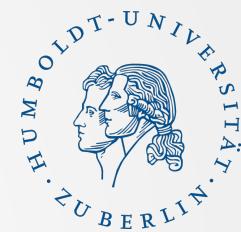


# WP 3: Market risk in financial robo advisory

Wolfgang Karl Härdle  
Alla Petukhina



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

The image shows the CRIX website homepage. At the top, there is a horizontal sequence of four logo variations, each featuring a yellow stylized letter 'C' with a black 'RIX' text next to it. The second logo includes a small yellow dot above the 'C', the third includes a wavy line above the 'C', and the fourth includes a wavy line above the 'C' and a yellow dot above the 'X'. Below this, the main header features the text "Smarter Than Crypto" next to a small gold coin icon. To the right of the header are navigation links: "About" (highlighted in blue), "Token", "Team", "FAQ", "Roadmap", "Login", "WhiteList" (highlighted in green), and "English ▾". The main content area has a dark blue background with a faint image of Earth below a horizon line. On the left, white text reads "CRIX Index Outperformance Token" and "40% more return and 40% less risk than the CRIX Crypto Index". Below this, a bulleted list states "STC TOKEN MAIN SALE - LAUNCHING SOON (1 STC = 1.00 US\$)" and "Final preparations are being made. Sign up NOW to still get 10% Bonus (1 STC = 0.90 US\$)". At the bottom left are two buttons: "Get in first" (green) and "Learn More" (white). On the right side, there is a large, detailed image of a gold coin. The coin has a profile of a person's head facing left, with a brain-like pattern visible inside the head. The text "SMARTER THAN CRYPTO INDEX" is repeated twice around the border of the coin.

 CRIX Code [thecrix.de](http://thecrix.de)



- ❑ a market cap weighted index
- ❑ Dominance of BTC...
- ❑ reallocation: 3M evaluation of  $k = \# \text{ constituents}$

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

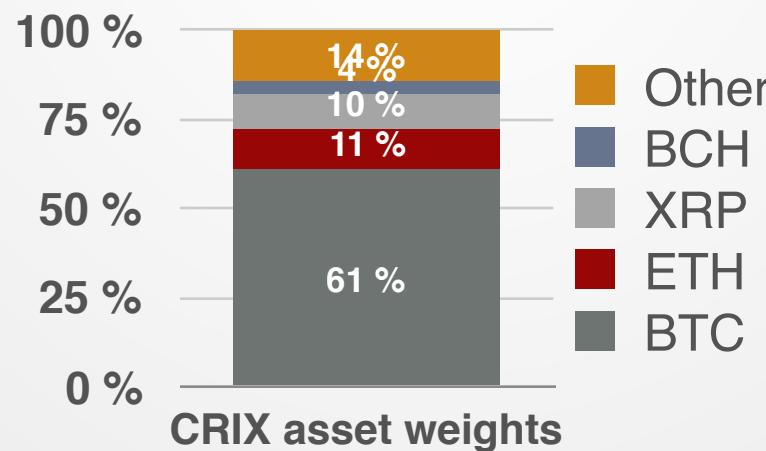
### Laspeyres' Index:

$$\text{INDEX}_t^{\text{Laspeyres}} = \frac{\sum_i P_{it} Q_{i0}}{\sum_i P_{i0} Q_{i0}}$$

$$\text{INDEX}_t^{\text{CRIX}} = \frac{\sum_i MV_{it}}{\text{Divisor}},$$

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

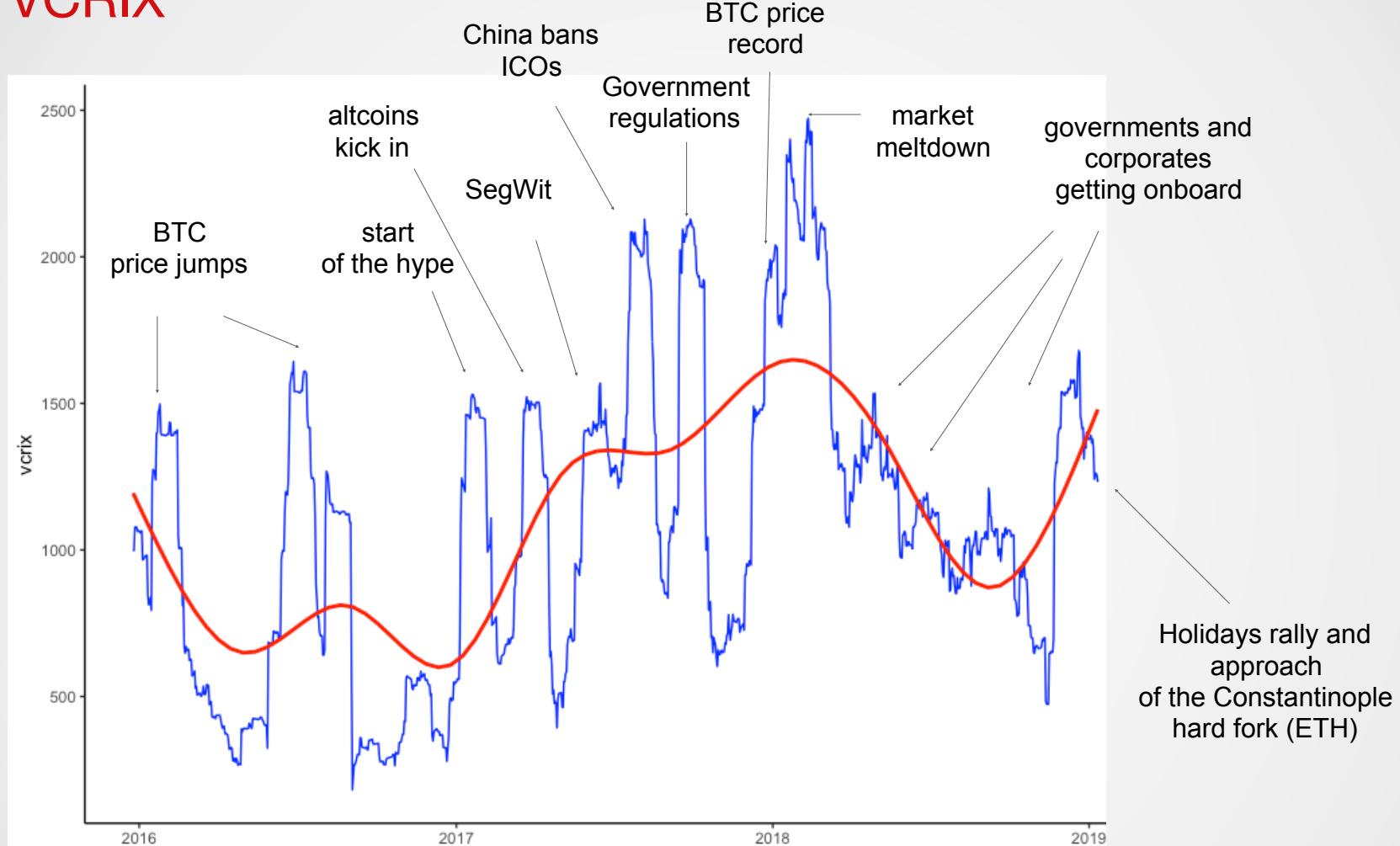


30 underlying cryptocurrencies  
 # constituent realloc 3 M  
 Constituent ranking every M

Source: CRIX



# VCRIX



VCRIX Code [thecrix.de](http://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)

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

$$RV_{t+1d}^d = \alpha + \beta^d RV_t^d + \beta^w RV_t^w + \beta^m RV_t^m + \omega_{t+1d}$$

$$RV_t^w = 1/7(RV_t^d + RV_{t-1d}^d + \dots + RV_{t-6d}^d)$$

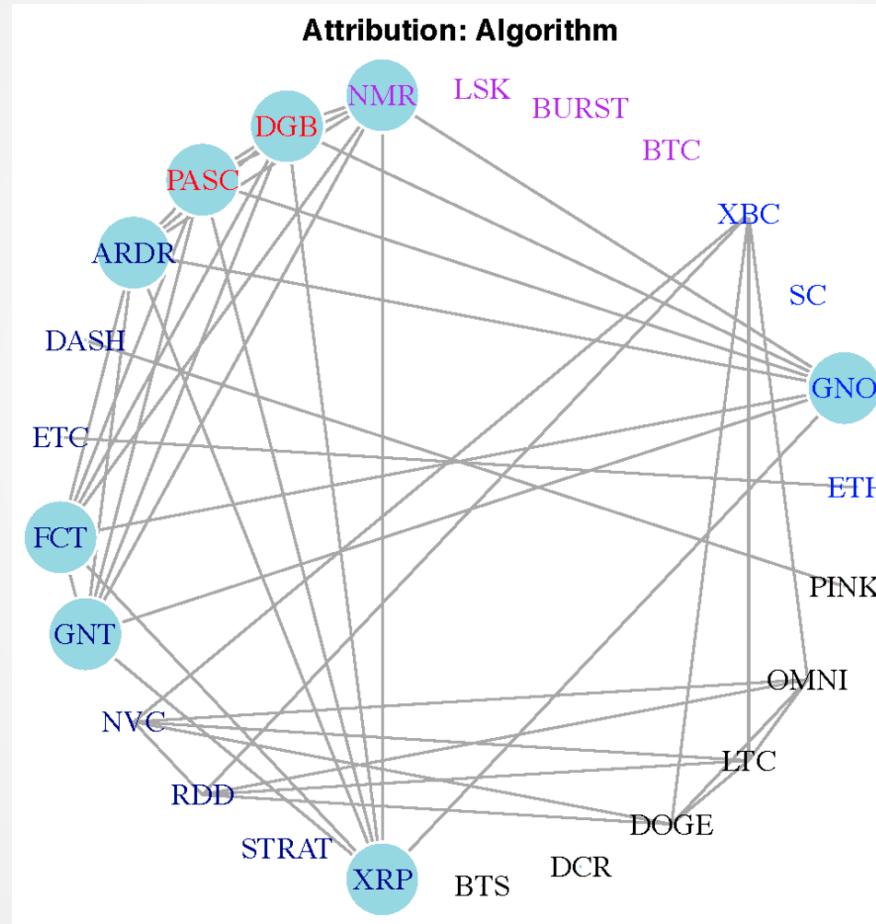
$$RV_t^m = 1/30(RV_t^d + RV_{t-1d}^d + \dots + RV_{t-29d}^d)$$

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 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

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

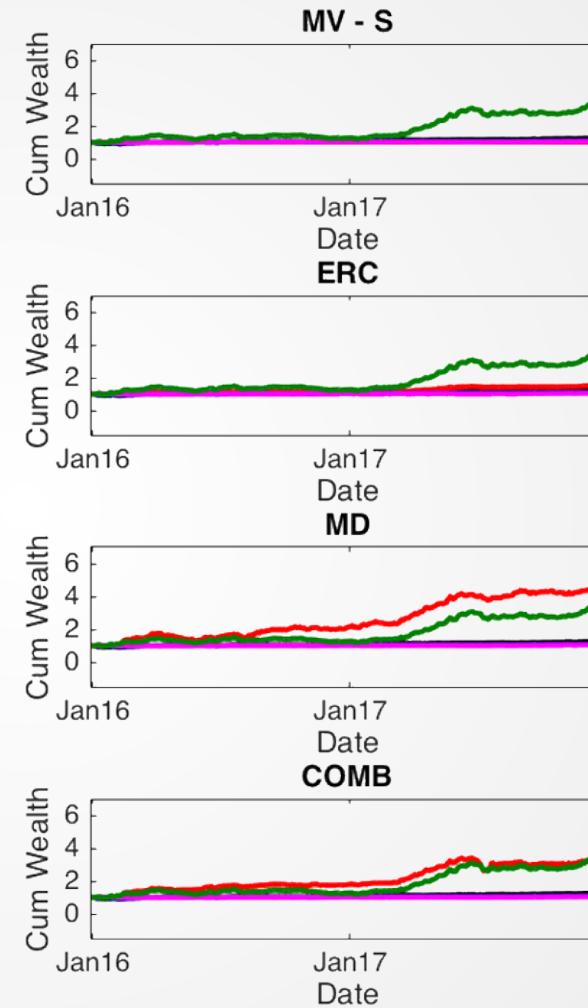
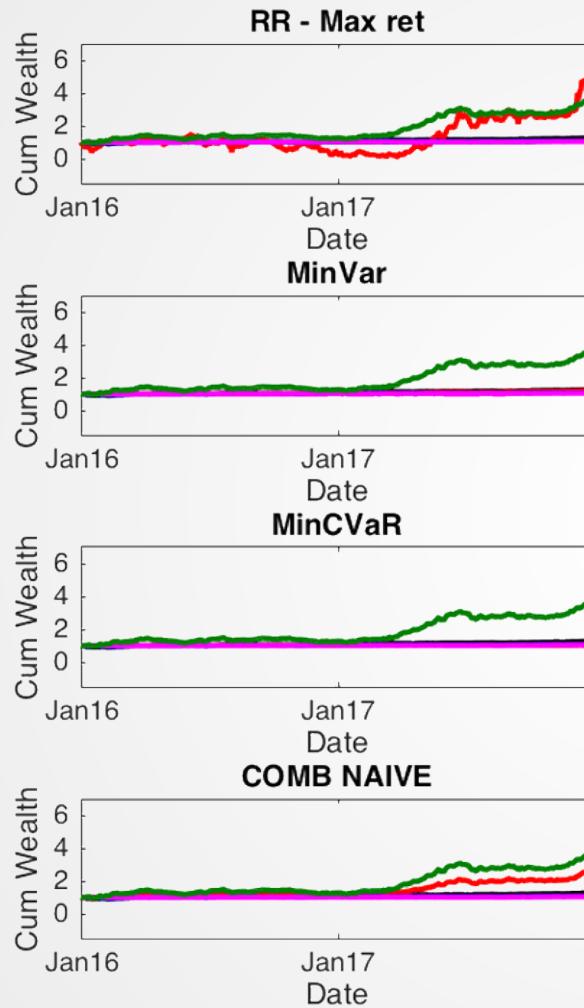
$$\mathcal{A}_t \stackrel{\text{def}}{=} \mathbb{E}(A_t | Z_t) = Z_t B_t Z_t^\top$$

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

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



# Asset allocation with Cryptos



# 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



## Contacts

Prof. Dr. Wolfgang Karl Härdle

[haerdle@hu-berlin.de](mailto:haerdle@hu-berlin.de)

[hu.berlin/wkh](http://hu.berlin/wkh)

Dr. Alla Petukhina

[petukhia@hu-berlin.de](mailto:petukhia@hu-berlin.de)

[hu.berlin/ap](http://hu.berlin/ap)

# Market risk in financial robot advisory

Paolo Pagnottoni<sup>1</sup>

<sup>1</sup>FinTech Lab. Department of Economics and Management, University of Pavia

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## 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)

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

- ▶  $\Delta p_t = (\Delta p_t^1, \Delta p_t^2, \dots, \Delta p_t^n)'$
- ▶  $\alpha$  :  $(n \times h)$  adjustment coefficients matrix
- ▶  $\beta$  :  $(n \times h)$  cointegrating matrix
- ▶  $\zeta_i$  :  $(n \times n)$  parameter matrices
- ▶  $k$  : autoregressive order
- ▶  $h$  : cointegrating rank
- ▶  $\varepsilon_t$  : zero-mean white noise process having variance-covariance matrix  $\Sigma_\varepsilon$

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

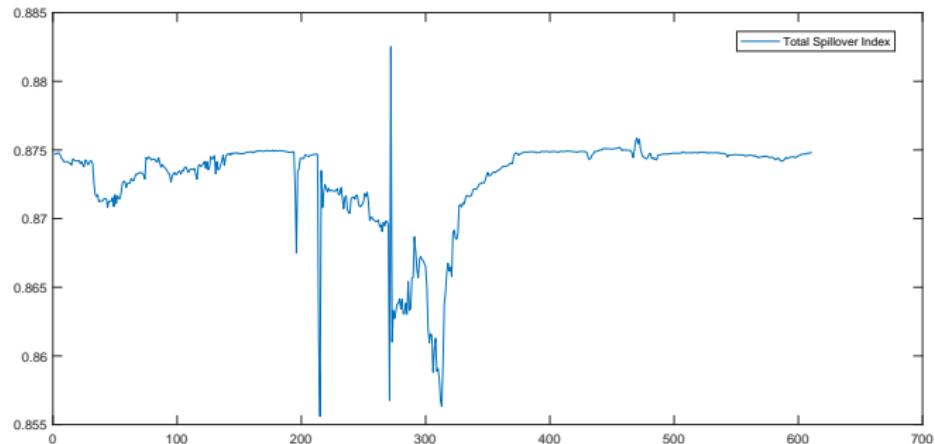
## Variance shares

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

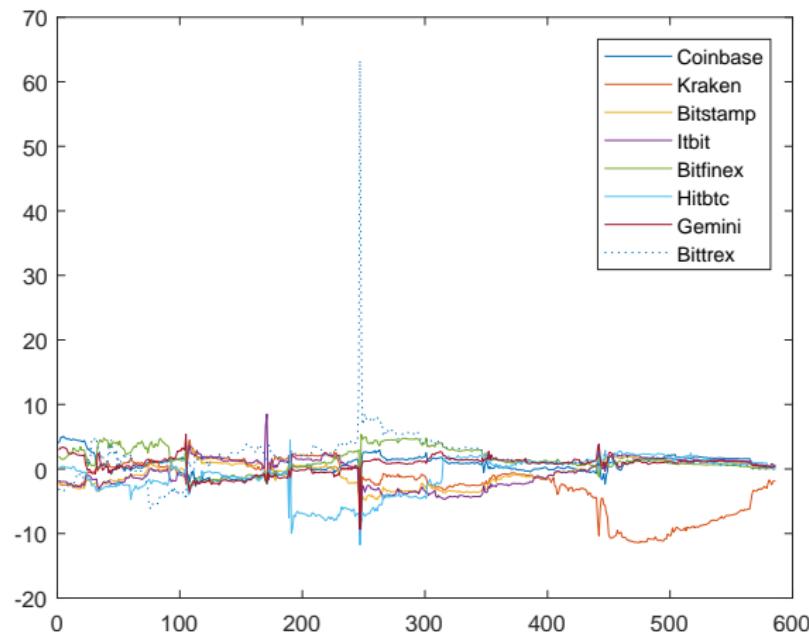
- ▶  $\sigma_{jj}$  is the standard deviation of the innovation for equation  $j$  and  $e_i$  represents the selection vector with one as element  $i$  and zeros elsewhere.
- ▶ Note that we extend the methodology from Diebold and Yilmaz (2012) - from a Vector AutoRegressive (VAR) framework to a VECM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

