Cryptocurrencies – Not for the faint-hearted

Joerg Osterrieder
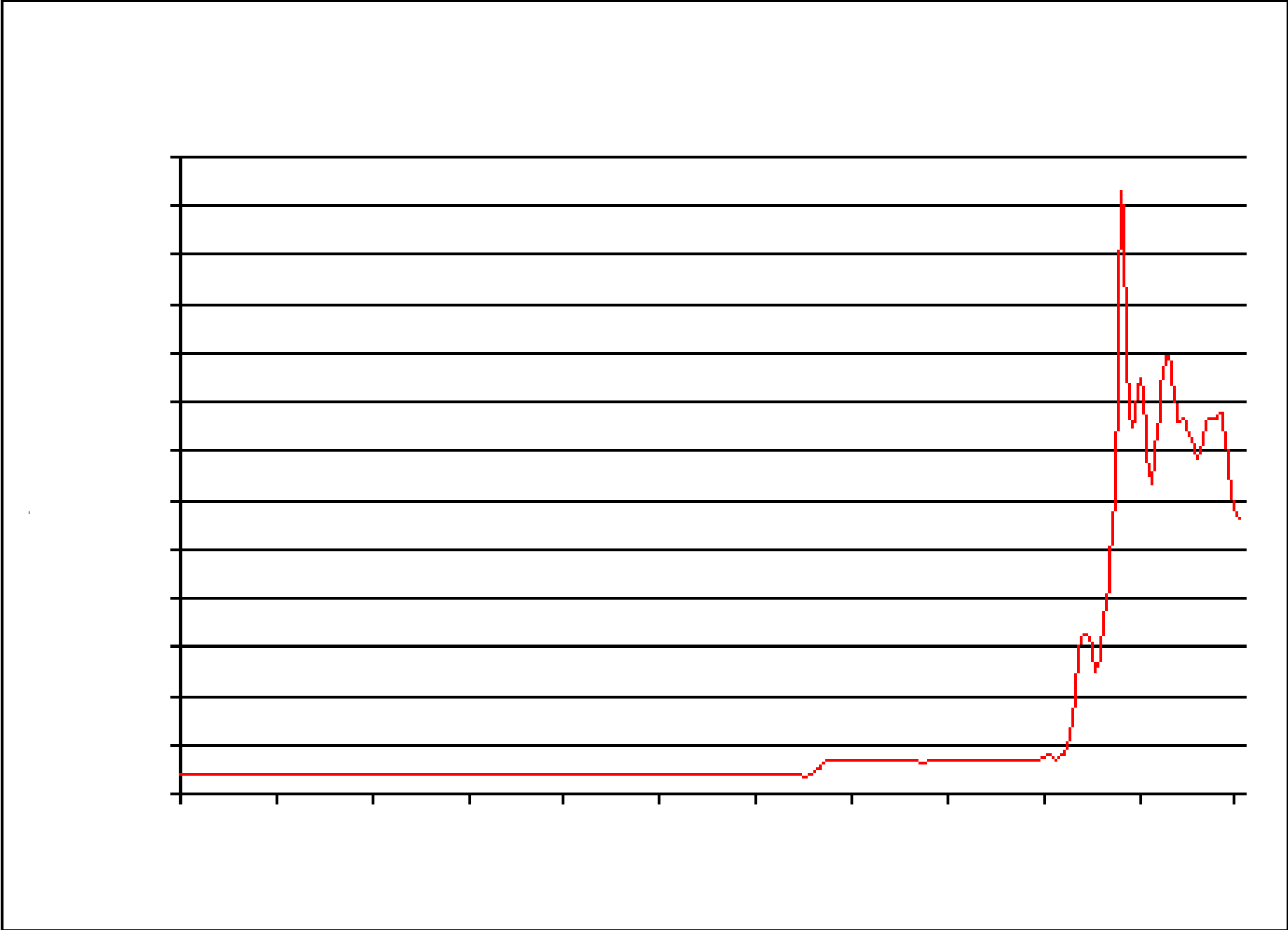
Zurich University of Applied Sciences

Switzerland
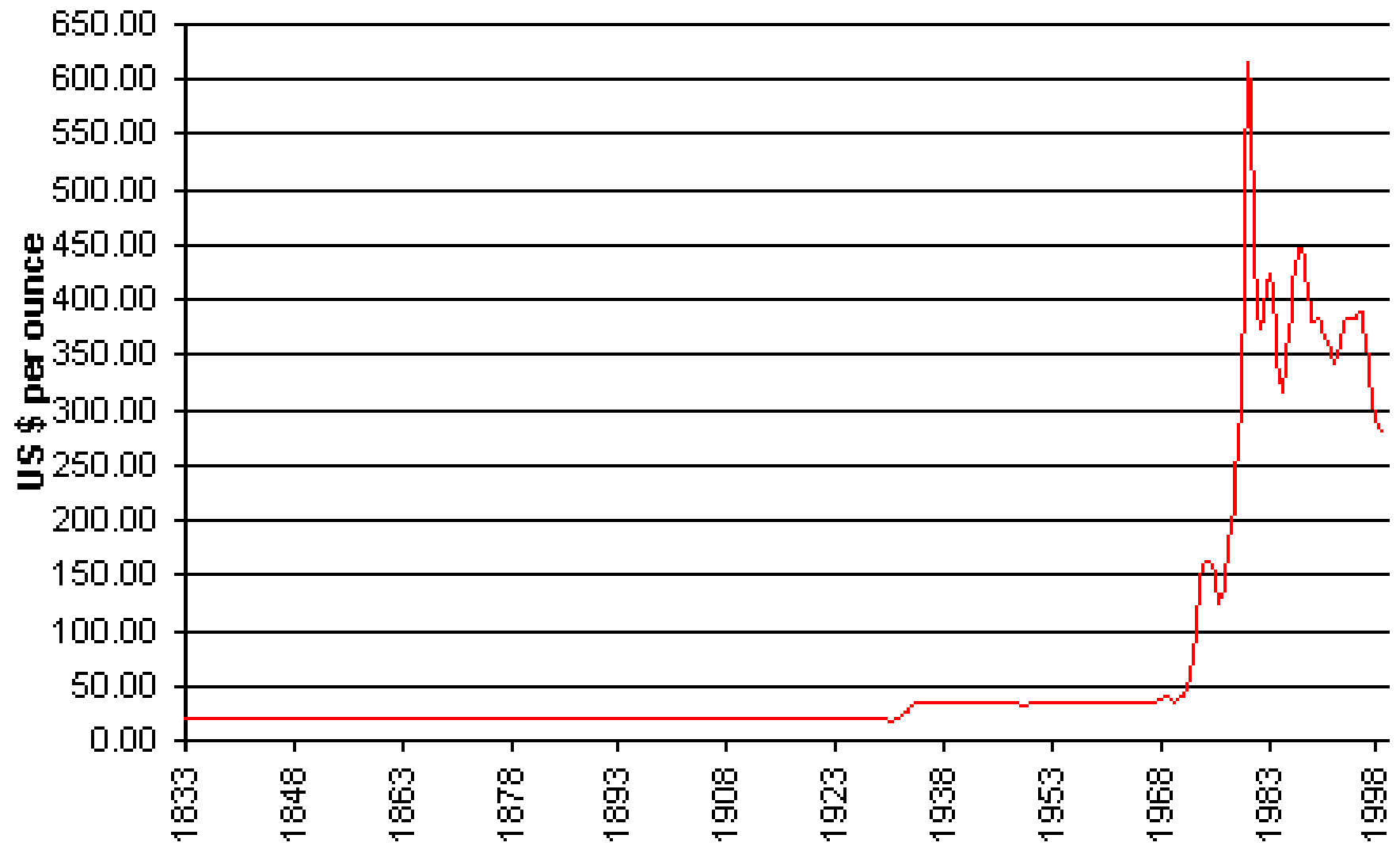
Crypto-currencies in a digital economy

Einstein Center Digital Future – TU Berlin

16. – 17. November 2017

GOLD - London PM Fix Averages - 1833 - 1999
kitco.com

Bitcoin (USD) Price

Closing Price ⬤ OHLC

| 1h | 12h | 1d | 1w | 1m | 3m | 1y | All |

Jul 18, 2010 to Oct 28, 2017 ⬇ Export

CoinDesk BPI in effect

2012   2014   2016

Bitcoin --- cryptocurrency and payment system

- First decentralized digital currency
- October 2008: Satoshi Nakamoto
- Peer-to-peer : no centralized authority
- Recorded in the blockchain: public distributed ledger
- Bitcoin today represents over 57% of the market (96bn USD)
- The second and third largest cryptocurrencies are Ethereum and Ripple, representing 17% and 5% of the market
- The top ten of those 1221 cryptocurrencies (Bitcoin, Ethereum, Ripple, Bitcoin Cash, Litecoin, Dash, NEM, BitConnect, NEO, Monero) represent about 89% of the market

Over 1221 cryptocurrencies exist today with a total market capitalization of 169bn USD (coinmarketcap.com, October 28, 2017)

Cryptocurrency

- A cryptocurrency is a digital asset designed to work as a medium of exchange that is created and managed through cryptography.

- Cryptocurrencies are a subset of alternative currencies, or specifically of digital currencies.

- Cryptocurrencies use decentralized control as opposed to centralized electronic money/centralized banking systems.

Managing Enormous Risk: Bitcoin and Altcoin Investment Strategies

Bitcoin Opinion / ICO / News

A 'Real Bubble': Warren Buffett Not Impressed by Bitcoin Price Surge or ICOs

Bitcoin Regulation   News

Bitcoin Poses no Risks to Warrant Regulation: Singapore Central Bank Chief

Samburaj Das on 25/10/2017

What about other crypto-currencies?

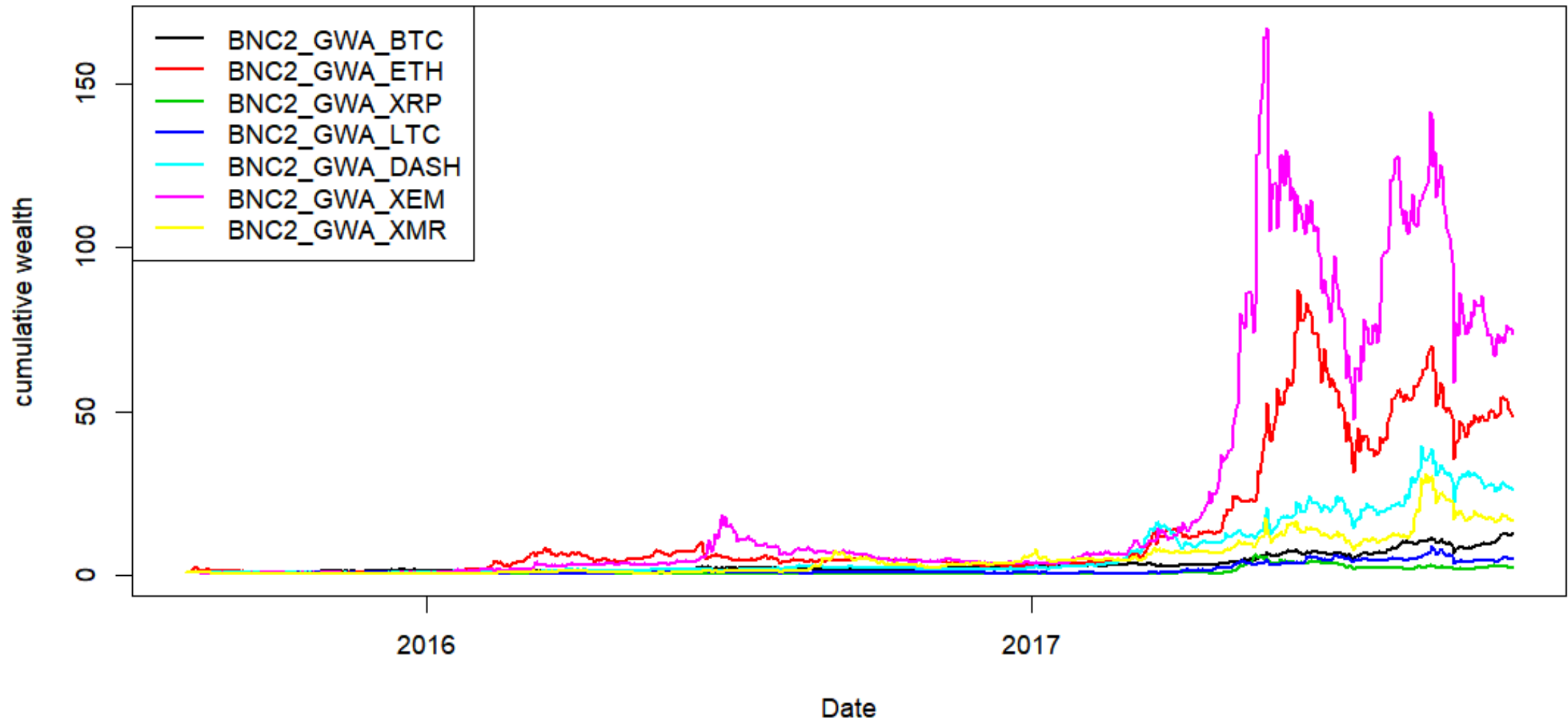# A short tour of bitcoin crashes

The Meltdown of April 2013

What happened: In the spring of 2013, a ghastly collapse saw the price of bitcoin fall from $233 to $67—overnight! That's a 71% drop. It would take seven months to recover.

Pop Goes the 2013 Bubble

What happened: Bitcoin spent most of the rest of 2013 around $120. Then prices jumped ten-fold in the fall: Bitcoin hit a high of $1,150 in late November and then the party ended abruptly, and prices tumbled below $500 by mid-December. It would take more than four years for bitcoin to reach $1,000 again.

The Mt. Gox Calamity of 2014

What happened: The price of bitcoin had been making big gains after the bubble pop of 2013 when, in February, the price fell from $867 to $439 (a 49% drop). This triggered a doldrums period for bitcoin that lasted until late 2016.

Summer Selloff of 2017

What happened: Fast forward to the go-go days of 2017. In early January, bitcoin broke $1,000 for the first time in years and started climbing like crazy. By June, the currency nudged $3,000—but then lurched back all of a sudden, falling 36% to $1,869 by mid-July.

The Great China Chill

What happened: After fears over the fork subsided, bitcoin went on another crazy tear: It climbed close to $5,000 at the start of September before plunging 37% by September 15, shaving off over $30 billion from bitcoin's total market cap in the process. A recovery is already underway, though, as prices climbed above $4,000 three days later.

| Aug 29 | Aug 31 | September | Sep 3 | Sep 5 | Sep 7 | Sep 9 | Sep 11 | Sep 13 | Sep 15 |

5,000
4,400
3,800
3,200

PREVIOUS CLOSE: 10,868.10

10,800

A Flash in The Market

Stock markets plunged suddenly on May 6 of this year and gained speed as computer programs prevented losses. But almost as quickly, the market recovered much of the decline.

Dow industrials

Close
10,520.32
−3.2%

10,600

1 1:00 Volatility in some stocks increases in a down market.

10,400

2 2:30 Unusually nervous trading pushes overall volatility up sharply; the Dow is down 2.5 percent.

3 2:32 A program to sell $4.1 billion in E-Mini futures starts; other traders react by starting to sell.

10,200

4 2:41 Selling in the futures market spreads to stocks; automated trading programs react to the sharp drops by shutting down.

5 2:46 After trading in E-Mini futures is paused for five seconds, alleviating the pressure to sell, the market begins to recover.

10,000

2:46
9,869.62
−9.2%

10 A.M.   11 A.M.   12 P.M.   1 P.M.   2 P.M.   3 P.M.

OLIVIA SOLON   BUSINESS   04.27.11   3:35 PM

HOW A BOOK ABOUT FLIES CAME TO BE PRICED $24 MILLION ON AMAZON

PETER A. LAWRENCE

The Making of a Fly
THE GENETICS OF ANIMAL DESIGN

Blackwell
Scientific
Publications
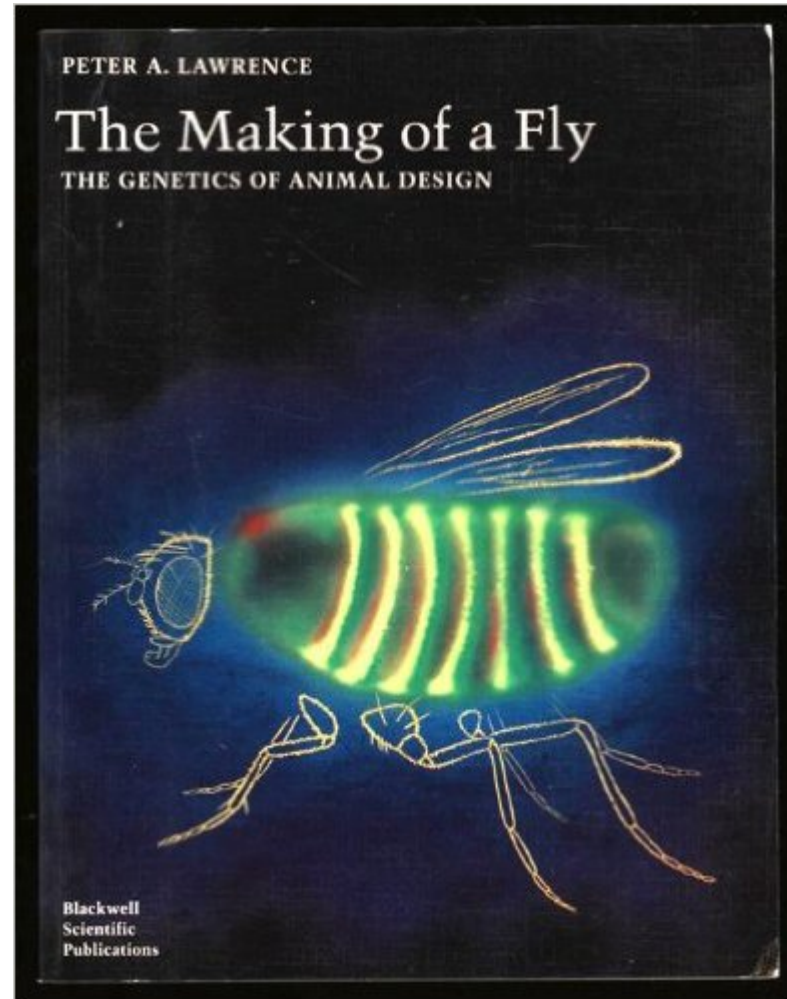
Bitcoin and Cryptocurrencies from a statistical point of view

- **http://crix.hu-berlin.de/**
- **The Statistics of Bitcoin and Cryptocurrencies**
  - https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2872158
  - First paper to fit parametric distributions to cryptocurrencies
- **A Statistical Risk Assessment of Bitcoin and Its Extreme Tail Behaviour**
  - https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2867339
  - First paper to look at the extreme value behavior of Bitcoin in comparison to G10 currencies
- **Bitcoin and Cryptocurrencies - Not for the Faint-Hearted**
  - https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2867671
  - First paper to look at the extreme value behavior of cryptocurrencies as well as their multivariate properties
- **GARCH modelling of cryptocurrencies**
  - https://ssrn.com/abstract=3047027
- **A statistical analysis of cryptocurrencies**
  - https://ssrn.com/abstract=2948315
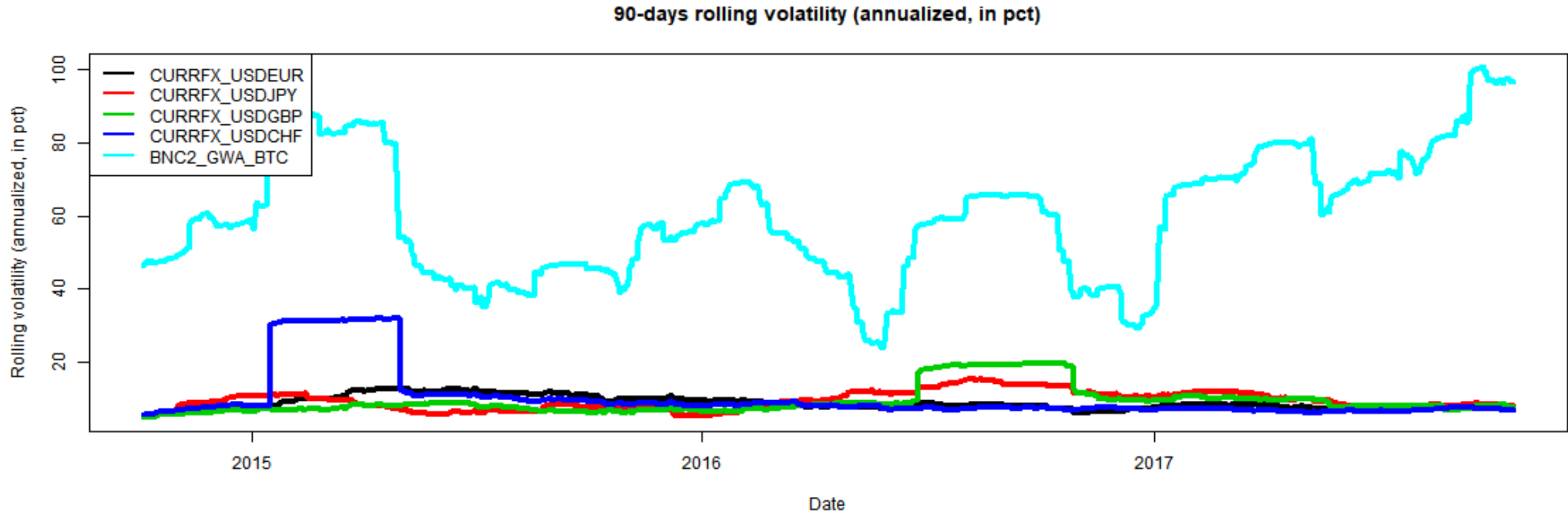
Non-normality of Bitcoin returns
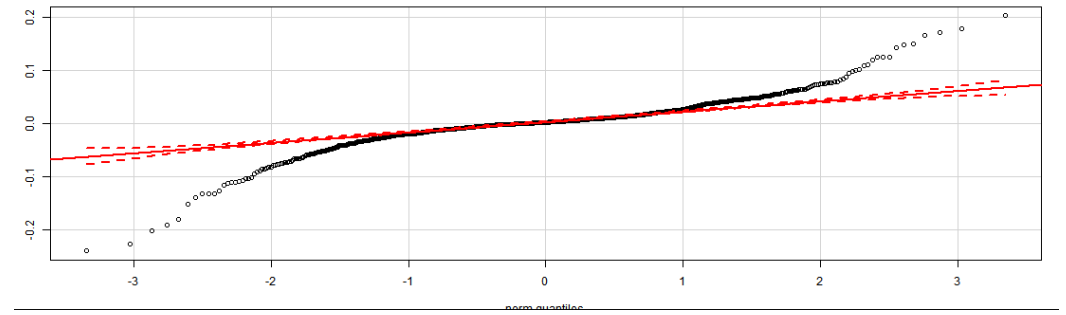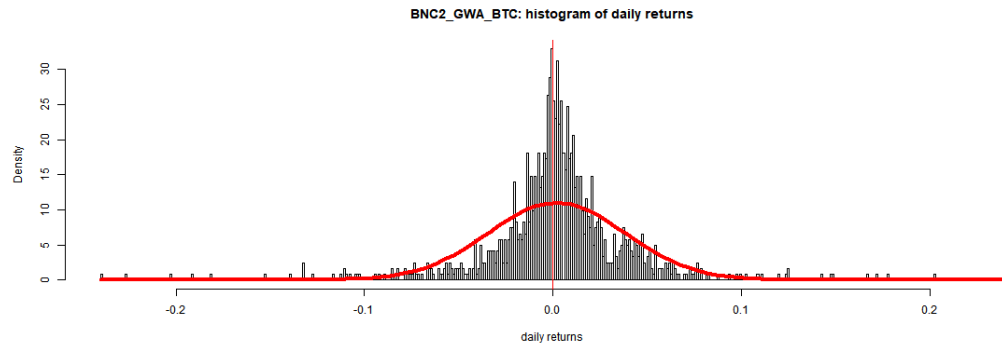
Non-normality of Bitcoin returns

Histogram of returns
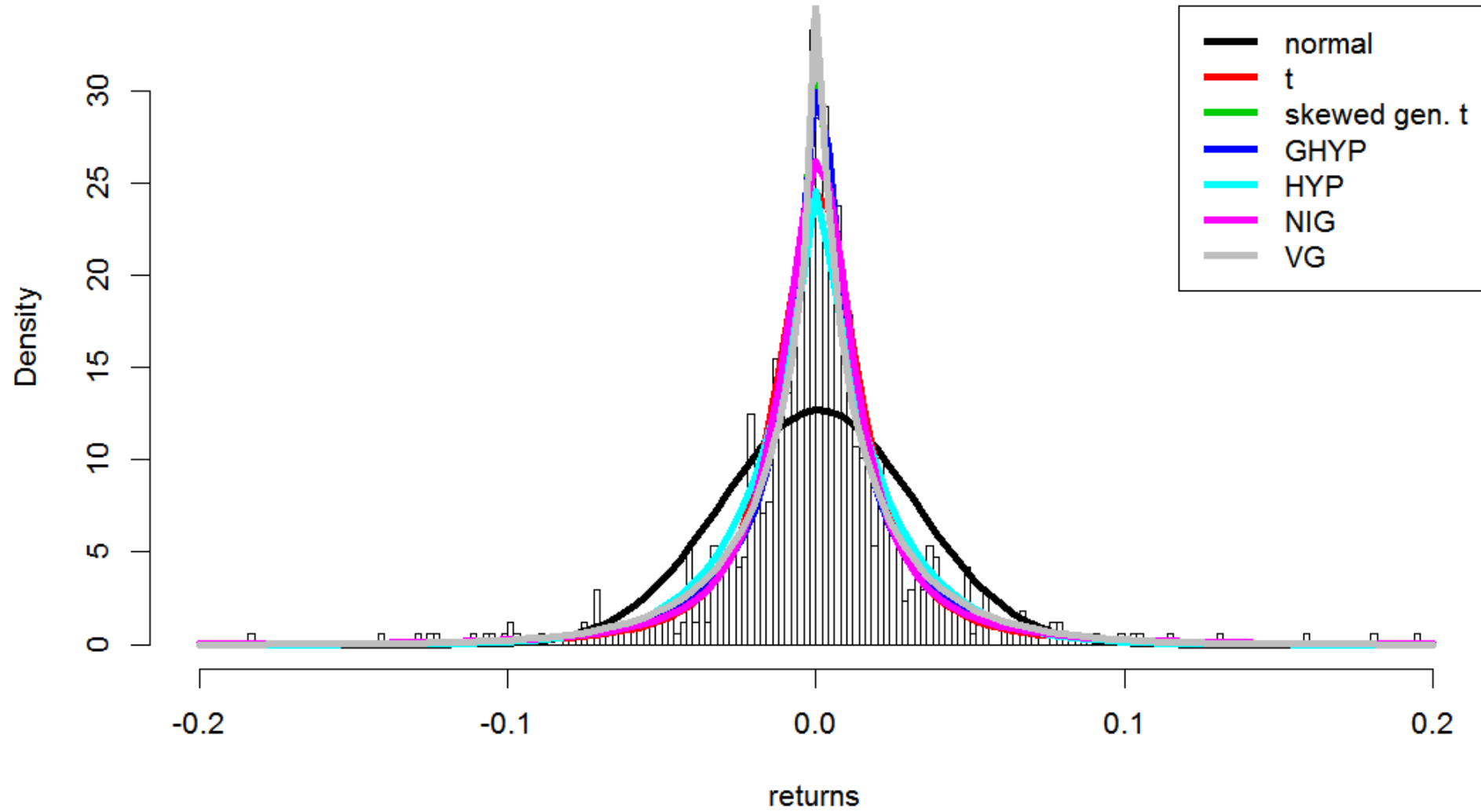
Well-known fact for many financial instruments

Volatility of Bitcoin and major currencies

90-days rolling volatility (annualized, in pct)

Legend:
- CURRFX_USDEUR
- CURRFX_USDJPY
- CURRFX_USDGBP
- CURRFX_USDCHF
- BNC2_GWA_BTC

y-axis: Rolling volatility (annualized, in pct)
x-axis: Date

Volatility of cryptocurrencies

90-days rolling volatility (annualized, in pct)
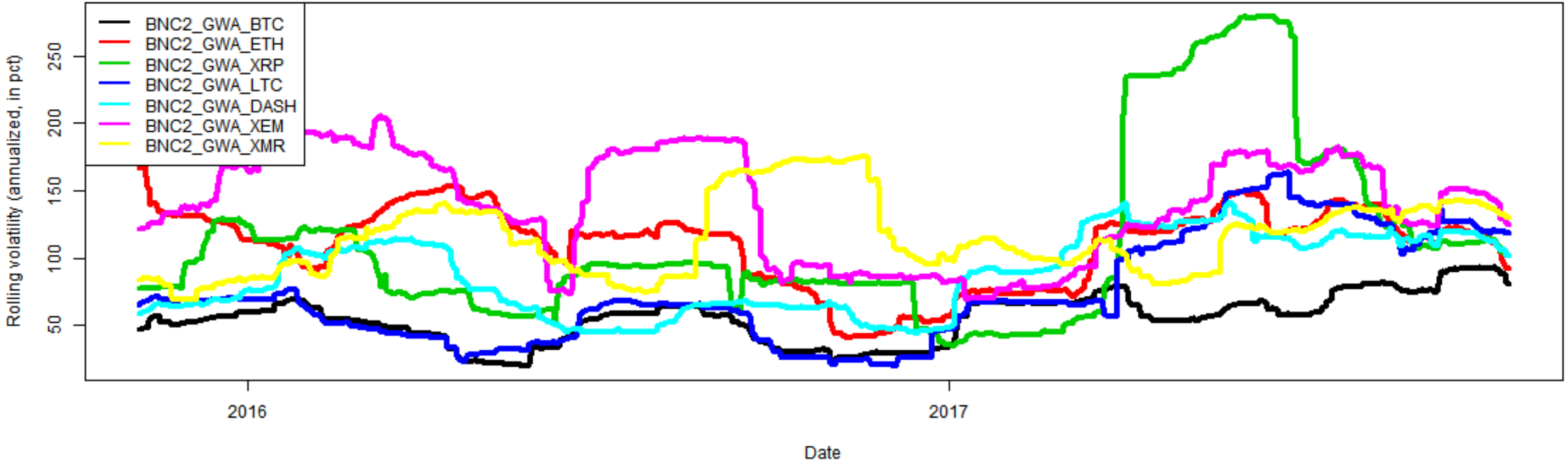
90-days rolling correlation of cryptocurrencies

Correlation of returns (90d)

Correlation of returns (120d)

Crypto-currencies will diversify your FX portfolio
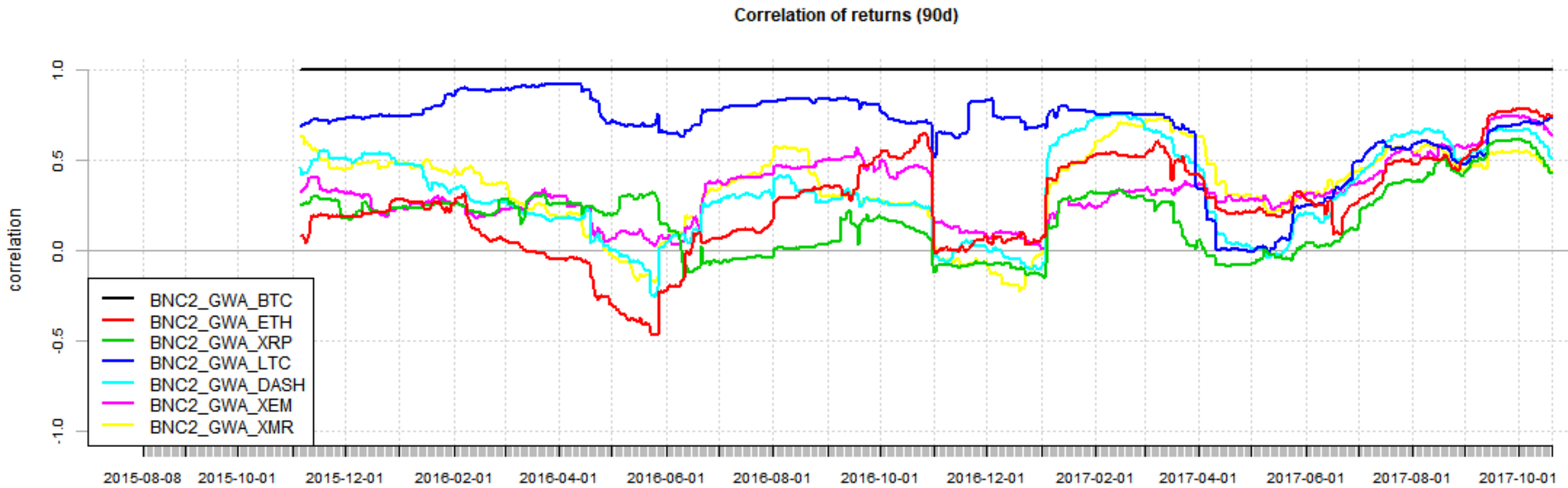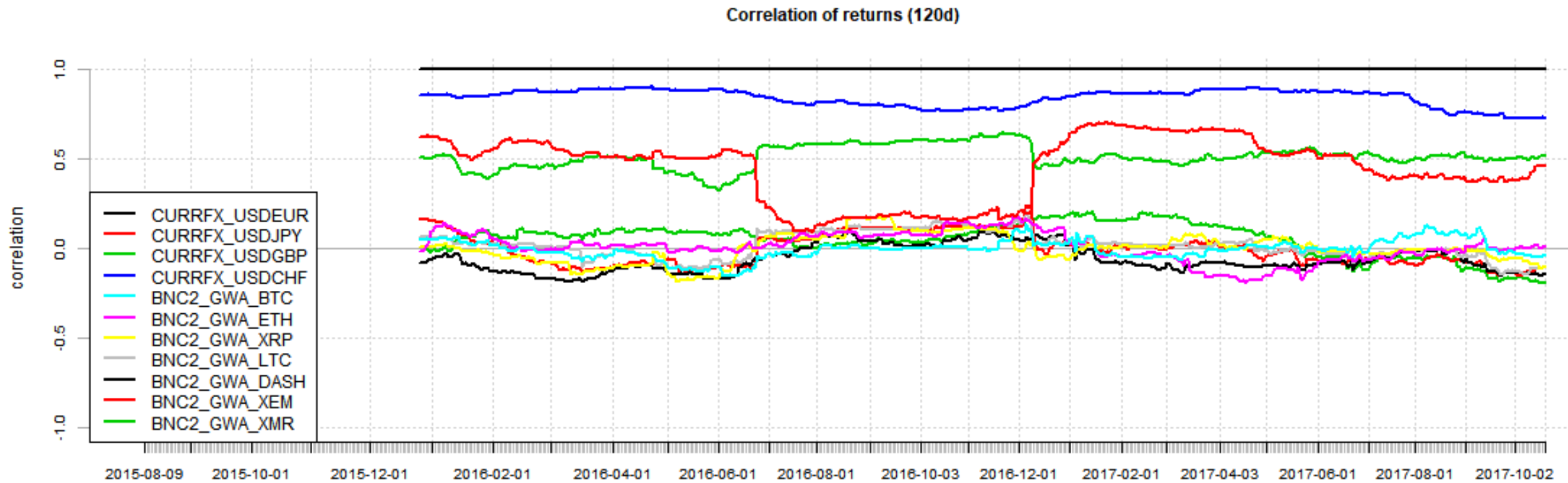
Expected Shortfall and Value at Risk 99% level

	historical VaR	gaussian VaR
CURRFX_USDEUR	-0.012	-0.012
CURRFX_USDJPY	-0.017	-0.015
CURRFX_USDGBP	-0.014	-0.016
CURRFX_USDCHF	-0.011	-0.011
BNC2_GWA_BTC	-0.128	-0.102
BNC2_GWA_ETH	-0.301	-0.208
BNC2_GWA_XRP	-0.293	-0.190
BNC2_GWA_LTC	-0.218	-0.147
BNC2_GWA_DASH	-0.207	-0.156
BNC2_GWA_XEM	-0.388	-0.256
BNC2_GWA_XMR	-0.325	-0.209

	historical ES	gaussian ES
CURRFX_USDEUR	-0.017	-0.014
CURRFX_USDJPY	-0.019	-0.017
CURRFX_USDGBP	-0.030	-0.018
CURRFX_USDCHF	-0.013	-0.013
BNC2_GWA_BTC	-0.167	-0.116
BNC2_GWA_ETH	-0.356	-0.237
BNC2_GWA_XRP	-0.415	-0.217
BNC2_GWA_LTC	-0.291	-0.167
BNC2_GWA_DASH	-0.286	-0.177
BNC2_GWA_XEM	-0.518	-0.291
BNC2_GWA_XMR	-0.452	-0.238

Bitcoin is risky?? Try the other crypto-currencies …

Randomness tests

Test for randomness using various tests

p-values

	Bartels	Cox-Stuart	Difference sign	Mann Kendall	Turning point
CURRFX_USDEUR	0.060	0.774	0.182	0.607	0.083
CURRFX_USDJPY	0.633	0.096	0.014	0.615	0.847
CURRFX_USDGBP	0.970	0.330	0.362	0.241	0.248
CURRFX_USDCHF	0.858	0.774	0.944	0.564	1.000
BNC2_GWA_BTC	0.763	0.014	0.068	0.020	0.608
BNC2_GWA_ETH	0.087	0.045	0.674	0.169	0.047
BNC2_GWA_XRP	0.114	0.528	0.575	0.526	0.235
BNC2_GWA_LTC	0.552	0.187	0.207	0.110	0.423
BNC2_GWA_DASH	0.484	0.863	0.262	0.023	0.320
BNC2_GWA_XEM	0.260	0.863	0.483	0.796	0.898
BNC2_GWA_XMR	0.295	0.528	0.161	0.411	0.188

Extreme Value Theory

Pickands-Balkema de Haan

Theorem 1 (Pickands-Balkema-de Haan). *Let $(X_1, \ldots, X_n)$ be a sequence of independent and identically-distributed random variables, and let F_u be their conditional excess distribution function. In (2) and (9), Pickands, Balkema and de Haan show that for a large class of underlying distribution functions F, and large u, F_u is well approximated by the generalized Pareto distribution. That is:*

$$F_u(y) \to G_{k,\sigma}(y), \quad as \ u \to \infty$$

where

$$G_{k,\sigma}(y) = 1 - \left(1 + \frac{ky}{\sigma}\right)^{-\frac{1}{k}}$$

if $k \neq 0$.

$$G_{k,\sigma}(y) = 1 - \exp\left(-\frac{y}{\sigma}\right)$$

if $k = 0$. Here $\sigma > 0$, and $y \geq 0$ when $k \geq 0$ and $0 \leq y \leq -\sigma/k$ when $k < 0$.

Distributions of returns over a given threshold are (approximately) given by a Generalized Pareto distribution

Fit of GPD to Bitcoin and G10
---100 extreme returns ---

	xi	beta	xi se	beta se	threshold	nllh
CURRFX_USDEUR	0.048	0.003	0.095	0.000	0.004	-466
CURRFX_USDGBP	0.036	0.004	0.098	0.000	0.005	-454
CURRFX_USDCHF	-0.024	0.004	0.097	0.000	0.004	-467
BNC2_GWA_BTC	0.305	0.025	0.160	0.005	0.019	-238
BNC2_GWA_ETH	0.048	0.053	0.135	0.009	0.045	-189
BNC2_GWA_XRP	0.177	0.037	0.145	0.006	0.042	-213
BNC2_GWA_LTC	0.268	0.032	0.124	0.005	0.025	-216
BNC2_GWA_DASH	0.113	0.036	0.124	0.006	0.035	-222
BNC2_GWA_XEM	-0.018	0.060	0.108	0.009	0.063	-183
BNC2_GWA_XMR	0.034	0.046	0.123	0.007	0.049	-204

Density for GPD distribution

USD/ EUR GPD Fit

Density for GPD distribution
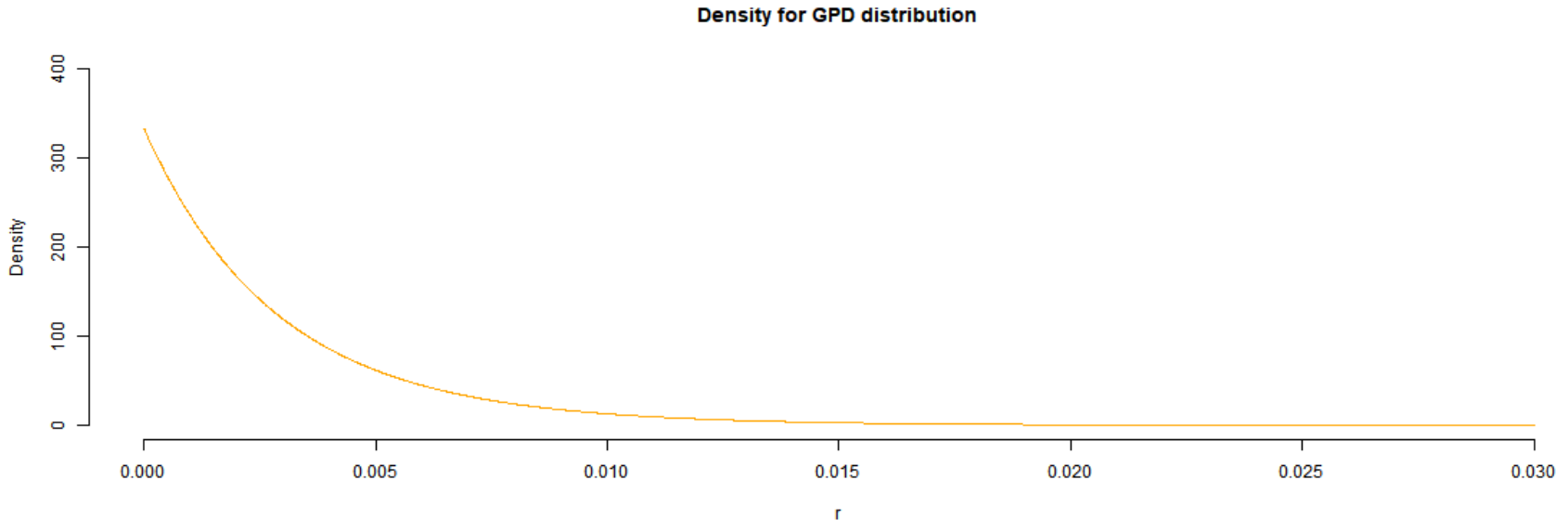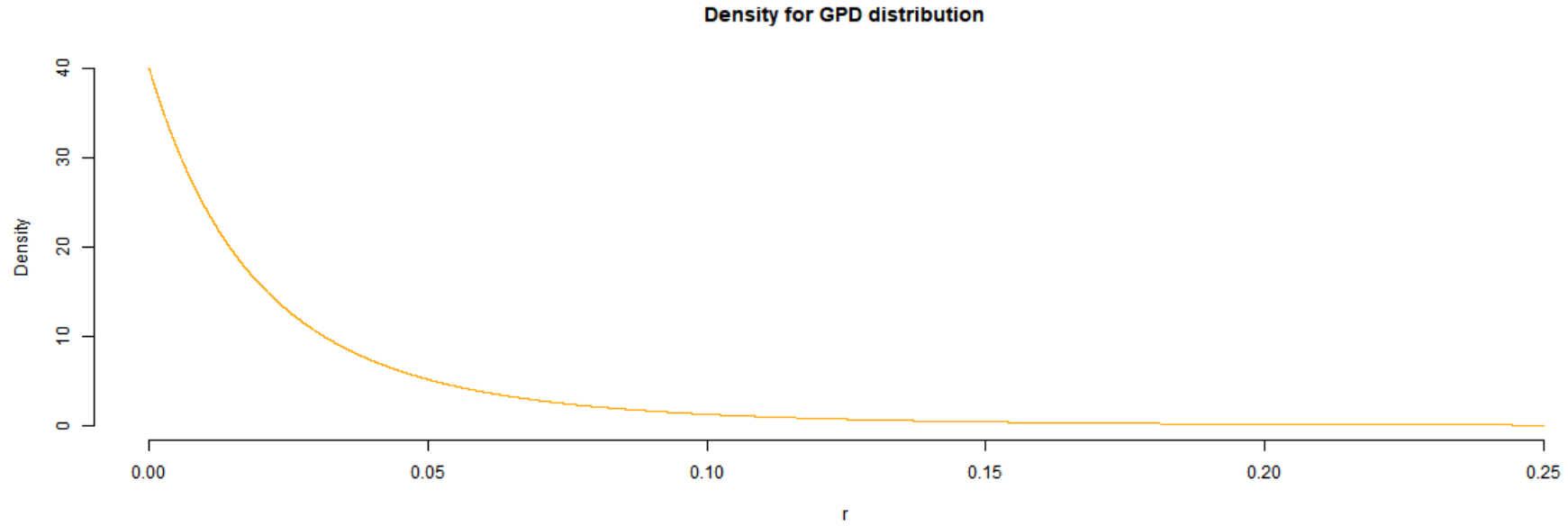
Bitcoin/ USD GPD Fit

Convergence of the maxima

Theorem 2 (Fisher-Tippet-Gnedenko). *Let* $(X_1, X_2, \ldots, X_n)$ *be a sequence of independent and identically-distributed random variables, and* $M_n = \max\{X_1, \ldots, X_n\}$. *If a sequence of pairs of real numbers* (a_n, b_n) *exists such that each* $a_n > 0$ *and* $\lim_{n \to \infty} P\left(\frac{M_n - b_n}{a_n} \leq x\right) = F(x)$ *where* F *is a non-degenerate distribution function, then the limit distribution* F *belongs to either the Gumbel, the Fréchet or the Weibull family. These can be grouped into the generalized extreme value distribution.*

By the extreme value theorem the GEV distribution is the only possible limit distribution of properly normalized maxima of a sequence of independent and identically distributed random variables.

Definition 2 (Generalized extreme value distribution). *The generalized extreme value distribution has cumulative distribution function*

$$F_{(\mu,\,\sigma,\,\xi)}(x) = \begin{cases} \exp\left\{-\left[1 + \xi\left(\frac{x-\mu}{\sigma}\right)\right]^{-\frac{1}{\xi}}\right\} & \text{for } \xi \neq 0 \\ \exp\left(-\exp\left(-\frac{x-\mu}{\sigma}\right)\right) & \text{for } \xi = 0 \end{cases}$$

for $1 + \xi(x - \mu)/\sigma > 0$, *where* $\mu \in \mathbb{R}$ *is the location parameter,* $\sigma > 0$ *the scale parameter and* $\xi \in \mathbb{R}$ *the shape parameter. For* $\xi > 0$, *the support is* $x > \mu - \sigma/\xi$, *while for* $\xi < 0$, *it is* $x < \mu - \sigma/\xi$. *For* $\xi = 0$, $x \in \mathbb{R}$

GEV Bitcoin vs EUR

Density for GEV distribution

Density for GEV distribution
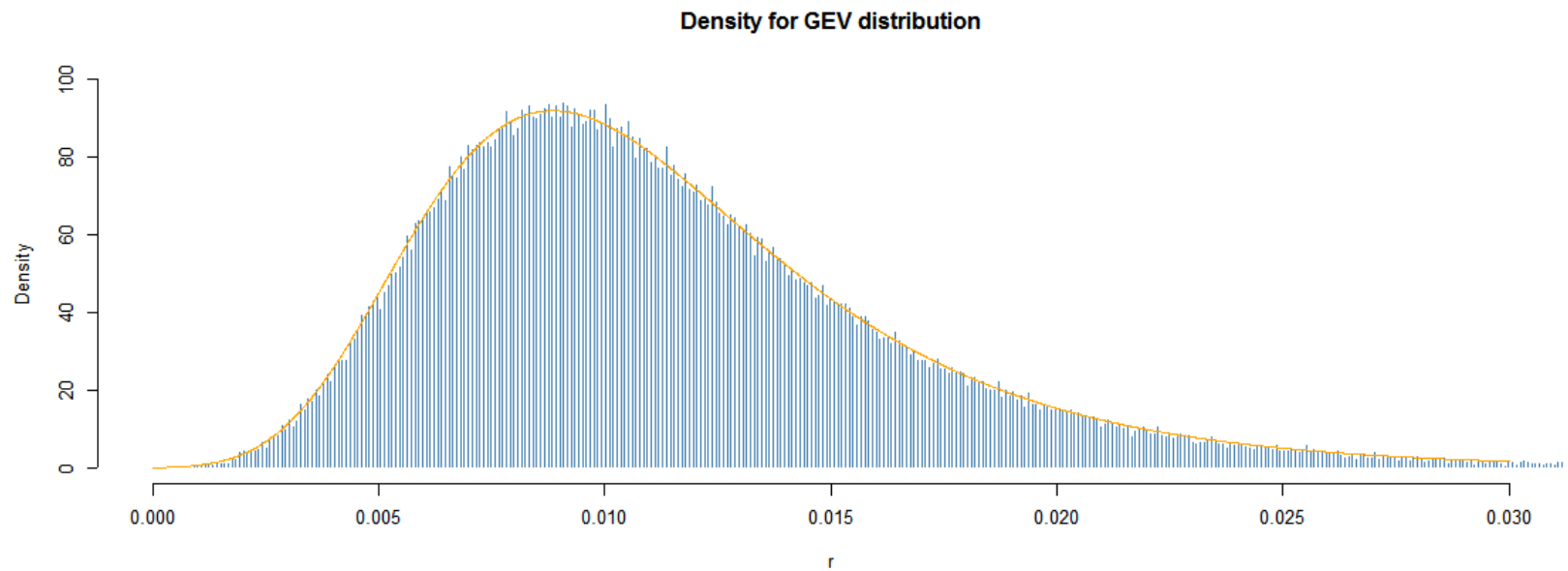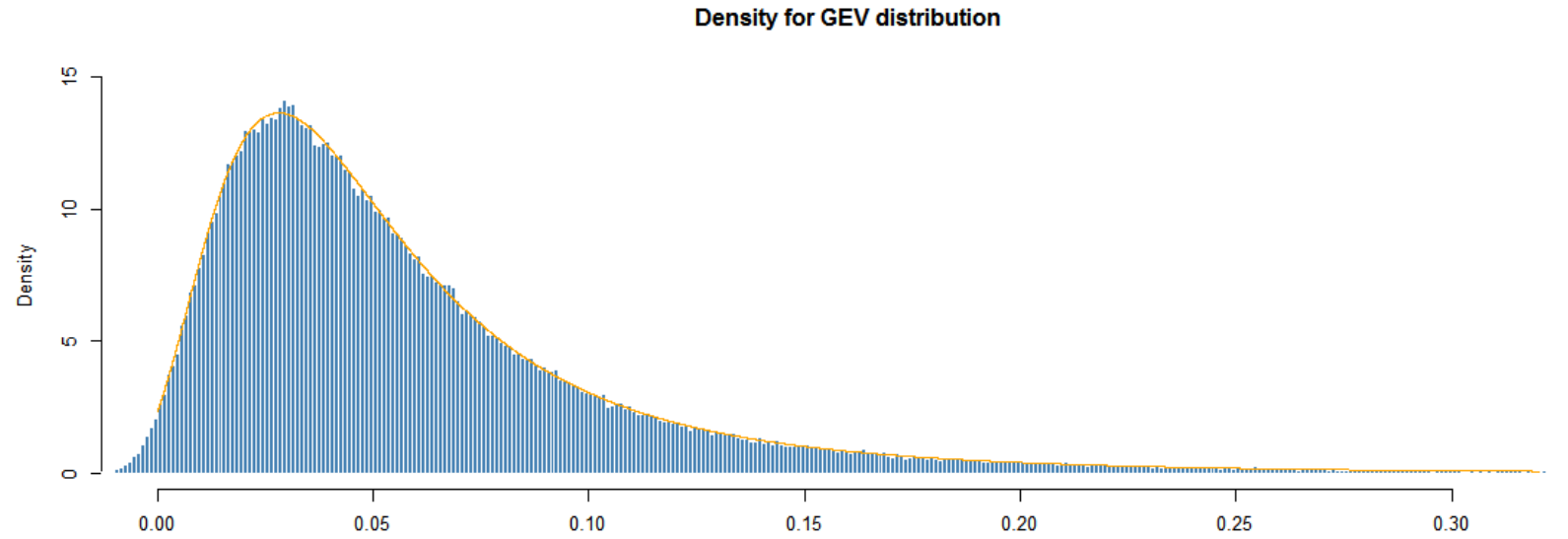
Extremal index

The extremal index is a useful indicator of how much clustering of exceedances of a threshold occurs in the limit of the distribution. For independent data, theta = 1, (though the converse does not hold) and if theta < 1, then there is some dependency (clustering) in the limit.

Table 2. Extremal index for the left tail of Bitoin and the G10 currencies

Exchange rate	Runs declustering			Intervals estimator		
	θ	#clusters	run length	θ	#clusters	run length
Bitcoin/USD	0.487	82	4	0.558	64	3
AUD/USD	0.641	50	4	0.738	57	3
CAD/USD	0.615	48	4	0.776	55	3
CHF/USD	0.654	51	4	0.806	59	2
EUR/USD	0.603	47	4	0.543	40	5
GBP/USD	0.577	45	4	0.489	39	6
JPY/USD	0.500	39	4	0.653	39	4
NOK/USD	0.487	38	4	0.450	34	5
NZD/USD	0.615	48	4	0.836	65	2
SEK/USD	0.718	56	4	0.890	66	2

Mean excess plot

Bitcoin/ USD

Eur / USD

The Blue Bandsaw

07-14-10
NASDAQ "Blue Bandsaw". Symbol SHG. (760 quotes in 1 second, taken from a total sampling of 10,000 quotes in 12 seconds).