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## CRIX or evaluating blockchain based currencies

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SFB 649 Discussion Paper 2015-048

**CRIX**  
**or evaluating Blockchain**  
**based currencies**

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# CRIX or evaluating Blockchain based currencies \*

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*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:

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

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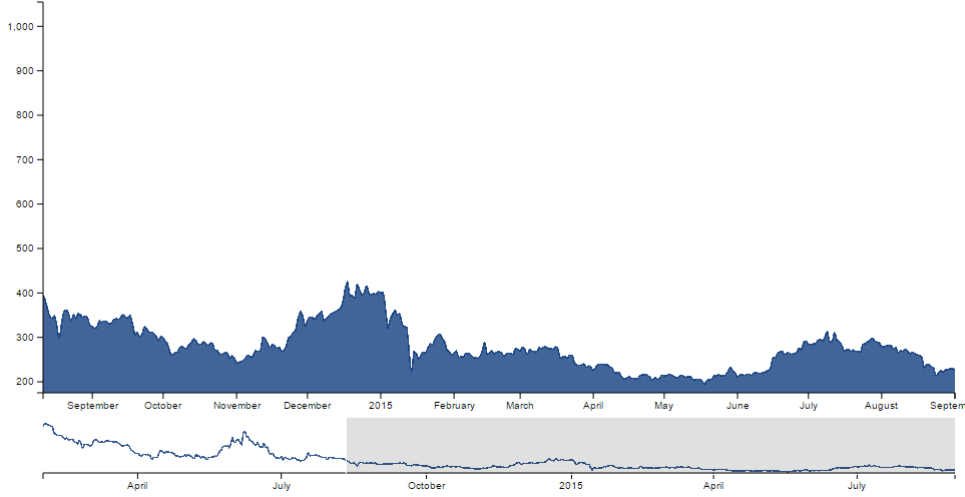


Figure 1: Snapshot of the CRIX website on the 24.09.2015

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

$$AW_{it} = \frac{CW_{it}}{W_{it}} \quad (2)$$

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:

$$\frac{\sum_i MV_{i,t-1}}{Divisor_{t-1}} = CRIX_{t-1} = CRIX_t = \frac{\sum_j MV_{j,t}}{Divisor_t}. \quad (3)$$

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 evolution 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,

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

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  $k_1 < k_2 < k_3 < \dots$ . The *BIC* criterion evaluates the differences,  $\varepsilon_{j,t}$ , between the candidates and the total market with the respective likelihood  $L_j$ ,

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

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:

$$\text{BIC}_j = -2 \log L_j + k_j \cdot \log(n_j), \quad (6)$$

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  $\text{BIC}_j$ , 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,

$$\text{BIC}_{j-1} < \text{BIC}_j. \quad (7)$$

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>.

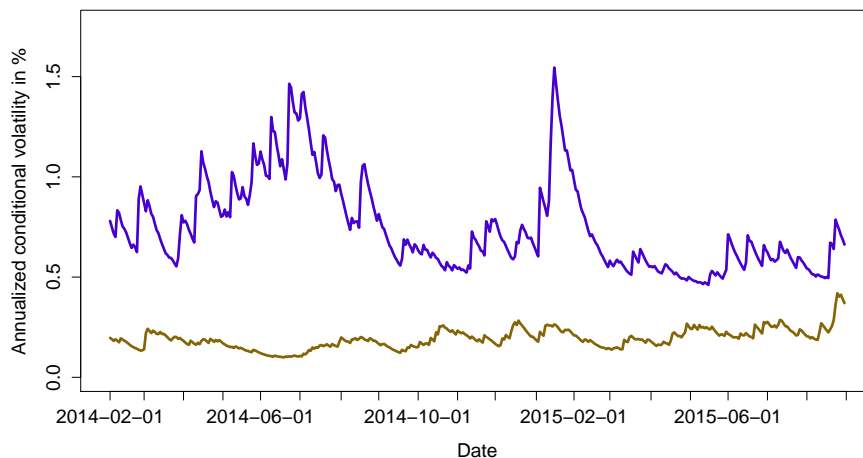


Figure 2: Annualized conditional volatility in % of CRIX and DAX

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

$$E[X|X < x_{0.01}]$$

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.

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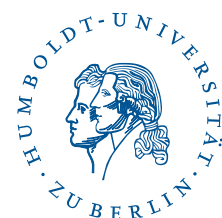
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