

March 2018

# The Blockchain Story: Birth of a new Asset Class?

31	-0.02	0.31	0.32	0.19	0.33	0.42	0.18	0.16	-0.14	0.52	-0.08	0.67	0.35	0.29	0.28	0.33	0.36	0.26	0.27	0.23	0.32
00	0.28	-0.25	0.26	0.15	0.74	0.39	0.37	0.46	-0.06	0.04	0.38	0.13	0.49	0.16	0.07	0.20	0.21	0.16	0.22	0.45	0.11
28	1.00	-0.17	0.21	0.21	0.56	0.11	0.26	0.38	-0.21	0.06	0.20	0.12	0.40	0.08	0.22	0.35	0.21	0.04	0.15	0.28	0.27
25	-0.17	1.00	0.01	0.30	0.00	0.09	0.23	0.11	-0.52	0.29	-0.03	0.09	0.01	-0.02	0.12	0.39	0.31	0.14	0.02	0.05	0.03
26	0.21	0.01	1.00	0.59	0.15	0.66	0.33	0.24	0.14	0.29	0.30	0.35	0.24	0.39	0.18	0.31	0.63	0.28	0.42	0.57	0.38
15	0.21	0.30	0.59	1.00	0.63	0.60	0.65	0.55	-0.54	0.35	0.44	0.39	0.53	0.52	0.83	0.89	0.65	0.42	0.62	0.71	0.68
74	0.56	0.00	0.15	0.63	1.00	0.53	0.40	0.29	-0.51	0.29	0.34	0.26	0.38	0.32	0.26	0.45	0.42	0.39	0.05	0.25	0.25
39	0.11	0.09	0.66	0.60	0.53	1.00	0.74	0.69	-0.17	0.50	0.53	0.42	0.45	0.58	0.47	0.23	0.66	0.42	0.50	0.74	0.55
37	0.26	0.23	0.33	0.65	0.40	0.74	1.00	0.27	-0.16	0.40	0.44	0.11	0.30	0.27	0.32	0.64	0.61	0.30	0.19	0.44	0.27
46	0.38	0.11	0.24	0.55	0.29	0.69	0.27	1.00	-0.11	0.27	0.22	0.19	0.13	0.18	0.24	0.26	0.42	0.16	0.09	0.28	0.10
06	-0.21	-0.52	0.14	-0.54	-0.51	-0.17	-0.16	-0.11	1.00	-0.60	-0.18	-0.14	-0.16	0.00	-0.42	-0.53	-0.12	-0.17	-0.11	-0.03	-0.53
04	0.06	0.29	0.29	0.35	0.29	0.50	0.40	0.27	-0.60	1.00	0.25	0.28	0.31	0.46	0.51	0.38	0.28	0.43	0.00	0.29	0.38
38	0.20	-0.03	0.30	0.44	0.34	0.53	0.44	0.22	-0.18	0.25	1.00	0.04	0.24	0.17	0.21	0.34	0.63	0.23	0.14	0.33	0.11
13	0.12	0.09	0.35	0.39	0.26	0.42	0.11	0.19	-0.14	0.28	0.04	1.00	0.33	0.31	0.38	0.16	0.33	0.47	0.49	0.24	0.42
49	0.40	0.01	0.24	0.53	0.38	0.45	0.30	0.13	-0.16	0.31	0.24	0.33	1.00	0.28	0.18	0.34	0.47	0.37	0.16	0.29	0.21
16	0.08	-0.02	0.39	0.52	0.32	0.58	0.27	0.18	0.00	0.46	0.17	0.31	0.28	1.00	0.27	0.45	0.59	0.43	0.38	0.47	0.50
07	0.22	0.12	0.18	0.83	0.26	0.47	0.32	0.24	-0.42	0.51	0.21	0.38	0.18	0.27	1.00	0.79	0.39	0.56	0.23	0.34	0.17
20	0.35	0.39	0.31	0.89	0.45	0.23	0.64	0.26	-0.53	0.38	0.34	0.16	0.34	0.45	0.79	1.00	0.67	0.32	0.30	0.34	0.26
21	0.21	0.31	0.63	0.65	0.42	0.66	0.61	0.42	-0.12	0.28	0.63	0.33	0.47	0.59	0.39	0.67	1.00	0.35	0.68	0.64	0.44
16	0.04	0.14	0.28	0.42	0.39	0.42	0.30	0.16	-0.17	0.43	0.23	0.47	0.37	0.43	0.56	0.32	0.35	1.00	0.39	0.47	0.34
22	0.15	0.02	0.42	0.62	0.05	0.50	0.19	0.09	-0.11	0.00	0.14	0.49	0.16	0.38	0.23	0.30	0.68	0.39	1.00	0.44	0.66
45	0.28	0.05	0.57	0.71	0.25	0.74	0.44	0.28	-0.03	0.29	0.33	0.24	0.29	0.47	0.34	0.34	0.64	0.47	0.44	1.00	0.43
11	0.27	0.03	0.38	0.68	0.25	0.55	0.27	0.10	-0.53	0.38	0.11	0.42	0.21	0.50	0.17	0.26	0.44	0.34	0.66	0.43	1.00
18	0.05	0.23	0.65	0.65	0.38	0.56	0.67	0.36	-0.18	0.10	0.52	0.67	0.56	0.77	0.66	0.71	0.83	0.44	0.66	0.35	0.50
28	0.09	0.05	0.45	0.55	0.18	0.44	0.20	0.07	0.29	-0.21	0.36	0.21	0.16	0.26	0.14	0.19	0.68	0.31	0.30	0.44	0.12

# A. Introduction

**While crypto assets have been around for almost a decade, they gained tremendously in popularity in 2017. With the price surge of some major tokens early 2017, the media coverage exploded and the wider public got interested in crypto assets.**

With this paper, we intend to evaluate whether this could mark the birth of a new asset class. **Are crypto assets a suitable addition to an investor's portfolio? What are the return distributions of crypto assets? Does the proclaimed zero correlation argument with other asset classes hold? How does the efficient frontier change by adding crypto assets?** Even though the findings should be taken with a grain of salt since crypto assets only have a limited price history and volumes tend to be low in the early days of a crypto asset, our analysis provides the interested reader with a general overview of the dynamics in the crypto asset markets.

Our study depicts substantially higher risk levels of crypto assets compared to traditional asset classes and illustrates which crypto assets still look attractive in a return-risk-comparison. We find that, for most crypto assets – unlike equities – positive outliers are more pronounced than negative outliers (positive skewness). And as expected, crypto assets exhibit high kurtosis, which makes extreme outcomes generally more likely to occur compared to a normal distribution. Among others, we also find that the intra crypto asset correlation is lower than expected and that the effects of adding only a small fraction of crypto assets to a portfolio are immense.

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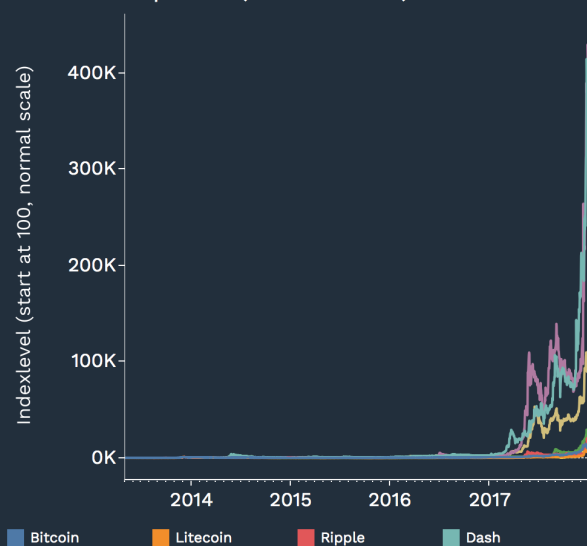
## B. Return and risk analysis

The following chapter analyses the return and risk measures of crypto assets in comparison with traditional asset classes. Moreover, we measure skewness and kurtosis of the different assets to gain more insight into the shape of the return distribution of crypto assets.

In a first step, we evaluated the historical returns and risk measures of crypto assets in comparison to traditional asset classes. The results are illustrated in **Figure 1** and **Figure 2**. For the crypto asset market, we looked at the Top 25 crypto assets as of January 2018. As an observation period start, we chose the beginning of 2013, as the crypto data provider coinmarketcap.com started to collect data in spring 2013. The “First Trading Date” in **Figure 2** on the very right gives the reader an idea since when the asset has been traded on an exchange or since when market data is available. Some coins only got listed in 2017

which leads to a limited dataset for the respective coin. In order to put the return and risk measures into perspective, we compare the crypto asset returns to some major equity indices, bond indices as well as real estate and gold returns. Moreover, we show the returns for some major tech companies as well as for some companies that belong to the main beneficiaries of the crypto asset hype. **AMD, Nvidia and Intel all produce hardware components that are very much in demand as a consequence of the massive investments in the crypto mining industry.**

Price development (normal scale)



Price development (log scale)

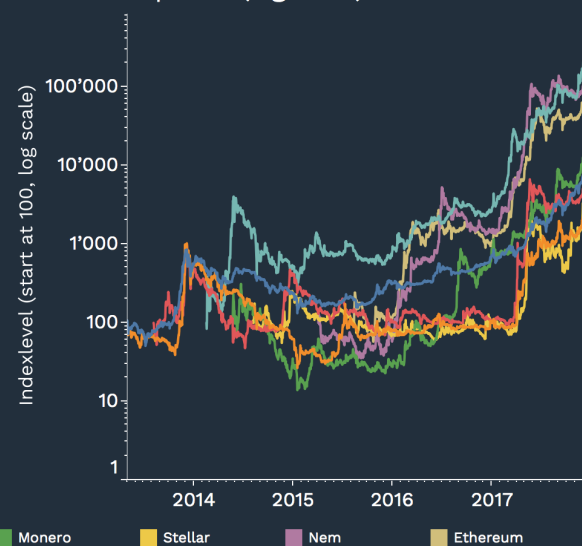


Figure 1: Crypto asset prices 2013-2017

Asset Class		Daily mean return	Annualized mean return	Total return in obs. period	Median daily return	Max daily return	Min daily return	Ann. standard deviation	Sharpe Ratio	Skewness	Excess kurtosis	No. of obs.	First trading date
Main Stock Indices	MSCI World	0.06%	17%	102%	0.10%	5%	-6%	15%	1.06	-0.41	5.06	1'131	31.12.12
	Nasdaq Composite	0.07%	18%	129%	0.10%	4%	-4%	14%	1.18	-0.50	2.37	1'259	31.12.12
	S&P 500	0.06%	16%	107%	0.06%	4%	-4%	12%	1.19	-0.43	3.22	1'259	31.12.12
	S&P Small-Cap	0.06%	17%	115%	0.10%	3%	-4%	15%	1.00	-0.27	0.91	1'259	31.12.12
	Stoxx Europe 600	0.04%	10%	59%	0.05%	5%	-7%	15%	0.58	-0.62	5.97	1'180	31.12.12
	MSCI EM	0.01%	4%	20%	0.04%	4%	-6%	17%	0.12	-0.33	1.81	1'259	31.12.12
Bonds	U.S. Aggregate Bonds	0.01%	2%	10%	0.02%	1%	-1%	3%	0.13	-0.37	1.64	1'259	31.12.12
	EM Bonds	0.01%	4%	19%	0.03%	3%	-4%	7%	0.29	-0.50	9.21	1'259	31.12.12
	IG Corporate Bonds	0.01%	4%	19%	0.03%	1%	-1%	5%	0.39	-0.38	1.74	1'259	31.12.12
	HY Corporate Bonds	0.02%	4%	24%	0.02%	2%	-2%	6%	0.47	-0.01	3.39	1'257	31.12.12
	Treasury Bonds	0.00%	1%	6%	0.00%	1%	-1%	4%	-0.10	-0.20	0.99	1'259	31.12.12
Gold	Gold	-0.02%	-5%	-23%	0.00%	5%	-9%	16%	-0.42	-0.67	8.13	1'259	31.12.12
RealEstate	U.S. REITs	0.03%	7%	37%	0.07%	3%	-4%	14%	0.36	-0.51	2.23	1'259	31.12.12
Major Tech Companies	Amazon	0.12%	36%	366%	0.09%	14%	-11%	29%	1.20	0.36	10.89	1'259	31.12.12
	Apple	0.07%	20%	146%	0.05%	8%	-12%	24%	0.76	-0.66	7.54	1'259	31.12.12
	Facebook	0.15%	46%	563%	0.11%	30%	-7%	31%	1.42	2.14	26.75	1'259	31.12.12
	Google	0.09%	24%	198%	0.06%	16%	-5%	22%	1.06	1.71	18.89	1'259	31.12.12
	IBM	-0.01%	-1%	-7%	0.01%	9%	-8%	19%	-0.16	-0.77	8.81	1'259	31.12.12
	Microsoft	0.10%	30%	266%	0.05%	10%	-11%	22%	1.26	-0.21	11.49	1'259	31.12.12
Mining Hardware	AMD	0.12%	34%	328%	0.00%	52%	-24%	59%	0.55	0.76	18.15	1'259	31.12.12
	Intel	0.08%	21%	163%	0.10%	9%	-9%	21%	0.92	-0.09	5.93	1'259	31.12.12
	Nvidia	0.22%	76%	1591%	0.16%	30%	-9%	34%	2.19	2.08	22.91	1'259	31.12.12
Crypto assets	Bitcoin	0.27%	171%	10448%	0.20%	43%	-23%	84%	2.01	-0.14	8.93	1'708	28.04.13
	Bitcoin Cash	1.13%	6004%	513%	-0.46%	54%	-36%	239%	25.11	0.58	2.76	161	23.07.17
	Bitcoin Gold	-0.93%	-97%	-48%	-0.63%	100%	-71%	435%	-0.23	-1.88	13.78	69	23.10.17
	BitConnect*	2.34%	456415%	287598%	1.63%	81%	-27%	188%	2425.80	1.53	8.29	345	20.01.17
	Bytecoin	0.36%	265%	9737%	0.00%	394%	-47%	221%	1.20	2.85	33.62	1'293	17.06.14
	Cardano	3.76%	71619275%	2782%	1.23%	137%	-25%	316%	226373	2.24	8.57	91	01.10.17
	Dash	0.56%	675%	281080%	-0.17%	256%	-37%	164%	4.10	3.16	41.69	1'416	14.02.14
	EOS	1.19%	7351%	768%	-0.74%	168%	-32%	249%	29.51	2.50	17.26	183	01.07.17
	Ethereum	0.79%	1682%	100352%	-0.04%	51%	-27%	139%	12.06	0.59	4.67	876	08.08.15
	Ethereum Classic	0.65%	968%	2915%	-0.38%	323%	-37%	197%	4.91	5.08	74.64	525	24.07.16
	ICON	3.72%	62345691%	976%	3.81%	59%	-32%	315%	198197	0.26	1.05	65	27.10.17
	IOTA	0.90%	2500%	501%	0.27%	47%	-31%	221%	11.28	0.15	1.96	201	13.06.17
	Lisk	0.27%	164%	441%	-0.27%	152%	-81%	300%	0.54	-1.60	28.89	634	06.04.16
	Litecoin	0.23%	134%	5236%	0.00%	129%	-40%	132%	1.00	1.88	26.90	1'708	28.04.13
	Monero	0.41%	344%	21714%	0.00%	79%	-31%	149%	2.30	0.75	6.12	1'319	21.05.14
	NEM	0.83%	1980%	425520%	0.00%	171%	-30%	178%	11.12	2.02	16.88	1'005	01.04.15
	NEO	1.03%	4158%	13501%	-0.33%	123%	-41%	232%	17.89	1.02	8.64	478	09.09.16
	OmiseGO	2.10%	195875%	3315%	1.09%	74%	-26%	242%	809.18	0.93	3.56	170	14.07.17
	Qtum	1.05%	4443%	908%	0.09%	75%	-36%	228%	19.51	1.01	5.52	221	24.05.17
	RaiBlocks	2.79%	2324577%	249583%	1.51%	102%	-29%	281%	8282.15	1.02	2.77	284	07.03.17
	Ripple	0.37%	287%	39002%	-0.23%	179%	-46%	152%	1.88	2.26	29.22	1'610	04.08.13
	Siacoin	0.77%	1568%	73924%	0.00%	81%	-38%	215%	7.28	0.98	4.44	857	26.08.15
	Stellar	0.40%	333%	14685%	-0.31%	106%	-31%	160%	2.08	2.14	15.83	1'244	05.08.14
TRON	2.90%	3377947%	2151%	0.42%	116%	-32%	352%	9601.49	1.22	3.63	109	13.09.17	
Verge	0.90%	2489%	3179900%	0.00%	580%	-60%	378%	6.57	1.00	9.86	1'163	25.10.14	

\*Please be aware that a big part of the crypto community believes that BitConnect is a scam. We recommend NOT to invest in BitConnect.

Figure 2: Return Analysis

### Average return

Unsurprisingly, most crypto assets are superior compared to all the other assets when it comes to the annualized return. Some younger crypto assets that only got listed in 2017, just before the crypto boom took off (Cardano, TRON, OmiseGo, ICON), show stunning annualized returns. They literally skyrocketed in autumn 2017. **Most crypto assets exhibit annualized returns far north of +100%.** The only crypto asset with a negative return is Bitcoin Gold which was a very controversial hard fork (similar to a spin-off in the equity world) from Bitcoin. From an early stage, it received very little support from the crypto community. **On the traditional investment side, Intel, AMD and particularly Nvidia benefited substantially from the high demand in crypto mining equipment, which is reflected in their superior returns compared to the wider equity indices.** Especially, Nvidia stands out with a total return in the observation period of roughly +1600%. However, most other major tech companies, with the exception of IBM, did extremely well too during the observation period. As expected, the returns for the bond as well as the equity indices are substantially lower compared to the crypto asset returns. On a side note, one has to bear in mind that we are comparing returns over different observation periods due to the varying and generally very recent first trading dates of crypto assets.

### Maximum and minimum returns

The risk measures of the different asset classes reveal a completely different story. If one looks at the highest and lowest ever achieved daily returns (“Max daily return” resp. “Min daily return” in **Figure 2**), he sees that there can be extreme price swings in crypto assets. **Some coins lost more than 70% of value in one single day.** Even Bitcoin lost almost 25% on its

worst day in the observation period. And bear in mind, this is when looking at a snapshot once a day. Intraday swings can be even more pronounced. However, many coins have massive swings to the upside too. **As the max daily returns show, many coins more than doubled on their best day** (max daily return of over 100%).

### Standard deviation

Another measure to illustrate the risk of an asset class is the annualized standard deviation (“volatility”). Bitcoin, being the most established crypto asset, has by far the lowest volatility of all the crypto assets, and it still amounts to 84%. As a comparison, Facebook has a volatility of around 30%, the same holds true for Amazon. Intel, Google, IBM and Microsoft even have volatilities of around 20%, which is more or less in line with the MSCI emerging markets stock index. **Some crypto assets on the other hand show annualized volatilities of over 300%.** The extremely high volatility as well as the large min/max return figures indicate clearly, that a crypto asset investor has to be able and willing to absorb large price swings. Crypto assets are therefore suitable only for investors with a relatively high risk tolerance. As expected, the volatilities of the various bond indices are much smaller compared to the other asset classes and are in the single digits.

### Sharpe ratio

While we examined the risk and the return individually, we now want to look at asset returns relative to their risk. The sharpe ratio puts the excess return (annualized return minus the average 5-year treasury yield) in perspective to the volatility. It basically says how much excess return an investor can expect for each unit of volatility. Crypto assets perform superior again. Due to the incredibly high annualized returns of some coins, the

sharpe ratio is stunningly high as well. However, on a closer look it is clear that the outliers to the upside (Cardano, ICON, OmiseGO, RaiBlocks, TRON) were listed only in 2017. Hence, they only benefited from the boom cycle in the crypto assets, while not having been around during the dire crypto times. Some of the somewhat more mature coins (Bitcoin, Monero, Ripple, Stellar) all show a more reasonable sharpe ratio, which lies around 2. Litecoin, another coin that has been around for a while, even shows a sharpe ratio of 1, which is lower than the sharpe ratio of the S&P 500, the Nasdaq or some individual tech stocks. Most tech stocks exhibited a sharpe ratio of around 1, the same holds true for most major equity indices (MSCI World, Nasdaq, S&P 500, S&P Small-Cap). European equity markets as well as emerging markets have significantly lower sharpe ratios, mainly due to their underperformance compared to the US equity markets in the chosen observation period. One has to consider that the observation period coincided with an equity boom phase lead by the US market, which resulted in much higher equity returns compared to using a longer history of equity returns. **However, the sharpe ratio still shows that the extraordinary returns of crypto assets come with a price.** An investor has to accept higher price swings, if he wants to benefit from the extraordinary crypto returns.

### Skewness

Let's turn to the higher moments of the return distributions – skewness and kurtosis. Skewness measures the symmetry of a return distribution. For example, an asset with a normal distribution has a skewness of zero – this tells you that returns deviate both in the positive as well as the negative direction to the same extent from the asset's average return. **Most crypto**

**asset return distributions have a skewness above zero (skewed to the right), which means the right tail of the distribution is longer than the left tail.** It basically says that positive outliers deviate more from the mean than the negative outliers. In a risk management perspective, this is a very convenient attribute, since extreme price shocks to the upside are more welcome than to the downside.

For equities, usually some kind of negative news (e.g. profit warnings, law suits, product recalls, etc.) lead to the biggest price swings. Hence, negative return outliers are more extreme than positive return outliers, which results in a negatively skewed return distribution for all the major equity indices. However, some tech stocks in our data set experienced positively skewed return distributions, which is most likely related to positive surprises when releasing quarterly earnings reports. Again, one has to consider that our observation period coincided with a major boom phase of the tech stocks.

### Kurtosis

Kurtosis on the other hand measures the likelihood of extreme returns (positive and negative). For example, an asset with a normal distribution has an excess kurtosis of zero. If an asset shows an excess kurtosis above zero, it is said to have fat tails (extreme positive and negative returns are very likely). Most crypto assets exhibit fat tails (excess kurtosis above zero, also known as leptokurtic). In other words, extreme outcomes are more likely to occur compared to what a normal distribution would suggest. **However, fat tail distributions are not unique to crypto assets.** Equities deviate from normal distributions as well. Especially, individual stocks show high excess kurtoses (e.g. Facebook has an excess kurtosis of 27).

# C. Correlations

In a next step, we perform a multivariate return analysis, i.e. we look at the correlation structure of the crypto asset returns with other asset classes.

Since crypto assets are traded 24/7 whereas stocks are only traded on regular business days, we based the calculations on weekly returns and correlations. We chose the same observation period with data from January 2013 or the earliest available date until the end of 2017. For the correlation analysis of crypto assets with other asset classes, we skipped the crypto assets with a very small price history. In order to obtain some meaningful data, we focused on the coins that have been around for a while. An exception is Ethereum. We included it in the analysis despite the short history, since it developed into one of the major coins besides Bitcoin.

Our main interest in this analysis is to see whether the zero correlation claim with other asset classes holds for crypto assets. Figure 3 shows immediately that all major crypto assets have close to zero correlation with all the other asset classes. Some correlations are even slightly negative. The correlations among crypto assets are lower than expected. The equity indices for instance experience a much higher intra-asset class correlation than we see for crypto assets. The only intra-asset class correlation above 0.5 is between Litecoin and Bitcoin. This does not come as a surprise as the two currencies are technically almost identical.

	Equity						Bonds					Gold	Real Estate	Crypto assets							
	MSCI World	Nasdaq	S&P 500	S&P Small Cap	Stoxx 600 Europe	MSCI EM	US Aggr. Bonds	EM Bonds	IG Bonds	HY Bonds	Treasury Bonds	Gold	US REITs	Bitcoin	Dash	Ethereum	Litecoin	Monero	Nem	Ripple	Stellar
MSCI World	1.00	0.79	0.82	0.70	0.91	0.61	-0.12	0.43	0.04	0.59	-0.27	-0.24	0.46	0.06	-0.02	-0.03	0.08	0.06	-0.07	0.01	0.10
Nasdaq	0.79	1.00	0.94	0.82	0.78	0.71	-0.11	0.47	0.05	0.64	-0.26	-0.13	0.51	0.08	0.00	-0.02	0.09	0.04	-0.05	0.06	0.05
S&P 500	0.82	0.94	1.00	0.86	0.80	0.74	-0.12	0.51	0.04	0.68	-0.28	-0.13	0.58	0.09	0.04	-0.01	0.09	0.06	-0.01	0.04	0.09
S&P Small Cap	0.70	0.82	0.86	1.00	0.68	0.59	-0.17	0.37	0.00	0.60	-0.34	-0.10	0.51	0.04	-0.05	-0.07	0.04	0.08	-0.04	0.01	0.00
Stoxx 600 Europe	0.91	0.78	0.80	0.68	1.00	0.66	-0.11	0.46	0.06	0.63	-0.27	-0.18	0.43	0.06	0.03	-0.07	0.07	0.11	-0.03	0.02	0.10
MSCI EM	0.61	0.71	0.74	0.59	0.66	1.00	0.13	0.68	0.24	0.66	-0.03	0.12	0.50	0.00	0.03	-0.02	0.02	0.03	0.04	0.01	0.07
US Aggr. Bonds	-0.12	-0.11	-0.12	-0.17	-0.11	0.13	1.00	0.53	0.91	0.24	0.94	0.42	0.36	0.02	0.01	0.06	-0.06	-0.07	0.04	0.01	-0.01
EM Bonds	0.43	0.47	0.51	0.37	0.46	0.68	0.53	1.00	0.62	0.73	0.35	0.23	0.51	-0.05	-0.01	0.06	-0.08	-0.05	0.02	-0.04	0.09
IG Bonds	0.04	0.05	0.04	0.00	0.06	0.24	0.91	0.62	1.00	0.42	0.80	0.34	0.44	0.02	0.01	0.00	-0.03	0.01	0.01	0.03	0.02
HY Bonds	0.59	0.64	0.68	0.60	0.63	0.66	0.24	0.73	0.42	1.00	0.03	0.10	0.51	-0.01	-0.04	-0.04	0.00	0.03	-0.07	0.00	0.03
Treasury Bonds	-0.27	-0.26	-0.28	-0.34	-0.27	-0.03	0.94	0.35	0.80	0.03	1.00	0.45	0.26	0.02	-0.01	0.08	-0.05	-0.08	0.03	0.03	0.00
Gold	-0.24	-0.13	-0.13	-0.10	-0.18	0.12	0.42	0.23	0.34	0.10	0.45	1.00	0.16	-0.07	-0.05	0.19	-0.15	0.01	0.11	-0.07	-0.06
US REITs	0.46	0.51	0.58	0.51	0.43	0.50	0.36	0.51	0.44	0.51	0.26	0.16	1.00	0.00	0.01	-0.01	0.01	-0.01	0.04	-0.02	0.02
Bitcoin	0.06	0.08	0.09	0.04	0.06	0.00	0.02	-0.05	0.02	-0.01	0.02	-0.07	0.00	1.00	0.33	0.18	0.67	0.35	0.29	0.27	0.32
Dash	-0.02	0.00	0.04	-0.05	0.03	0.03	0.01	-0.01	0.01	-0.04	-0.01	-0.05	0.01	0.33	1.00	0.40	0.26	0.38	0.32	0.05	0.25
Ethereum	-0.03	-0.02	-0.01	-0.07	-0.07	-0.02	0.06	0.06	0.00	-0.04	0.08	0.19	-0.01	0.18	0.40	1.00	0.11	0.30	0.27	0.19	0.27
Litecoin	0.08	0.09	0.09	0.04	0.07	0.02	-0.06	-0.08	-0.03	0.00	-0.05	-0.15	0.01	0.67	0.26	0.11	1.00	0.33	0.31	0.49	0.42
Monero	0.06	0.04	0.06	0.08	0.11	0.03	-0.07	-0.05	0.01	0.03	-0.08	0.01	-0.01	0.35	0.38	0.30	0.33	1.00	0.28	0.16	0.21
Nem	-0.07	-0.05	-0.01	-0.04	-0.03	0.04	0.04	0.02	0.01	-0.07	0.03	0.11	0.04	0.29	0.32	0.27	0.31	0.28	1.00	0.38	0.50
Ripple	0.01	0.06	0.04	0.01	0.02	0.01	0.01	-0.04	0.03	0.00	0.03	-0.07	-0.02	0.27	0.05	0.19	0.49	0.16	0.38	1.00	0.66
Stellar	0.10	0.05	0.09	0.00	0.10	0.07	-0.01	0.09	0.02	0.03	0.00	-0.06	0.02	0.32	0.25	0.27	0.42	0.21	0.50	0.66	1.00

Figure 3: Weekly correlations with other asset classes

In **Figure 4** we compare the weekly crypto asset returns to the returns of the main tech stocks and the companies that benefit most from the heavy investment boom in the crypto mining equipment. The correlations remain very low. **Crypto asset returns are not even correlated to the returns of the companies benefiting most from the**

**crypto boom (mining hardware producers)**. This leads to the conclusion that crypto assets are driven by completely different price factors. This makes them extremely valuable in a portfolio context, as they should be unaffected in case of distress of other asset classes.

	Main Tech Companies						Mining Hardware			Crypto assets							
	Amazon	Aaple	Face-book	Google	IBM	Micro-soft	AMD	Intel	Nivida	Bitcoin	Dash	Ethe-reum	Litecoin	Monero	Nem	Ripple	Stellar
Amazon	1.00	0.27	0.38	0.56	0.11	0.35	0.20	0.32	0.31	0.11	-0.05	0.06	0.14	0.02	-0.04	0.06	0.00
Aaple	0.27	1.00	0.21	0.35	0.20	0.26	0.16	0.32	0.27	0.08	0.12	0.02	0.07	0.03	0.08	0.09	0.13
Facebook	0.38	0.21	1.00	0.49	0.09	0.31	0.20	0.30	0.27	0.04	-0.05	-0.02	0.04	-0.01	-0.07	0.05	0.03
Google	0.56	0.35	0.49	1.00	0.22	0.52	0.19	0.40	0.35	0.10	0.05	0.09	0.09	-0.01	-0.08	0.04	0.10
IBM	0.11	0.20	0.09	0.22	1.00	0.27	0.25	0.33	0.24	-0.02	0.02	-0.15	-0.05	-0.02	-0.07	-0.07	-0.02
Microsoft	0.35	0.26	0.31	0.52	0.27	1.00	0.19	0.52	0.42	0.11	0.03	0.01	0.05	0.00	-0.05	0.05	0.03
AMD	0.20	0.16	0.20	0.19	0.25	0.19	1.00	0.25	0.42	0.00	-0.03	-0.07	0.04	-0.06	-0.17	-0.02	-0.15
Intel	0.32	0.32	0.30	0.40	0.33	0.52	0.25	1.00	0.39	0.04	-0.10	-0.10	0.00	0.00	-0.09	0.06	0.06
Nivida	0.31	0.27	0.27	0.35	0.24	0.42	0.42	0.39	1.00	0.06	-0.03	-0.05	0.00	0.03	-0.09	0.02	-0.02
Bitcoin	0.11	0.08	0.04	0.10	-0.02	0.11	0.00	0.04	0.06	1.00	0.33	0.18	0.67	0.35	0.29	0.27	0.32
Dash	-0.05	0.12	-0.05	0.05	0.02	0.03	-0.03	-0.10	-0.03	0.33	1.00	0.40	0.26	0.38	0.32	0.05	0.25
Ethereum	0.06	0.02	-0.02	0.09	-0.15	0.01	-0.07	-0.10	-0.05	0.18	0.40	1.00	0.11	0.30	0.27	0.19	0.27
Litecoin	0.14	0.07	0.04	0.09	-0.05	0.05	0.04	0.00	0.00	0.67	0.26	0.11	1.00	0.33	0.31	0.49	0.42
Monero	0.02	0.03	-0.01	-0.01	-0.02	0.00	-0.06	0.00	0.03	0.35	0.38	0.30	0.33	1.00	0.28	0.16	0.21
Nem	-0.04	0.08	-0.07	-0.08	-0.07	-0.05	-0.17	-0.09	-0.09	0.29	0.32	0.27	0.31	0.28	1.00	0.38	0.50
Ripple	0.06	0.09	0.05	0.04	-0.07	0.05	-0.02	0.06	0.02	0.27	0.05	0.19	0.49	0.16	0.38	1.00	0.66
Stellar	0.00	0.13	0.03	0.10	-0.02	0.03	-0.15	0.06	-0.02	0.32	0.25	0.27	0.42	0.21	0.50	0.66	1.00

**Figure 4: Weekly correlations with single stocks**



**Figure 5** provides a closer look at the intra-crypto asset correlations. To obtain a complete overview, we added all the coins. One should take into account that some of the currencies have only been listed in 2017 and the price history is very limited (see **Figure 2** for first trading date of each coin).

As noted previously, the intra-crypto asset correlations are lower than expected. **This suggests that it is worthwhile investing in a diversified basket of crypto assets, as it helps substantially reduce the volatility of the investment.**

Among the coins that show higher correlations with the other crypto assets are many coins that have been listed only very recently (2017). For example, Cardano, Qtum, Tron and EOS all show somewhat elevated intra-crypto correlations. This has much to do with timing. These coins were listed just before the crypto assets took off and the majority of their price history falls in the period of the massive crypto boom in the second half of 2017. It is very likely that the correlation structure for these coins will change once they experienced different cycles.

	Crypto assets																								
	Bitcoin	Bitcoin Cash	Bitcoin Gold	Bit-Connect	Bytecoin	Cardano	Dash	EOS	Ethereum	Ethereum Classic	Icon	Iota	Lisk	Litecoin	Monero	Nem	Neo	OmiseGO	Qtum	Rai-blocks	Ripple	Stacoin	Stellar	Tron	Verge
Bitcoin	1.00	-0.31	-0.02	0.31	0.32	0.19	0.33	0.42	0.18	0.16	-0.14	0.52	-0.08	0.67	0.35	0.29	0.28	0.33	0.36	0.26	0.27	0.23	0.32	0.34	0.22
Bitcoin Cash	-0.31	1.00	0.28	-0.25	0.26	0.15	0.74	0.39	0.37	0.46	-0.06	0.04	0.38	0.13	0.49	0.16	0.07	0.20	0.21	0.16	0.22	0.45	0.11	0.18	0.28
Bitcoin Gold	-0.02	0.28	1.00	-0.17	0.21	0.21	0.56	0.11	0.26	0.38	-0.21	0.06	0.20	0.12	0.40	0.08	0.22	0.35	0.21	0.04	0.15	0.28	0.27	0.05	0.09
BitConnect	0.31	-0.25	-0.17	1.00	0.01	0.30	0.00	0.09	0.23	0.11	-0.52	0.29	-0.03	0.09	0.01	-0.02	0.12	0.39	0.31	0.14	0.02	0.05	0.03	0.23	0.05
Bytecoin	0.32	0.26	0.21	0.01	1.00	0.59	0.15	0.66	0.33	0.24	0.14	0.29	0.30	0.35	0.24	0.39	0.18	0.31	0.63	0.28	0.42	0.57	0.38	0.65	0.45
Cardano	0.19	0.15	0.21	0.30	0.59	1.00	0.63	0.60	0.65	0.55	-0.54	0.35	0.44	0.39	0.53	0.52	0.83	0.89	0.65	0.42	0.62	0.71	0.68	0.65	0.55
Dash	0.33	0.74	0.56	0.00	0.15	0.63	1.00	0.53	0.40	0.29	-0.51	0.29	0.34	0.26	0.38	0.32	0.26	0.45	0.42	0.39	0.05	0.25	0.25	0.38	0.18
EOS	0.42	0.39	0.11	0.09	0.66	0.60	0.53	1.00	0.74	0.69	-0.17	0.50	0.53	0.42	0.45	0.58	0.47	0.23	0.66	0.42	0.50	0.74	0.55	0.56	0.44
Ethereum	0.18	0.37	0.26	0.23	0.33	0.65	0.40	0.74	1.00	0.27	-0.16	0.40	0.44	0.11	0.30	0.27	0.32	0.64	0.61	0.30	0.19	0.44	0.27	0.67	0.20
EthereumClassic	0.16	0.46	0.38	0.11	0.24	0.55	0.29	0.69	0.27	1.00	-0.11	0.27	0.22	0.19	0.13	0.18	0.24	0.26	0.42	0.16	0.09	0.28	0.10	0.36	0.07
Icon	-0.14	-0.06	-0.21	-0.52	0.14	-0.54	-0.51	-0.17	-0.16	-0.11	1.00	-0.60	-0.18	-0.14	-0.16	0.00	-0.42	-0.53	-0.12	-0.17	-0.11	-0.03	-0.53	-0.18	0.29
Iota	0.52	0.04	0.06	0.29	0.29	0.35	0.29	0.50	0.40	0.27	-0.60	1.00	0.25	0.28	0.31	0.46	0.51	0.38	0.28	0.43	0.00	0.29	0.38	0.10	-0.21
Lisk	-0.08	0.38	0.20	-0.03	0.30	0.44	0.34	0.53	0.44	0.22	-0.18	0.25	1.00	0.04	0.24	0.17	0.21	0.34	0.63	0.23	0.14	0.33	0.11	0.52	0.36
Litecoin	0.67	0.13	0.12	0.09	0.35	0.39	0.26	0.42	0.11	0.19	-0.14	0.28	0.04	1.00	0.33	0.31	0.38	0.16	0.33	0.47	0.49	0.24	0.42	0.67	0.21
Monero	0.35	0.49	0.40	0.01	0.24	0.53	0.38	0.45	0.30	0.13	-0.16	0.31	0.24	0.33	1.00	0.28	0.18	0.34	0.47	0.37	0.16	0.29	0.21	0.56	0.16
Nem	0.29	0.16	0.08	-0.02	0.39	0.52	0.32	0.58	0.27	0.18	0.00	0.46	0.17	0.31	0.28	1.00	0.27	0.45	0.59	0.43	0.38	0.47	0.50	0.77	0.26
Neo	0.28	0.07	0.22	0.12	0.18	0.83	0.26	0.47	0.32	0.24	-0.42	0.51	0.21	0.38	0.18	0.27	1.00	0.79	0.39	0.56	0.23	0.34	0.17	0.66	0.14
OmiseGO	0.33	0.20	0.35	0.39	0.31	0.89	0.45	0.23	0.64	0.26	-0.53	0.38	0.34	0.16	0.34	0.45	0.79	1.00	0.67	0.32	0.30	0.34	0.26	0.71	0.19
Qtum	0.36	0.21	0.21	0.31	0.63	0.65	0.42	0.66	0.61	0.42	-0.12	0.28	0.63	0.33	0.47	0.59	0.39	0.67	1.00	0.35	0.68	0.64	0.44	0.83	0.68
RaiBlocks	0.26	0.16	0.04	0.14	0.28	0.42	0.39	0.42	0.30	0.16	-0.17	0.43	0.23	0.47	0.37	0.43	0.56	0.32	0.35	1.00	0.39	0.47	0.34	0.44	0.31
Ripple	0.27	0.22	0.15	0.02	0.42	0.62	0.05	0.50	0.19	0.09	-0.11	0.00	0.14	0.49	0.16	0.38	0.23	0.30	0.68	0.39	1.00	0.44	0.66	0.66	0.30
Stacoin	0.23	0.45	0.28	0.05	0.57	0.71	0.25	0.74	0.44	0.28	-0.03	0.29	0.33	0.24	0.29	0.47	0.34	0.34	0.64	0.47	0.44	1.00	0.43	0.35	0.44
Stellar	0.32	0.11	0.27	0.03	0.38	0.68	0.25	0.55	0.27	0.10	-0.53	0.38	0.11	0.42	0.21	0.50	0.17	0.26	0.44	0.34	0.66	0.43	1.00	0.50	0.12
Tron	0.34	0.18	0.05	0.23	0.65	0.65	0.38	0.56	0.67	0.36	-0.18	0.10	0.52	0.67	0.56	0.77	0.66	0.71	0.83	0.44	0.66	0.35	0.50	1.00	0.71
Verge	0.22	0.28	0.09	0.05	0.45	0.55	0.18	0.44	0.20	0.07	0.29	-0.21	0.36	0.21	0.16	0.26	0.14	0.19	0.68	0.31	0.30	0.44	0.12	0.71	1.00

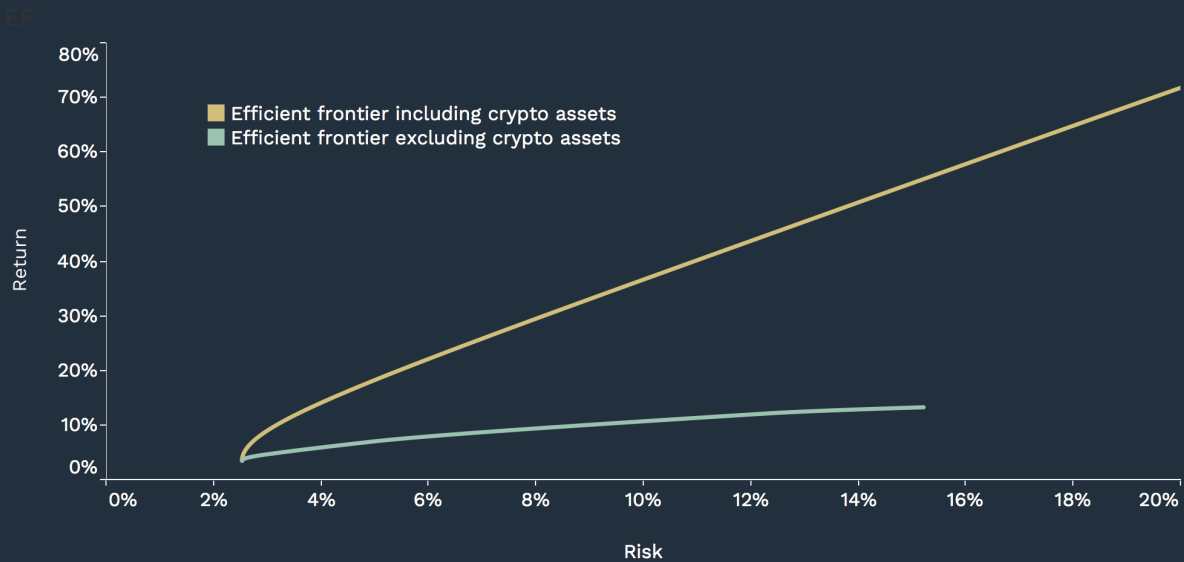
**Figure 5: Weekly correlations among crypto assets**

## D. Portfolio Context

**In this part, we will investigate the impact on the efficient frontier when adding crypto assets to the investment universe. The efficient frontier shows investment portfolio allocations that, for any given risk level, have the highest possible return.**

As a preparation, we built a diversified investment universe with equity, bond and alternative investments (details of investment universe in appendix). We ran a portfolio optimization without crypto assets in order to obtain the efficient frontier for a well-diversified non-crypto portfolio. In a second step, we added four crypto assets to the investment universe that have a long enough price history. We ran the optimization again with the new investment universe in order to get the new efficient frontier.

**Figure 6** compares the efficient frontiers with and without crypto assets. It shows that the portfolio with crypto assets clearly dominates a portfolio without crypto assets due to the broadened investment universe. **In other words, for the same risk level one can achieve substantially higher returns by adding crypto assets to the investment portfolio.**



**Figure 6: Efficient frontier with and without crypto assets**

An investor should choose the size of the crypto asset allocation depending on the individual risk profile. The risk profile is derived from the **risk ability** (free assets, time horizon, liabilities, income) as well as the **risk tolerance** (risk awareness, experience, return expectations). We constructed nine portfolios with different combinations of high/medium/low levels for both risk ability and risk tolerance. For each portfolio, we defined example allocations to each asset class and calculated portfolio return and risk measures. Thereby, we always ran the analysis once with crypto assets and once without crypto assets to allow for a comparison of the two outcomes.

For instance, a younger person with a steady income, low liabilities and a high risk tolerance can invest a bigger proportion of his/her investable assets in risky assets (including both equities and crypto assets). A person that is already retired and completely relies on his assets to finance the standard of living should invest a lower proportion of the investable assets in equities. An investor with a low risk ability in combination with a low risk tolerance,

should completely refrain from investing in crypto assets. **Figure 7** shows the portfolio risk and return for the different asset allocations. The figure reports the measures without crypto assets (first table), when including crypto assets (second table) and the difference between the two (third table).

**Figure 7** shows that the recommended allocations to the crypto assets never exceed 12%. For investors with a medium risk profile for instance, the recommended allocation is 5%. Even though the recommended allocation to crypto assets is only a small proportion of the total assets, it can substantially change the portfolio return and portfolio risk. By adding 3% crypto assets to a portfolio with low risk tolerance and high risk ability, the expected portfolio return increases by 5% while the portfolio risk increases by 0.7%. By adding 10% crypto assets to the Medium&High Portfolio, the expected portfolio return even increases by over 15% and the portfolio risk rises 3%. **This shows that already small allocations to crypto assets can have a significant impact on the portfolio return figures.**

**Sample portfolio for different risk profiles - without crypto assets**

Portfolio Name	Risk Tolerance	Risk Ability	Equity	Bonds	Real Estate	Gold	Crypto	Total	Portfolio Return	Portfolio Risk
High&High	High	High	75%	15%	7%	3%	0%	100%	10.9%	9.8%
Medium&High	Medium	High	63%	25%	7%	5%	0%	100%	9.4%	8.3%
Low&High	Low	High	30%	60%	5%	5%	0%	100%	5.4%	4.7%
High&Medium	High	Medium	63%	25%	7%	5%	0%	100%	9.4%	8.3%
Medium&Medium	Medium	Medium	40%	50%	5%	5%	0%	100%	6.6%	5.6%
Low&Medium	Low	Medium	22%	68%	5%	5%	0%	100%	4.4%	4.0%
High&Low	High	Low	30%	60%	5%	5%	0%	100%	5.4%	4.7%
Medium&Low	Medium	Low	22%	68%	5%	5%	0%	100%	4.4%	4.0%
Low&Low	Low	Low	10%	80%	5%	5%	0%	100%	2.9%	3.6%

**Sample portfolio for different risk profiles - with crypto assets**

Portfolio Name	Risk Tolerance	Risk Ability	Equity	Bonds	Real Estate	Gold	Crypto	Total	Portfolio Return	Portfolio Risk
High&High	High	High	70%	10%	5%	3%	12%	100%	29.9%	13.9%
Medium&High	Medium	High	55%	25%	5%	5%	10%	100%	24.7%	11.4%
Low&High	Low	High	30%	57%	5%	5%	3%	100%	10.3%	5.4%
High&Medium	High	Medium	55%	25%	5%	5%	10%	100%	24.7%	11.4%
Medium&Medium	Medium	Medium	35%	50%	5%	5%	5%	100%	14.1%	6.7%
Low&Medium	Low	Medium	20%	68%	5%	5%	2%	100%	7.4%	4.3%
High&Low	High	Low	30%	57%	5%	5%	3%	100%	10.3%	5.4%
Medium&Low	Medium	Low	20%	68%	5%	5%	2%	100%	7.4%	4.3%
Low&Low	Low	Low	10%	80%	5%	5%	0%	100%	2.9%	3.6%

**Difference of the two portfolios**

Portfolio Name	Risk Tolerance	Risk Ability	Equity	Bonds	Real Estate	Gold	Crypto	Total	Portfolio Return	Portfolio Risk
High&High	High	High	-5%	-5%	-2%	-	12%	0%	19.0%	4.1%
Medium&High	Medium	High	-8%	-	-2%	-	10%	0%	15.4%	3.0%
Low&High	Low	High	-	-3%	-	-	3%	0%	4.9%	0.7%
High&Medium	High	Medium	-8%	-	-2%	-	10%	0%	15.4%	3.0%
Medium&Medium	Medium	Medium	-5%	-	-	-	5%	0%	7.6%	1.2%
Low&Medium	Low	Medium	-2%	-	-	-	2%	0%	3.0%	0.3%
High&Low	High	Low	-	-3%	-	-	3%	0%	4.9%	0.7%
Medium&Low	Medium	Low	-2%	-	-	-	2%	0%	3.0%	0.3%
Low&Low	Low	Low	-	-	-	-	0%	0%	0.0%	0.0%

Equities: S&P 500  
 Bonds: US Aggregate Bond Index  
 Real Estate: U.S. REITs  
 Gold: Gold  
 Crypto: Bitcoin

Observation period Apr 2013 - Dec 17

**Figure 7: Sample portfolios for different risk profiles with and without crypto assets**

## E. Quo vadis?

**As happened with other assets and asset classes (e.g. commodities), the dynamics of crypto assets will change the more the crypto asset market matures. What do we have to expect to change in the future?**

It is very likely that with increased market integration (more professionally managed money flowing in the crypto asset market), the correlation with other asset classes will rise. **Hence, it is possible that the zero correlation argument, which currently makes crypto assets so valuable in a portfolio context, slightly weakens over time.**

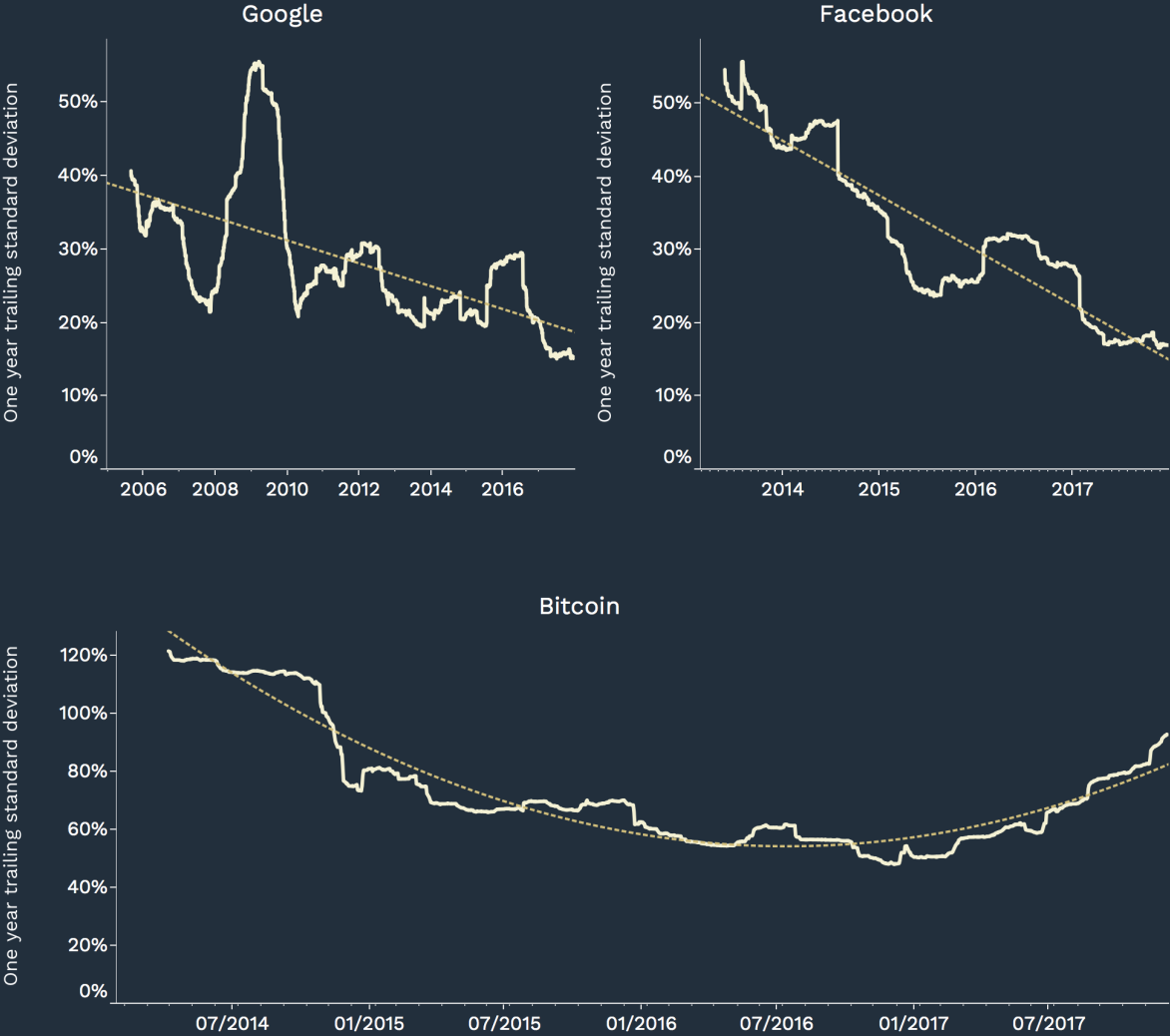
It is obvious that the extraordinary returns most crypto assets experienced in 2017 cannot be extrapolated to predict future returns. As crypto assets mature, the returns will somehow normalize as well. The same is true for the risk of a new asset. It is expected that it takes a while for a new asset to find its price level, especially if they are as hard to value with the common valuation models as crypto assets. It is very likely that the volatility of crypto assets will decrease once the market becomes more mature.

To illustrate the effect of a maturing asset, we calculated the one year trailing standard deviation for Google after the IPO (see **Figure 8**). One can see that at the beginning it had a volatility

of around 40%. Currently, the historical one year trailing volatility is around 15%. The peak around 2008/2009 is not related to idiosyncratic risks, but to the financial crisis that let volatilities skyrocket across all equities.

For Facebook, the effect is even more pronounced. In the first year, the volatility was around 55%. Ever since, it steadily decreased and is now below 20%.

Now looking at the one year trailing volatility of Bitcoin, one can see that the price fluctuations decreased between 2013 and 2016 substantially. This is exactly the effect one would expect from a maturing asset. However, this year, with the crypto boom, the volatility started to increase again. **While the volatility of Bitcoin was for a short period of time in late 2016 below 50%, it started to surge in 2017 and even surpassed 90% at the end of 2017.** A possible explanation for this development is the entrance of speculation-driven retail traders as opposed to “Hodl”-driven tech enthusiasts – the most important investor category in crypto asset before the boom.



**Figure 8: One Year Trailing Standard Deviations**

## F. Summary

Our study indicates that most of the Top 25 crypto assets show superior annualized returns compared to other asset classes, with sometimes staggering return levels. **However, the higher returns come with a price in form of higher volatility that sometimes exceeds 300%.** Crypto assets look attractive in a return-risk-comparison. However, the highest sharpe ratios belong to the recently launched coins, which has a lot to do with the timing of their listing. **Most of the more mature coins show sharpe ratios on a more reasonable level.** Unlike equities, most crypto assets have a positively skewed return distribution, indicating that positive outliers are more pronounced than negative outliers. Similar to equities however, crypto assets exhibit high kurtosis, which makes extreme outcomes generally more likely to occur compared to a normal distribution.

**Furthermore, this study confirms that most crypto assets exhibit close to zero correlation with other asset classes.** The intra crypto asset correlation is also lower than expected and explains the major benefit of setting up a diversified crypto portfolio containing a broad range of different coins as opposed to simply holding Bitcoin. This study shows that crypto assets are very beneficial in a portfolio context. The efficient frontier of a portfolio is shifted significantly upwards when adding crypto assets to the investment universe – meaning that for a similar level of risk, a higher return can be generated. **By testing different portfolio allocations while accounting for different investor risk profiles, we show that already small allocations in crypto assets can have a significant impact on the portfolio risk and return characteristics.**

# Appendix

## Efficient Frontier Investment Universe

Equities	Bonds	Alternatives	Cryptocurrencies
Nasdaq Composite	U.S.Aggregate Bonds	Gold	Ripple
S&P 500	High Yield Bonds	US REITs	Litecoin
Stoxx Europe 600	US Treasuries		Bitcoin
MSCI Emerging Markets	Emerging Market Bonds		Dash
S&P Small Cap	Investment Grade Bonds		

Observation period: Feb 2014- Dec 2017





## About Us

**vision&** is a Swiss based, SRO-regulated asset manager facilitating the access to innovative blockchain investment opportunities, based on professional investment research and integrated into a traditional banking framework.

### The authors

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**CEO**

Lidia brings in vast experience in quantitative finance, asset management and complex tech projects. Before co-founding a startup in the field of machine learning applications, Lidia was Managing Partner of a Swiss advisory boutique specialized in quantitative finance. Earlier in her career she worked for major investment firms (J.P. Morgan, Swiss Re, Man Investments) in various asset management roles in Zurich, London and Hong Kong. Lidia holds a PhD from the University of St. Gallen, specializing in investment strategies and asset management, and acts as advisor to blockchain startups in that field.

### Get in touch

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Christian's career path proves his strong passion for financial markets. He worked 15+ years for Credit Suisse in Zurich and New York where he held positions in trading, investment consulting and research. He is a senior trader with vast experience in risk managing derivative trading books in different asset classes (equity, precious metals, foreign exchange). Due to his explicit tech skills, he was substantially involved in the digitalization of the bank's structured product platform and the automation of trading processes. Christian holds a Master of Arts in Banking & Finance from the University of St. Gallen.