PhD Project Proposal 3

Effects of predictive causality in long-term trends of cryptocurrency data

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The cryptocurrency market (currently worth around 2.5 trillion USD) receives considerable attention due to the emergence of blockchain technology that ensures the possibility of any financial transaction between two nodes with a commonly shared ledger, making the system completely decentralized. These cryptocurrencies (that are used for transactions and for maintaining security & sanity of the cryptography based shared ledger-blockchain system) are considered together as an asset-class in several countries. Their time evolutions are immensely volatile due to lack of regulations following the much-desired decentralized nature of the system. Empirical work on understanding causal dependency of leading cryptocurrencies is provided in [2],[1]. Particularly in [2], Granger type non-causality tests on quantiles were used to deduce the causal dependency of leading cryptocurrency to others in certain quantile levels. However, there is no evidence in the literature on explicit long-term predictive time series models of daily returns of leading cryptocurrencies (both jointly and marginally), incorporating their time-varying dependencies with each other. This is the primary motivation behind the PhD project proposed here. The ideal candidate for this project will be interested in the intersection of statistical computing, time series and stochastic processes and would have covered at least two courses on these topics at the post-graduate level.

Ideally the logarithm of daily returns of major cryptocurrencies will be modelled as regime switching time series, to analyse the cyclic nature of their growth patterns. It is observed that the tendency of buying/selling crypto assets is largely associated with the underlying market trends (bullish, bearish, closer to halving cycles or sometimes inflationary warnings etc.) where each regime determines the overall mood of the market. This latent regime process can be modelled by an independent Markov chain X with finite state space S={1,2,…,k}, for some k denoting the total number of regimes. Both parametric and non-parametric hidden Markov model-based formulations (similar to Chevallier et al. (2017)) will be applied on cryptocurrency data that are easily available from www.coinbase.com. The joint predictive time series based model with estimated coefficients will make the following non-trivial questions easier to address:

1. How do extreme observations of one currency impact other cryptocurrencies, given a certain latent regime? In other words, how to predict extremal dependence of the regime switching processes over different coordinates, given a particular regime of the model.

2. When will an upcoming bubble form for one currency, and how it impacts on others when it bursts?

The following are basic outlines of the PhD project.

Step 1: (Estimation) Transformations of the first two cryptocurrency (BTC and ETH) prices will be modelled as bivariate discrete time auto-regressive processes under Markovian regime switching process X. Under certain structures of the auto-regression coefficient matrix and noise being either Gaussian or Normal-inverse Gaussian (NIG), it is possible to estimate unknown model parameters using incomplete likelihood-based iterative approaches such as the EM (or stochastic EM) algorithm. Here, accurate estimation of the total number of regimes k is crucial; various methods will be proposed and evaluated.

Step 2: (Model stability and behaviour at the boundary) One particular coordinate in the above bivariate process marginally may evolve as a threshold modulated auto-regressive (TAR) process. There are no explicit stability conditions established for the overall bivariate process in such cases. Consistency of least square or other estimators of the unknown parameters will be investigated in different critical cases.

References:

1. “Cryptocurrencies as a financial asset: A systematic analysis” by Corbet, Shaen and Lucey, Brian and Urquhart, Andrew and Yarovaya, Larisa; International *Review of Financial Analysis* (62) 182 - 199.

“Causal relationship among cryptocurrencies: A conditional quantile approach” by Kim**,** Myeong Jun and Canh, Nguyen