

HISTORICAL VOLATILITY FLUCTUATIONS OF BITCOIN: INFLUENCED BY REAL-WORLD EVENTS

(Sejarah Turun-Naik Kemeruapan Bitcoin: Dipengaruhi oleh Peristiwa Dunia Sebenar)

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ABSTRACT

Bitcoin market has exhibited substantial volatility over time. Bitcoin returns exhibit high standard deviation. This study employs the GARCH (1,1) model with normal (norm), Student-t (std), and generalized error distributions (ged) to estimate Bitcoin conditional volatility. Bitcoin exhibits fat-tailed returns, volatility clustering, and a remarkably high persistence value. The GARCH (1,1)-ged model showed superior performance compared to other models when evaluated using LL, AIC, and BIC criteria. The indicator saturation (IS) method was employed to concurrently detect historical daily breaks, trend breaks, and outliers in Bitcoin volatility data. The indicator saturation approach revealed that, for the past decade, historical Bitcoin volatility has had 6 outliers, 31 breaks, and 74 trend breaks under the normal distribution, 0 outliers, 26 breaks, and 83 trend breaks under the student-t distribution, and 1 outlier, 29 breaks, and 77 trend breaks under the ged distribution. This shows that assuming a heavy tail led to fewer outliers and breaks, and as the frequency of trend breaks increases, it also shows more volatility clusters represented by GARCH. These discoveries have the potential to comprehend the influence of events on financial markets and guarantee stability in the evaluation of financial risk, management of portfolios, and modeling endeavors.

Keywords: breaks; outliers; indicator saturation; Bitcoin; volatility

ABSTRAK

Pasaran Bitcoin menunjukkan perubahan dan kemeruapan yang ketara sepanjang sejarah. Pulangan Bitcoin dikenali kerana mempunyai sisihan piawai yang tinggi. Kajian ini menggunakan model GARCH (1,1) dengan taburan normal (norma), Student-t (std), dan taburan ralat umum (ged) untuk menganggarkan kemeruapan bersyarat Bitcoin. Bitcoin mempamerkan pulangan berekor tebal, pengelompokan kemeruapan, dan nilai kegigihan yang sangat tinggi. Model GARCH (1,1)-ged menunjukkan prestasi unggul berbanding model lain apabila dinilai menggunakan kriteria LL, AIC, dan BIC. Kaedah penunjuk ketepuan (IS) digunakan untuk secara serentak mengesan sejarah putusan harian, putusan aliran dan data terpendil dalam data kemeruapan Bitcoin. Pendekatan petunjuk ketepuan mendedahkan bahawa, sepanjang dekad yang lalu, sejarah kemeruapan Bitcoin mempunyai 6 data terpendil, 31 putusan dan 74 putusan trend di bawah taburan normal, 0 data terpendil, 26 putusan dan 83 putusan trend di bawah student-t, dan 1 data terpendil, 29 putusan dan 77 putusan trend di bawah taburan ged. Ini menunjukkan bahawa menganggap ekor yang tebal membawa kepada lebih sedikit data terpendil dan putusan, dan apabila kekerapan putusan trend meningkat, ia juga menunjukkan lebih banyak kelompok kemeruapan yang diwakili oleh GARCH. Penemuan ini berpotensi untuk memahami pengaruh peristiwa ke atas pasaran kewangan, dan menjamin kestabilan dalam penilaian risiko kewangan, pengurusan portfolio dan usaha pemodelan.

Kata kunci: putusan; data terpendil; penunjuk ketepuan; Bitcoin; kemeruapan

References

- Abakah E.J.A., Gil-Alana L.A., Madigu G. & Romero-Rojo F. 2020. Volatility persistence in cryptocurrency markets under structural breaks. *International Review of Economics and Finance* **69**: 680-691.
- Aharon D.Y., Butt H.A. Jaffri A. & Nichols B. 2023. Asymmetric volatility in the cryptocurrency market: New evidence from models with structural breaks. *International Review of Financial Analysis* **87**: 102651.
- Ahmed W.M.A. 2018. On the interdependence of natural gas and stock markets under structural breaks. *Quarterly Review of Economics and Finance* **67**: 149-161.
- Ahmed M.S. & Bouri E. 2023. Long memory and structural breaks of cryptocurrencies trading volume. *Eurasian Economic Review* **13**(3): 469-497.
- Ané T., Ureche-Rangau L., Gambet J.B. & Bouverot J. 2008. Robust outlier detection for Asia-Pacific stock index returns. *Journal of International Financial Markets, Institutions and Money* **18**(4): 326-343.
- Alam M.S., Amendola A., Candila V. & Jabarabadi S.D. 2024. Is monetary policy a driver of cryptocurrencies? Evidence from a structural break Garch-Midas approach. *Econometrics* **12**(1): 2.
- Bai J. & Perron P. 1998. Estimating and testing linear models with multiple structural changes. *Econometrica* **66**(1): 47-78.
- Bai J. & Perron P. 2003. Computation and analysis of multiple structural change models. *Journal of Applied Econometrics* **18**(1): 1-22.
- Bollerslev T. 1987. A conditionally heteroskedastic time series model for speculative prices and rates of return. *The Review of Economics and Statistics* **69**(3): 542-547.
- Bouri E., Gil-Alana L.A., Gupta R. & Roubaud D. 2019. Modelling long memory volatility in the Bitcoin market: Evidence of persistence and structural breaks. *International Journal of Finance & Economics* **24**(1): 412-426.
- Brooks C. 2019. *Introductory Econometrics for Finance, Fourth Edition*. 4th Ed. Cambridge, United Kingdom: Cambridge University Press.
- Canh N.P., Wongchoti U., Thanh S.D. & Thong N.T. 2019. Systematic risk in cryptocurrency market: Evidence from DCC-MGARCH model. *Finance Research Letters* **29**: 90-100.
- Castle J.L., Doornik J.A. & Hendry D.F. 2012. Model selection when there are multiple breaks. *Journal of Econometrics* **169**(2): 239-246.
- Castle J.L., Doornik J.A., Hendry D.F. & Pretis F. 2015. Detecting location shifts during model selection by Step-Indicator Saturation. *Econometrics* **3**(2): 240-264.
- Charles A. & Darné O. 2005. Outliers and GARCH models in financial data. *Economics Letters* **86**(3): 347-352.
- Charles A. & Darné O. 2019. Volatility estimation for cryptocurrencies: Further evidence with jumps and structural breaks. *Economics Bulletin* **39**(2): 954-968.
- Doornik J.A. & Ooms M. 2005. *Outlier detection in GARCH models* (Tinbergen Institute Discussion Paper No. 05-092/4). Tinbergen Institute.
- Dutta A. & Bouri E. 2022. Outliers and time-varying jumps in the cryptocurrency markets. *Journal of Risk and Financial Management* **15**(3): 128.
- Engle R.F. 1982. Autoregressive conditional heteroscedasticity with estimates of the variance of United Kingdom inflation. *Econometrica* **50**(4): 987-1007.
- Franses P.H. & Ghijsels H. 1999. Additive outliers, GARCH and forecasting volatility. *International Journal of Forecasting* **15**(1):1-9.
- Gorman M. & Huguen W.K. 2024. Does bitcoin still enhance an investment portfolio in a post Covid-19 world? *Finance Research Letters* **62**: 105170.
- Harb E., Bassil C., Kassamany T. & Baz R. 2022. Volatility interdependence between cryptocurrencies, equity, and bond markets. *Computational Economics* **63**(3): 951-981.
- He Z. & Maheu J.M. 2010. Real time detection of structural breaks in GARCH models. *Computational Statistics & Data Analysis* **54**(11): 2628-2640.
- Hendry D. 1999. An econometric analysis of US food expenditure, 1931-1989.
- Hendry D. 1999. An econometric analysis of US food expenditure, 1931-1989. In Magnus J. & Morgan M. (eds.). *Methodology and Tacit Knowledge: Two Experiments in Applied Econometrics*: 341-361. Hoboken, NJ: John Wiley & Sons.
- Hendry D.F. & Doornik J.A. 2014. *Empirical Model Discovery and Theory Evaluation: Automatic Selection Methods in Econometrics*. Cambridge, MA: MIT Press.
- Hu A.S., Parlour C.A. & Rajan U. 2019. Cryptocurrencies: Stylized facts on a new investible instrument. *Financial Management* **48**(4): 1049-1068.
- Inclán C. & Tiao G.C. 1994. Use of cumulative sums of squares for retrospective detection of changes of variance. *Journal of the American Statistical Association* **89**(427): 913-923.
- Ismail M.T. & Nasir I.N.M. 2018. Structural breaks and outliers in ASEAN Shariah compliant indices: The impulse indicator saturation approach. *AIP Conference Proceedings* **2013**(1): 020130.
- Ismail M.T. & Nasir I.N.M. 2020. Outliers and structural breaks detection in volatility data: A simulation study using step indicator saturation. *Menemui Matematik (Discovering Mathematics)* **42**(2): 76-85.

- Javid A.Y. & Ahmad B. 2020. Event study and impulse indicator saturation analysis to assess reaction of terrorist and political events: Evidence from oil and gas sector of Pakistan. *Journal of Quantitative Methods* 4(1): 1-1.
- Jiang Z., Mensi W. & Yoon S.M. 2023. Risks in major cryptocurrency markets: Modeling the dual long memory property and structural breaks. *Sustainability* 15(3): 2193.
- Johansen S. & Nielsen B. 2009. An analysis of the indicator saturation estimator as a robust regression estimator. *Castle, and Shephard (2009)* 1:1-36.
- Johansen S. & Nielsen B. 2009. An analysis of the indicator saturation estimator as a robust regression estimator. In Castle J.L. & Shephard N. (eds.). *The Methodology and Practice of Econometrics: A Festschrift in Honour of David F. Hendry*: 1-36. Oxford, United Kingdom: Oxford University Press.
- Kaseke F., Ramroop S. & Mwambi H. 2022. A comparative analysis of the volatility nature of cryptocurrency and JSE market. *Investment Management and Financial Innovations* 19(4): 23-39.
- Katsiampa P., Corbet S. & Lucey B. 2019. Volatility spillover effects in leading cryptocurrencies: A BEKK-MGARCH analysis. *Finance Research Letters* 29: 68-74.
- Lamoureux C.G. & Lastrapes W.D. 1990. Persistence in variance, structural change, and the GARCH model. *Journal of Business & Economic Statistics* 8(2): 225-234.
- Mandaci P.E. & Cagli E.C. 2022. Herding intensity and volatility in cryptocurrency markets during the COVID-19. *Finance Research Letters* 46: 102382.
- Mohamed S.D., Ismail M.T. & Ali M.K.M. 2023. Detecting structural breaks in cryptocurrency market. *Jurnal Ekonomi Malaysia* 57(2):107-122.
- Mohamed S.D., Ismail M.T. & Ali M.K.M. 2024. Cryptocurrency Returns Over a Decade: Breaks, Trend Breaks and Outliers. *Scientific Annals of Economics and Business* 71(1):1-20.
- Moore T. 2009. Sudden changes in volatility: The case of five Central European stock markets. *Journal of International Financial Marketing, Institutions & Money* 19(1): 33-46.
- Mužić I. & Gržeta I. 2022. Expectations of macroeconomic news announcements: Bitcoin vs. Traditional assets. *Risks* 10(6), 123.
- Nakamoto S. 2008. Bitcoin: A peer-to-peer electronic cash system. *Decentralized business review*.
- Nasi I.N.M., Ismail M.T. & Karim S.A.A. 2022. Detecting structural breaks and outliers for volatility data via impulse indicator saturation. In: Abdul Karim S.A.A. (ed.). *Intelligent Systems Modeling and Simulation II: Machine Learning, Neural Networks, Efficient Numerical Algorithm and Statistical Methods*: 679-687. Cham, Switzerland: Springer International Publishing.
- Nasir I.N.M. & Ismail M.T. 2020. Detection of outliers in the volatility of Malaysia shariah compliant index return: The impulse indicator saturation approach. *ASM Science Journal* 13: 1-7.
- Patra S. & Gupta N. 2025. Unravelling the volume-volatility nexus in cryptos under structural breaks using fat-tailed distributions: mixture of distribution hypothesis and implications for market efficiency. *The European Journal of Finance* 1-20.
- Pretis F., Mann M.L. & Kaufmann R.K. 2015. Testing competing models of the temperature hiatus: assessing the effects of conditioning variables and temporal uncertainties through sample-wide break detection. *Climatic Change* 131(4): 705-718.
- Pretis F., Schneider L., Smerdon J. E. & Hendry D.F. 2017. Detecting volcanic eruptions in temperature reconstructions by designed break-indicator saturation. In Lin B.C. & Zheng S. (eds.). *Environmental Economics and Sustainability*: 7-37. Hoboken, NJ: John Wiley & Sons.
- Pretis F., Reade J.J. & Sucarrat G. 2018. Automated general-to-specific (GETS) regression modeling and indicator saturation for outliers and structural breaks. *Journal of Statistical Software* 86(3): 1-44.
- Reade J.J. & Volz U. 2011. From the General to the Specific—Modelling Inflation in China. *Applied Economics Quarterly* 57(1): 27-44.
- Rodrigues P.M.M. & Rubia A. 2011. The effects of additive outliers and measurement errors when testing for structural breaks in variance. *Oxford Bulletin of Economics and Statistics* 73(4): 449-468.
- Russell B., Banerjee A., Malki I. & Ponomareva N. 2010. A multiple break panel approach to estimating United States Phillips curves (Dundee Discussion Papers in Economics No. 232). University of Dundee.
- Sahoo P.K. 2021. COVID-19 pandemic and cryptocurrency markets: An empirical analysis from a linear and nonlinear causal relationship. *Studies in Economics and Finance* 38(2): 454-468.
- Santos C., Hendry D.F. & Johansen S. 2008. Automatic selection of indicators in a fully saturated regression. *Computational Statistics* 23: 317-335.
- Sen R. & Das S. 2023. *Computational Finance with R*. Singapore: Springer Nature.
- Shen D., Urquhart A. & Wang P. 2020. Forecasting the volatility of Bitcoin: The importance of jumps and structural breaks. *European Financial Management* 26(5): 1294-1323.
- Song J. & Kang J. 2021. Change point analysis in Bitcoin return series: a robust approach. *Communications for Statistical Applications and Methods* 28(5): 511-520.
- Teterin M.A. & Peresetsky A.A. 2024. Google Trends and Bitcoin volatility forecast. *Journal of the New Economic Association* 65(4): 118-135.

- Vo V.X. & Nguyen N.T.K. 2011. Volatility in stock return series of Vietnam stock market. *VNUHCM Journal of Science and Technology Development* **14**(3): 5-21.
- Tan C.Y., Koh Y.B., Ng K.H. & Ng K.H. 2022. Structural change analysis of active cryptocurrency market. *Asian Academy of Management Journal of Accounting and Finance* **18**(2): 63–85.
- Zhang W., Wang P., Li X. & Shen D. 2018. Some stylized facts of the cryptocurrency market. *Applied Economics* **50**(55): 5950-5965.

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