CIF200: a cryptocurrency index fund

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Abstract

As cryptocurrencies could emerge as a new asset class that establish itself as a viable investment and diversification tool, this work addresses the creation of an passively managed cryptocurrency index fund (CIF) that meets the needs of capital investors. Therefore, a portfolio by the weighted average of the market capitalization of the underlying cryptocurrencies with a rebalancing/capping-strategy is introduced. Comprehensive backtests on historical data has been carried out in order to find an efficient indexing strategy. This ultimately results in a passively managed portfolio with 200 coins, a 14 days rebalancing interval and a 2% capping value, termed "Cryptocurrency Index Fund 200" (CIF200) showing growth rates up to 14950% in backtesting. Finally, a Monte Carlo simulation using geometric fractional Brownian motions is performed, indicating high growth potential at low risk.

Keywords: Cryptocurrency, Index Fund, ETF, passively managed, ROIC

1. Introduction and motivation

The global financial crisis following the collapse of Lehman Brothers a decade ago hurt confidence in existing financial systems and related institutions worldwide. It was against this background, that the proliferation of cryptocurrencies gathered momentum as a basis of an alternative, contemporary payment system liberated from necessarily trusted institutions and at the same time capable of meeting the demands of the digital age [24]. Cryptocurrencies are a completely new approach to organize payment, where one unit or coin is displayed as encrypted data, protecting it against unauthorized copying and counterfeiting. Hence, they are an element of a payment system based on cryptographic proof rather than trust [24]. It is a straightforward peer-to-peer system using a decentralized ledger, a so called

blockchain, which does not need a central authority, repository, or any kind of intermediation of trusted third parties such as banks or payment system providers to verify a transaction [15].
"Initial Coin Offerings" (ICO) enables companies to raise capital according to a kind of crowdfunding system [15, 9]. Corresponding to the overall development of cryptocurrencies, the years 2017/18 witnessed a sharp increase in ICOs [15]. Most ICO activity can be found in the USA (equivalent to 1031 million US$), followed by Russia (310 million US$), Singapore (260 million US$), and China (256 million US$). Germany (187 million US$) is in the seventh place worldwide and leads the ranking in Europe [19, as of December 2017]. The values of the new ICOs and the numbers of existing cryptoccurencies worldwide, as in figure 1, shows that this is a global evolution and it looks like cryptocurrencies have come to stay in the market.

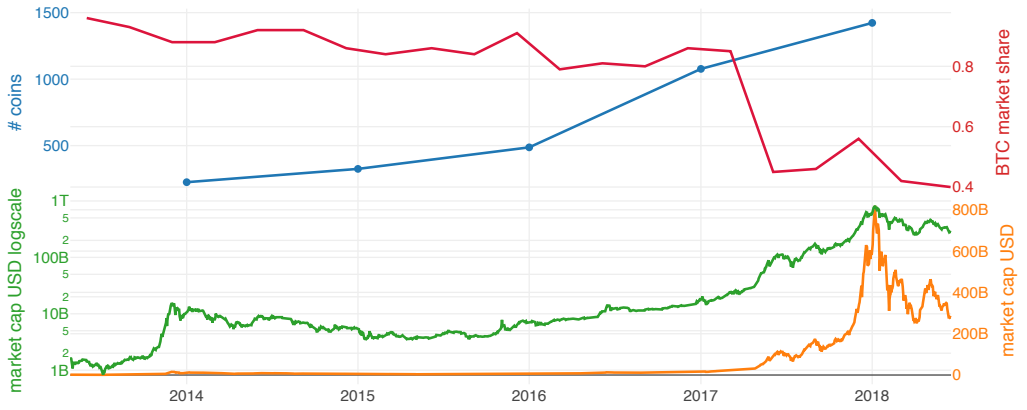

Figure 1: Development of the number of coins, the bitcoin market share in percent and the total market capitalization of cryptocurrencies in US$ over the last 5 years. Data sourced from [1].

Are cryptocurrencies a new asset class? It appears that cryptocurrencies might emerge as a new asset class with the potential to set up as a viable investment and diversification instrument [3]. There is some evidence that cryptocurrency returns are essentially uncorrelated with customary asset classes, so they might well serve as a new instrument to diversify port-

folios [8]. While there is still some disagreement on the question of whether cryptocurrencies should be classified similar to precious metals, speculative assets, or as something in between a commodity and a currency [8], they are undoubtedly a highly speculative investment with a still rather limited market capitalization [9]. Figure 1 shows that market capitalization and prices had emerged rather slowly over the years until the first half of 2017, but then suddenly increased drastically and reached a peak in the first quarter of 2018. In fact, the total capitalization of the cryptocurrency market increased by more than 1100% during the year 2017, outperforming many traditional assets and this way attracting the interest of investors already searching for new investment opportunities.

How important is a cryptocurrency index fund? A viable strategy for investors with a long-term focus is the so-called indexing, i.e. the allocation of assets in a portfolio that matches the composition of an index. A portfolio that tracked the top ten cryptocurrencies clearly outperformed the development of the Bitcoin currency already in 2017 [5]. This obviously calls for the creation of a cryptocurreny index fund (CIF) similar to equity index funds allowing investors to follow a passive investment strategy by providing them with a viable instrument to track market developments and replicate the index at low cost [5].
Principally, a CIF should model the development of cryptocurrency prices in a similar way a stock market index records value changes of an equity basket or portfolio representing a specific market or market segment [5]. Table 1 shows a collection of assorted equity indices with the respective number of constituents and market capitalization. It is apparent that the capitalization of equity markets - especially in a global context - is still far beyond the capitalization of the cryptocurrency market which is apparently only at the beginning of its development.

How significant are exchange-traded funds for investors? Index funds are a special type of mutual funds with a portfolio that replicates a specific equity index both in terms of structure and value [7]. Exchange-traded funds (ETF) essentially are open-end index funds which track an index as closely as possible and are traded like a common stock at the stock exchange in real time. Therefore, they combine the efficiency and simplicity of on-exchange trading with the advantages of indexing [22]. Investments in ETFs showed an impressive development in recent years. In Europe, there are more than

Index	Number of Constituents	Total Market Capitalization $[10^9$ US$]$
Dow Jones Industrial (USA)	30	6967
S&P 500 (USA)	500	23596
Nikkei 225 (Japan)	225	6235
FTSE 100 (United Kingdom)	100	2677
DAX (Germany)	30	1287
FTSE 100 MIB (Italy)	34	478
MSCI World Index (23 Developed Market Countries, 85% Coverage)	1644	40160

Table 1: Characteristics of Assorted Equity Indices (as of April/June 2018) Source: Own depiction based on information provided by: Boerse.de; Japan Exchange Group; MSCI (2018)

50 fund companies offering nearly 1600 ETFs. The total volume of invested assets exceeds 540 billion US$ compared to a volume of a good 100 billion US$ a decade ago. Worldwide, there are more than 100 fund companies offering about 4800 ETFs and the volume of assets invested amounts to 3400 billion US$ [12, as of December 2016]. Assuming efficiency of capital markets, this is actually the most yielding long-term strategy for a given level of risk [25]. Actively managed funds with individual portfolios are associated with extra expenditure for transactions fees and research cost and are, in fact, often outperformed by the market in the long run[25].

How to design a framework for a cryptocurrency index fund? The cryptocurrency market is presently more and more gaining efficiency "with updated versions of traditional financial intermediaries" [14]. In the cryptocurrency market, there are currently very few options for easily diversifying a portfolio. There exist only a few cryptocurrency indices like the TaiFu 30, and these are mainly intended to "gauge the health and pulse of the cryptocurrency markets" rather than serving investment purposes [5]. A CIF designed for the latter should "provide a broad-based exposure to the crypto market, where no single cryptocurrency or specific group thereof dominates the index" and therefore should aim at fairly representing the complete diversity

of the cryptocurrency market [5]. As a result, a CIF designed for investment purposes should incorporate a considerable number of well assorted currencies. Finally, a CIF should be based on market capitalization and liquidity data to appropriately reflect cryptocurrency market dynamics [5]. Sufficient liquidity of the constituents is an important prerequisite for the attractiveness of such an index as a guideline for investors. In order to find an efficient portfolio indexing strategy we will determine the factors for the composition of a suitable portfolio.

2. Weighted average cryptocurrency index fund

In this context, a CIF is built by a weighted average of the market capitalization of the underlying assets. If V is the total value of the fund the value of a certain asset v_i can be calculated by

$$v_i = w_i \cdot V \,, \tag{1}$$

where w_i is a weight. Since the market capitalization and the price are continuously changing, the weight w_i has to be recalculated in certain intervals to actually let the fund track the index. This procedure is termed rebalancing of the portfolio. In addition, to not become to overly depended on single positions we will also introduce a capping methodology, which will restrict the percentage share of single cryptocurrencies.

2.1. Rebalancing/capping-strategy

Let J be the set of all available coins and $c_i \in J$ a coin with associated market capitalization m_i, and $i \in \mathcal{I}(J)$ a unique identifier. We choose the subset C of J, with $|C| = N$, such that $m_i > m_j$ for all $c_i \in C$ and $c_j \in J \backslash C$. Consequently, the weights for the weighted index strategy are calculated by

$$w_i = \frac{m_i}{\sum\limits_{j \in \mathcal{I}(C)} m_j} \,, \text{ for all } i \in \mathcal{I}(C) \,. \tag{2}$$

In order to mitigate risks, we introduce a capping methodology according to [20]. Let Z be the maximum weight for a single coin. Then

$$W^O = \{w_i \,:\, w_i > Z \,,\, i \in \mathcal{I}(C)\} \tag{3}$$

is the set of weights that exceeds the capping limit. In contrast

$$W^U = \{w_i \,:\, w_i \leq Z \,,\, i \in \mathcal{I}(C)\} \tag{4}$$

is the set of weights which are smaller than the capping limit. The new weights can then be calculated by

$$w_i' = \begin{cases} Z & \text{if} \quad w_i \in W^O \\ m \cdot w_i & \text{if} \quad w_i \in W^U \end{cases}, \text{ for all } i \in \mathcal{I}(C)\,, \tag{5}$$

with the capping multiplier

$$m = \frac{1 - Z \cdot |W^O|}{\sum\limits_{i \in \mathcal{I}(W^U)} w_i}\,. \tag{6}$$

In case some of the new weights $w_i = w_i'$ exceeds the limit Z, the capping algorithm is applied repetitively until $w_i \leq Z$ for all $i \in \mathcal{I}(C)$.

3. Parameter studies for a efficient cryptocurrency portfolio

Referring to the previous sections, there are three possible adjustments to the portfolio in order to increase profitability and decrease expenses:

1. The capping factor for the weight of a single coin in the portfolio,
2. the frequency with which the portfolio is rebalanced and
3. the number of coins in the portfolio.

To derive an efficient solution, a series of back-tests were performed on recorded cryptocurrency data [1] in a time frame from 1st January 2017 until 1st June 2018 with a start value of the portfolio of 1 USD. Expenses are neglected for this series of test. Furthermore, at least 1000 coins have to be traded on a daily basis in order that the coins is eligible.

3.1. The capping factor

As mentioned before, the capping value limits the influence of single coins in the portfolio. Because of the artificial character of this value a comprehensive parameter study is necessary in order to determine an absolute value.

Hypothesis. Our expectations were, that a smaller capping factor will reduce the risks and increase performance as it reduces the dominance of single coins.

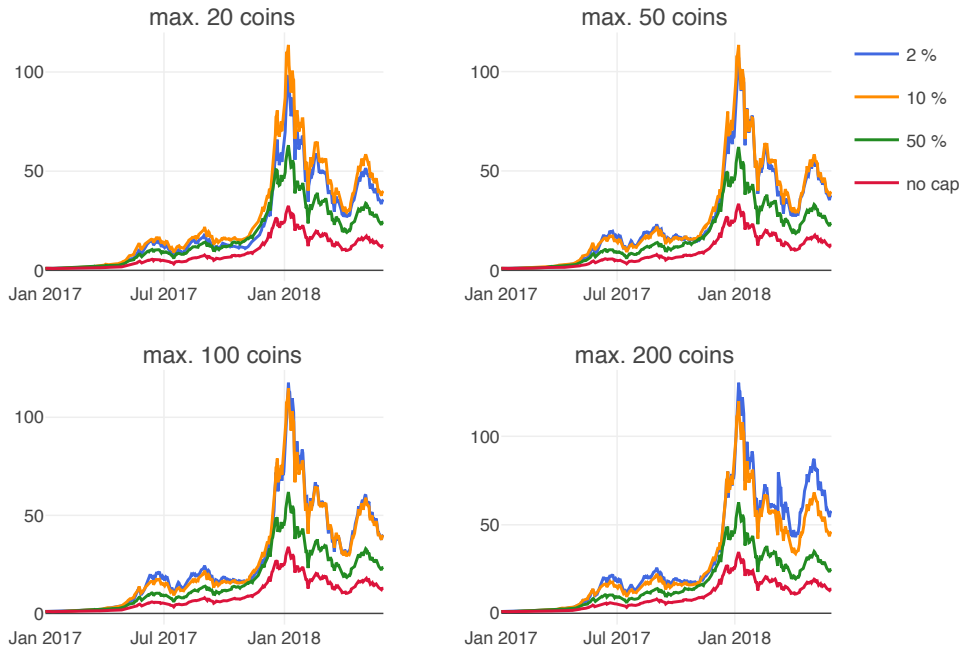

Figure 2: Portfolio performance in USD for different maximal number of coins, all 14 days rebalancing interval, seed capital 10k USD.

Tests. In order to determine a value for the capping factor, simulations have been carried out with a broadly number of different coins and different capping values[1] for a fixed rebalancing frequency of 14 days. For a better visualization only the results with 20, 50, 100 and 200 different coins in combinations with no cap, 50% cap, 10% cap and 2% cap are shown here.

Conclusions. Figure 2 shows, that a small capping factor actually leads to a better performance of the portfolio, thus our hypotheses can be confirmed. Furthermore it can be said, that the more coins are in the portfolio, the smaller the capping factor can be chosen. Simulations with more than 200 coins could not show a better performance, probably because the number of suitable coins is limited at this point in time.

[1]The nominal value of the capping factor is applied if possible, otherwise the next best possible capping factor is applied: e.g. for a portfolio with 20 Coins 2% cap is not possible and 5% cap is applied instead. This procedure is applied in the following, as well, if necessary.

3.2. The rebalancing interval

As our portfolio is built by a weighted average of the market capitalizations, it has to be rebalanced in certain intervals. For the determination of these intervals the capping value is chosen according to the results in the latter section. Since all transactions generates some costs, we would like to rebalance our portfolio as often as necessary, but as less as possible.

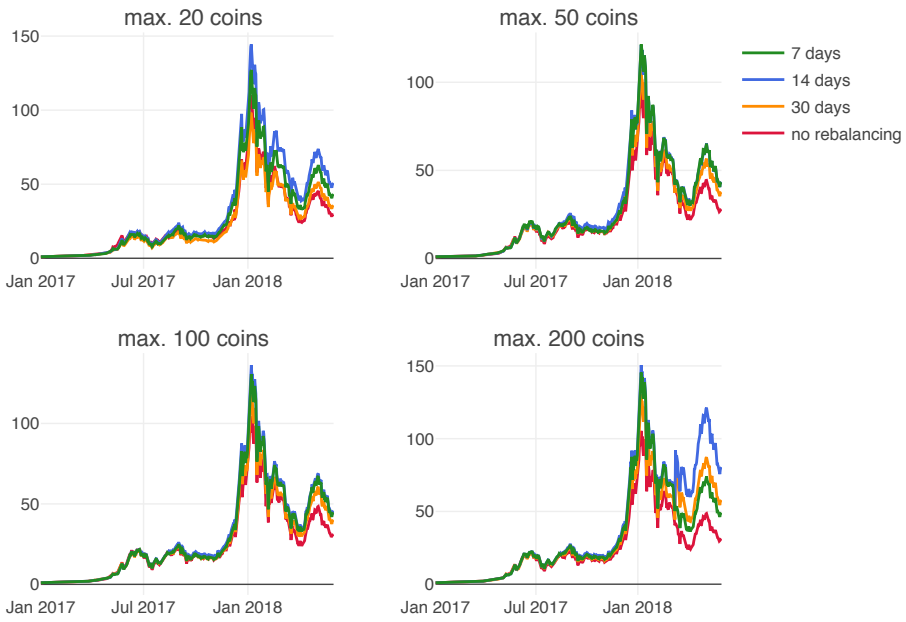

Figure 3: Portfolio performance in USD for different maximal number of coins and different rebalancing frequencies, all with 2% maximum cap, seed capital 10k USD.

Hypothesis. We assume, that a balanced portfolio outperforms a unbalanced portfolio as it accounts for changes of the market capitalization.

Tests. In order to establish an efficient rebalancing interval, we performed simulations with a broad number of different coins and different rebalancing frequencies, while holding the capping factor fixed at 2%. For a better visualization only the results with 20, 50, 100 and 200 different coins in combination with rebalancing frequencies of 7 days, 14 days, 30 days and without rebalancing are shown here.

Conclusions. Referring to figure 3, it seem favorable to pick a mid-range frequency of 14 days. Our hypothesis, that a balanced portfolio outperforms a unbalanced one, seems to be confirmed.

3.3. The number of coins

In the following a series of back-tests for the determination of the optimal number of coins in the portfolio is shown.

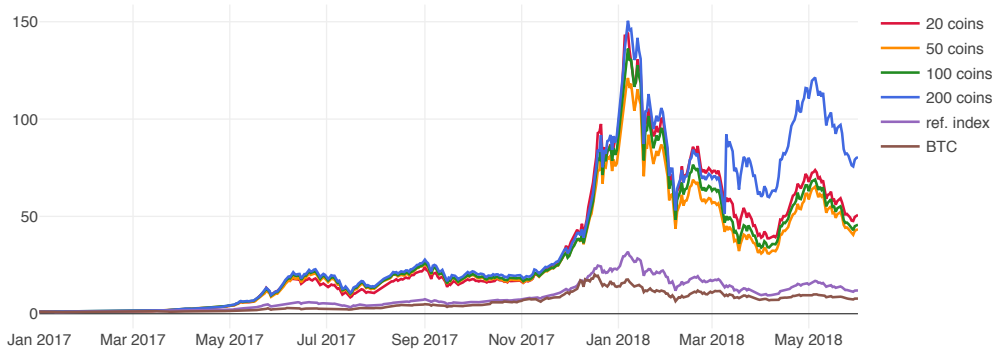

Figure 4: Portfolio performance in USD for different maximal number of coins and different caps, all 14 days rebalancing interval and 2% maximum cap, seed capital 10k USD.

Hypothesis. In the previous parameter studies it was emphasized, that a smaller capping value will increase the return. So the hypothesis to be tested is: more coins in the portfolio lead to a improved performance, since this allows for a smaller capping value.

Tests. Back-Tests with a broad range of different parameter combinations like in the previous sections were performed. In figure 4, only the results with a 14 days rebalancing frequency and 2% capping value in combination with 20, 50, 100 and 200 coins, are depicted, since they outperformed all other tests. For comparison only, a reference index with the weighted average of all available coins and the development of a Bitcoin-only portfolio is shown as well. For the sake of clarity, the high-mark, the drawdown and the price at the end of the simulation interval are specified in table 2.

	high-mark		drawdown		close	
Index	value	rate	diff.	rate	value	rate
200 coins	150$	14950%	-99$	-66%	80$	7942%
100 coins	136$	13523%	-102$	-75%	45$	4473%
50 coins	121$	12011%	-90$	-75%	43$	4241%
20 coins	144$	14347%	-105$	-73%	51$	4977%
ref. index	31$	3082%	-22$	-71%	12$	1096%
Bitcoin	20$	1908%	-14$	-68%	8$	677%

Table 2: High-mark, drawdown and close of different portfolio in comparison to the reference index and Bitcoin. All portfolios have an initial value of 1 US$.

Conclusions. Figure 4 shows that the portfolio with 200 coins clearly outperforms the portfolio with less coins, which indicates that our hypothesis is confirmed.
Since reasonable back-tests with more than 200 coins could not be performed at this time due to the lack of suitable coins, improving the performance by increasing the number of coins in the portfolio may be possible in the future. Furthermore, table 2 shows, that the portfolio with 200 coins owns higher high-mark and close values while having a smaller drawdown-rate than any other tested portfolio.
In addition, figure 4 and table 2 shows the change in development in the crypto-market. At the peak (high mark value) of the different portfolios, the values were rather close together. The development of small, medium and large market capitalization coins after the high mark value in January 2018 was different, so that the composition of the portfolio makes a significant difference to the performance, as shown by the closing value in table 2.

3.4. End result: The Cryptocurrency Index Fund 200

As comprehensive back-tests shows, a so called "Cryptocurrency index fund 200 (CIF200)" with a passively managed portfolio with the fairly large number of 200 coins, a 14 days rebalancing interval and a 2% capping value leads to the greatest returns.

4. The CIF200 portfolio composition

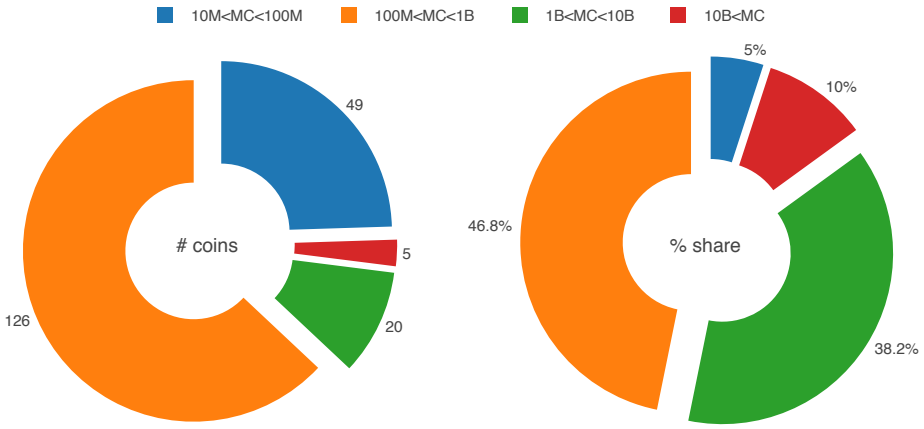

Figure 5: Porfolio composition by market cap (MC) in US$ at the end of the simulation time window for a portfolio with 200 different coins.

In order to investigate the composition of the CIF200 portfolio, the coins are divided in different classes according to theirs market capitalization:

- micro coins, with a market capitalization from 10 to 100 million US$,
- small coins, with a market capitalization from 100 to 1000 million US$,
- medium coins, with a market capitalization from 1 to 10 billion US$ and
- big coins, with a market capitalization above 10 billion US$.

In figure 5 the composition of the portfolio in terms of market capitalization is depicted at the end of the simulation time window. Here we can see, that 49 out of 200 coins in this portfolio belong to the class of micro coins. The percentage share of this class of coins is rather small with 5% indicating a future grow potential with limited risk of loss.
The vast majority of all coins are either from the class of small or medium coins with a percentage value to the portfolio of 85%.
The class of big coins is represented with 5 coins owning a share of 10%, illustrating the function of the capping algorithm.

5. Performance forecasting of the CIF200 portfolio

Geometric Brownian motion is a widely used model for the prediction of future stock prices within a certain level of confidence. Thereby, a continuous-time stochastic process (Wiener process) with drift is created, which has independent increments. A further development of this model is the fractional geometric Brownian motion (gfBm) [17], which accounts for long-term-dependencies via the *Hurst* exponent [18]. It was shown, that gfBm outperforms the classical geometrical Brownian motion in the prediction of future share prices in many markets [6, 11, 2].

Methods. A gfBm can be described by the stochastic differential equation

$$dX(t) = \mu X(t)\,\mathrm{d}t + \sigma X(t)\,\mathrm{d}B^H(t)\,, \tag{7}$$

where μ is the drift, σ is the volatility and B^H is a fractional Brownian motion with constant Hurst exponent H. A solution to this equation is given by [13]:

$$X(t) = X_0\, e^{\mu t + \sigma B^H(t)} \quad X_0 > 0\,. \tag{8}$$

In this attempt, a Monte Carlo approach was used for the prediction of the future performance of the index. Hereby, each Monte Carlo shot is a realization of a gfBm, which was generated according to [21, 16] using fast Fourier transformation.

Parameter estimation. In order to estimate the parameter for the gfBm, the data shown in figure 4 with 200 coins, a 14 days rebalancing interval and 2% capping value (CIF200) was used. The historical volatility $\sigma \approx 1.036$ was measured by the standard deviation of the price return [4], the drift $\mu \approx 3.284$ was estimated by the mean of the log-return [10]. The Hurst exponent $H \approx 0.671$ was estimated by the *absolute moment method* [see e.g. 23].

Simulations. For the calculation of the expected value of the price development a Monte Carlo simulation with 1.000.000 samples has been carried out. Each realization of the gfBm has a time window from 1st January 2017 until 1st January 2019. The value of the portfolio was set to 1 US$, arbitrarily, at the beginning of the simulation time window. The expected value and the interquartile range was calculated. The results are shown in figure 6.

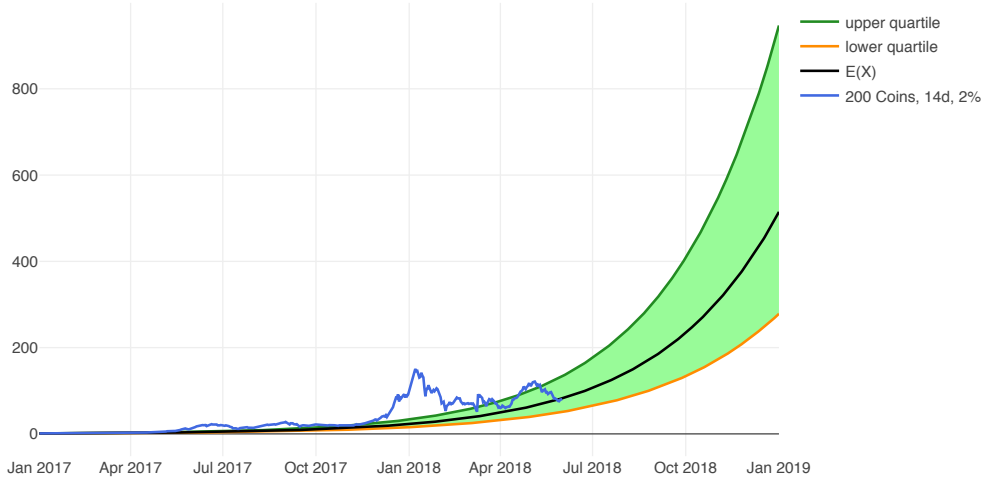

Figure 6: Interquartile range of the future price development of the market capitalization

Conclusions. Several simplifications had been made, like assigning constant values to μ, σ and H, which holds not true for longer time-periods. Additionally, it should be noted, that extreme events like the global financial crisis 2008-2009 cannot be predicted by this kind of model. Nevertheless, just 2% of all generated realizations suffer a loss, which shows, that the creation of a cryptocurrency index fund has a high growth potential.

6. Conclusions

This work addresses the creation of a cryptocurrency index fund. Therefore, it was outlined in section 1 that the creation of a CIF based on market capitalization could establish a new asset class serving as viable investment and diversification instrument.
Section 2 explains the construction of a CIF by the weighted average of the market capitalization of the underlying positions and the use of a combined rebalancing/capping-strategy.
Comprehensive numerical studies on historical data had been carried out in section 3 in order to determine appropriate values for parameters such as the capping value, the rebalancing frequency and the number of coins in the portfolio. Performance testing shows, that a portfolio termed CIF200 with 200 coins, a capping value of 2% and a 14 daily rebalancing frequency generated the greatest return. In figure 4 it can be seen, that this CIF200

portfolio outperforms a single coin like Bitcoin and the weighted average of the complete cryptocurreny market by far.
Section 4 shows the complex composition of the index at the end of the simulation window, illustrating the superiority of passive managed funds, which are able to reduce both costs and risks by the use of simple and clear rules.
Section 5 gives an outlook on the possible price development in the near future indicating the high potential of the CIF200 in the near future.
To conclude this work it can be said, that the cryptocurrency index fund defined in the latter could serve as viable investment tool which provides easy access to the cryptocurrency market at low risks.

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