. 378-414.

Wendl, M., M. H. Doan, and R. Sassen, (2023), "The environmental impact of cryptocurrencies using proof of work and proof of stake consensus algorithms: A systematic review", *Journal of Environmental Management*, Vol. 326, Article No. 116530.

Yin, L., J. Nie, and L. Han, (2021), "Understanding cryptocurrency volatility: The role of oil market shocks", *International Review of Economics & Finance*, Vol. 72, pp. 233-253.

Yousaf, I., Y. Riaz, and J. W. Goodell, (2023), "Energy cryptocurrencies: Assessing connectedness with other asset classes", *Finance Research Letters*, Vol. 52, Article No. 103389.

Zhang, W., P. Wang, X. Li, and D. Shen, (2018), "The inefficiency of cryptocurrency and its cross-correlation with DOW Jones Industrial Average", *Physica A: Statistical Mechanics and its Applications*, Vol. 510, pp. 658-670.

Zhang, Y., S. Chan, J. Chu, and S. Nadarajah, (2019), "Stylised facts for high frequency cryptocurrency data", *Physica A: Statistical Mechanics and its Applications*, Vol. 513, pp. 598-612.