Härdle, Wolfgang Karl; Trimborn, Simon

Working Paper

CRIX or evaluating blockchain based currencies

SFB 649 Discussion Paper, No. 2015-048

Provided in Cooperation with:
Collaborative Research Center 649: Economic Risk, Humboldt University Berlin

Suggested Citation: Härdle, Wolfgang Karl; Trimborn, Simon (2015) : CRIX or evaluating blockchain based currencies, SFB 649 Discussion Paper, No. 2015-048

This Version is available at:
http://hdl.handle.net/10419/122006

SFB 649 Discussion Paper 2015-048

CRIX or evaluating Blockchain based currencies

Wolfgang K. Härdle*
Simon Trimborn*

* Humboldt-Universität zu Berlin, Germany

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

http://sfb649.wiwi.hu-berlin.de
ISSN 1860-5664

SFB 649, Humboldt-Universität zu Berlin
Spandauer Straße 1, D-10178 Berlin

CRIX or evaluating Blockchain based currencies *

Simon Trimborn †
Wolfgang Karl Härdle ‡

Oktober 15, 2015

JEL classification: C51, C52, G10

Keywords: Index construction, CRIX, risk analysis, bitcoin, cryptocurrency

More and more companies start offering digital payment systems. Smartphones evolve to a digital wallet such that it seems like we are about to enter the era of digital finance. In fact we are already inside an digital economy. The market of e-x (x = "finance", "money", "book", you name it ...) has not only picked up enormous momentum but has become standard for driving innovative activities of the global economy. A few clicks at y and payment at z brings our purchase to location w. Own currencies for the digital market were therefore just a matter of time. The idea of the Nobel Laureate Hayek, see [1], to let companies offer concurrent currencies seemed for a long time scarcely probabilistic, but the invention of the Blockchain made it possible to fill his vision with life. Cryptocurrencies (abbr. cryptos) came up and widened the angle towards this new level of economic interaction. Since bitcoins' appearance a bunch of new cryptos spread the web and offered new ways of proliferation. The crypto market then fanned out and showed clear signs of acceptance and deep liquidity so that one has to look closer at the general moves and dynamics.
CRIX - a CRyptocurrency IndeX, `http://crix.hu-berlin.de`, has been created for this purpose, Figure 1.
CRIX follows Laspeyres' idea:

$$\text{CRIX}(k)_t = \frac{\sum_i^k MV_{it} \cdot AW_{it}}{Divisor} \tag{1}$$

*Financial support from the Deutsche Forschungsgemeinschaft via CRC 649 "Economic Risk" and IRTG 1792 "High Dimensional Non Stationary Time Series", Humboldt-Universität zu Berlin, is gratefully acknowledged.

†Humboldt-Universität zu Berlin, C.A.S.E. - Center for Applied Statistics and Economics, Spandauer Str. 1, 10178 Berlin, Germany, tel: +49 (0)30 2093-5703, fax: +49 (0)30 2093-5649, E-Mail: simon.trimborn@wiwi.hu-berlin.de

‡Humboldt-Universität zu Berlin, C.A.S.E. - Center for Applied Statistics and Economics, Spandauer Str. 1, 10178 Berlin, Germany and SKBI School of Business, Singapore Management University, 50 Stamford Road, Singapore 178899, tel: +49 (0)30 2093-5630, E-Mail: haerdle@hu-berlin.de

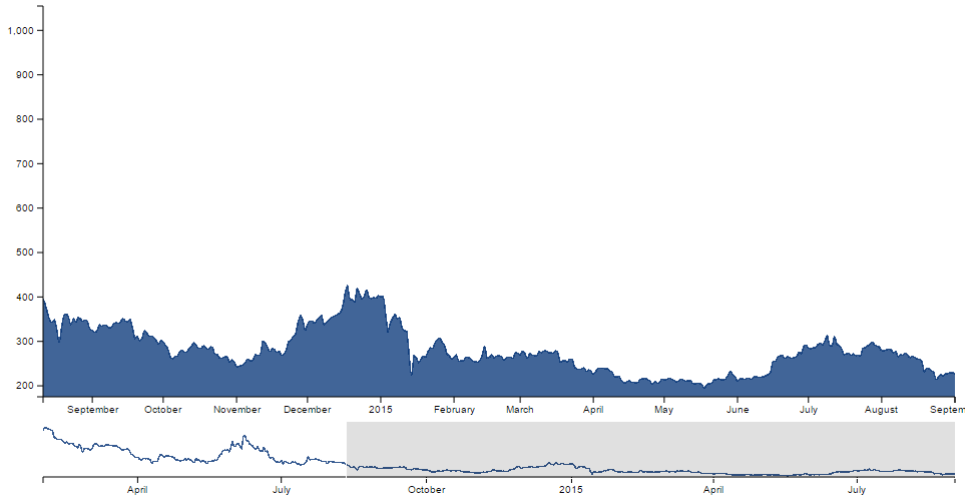

Figure 1: Snapshot of the CRIX website on the 24.09.2015

where MV_{it} is the market capitalization of the crypto i at time point t and k the number of constituents. AW_{it} is the adjusted weight, defined as

$$AW_{it} = \frac{CW_{it}}{W_{it}} \tag{2}$$

with CW_{it} the capped weight and $W_{it} = \frac{MV_{it}}{\sum_i MV_{it}}$ the weight the crypto i would normally have in CRIX. The weight will be capped if a single crypto i would have an influence of 50% or more in CRIX. The cap is part of the index rules since the analysis of the trading volume showed that bitcoin has a major influence in the market besides its trading volume, relative to all outstanding bitcoins, is much lower than for alternative cryptocurrencies. This implies a higher interest of interested parties in alternative cryptos than their market value suggests, which motivates to lower the influence of bitcoin. The *Divisor* with the starting value $\frac{\sum_i MV_i}{1000}$ controls that CRIX is not affected by a shifting of its constituents, just by price changes. To ensure this, it is adjusted when necessary:

$$\frac{\sum_i MV_{i,t-1}}{Divisor_{t-1}} = \text{CRIX}_{t-1} = \text{CRIX}_t = \frac{\sum_j MV_{j,t}}{Divisor_t}. \tag{3}$$

The index rules, which form the CRIX methodology, ensure that CRIX reacts fast and dynamically to changes in the market, such that it gives insight into the evolvement of cryptos which surfaced in the digital economy. CRIX relies on liquidity measures and on the Bayesian information criterion (BIC), see [3]. The BIC is used to decide how many cryptos shall participate in a representative proxy of the market. CRIX will be just the perfect benchmark, if the amount of constituents is always optimal. For this purpose, a procedure was created which compares the difference between the total market (all market participants) and several candidate indices,

$$\varepsilon_{j,t} = \text{total market}_t - \text{CRIX}(k)_{j,t}, \tag{4}$$

where $\text{CRIX}(k)_{j,t}$ is the CRIX version j with k_j constituents and $\varepsilon_{j,t}$ is the respective difference. The total market is represented by an index of all market participants, which is computed by the formulas (1), (2) and (3). The candidate indices, $\text{CRIX}(k)_j$, have different amounts of constituents which fulfill $k_1 < k_2 < k_3 < \cdots$. The BIC criterion evaluates the differences, $\varepsilon_{j,t}$, between the candidates and the total market with the respective likelihood L_j,

$$L_j = \prod_t f_j(\varepsilon_{j,t}), \tag{5}$$

where f_j represents the density of the $\varepsilon_{j,t}$ over all t. It penalizes L_j with the amount of constituents, k_j, such that the following formula results:

$$BIC_j = -2 \log L_j + k_j \cdot \log(n_j), \tag{6}$$

where n_j is the number of observations. The density, f_j, is estimated nonparametrically with a Gaussian kernel. Since the same data are used to estimate f_j and the BIC_j, a "leave-one-out" cross-validation procedure is performed, described in [4], to overcome the bias. The search for the optimal model stops, when the BIC becomes worse for the first time,

$$BIC_{j-1} < BIC_j. \tag{7}$$

The entire procedure runs every third month and the resulting number of index members, k, will be fixed for the coming 3 month. In connection with the liquidity rules and a frequent reallocation results CRIX, a state-of-the-art index which fits the demands of the young and innovative cryptocurrency market. A detailed version of the methodology can be found on the website, `http://crix.hu-berlin.de`.

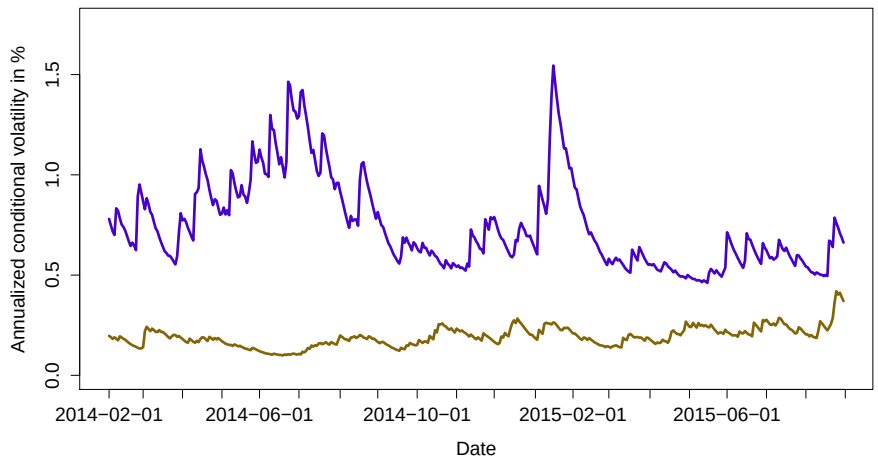

Figure 2: Annualized conditional volatility in % of CRIX and DAX

Satoshi Nakamoto described in his paper, see [2], a decentralized payment system. While many just think about bitcoin and other cryptos as currencies, some argue that cryptos can be seen as commodities, see

e.g. [6]. Being treated as a commodity, makes it a store of value and by this means an exchangeable, investable product. CRIX was created to investigate this feature of cryptos by comparing the crypto market against other investment universes and classifying CRIX in terms of economic risk against them. We perform our analysis on data in the time period 01.02.2014 - 01.09.2015 and observe, that the annualized conditional volatility, measured with a GARCH(1,1) model, has a higher base level than the DAX but that the amount of high spikes in the volatility decreases, see Figure 2. This indicates us, that CRIX bears a higher risk than the german bluechip index but is stabilizing although on a higher level.
The detected Expected Shortfall (ES) lies far away from that of fiat fx rates, where the ES is defined as the conditional expectation

$$\mathrm{E}\left[X | X < x_{0.01}\right]$$

with $x_{0.01}$ the 0.01-quantile and assuming the tails to follow a generalized Pareto distribution, see [5]. The risk level, which ES indicates, lies much closer to risky stock markets like the Greece or Russian one, see Table 1.

	ES
CRIX	-0.1579
SP500	-0.0528
DAX	-0.0700
RTSI	-0.1343
ATHEX	-0.1288
EUR to USD	-0.0223
RUB to USD	-0.0637

Table 1: Extreme value theory based ES at $\alpha = 0.01$ and with threshold $u_t = 0.1$ for CRIX SP500 DAX RTSI ATHEX EUR to USD RUB to USD.

Finally, option prices are computed to attach a price tag to the risk which CRIX bears. Based on these insights one may conclude that if options would exist for CRIX, they would currently be such expensive that it - most likely - doesn't pay out to protect ones investment with them. Besides this findings, it appears that this market is stabilizing and qualifies itself little by little as a serious investment alternative. CRIX and the risk statistics will be computed continuously and be published on `http://crix.hu-berlin.de` to offer interested parties a comprehensive overview.

References

[1] F.A. Hayek *Denationalization of Money: An Analysis of the Theory and Practice of Concurrent Currencies*, London: Institute of Economic Affairs (1976).

[2] S. Nakamoto *Bitcoin: A Peer-to-Peer Electronic Cash System*, (2008).

[3] G. Schwarz *Estimating the Dimension of a Model*, The Annals of Statistics **6**, (1978) 461–464.

[4] A. Potapov, J.R. Muirhead, S.R. Lele, M.A. Lewis *Stochastic gravity models for modeling lake invasions*, Ecological Modelling **222**, (2011) 964-972.

[5] A.J. McNeil, R. Frey *Estimation of tail-related risk measures for heteroscedastic financial time series: an extreme value approach*, Journal of Empirical Finance **7**, (2000) 271-300.

[6] W. Buiter *Gold: a six thousand year-old bubble revisited*, Citi Research Economics, (2014).

SFB 649 Discussion Paper Series 2015

For a complete list of Discussion Papers published by the SFB 649, please visit http://sfb649.wiwi.hu-berlin.de.

001 "Pricing Kernel Modeling" by Denis Belomestny, Shujie Ma and Wolfgang Karl Härdle, January 2015.
002 "Estimating the Value of Urban Green Space: A hedonic Pricing Analysis of the Housing Market in Cologne, Germany" by Jens Kolbe and Henry Wüstemann, January 2015.
003 "Identifying Berlin's land value map using Adaptive Weights Smoothing" by Jens Kolbe, Rainer Schulz, Martin Wersing and Axel Werwatz, January 2015.
004 "Efficiency of Wind Power Production and its Determinants" by Simone Pieralli, Matthias Ritter and Martin Odening, January 2015.
005 "Distillation of News Flow into Analysis of Stock Reactions" by Junni L. Zhang, Wolfgang K. Härdle, Cathy Y. Chen and Elisabeth Bommes, January 2015.
006 "Cognitive Bubbles" by Ciril Bosch-Rosay, Thomas Meissnerz and Antoni Bosch-Domènech, February 2015.
007 "Stochastic Population Analysis: A Functional Data Approach" by Lei Fang and Wolfgang K. Härdle, February 2015.
008 "Nonparametric change-point analysis of volatility" by Markus Bibinger, Moritz Jirak and Mathias Vetter, February 2015.
009 "From Galloping Inflation to Price Stability in Steps: Israel 1985–2013" by Rafi Melnick and till Strohsal, February 2015.
010 "Estimation of NAIRU with Inflation Expectation Data" by Wei Cui, Wolfgang K. Härdle and Weining Wang, February 2015.
011 "Competitors In Merger Control: Shall They Be Merely Heard Or Also Listened To?" by Thomas Giebe and Miyu Lee, February 2015.
012 "The Impact of Credit Default Swap Trading on Loan Syndication" by Daniel Streitz, March 2015.
013 "Pitfalls and Perils of Financial Innovation: The Use of CDS by Corporate Bond Funds" by Tim Adam and Andre Guettler, March 2015.
014 "Generalized Exogenous Processes in DSGE: A Bayesian Approach" by Alexander Meyer-Gohde and Daniel Neuhoff, March 2015.
015 "Structural Vector Autoregressions with Heteroskedasticy" by Helmut Lütkepohl and Aleksei Netšunajev, March 2015.
016 "Testing Missing at Random using Instrumental Variables" by Christoph Breunig, March 2015.
017 "Loss Potential and Disclosures Related to Credit Derivatives – A Cross-Country Comparison of Corporate Bond Funds under U.S. and German Regulation" by Dominika Paula Gałkiewicz, March 2015.
018 "Manager Characteristics and Credit Derivative Use by U.S. Corporate Bond Funds" by Dominika Paula Gałkiewicz, March 2015.
019 "Measuring Connectedness of Euro Area Sovereign Risk" by Rebekka Gätjen Melanie Schienle, April 2015.
020 "Is There an Asymmetric Impact of Housing on Output?" by Tsung-Hsien Michael Lee and Wenjuan Chen, April 2015.
021 "Characterizing the Financial Cycle: Evidence from a Frequency Domain Analysis" by Till Strohsal, Christian R. Proaño and Jürgen Wolters, April 2015.

SFB 649, Spandauer Straße 1, D-10178 Berlin
http://sfb649.wiwi.hu-berlin.de

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

SFB 649 Discussion Paper Series 2015

For a complete list of Discussion Papers published by the SFB 649, please visit http://sfb649.wiwi.hu-berlin.de.

022 "Risk Related Brain Regions Detected with 3D Image FPCA" by Ying Chen, Wolfgang K. Härdle, He Qiang and Piotr Majer, April 2015.
023 "An Adaptive Approach to Forecasting Three Key Macroeconomic Variables for Transitional China" by Linlin Niu, Xiu Xu and Ying Chen, April 2015.
024 "How Do Financial Cycles Interact? Evidence from the US and the UK" by Till Strohsal, Christian R. Proaño, Jürgen Wolters, April 2015.
025 "Employment Polarization and Immigrant Employment Opportunities" by Hanna Wielandt, April 2015.
026 "Forecasting volatility of wind power production" by Zhiwei Shen and Matthias Ritter, May 2015.
027 "The Information Content of Monetary Statistics for the Great Recession: Evidence from Germany" by Wenjuan Chen and Dieter Nautz, May 2015.
028 "The Time-Varying Degree of Inflation Expectations Anchoring" by Till Strohsal, Rafi Melnick and Dieter Nautz, May 2015.
029 "Change point and trend analyses of annual expectile curves of tropical storms" by P.Burdejova, W.K.Härdle, P.Kokoszka and Q.Xiong, May 2015.
030 "Testing for Identification in SVAR-GARCH Models" by Helmut Luetkepohl and George Milunovich, June 2015.
031 "Simultaneous likelihood-based bootstrap confidence sets for a large number of models" by Mayya Zhilova, June 2015.
032 "Government Bond Liquidity and Sovereign-Bank Interlinkages" by Sören Radde, Cristina Checherita-Westphal and Wei Cui, July 2015.
033 "Not Working at Work: Loafing, Unemployment and Labor Productivity" by Michael C. Burda, Katie Genadek and Daniel S. Hamermesh, July 2015.
034 "Factorisable Sparse Tail Event Curves" by Shih-Kang Chao, Wolfgang K. Härdle and Ming Yuan, July 2015.
035 "Price discovery in the markets for credit risk: A Markov switching approach" by Thomas Dimpfl and Franziska J. Peter, July 2015.
036 "Crowdfunding, demand uncertainty, and moral hazard - a mechanism design approach" by Roland Strausz, July 2015.
037 ""Buy-It-Now" or "Sell-It-Now" auctions : Effects of changing bargaining power in sequential trading mechanism" by Tim Grebe, Radosveta Ivanova-Stenzel and Sabine Kröger, August 2015.
038 "Conditional Systemic Risk with Penalized Copula" by Ostap Okhrin, Alexander Ristig, Jeffrey Sheen and Stefan Trück, August 2015.
039 "Dynamics of Real Per Capita GDP" by Daniel Neuhoff, August 2015.
040 "The Role of Shadow Banking in the Monetary Transmission Mechanism and the Business Cycle" by Falk Mazelis, August 2015.
041 "Forecasting the oil price using house prices" by Rainer Schulz and Martin Wersing, August 2015.
042 "Copula-Based Factor Model for Credit Risk Analysis" by Meng-Jou Lu, Cathy Yi-Hsuan Chen and Karl Wolfgang Härdle, August 2015.
043 "On the Long-run Neutrality of Demand Shocks" by Wenjuan Chen and Aleksei Netsunajev, August 2015.

SFB 649, Spandauer Straße 1, D-10178 Berlin
http://sfb649.wiwi.hu-berlin.de

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".

SFB 649 Discussion Paper Series 2015

For a complete list of Discussion Papers published by the SFB 649, please visit http://sfb649.wiwi.hu-berlin.de.

044 "The (De-)Anchoring of Inflation Expectations: New Evidence from the Euro Area" by Laura Pagenhardt, Dieter Nautz and Till Strohsal, September 2015.
045 "Tail Event Driven ASset allocation: evidence from equity and mutual funds' markets" by Wolfgang Karl Härdle, David Lee Kuo Chuen, Sergey Nasekin, Xinwen Ni and Alla Petukhina, September 2015.
046 "Site assessment, turbine selection, and local feed-in tariffs through the wind energy index" by Matthias Ritter and Lars Deckert, September 2015.
047 "TERES - Tail Event Risk Expectile based Shortfall" by Philipp Gschöpf, Wolfgang Karl Härdle and Andrija Mihoci, September 2015.
048 "CRIX or evaluating Blockchain based currencies" by Wolfgang Karl Härdle and Simon Trimborn, October 2015.

SFB 649, Spandauer Straße 1, D-10178 Berlin
http://sfb649.wiwi.hu-berlin.de

This research was supported by the Deutsche Forschungsgemeinschaft through the SFB 649 "Economic Risk".