WP 3: Market risk in financial robo advisory

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FIN-TECH HO2020 Project Kick-off
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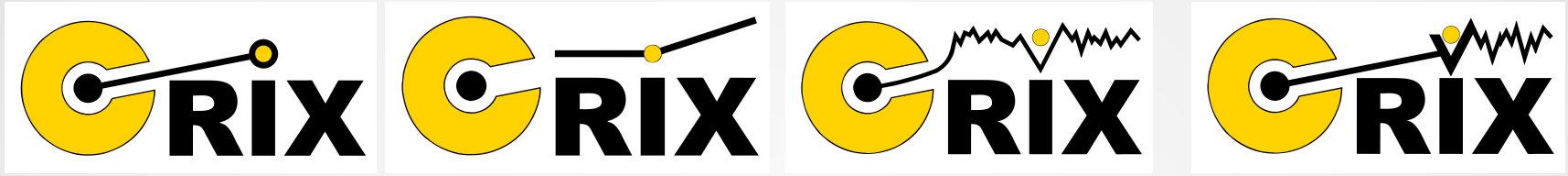
Content of WP3

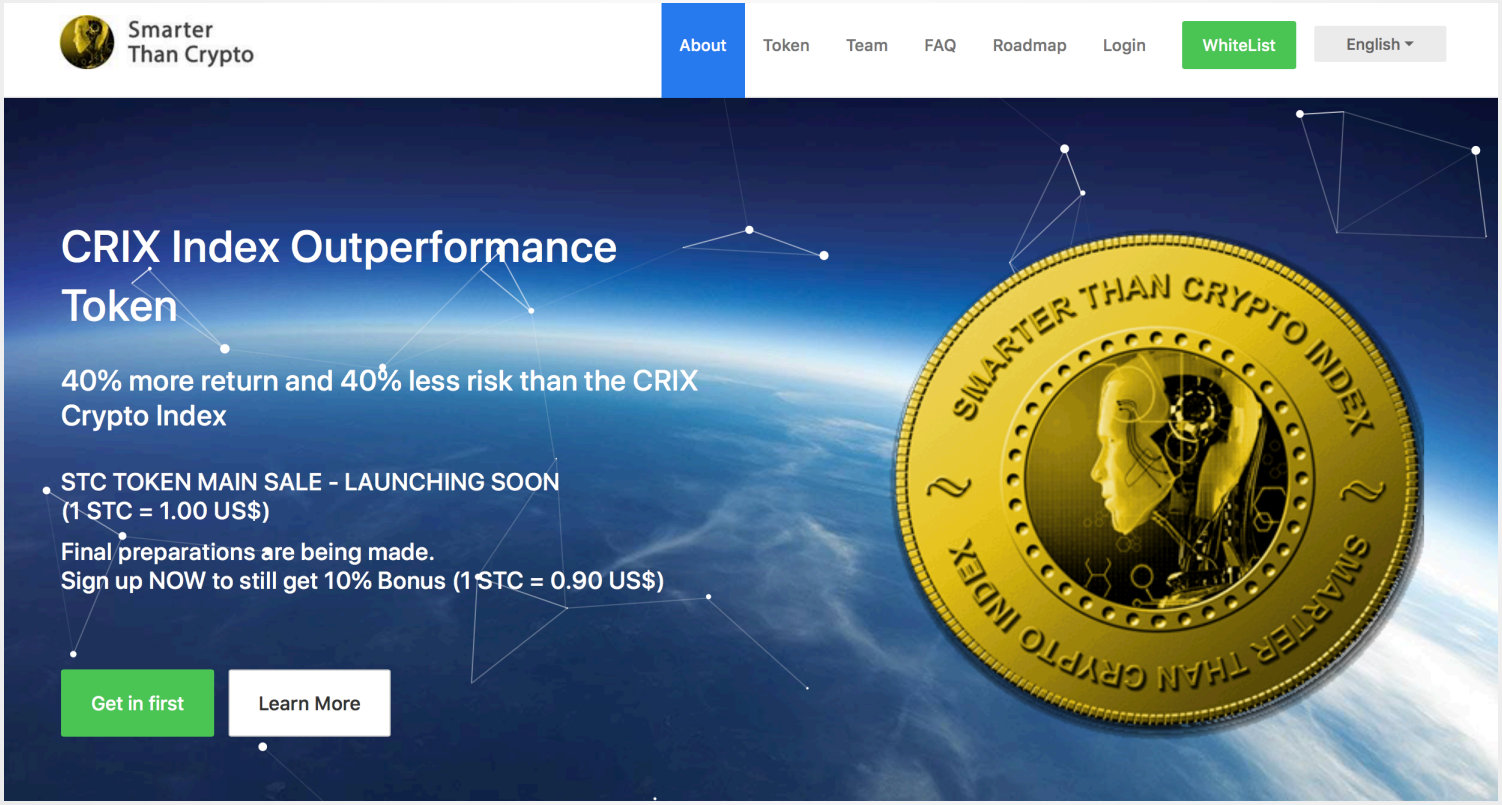
- Methods
  - AI in finance, application to robo advisory, main risk concerns
  - Cluster analysis, distance models and community detection
  - Volatility and connectedness models, VAR and VECM models
- Risk management (case-studies)
  - Market risk and contagion models in financial markets
  - Market risk and contagion models in crypto markets
  - Asset allocation and compliance risk management

Data for case studies and coding sessions

- Data on price and trading volume of cryptocurrencies
- Start date: 20131227
- Daily data
- 3792 coins (as on 20190121)

CRIX





CRIX Code thecrix.de

- a market cap weighted index
- Dominance of BTC…
- reallocation: 3M evaluation of k = # constituents

$$Divisor = \frac{\sum_i MV_{i0}}{1000}.$$

CRIX Methodology

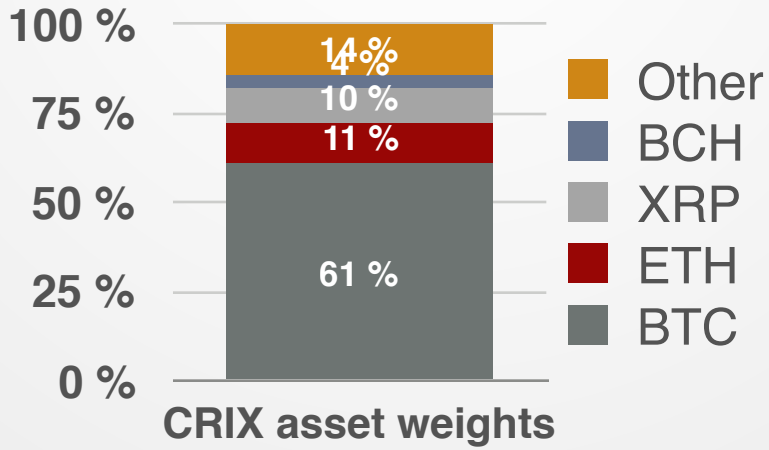
Laspeyres' Index:

$$INDEX_t^{Laspeyres} = \frac{\sum_i P_{it} Q_{i0}}{\sum_i P_{i0} Q_{i0}}$$

$$INDEX_t^{CRIX} = \frac{\sum_i MV_{it}}{Divisor},$$

Only price changes cause a change in index development
Divisor :changes in coin volume does not affect index price

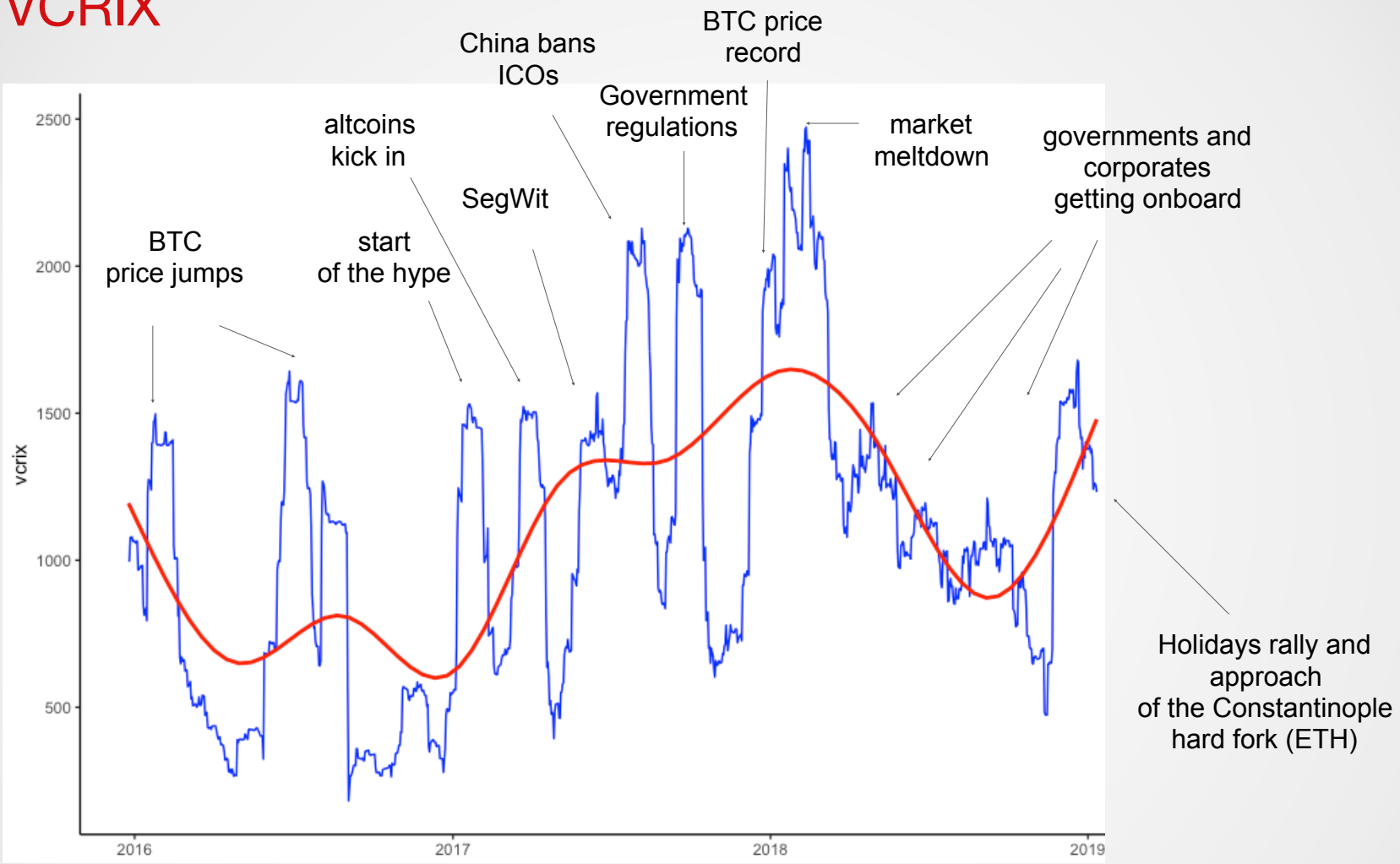
20181031 Underlying Crypto Assets and Weights



30 underlying cryptocurrencies
constituent realloc 3 M
Constituent ranking every M

Source: CRIX

VCRIX



VCRIX Code thecrix.de

VCRIX

- log-returns of CRIX from 12.2015 to 01.2019 (T = 1626), (RV=realised volatility, in case of VCRIX a 30-day rolling volatility)

$$VCRIX = \frac{RV^d_{t+1d}}{Divisor}$$

$$RV^d_{t+1d} = \alpha + \beta^d RV^d_t + \beta^w RV^w_t + \beta^m RV^m_t + \omega_{t+1d}$$

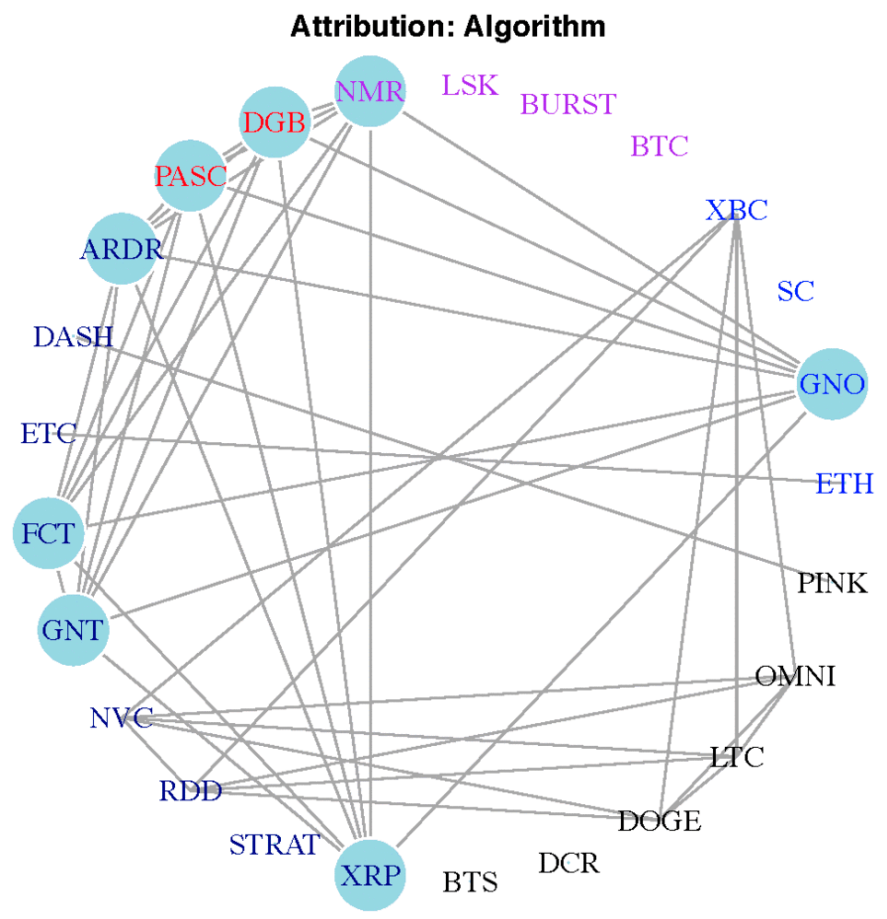
$$RV^w_t = 1/7(RV^d_t + RV^d_{t-1d} + ... + RV^d_{t-6d})$$

$$RV^m_t = 1/30(RV^d_t + RV^d_{t-1d} + ... + RV^d_{t-29d})$$

where d, w, m stand for daily, weekly and monthly

- $VCRIX_1 = 1000$
- Divisor adjusts to changes in constituents

Covariate-assisted Spectral Clustering in Dynamic Networks: An Application to CCs Market



Node Features (Attribution Network Structure).

Node size - eigenvector centrality of a CC

Covariate-assisted Spectral Clustering in CCs Market

- Return network structure from Adaptive LASSO
  - Find connection between returns of top 200 cryptos

$$Ret_{eth} = \beta_1 Ret_{btc} + \beta_2 Ret_{xrp} + \beta_3 Ret_{qtum} + \dots$$

  - Result 24 cryptos

Dynamic Stochastic Block Model

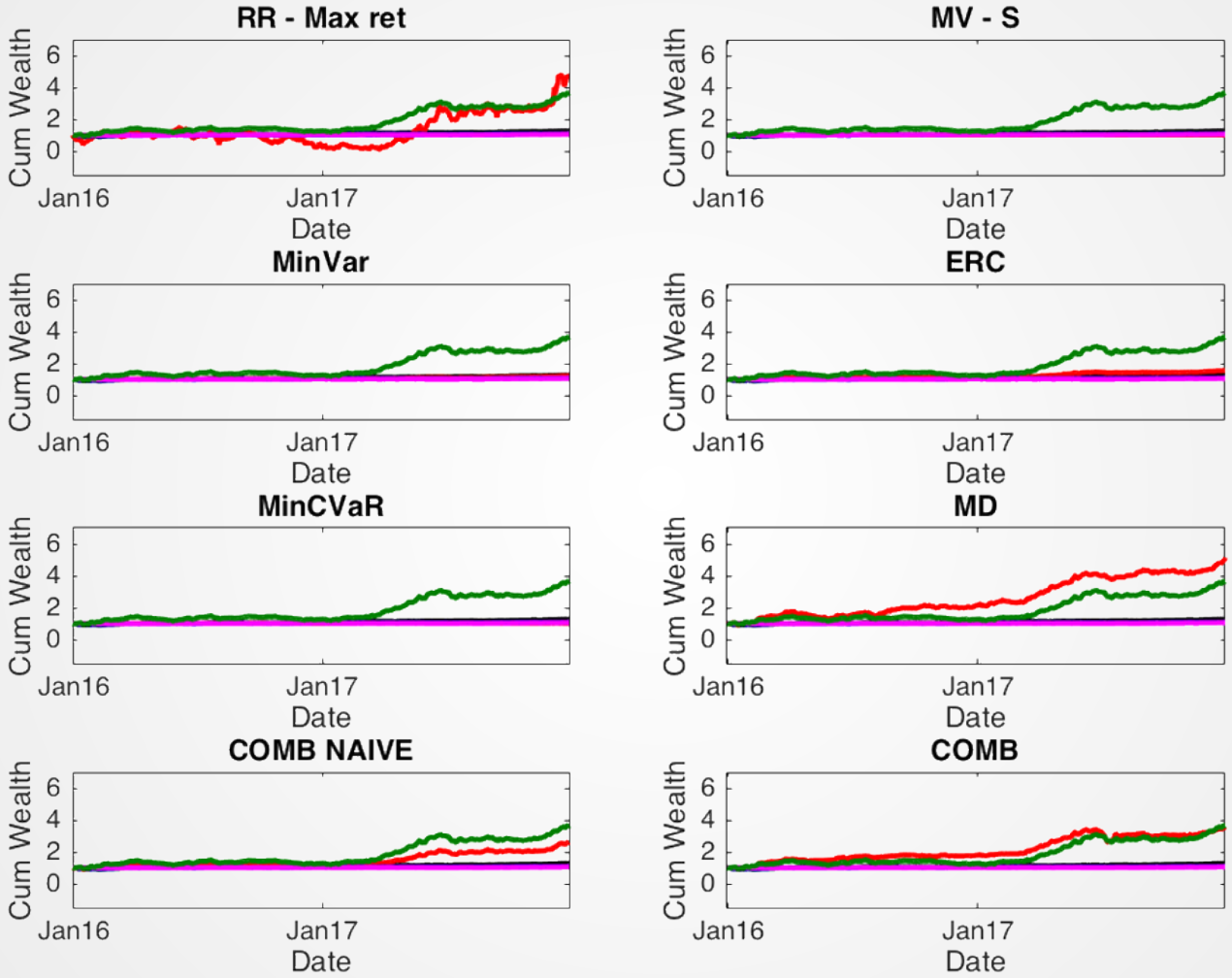
$$A_t(i,j) = \begin{cases} \text{Bernoulli}\left\{P_t(i,j)\right\}, & \text{if } i < j \\ 0, & \text{if } i = j \\ A_t(j,i), & \text{if } i > j \end{cases}$$

$$\mathcal{A}_t \overset{\text{def}}{=} \mathrm{E}(A_t|Z_t) = Z_t B_t Z_t^\top$$

- Adjacency matrix based on return information A_t
- Connection between i and j: $P_t(i,j) = P\left\{A_t(i,j) = 1\right\}$
- Clustering Matrix: $Z_t \in \{0,1\}^{N\times K}$
- Block Probability Matrix: $B_t \in \mathscr{M}^{K\times K}$ and

$$B_t(k,k') = P_t(i,j), \forall k,k' = \{1,\cdots,K\}$$

Asset allocation with Cryptos



CCP Code

Asset allocation with Cryptos

Model	Reference	Abbreviation
Equally weighted	DeMiguel et al. (2009)	EW
Risk-return-oriented strategies		
Mean – Var – max Sharpe	Jagannathan and Ma (2003)	MV – S
Return-oriented strategies		
Risk – Return – max return	Markowitz (1952)	RR – max ret
Risk-oriented strategies		
Mean – Var – min var	Merton (1980)	MinVar
Equal Risk Contribution ERC	Roncalli et al. (2010)	ERC
Mean – CVaR – min risk	Rockafellar and Uryasev (2000)	MinCVaR
Maximum Diversification	Rudin and Morgan(2006)	MD
Combination of models		
Naïve combination	Schanbacher (2015)	COMB NAÏVE
Combination bootstrap	Schanbacher (2014)	COMB

Research ideas and ongoing projects

- LSTM for trading and portfolio allocation
- Modelling Systemic Risk using Neural Network Quantile Regression
- Ensemble machine learning in portfolio allocation with cryptocurrencies

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Market risk in financial robot advisory

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1st FIN-TECH Workshop
1 February 2019

Main research questions:

- How much are Bitcoin exchanges interconnected? And which are the exchanges showing high/low degree of interconnectedness among each other?
- Which are the price setter exchanges and which are the followers?
- To answer the questions we analyze the spillovers proposed by Diebold and Yilmaz (2012, 2014), providing an extension of their methodology

- Granger Representation Theorem (Engle and Granger, 1987)

Vector Error Correction Model (VECM)

$$\Delta p_t = \alpha\beta' p_{t-1} + \sum_{i=1}^{k-1} \zeta_i \Delta p_{t-i} + \varepsilon_t \tag{1}$$

- $\Delta p_t = (\Delta p_t^1, \Delta p_t^2, ..., \Delta p_t^n)'$
- α : $(n \times h)$ adjustment coefficients matrix
- β : $(n \times h)$ cointegrating matrix
- ζ_i : $(n \times n)$ parameter matrices
- k : autoregressive order
- h : cointegrating rank
- ε_t : zero-mean white noise process having variance-covariance matrix Σ_ε

- using $\theta_{ij}^{g}(H)$ to denote the KPSS H-step forecast error variance decompositions, with $H = 1, \cdots, n$, we have:

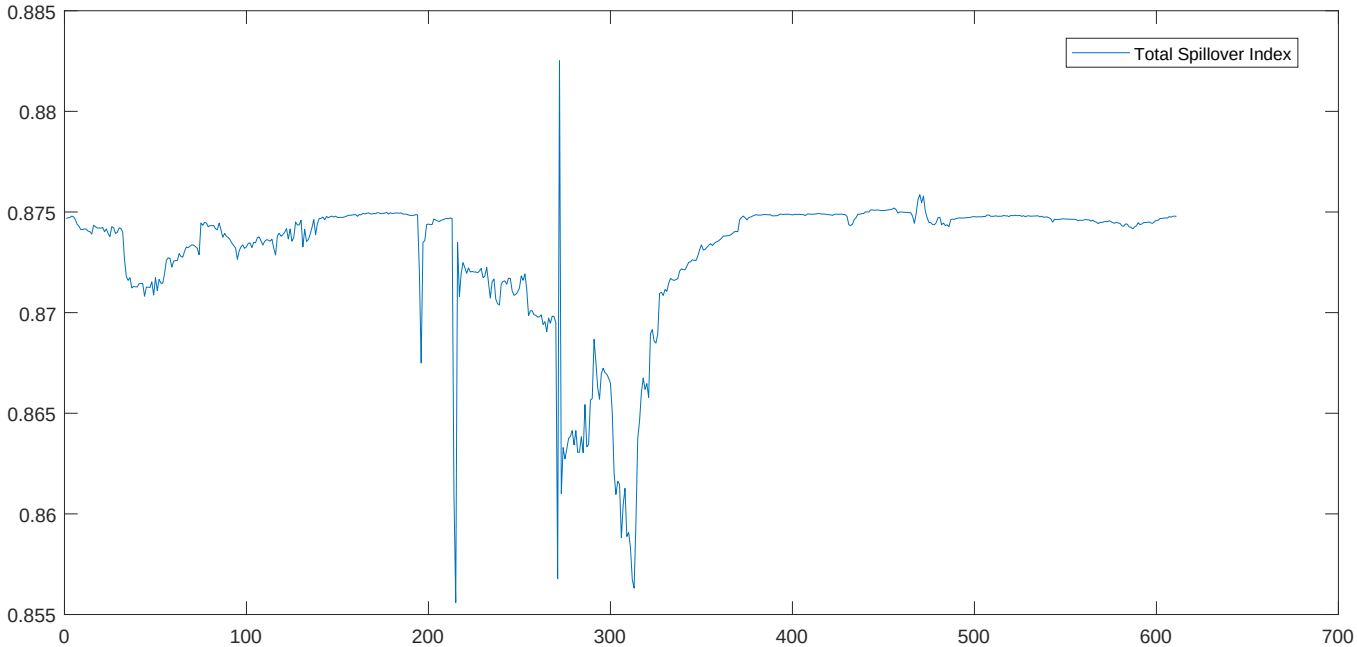
Variance shares

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' \Psi_h \Sigma_\varepsilon e_j)^2}{\sum_{h=0}^{H-1} (e_i' \Psi_h \Sigma_\varepsilon \Psi_h' e_j)} \tag{2}$$

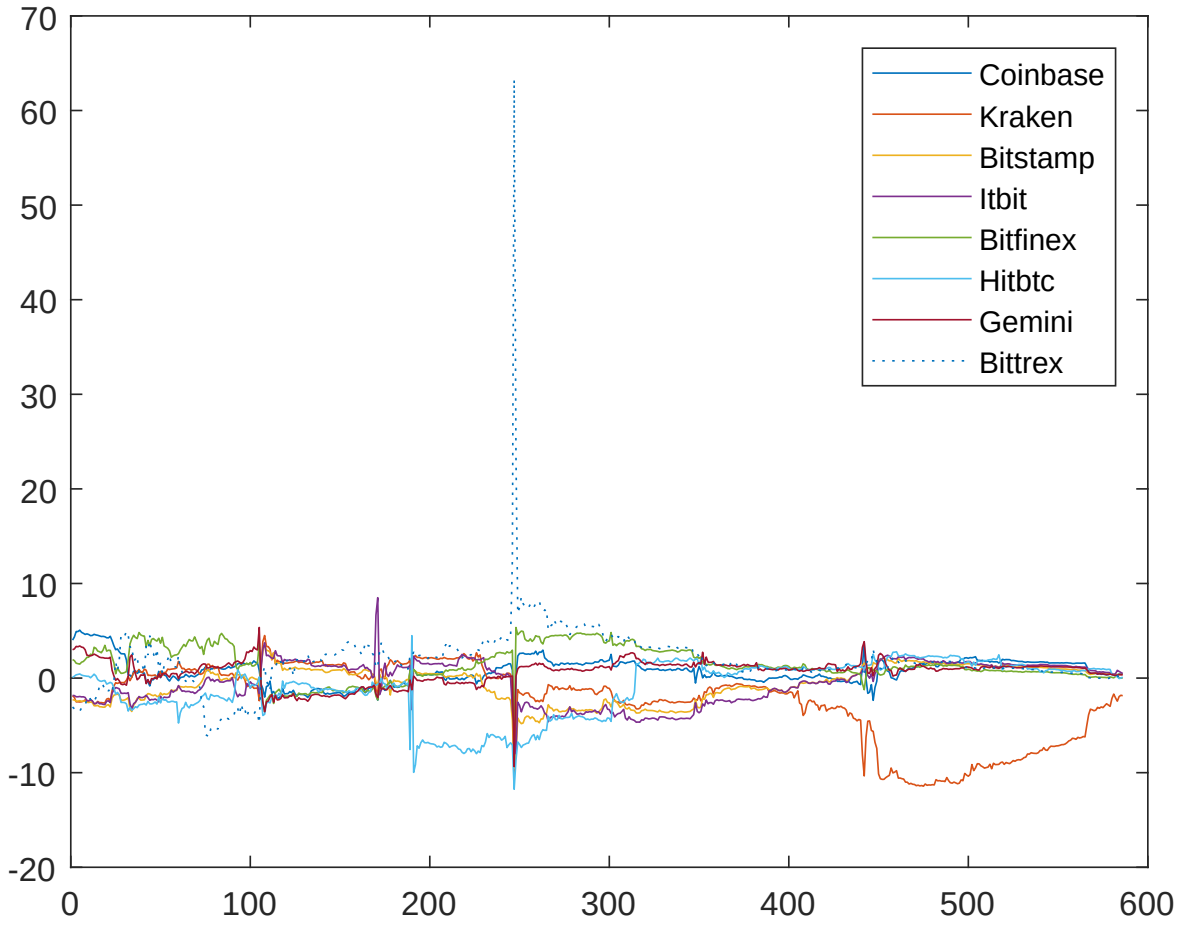
- σ_{jj} is the standard deviation of the innovation for equation j and e_i represents the selection vector with one as element i and zeros elsewhere.
- Note that we extend the methodology from Diebold and Yilmaz (2012) - from a Vector AutoRegressive (VAR) framework to a VECM framework - as well as the analysis of Giudici and Abu-Hashish (2018)

- 8 price series (USD) belonging to selected Bitcoin exchanges
  - Bitfinex
  - Coinbase
  - Bitstamp
  - Kraken
  - Hitbtc
  - Gemini
  - Itbit
  - Bittrex
- Market exchanges make up at least 60% of BTC daily trading volume during the sample period
- Time period analyzed: 18 May 2016 - 30 April 2018
- sampling interval: daily

Total Spillover Index



Net Spillover Index



Pairwise Spillover Index