“Assessment of cryptocurrencies as an asset class by their characteristics”

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ASSESSMENT OF CRYPTOCURRENCIES AS AN ASSET CLASS BY THEIR CHARACTERISTICS

Abstract

The cryptocurrency market has witnessed significant growth in the past few months. The emergence of hundreds of new digital currencies and the huge increase in the prices of their leading representatives have attracted a lot of attention from investors. However, the financial characteristics of the cryptocurrency markets have not been systematically evaluated yet. As a consequence, there is currently no consensus on whether cryptocurrencies constitute an individual asset class or if they share substantial similarities to stocks, bonds, commodities or foreign exchange. Based on Markowitz et al. (2017), this paper aims to fill this lack of research by evaluating the cryptocurrency market based on seven requirements of an individual asset class. The authors find that the cryptocurrency market distinguishes itself remarkably from established asset classes in terms of risk and return. Additionally, the low correlation between the cryptocurrency markets and these established asset classes induces a diversification potential for investors, leading to more favorable risk/return profiles of their portfolios. But also the emergence of investment services and products provided by the financial industry and the increasingly cost-effective access to cryptocurrencies corroborate the conclusion that cryptocurrencies can be seen as an individual asset class.

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INTRODUCTION

Digitalization is considered an opportunity to counteract the pressure on the financial industry. FinTech, as the innovative spearhead of digitalization, benefits from this situation by acting as a provider or integrator of new technologies, products and services for established financial institutions (Ankenbrand, Dietrich, & Bieri, 2017). One of these innovations which has enjoyed a lot of attention from the financial industries in the past few months are cryptographic tokens or cryptocurrencies. A cryptographic token is an alternative medium of exchange, controlled by cryptography rather than a governmental authority. The security of the transactions is based on asymmetric encryption in a decentralized environment known as distributed ledger technology. The last few months have seen an increasing emergence of hundreds of these tokens. This is reflected in the rapid growth of the total market capitalization from roughly USD 5 billion at the beginning of 2015 to more than USD 130 billion as of mid-August 2017 (CoinMarketCap, 2017). The largest and most prominent cryptocurrency so far is Bitcoin, first described in a whitepaper written under the pseudonym Satoshi Nakamoto in 2008 (Nakamoto, 2008). Its sharp price increase in the first two quarters of 2017 has attracted a lot of attention from the investor side. As a consequence, several financial institutions have launched initiatives to provide Bitcoin-based products or the currency itself to interested clients. Apart from Bitcoin, other cryptocurrencies such as Ethereum, Bitcoin Cash, Ripple, Litecoin, NEM, IOTA, NEO, Dash, and Ethereum Classic, have all reached a significant market capitalization of more than USD 1 billion (CoinMarketCap, 2017). Moreover, these cryptocurrencies have increasingly found their way into mainstream financial news and continuously come into the focus of financial institutions, investors and regulators. Despite all the media attention, there is still a lack of academic research on the characteristics of cryptocurrencies and their similarities and dissimilarities with established asset classes such as stocks, bonds, foreign exchange and commodities. In particular, there is no consensus on whether cryptocurrencies can be considered an individual asset class that could help to improve investors' risk-adjusted portfolio performance. This study aims to fill this lack of research by analyzing the characteristics of cryptocurrencies and putting them in comparison to established asset classes, not only in a qualitative, but also in a quantitative way. The quantitative evaluation starts with the development of a cryptocurrency index, which enables a positioning of the cryptocurrency market into the existing asset universe.

The paper starts with a literature review that captures the results of the most relevant studies on this matter. It is followed by the description of the theoretical framework. Section 3 describes the methods used in this study and the data. The main results and a conclusion are presented in section 4 and final section, respectively.

1. LITERATURE REVIEW

Hileman and Rauchs (2017) give a general overview of the cryptocurrency industry. Their study is based on a survey among nearly 150 cryptocurrency companies and individuals with the aim to systematically analyze the four key sectors in the cryptocurrency industry, i.e. cryptocurrency exchanges, wallets (application in which cryptocurrencies are stored), payment companies, and miners (system nodes who devote computing power to validate the ledger in order to receive a reward). Furthermore, it sheds light on the numbers of companies, employees, end-users, etc. in the individual sectors, without investigating the cryptocurrency market from an investor's point of view.

A comprehensive analysis of similarities and dissimilarities between five major cryptocurrencies is given in Hameed (2016). The paper concludes by providing a taxonomy of cryptocurrencies based on the following five characteristics: consensus scheme, decentralized control, low latency, flexible trust and asymptotic security. The results show that the in-scope cryptocurrencies, i.e. Bitcoin, Ripple, LiteCoin, Dash Coin and Stellar, are designed differently, but can be classified into two groups. One group consisting of Bitcoin and LiteCoin is characterized by applying a proof-of-work consensus and is subject to comparably high latency of the system, inflexible trust, as well as susceptibility to hazardous 51% attacks. The second group consists of Dash Coin, Ripple and Stellar. Whereas the former uses a proof-of-work system, the latter two use a (Federated) Byzantine Agreement system. Ripple is the only cryptocurrency which is not controlled in a decentralized organization. With respect to the other three characteristics, the second group is relatively homogeneous. All these cryptocurrencies are characterized by a low latency of their transactions, robustness of the system to changing trust network and provision of asymptotic security (however, the latest point is not perfectly clear for Dash Coin).

A specific overview on the initial coin offering (ICO) ecosystem is given in Sokolin (2017). An ICO is a cryptocoin crowd sale, where a blockchain-based project allows enthusiasts and supporters to invest in the project by purchasing part of its cryptocurrency tokens in advance. The study reveals that in the first half of 2017, over USD 1.2 billion were raised through ICOs, an amount larger than investments from venture capitalists into Blockchain companies. The offerings are often issued by a set of people, which may or may not be organized as a legal entity. Following the sharp increase in funds raised, governmental authorities have increasingly become aware of ICOs. However, there is no global consensus on whether tokens issued at ICOs have to be treated as assets, commodities or currencies, since coins can be designed as an investment product, a medium of exchange or be more functional. Additionally, Sokolin (2017) warns that some ICOs are fraudulent and intend to take advantage of speculation in the ecosystem by leveraging social media promotion and exploiting the lack of regulation. Moreover, the author states that the current demand for cryptocurrencies is driven by the entry of mainstream investors, the enterprise efforts in the financial industry and the speculation/diversification of the ecosystem.

A recent study that investigates characteristics of the two largest cryptocurrencies, i.e. Bitcoin and Ether, from an investor's perspective stems from Bouoiyour and Selmi (2017). Among other things, the paper analyzes the correlation between the two currencies and other asset classes and studies the diversification potential from an inclusion of Bitcoin or Ether into different sample portfolios. Bouoiyour and Selmi (2017) conclude that both cryptocurrencies show a negative correlation with US stocks (S&P500), US bonds and oil, and are therefore suitable for hedging price movements in established asset classes. Their results suggest an inclusion of either Bitcoin or Ether into a diversified portfolio. Nevertheless, by including Ether, investors may face heavy losses in times of declining markets.

2. THEORETICAL FRAMEWORK

In the literature, there is a broad consensus that at least three different asset classes exist, i.e. stocks, bonds and cash equivalents. Additionally, foreign exchange, real estate and commodities are often also considered as individual asset classes. With the strong emergence of cryptocurrencies in the past few years, a discussion on whether cryptocurrencies can be seen as an individual asset class has started. The total market capitalization illustrated in Figure 1 reflects the growing importance of the cryptocurrency market.

To evaluate whether cryptocurrencies can be considered an individual asset class, it is necessary first to define this term in more detail. According to Markowitz et al. (2017), an asset class is "a stable aggregation of investable units that is internally homogeneous and externally heterogeneous, that when added to a portfolio raises its expected utility without benefit of selection skill, and which can be accessed cost effectively in size" (p. 3). Based on this definition, there are seven requirements cryptocurrencies need to fulfill in order to be considered an individual asset class. The following paragraphs describe these requirements in more depth.

2.1. Stable aggregation

This first requirement refers to the composition of the cryptocurrency market. In order to qualify as an asset class, the cryptocurrency market should not be subject to major fluctuations in its composition. Otherwise, constant efforts would be needed to identify its actual components. To show whether the cryptocurrency market has this required characteristic of stable aggregation, the authors assess the main differences between cryptocurrencies and established asset classes in a qualitative way.

2.2. Investable

Cryptocurrencies need to be directly investable in order to qualify as an asset class. The replication of an asset is not considered a direct investment, since it causes rebalancing costs for maintaining

Source: CoinMarketCap.com

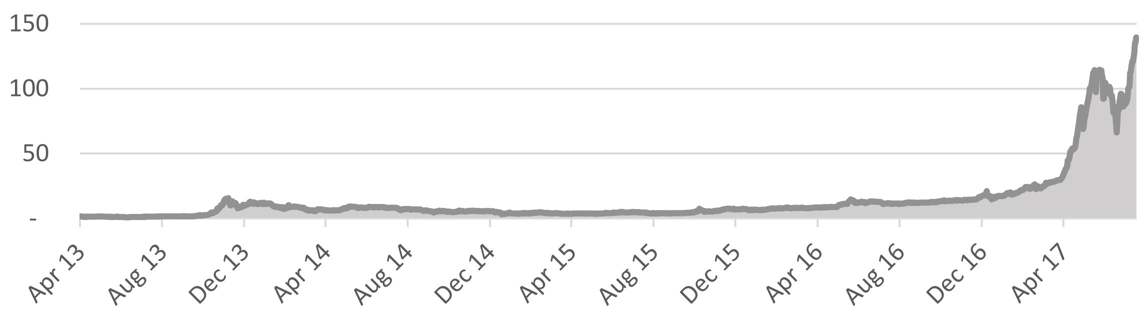

Figure 1. Total market capitalization of cryptocurrencies as of August 14, 2017, in USD bn

an optimal composition among other issues. To evaluate whether cryptocurrencies are in fact investable, the authors describe if and how a direct investment in cryptocurrencies can be undertaken.

2.3. Internally homogeneous

A third characteristic of an independent asset class is a certain degree of homogeneity of its components. To evaluate this requirement, the authors identify the similarities of the major cryptocurrencies and their main drivers.

2.4. Externally heterogeneous

To justify the potential status of an individual asset class, cryptocurrencies need to show sufficient dissimilarities to established asset classes such as equities and bonds. In order to provide a quantitative evaluation of similarities and dissimilarities of the cryptocurrency market with other asset classes, the authors first derive a proxy for measuring the performance of the market as a whole. For that purpose, the authors construct a Laspeyres-type price index, including the largest cryptocurrencies as measured by market capitalization. The authors evaluate the characteristic of external homogeneity by means of the correlation coefficients between the cryptocurrency market, proxied by the developed cryptocurrency price index, and proxies for established asset classes. Additionally, the authors compare different quantitative properties of the index, for example, its risk/return profile and other key figures such as the Sharpe ratio and maximum drawdown, to the properties of established asset classes.

2.5. Expected utility

The characteristic of expected utility refers to the ability of an asset class either to increase a portfolio's expected return or to lower its risk. The latter effect can be achieved by the low risk of the asset class itself or by a low correlation with other assets in the portfolio. The authors evaluate the characteristic of expected utility by means of efficient frontiers. In particular, the authors analyze the effect of an inclusion of cryptocurrencies into a sample portfolio of established assets.

2.6. Selection skill

Since an asset class is required to be internally homogeneous, investors should not need to be skilled in actively picking specific components in order to raise the expected utility of their portfolio. Again, the authors draw on the cryptocurrency index to validate this requirement.

2.7. Cost-effective access

To decide if an asset class should be included in a portfolio, the expected utility after deduction of all costs is of relevance for investors. Therefore, an asset class must be accessible at reasonable transaction costs. The asset class should not impair the liquidity of the portfolio significantly in order to allow for regular portfolio rebalancing without causing high costs. To evaluate if cryptocurrencies meet this criterion of cost-effective access, the authors compare the fees of crypto exchanges to conventional exchanges and highlight bid-ask spreads in trading cryptocurrencies.

3. METHOD

To test the hypothesis of cryptocurrencies being an individual asset class, the authors apply the seven properties described in the previous section. In doing so, the authors occasionally apply simple statistical concepts or risk measurements, such as the standard deviation or Sharpe ratio, which need no further explanation. One concept that does need further explanation is the construction of the cryptocurrency index, as illustrated in subsection 3.1. Subsection 3.2 covers the process of portfolio optimization used to evaluate the impact of an inclusion of cryptocurrencies into a given portfolio. The last subsection describes the data set.

3.1. Construction of the cryptocurrency index

The authors construct the cryptocurrency index to track the development of the cryptocurrency market as a whole. It is constructed following the Laspeyres approach by weighting the prices of the underlying cryptocurrencies with the corresponding share on their aggregated market capitalization (Janssen & Rudolph, 1992), i.e.

$$CCI(t) = K(T) \cdot \frac{\sum_{i=1}^{n} p(i,t) \cdot q(i,T)}{\sum_{i=1}^{n} p(i,0) \cdot q(i,0)} \cdot 100, \quad (1)$$

where $CCI(t)$ – value of the cryptocurrency index at time t, T – date of last index adjustment, n – number of assets included in the index, $K(T)$ – chain factor at time T (equals 1 at base date), $p(i,t)$ – price of cryptocurrency i at time t, $q(i,t)$ – index weight of cryptocurrency i at time T, $p(i,0)$ – price of cryptocurrency i at base date, $q(i,0)$ – index weight of cryptocurrency i at base date.

The index is calculated on a weekly basis. Every time the index composition changes, the index weightings are adjusted accordingly and the chain factor is recalculated as

$$K(T) = \frac{K(T_{old}) \cdot \frac{\sum_{i=1}^{n} p(i,T-1) \cdot q(i,T_{old})}{\sum_{i=1}^{n} p(i,0) \cdot q(i,0)} \cdot 100}{\frac{\sum_{i=1}^{n} p(i_{new},T-1) \cdot q(i_{new},T)}{\sum_{i=1}^{n} p(i_{new},0) \cdot q(i_{new},0)} \cdot 100}. \quad (2)$$

The resulting chaining factor and the adjusted index weightings are held constant until the next adjustment of the index composition.

3.2. Portfolio optimization

In order to assess the potential of cryptocurrencies from an investor's point of view, minimum variance frontiers are calculated. This is done by solving an optimization problem, where for a given range of expected returns, the corresponding variances of a portfolio are minimized. Hereby, two conditions have to be met: first, weightings of the portfolio components have to add up to one, and second, only long positions in the assets are allowed. In mathematical terms,

$$\min_{w} Var(r_p) = \sum_{i=1}^{n} w_i^2 Var(r_i) + \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} w_i w_j Cov(r_i, r_j), \quad (3)$$

subject to

$$E(r_p) = \sum_{i=1}^{n} w_i E(r_i) = \mu \quad (4)$$

and

$$\sum_{i=1}^{n} w_i = 1, \;\; w_i \geq 0, \quad (5)$$

where $Var(r_p)$ – variance of the portfolio returns, w_i – portfolio weight of asset i, r_i – return of asset i, μ – values for which the optimization problem is solved.

The efficient frontier shows all efficient combinations of individual assets that minimize the risk given a certain level of expected return or maximize the expected return at a certain level of risk (Markowitz, 1959).

3.3. Data generation and preparation

Contingent on the availability of information on cryptocurrencies, our sample consists of weekly data points ranging from April 28, 2013 to August

Table 1. Components of the cryptocurrency index as of August 13, 2017

Cryptocurrency	Weeks	Cryptocurrency	Weeks	Cryptocurrency	Weeks	Cryptocurrency	Weeks
Bitcoin	225	Dogecoin	36	NEM	7	Bitcoin Cash	2
Litecoin	217	Namecoin	35	Stellar	7	Feathercoin	2
Ripple	204	Monero	23	MaidSafeCoin	6	Terracoin	2
Ethereum	105	Nxt	19	Steem	6	Aphroditecoin	1
Dash	70	Ethereum Classic	16	The DAO	6	GridPay	1
Peercoin	63	Novacoin	11	Mastercoin	5		
BitShares	43	PayCoin	8	Auroracoin	4		

6, 2017. The dataset stems from two different sources, the first of which being CoinMarketCap, a website that provides a broad range of information about the cryptocurrency market. Table 1 lists all cryptocurrencies that are included in the cryptocurrency index for at least one week. All relevant information on these cryptocurrencies, such as prices and market capitalization, is obtained from CoinMarketCap.

A second data set has been collected in order to compare the characteristics of the cryptocurrency market to other asset classes. Table 2 gives an overview on the in-scope asset classes and their proxies. Corresponding weekly index values were obtained from Bloomberg. All indexes are denominated in U.S. dollars in order to avoid distortions from exchange rate fluctuations.

Table 2. Asset classes and their proxies

Asset class	Proxy	Details
Stocks	S&P500 Index	Index consisting of 500 stocks of large U.S. companies
Bonds	Bloomberg Barclays U.S. Aggregate Bond Index	Broad-based bond index commonly used as multi-category bond benchmark
Foreign Exchange	Trade-weighted U.S. Dollar Index	Trade-weighted index measuring the value of the U.S. Dollar relative to other world currencies
Commodities	Bloomberg Commodity Index	Broadly diversified index that tracks all major commodities markets

4. RESULTS

This section aims to shed some light on the legitimacy of cryptocurrencies as an individual asset class. It is structured analogue to section 3, where all seven characteristics of an asset class, as defined by Markowitz et al. (2017), are listed.

4.1. Stable aggregation

In a broad sense, there are three different types of cryptographic tokens. Type one are crypto shares or tokenized securities, which represent a certain share in a company or project. One example of such a crypto share was the DAO token, launched in April 2016 as a crowd sale initiative. A DAO token represented ownership over the DAO, a decentralized autonomous organization similar to a venture capital fund, and enabled its owners to vote for specific projects to support with its funds. Shortly after its launch, the DAO was subject to an attack that exploited security vulnerabilities, leading to the theft of USD 50 million (Price, 2016). Due to this attack, the Ethereum developers decided to resolve this issue with a hard-fork of the Ethereum platform. Because of its similarities to securities, the DAO token was retrospectively classified as subject to U.S. securities law by the U.S. Security and Exchange Commission (SEC). The second type of cryptographic tokens are utility tokens, which represent a certain good or service and/or are needed to run smart contracts. Ether, the token of the Ethereum platform, is a representative of this type. The third type are cryptocurrencies. In general, a cryptocurrency is a digital asset designed to function like money (Latham & Watkins, 2015). A cryptocurrency therefore serves as a medium of exchange, unit of account and store of value. These purposes distinguish cryptocurrencies from established asset classes such as stocks, bonds and commodities[1], but not from classical fiat currencies. Nevertheless, there are three characteristics that distinguish cryptocurrencies from their fiat counterparts: they are electronic; are not the liability of anyone; and feature peer-to-peer exchange (Bech & Garrat, 2017). In particular, a fiat currency is controlled by a central bank, which manages the money supply. Most cryptocurrencies, on the contrary, are built on a decentralized peer-to-peer network, which collectively governs the management of the money supply following a specific protocol. The creation of new units of Bitcoin, for example, is based on a proof-of-work consensus mechanism. Every time a new block of transactions is validated, its miner gets rewarded with newly created Bitcoin and the block is distributed to all network nodes. Other consensus mechanisms include Practical Byzantine Fault Tolerance, (delegated) proof-of-stake, and proof-of-burn. All of these mechanisms are based on algorithms to reach a consensus on the current state of the system rather than on a centralized au-

1 Note that these asset classes do in fact fulfill some of these purposes, but not primarily and not to the same degree.

thority to validate transactions. Hence, all types of cryptographic tokens distinguish from established asset classes in terms of purpose and/or cryptographic backbone and their decentralized governance. Therefore, the composition of cryptographic tokens as an asset class is considered relatively stable, leading to a positive assessment of the first characteristics of asset classes. For the sake of simplicity, the authors will refer to cryptocurrencies as representatives of all three types of cryptographic tokens in the following sections. From an investor's point of view, this generalization is unproblematic, since there is currently no distinction between the three different types with respect to their investability, as shown in the next subsection.

4.2. Investible

The second characteristic of an individual asset class refers to its investability for a broad range of investors. Currently, there are multiple ways of investing in cryptocurrencies. A growing number of digital exchanges allow investors to directly trade in selected cryptocurrencies. Hileman and Rauch (2017) distinguish between three different types of exchange services. The first type is the provision of a platform to match buy and sell orders from users, known as order-book exchanges. The second service encompasses the acquisition and/or selling of cryptocurrencies to users at a given price. The third type of service involves the provision of a platform to directly connect to other exchanges and/or offering leveraged trading, as well as cryptocurrency derivatives. As of mid-August, 2017, there were 21 cryptocurrency exchanges with a daily trading volume of over USD 50 million (CoinMarketCap, 2017). These exchanges differ in their services provided, tradable currency pairs (including all types of cryptographic tokens), payment methods, verification requirements, trading limits, geographical restrictions, as well as their fee structure. Apart from the emergence of the mentioned exchanges, multiple established financial institutions have launched initiatives to offer cryptocurrencies, especially Bitcoin, to their clients. However, the total number of financial institutions offering cryptocurrency-related services and products is still relatively low. In Switzerland, for example, Swissquote and Falcon Private Bank were the first two banks to introduce direct Bitcoin investment, after Vontobel introduced a tracker certificate on Bitcoin on the Swiss Exchange in July 2016. Falcon Private Bank expanded its services by offering Ether, Litecoin and Bitcoin Cash in addition to Bitcoin as of August 2017. Another bank that offers indirect trading in cryptocurrencies in Switzerland is IG Bank with contracts for difference on Bitcoin and Ether. ICOs are another way to invest in cryptocurrencies. However, most ICOs do not accept fiat currencies to purchase newly created tokens, but only cryptocurrencies (mostly Bitcoin or Ether). Hence, interested investors first need to purchase Bitcoin or Ether in order to take part in most ICOs. To summarize, there are multiple ways to gain exposure in the cryptocurrency market. The reduction of the exposure is more difficult due to compliance requirements. The trading and settlement from cryptocurrencies to fiat money is not common because of the money laundering potential of cryptocurrencies. Overall, offerings from financial institutions are still relatively scarce. The second condition for cryptocurrencies to be considered an individual asset class is therefore not fully met. The ever increasing number of products and services offered by banks increases the accessibility to the cryptocurrency market, pointing towards a positive assessment of the investability condition in the near future.

4.3. Internally homogeneous

As illustrated above, cryptographic tokens can be classified into three different types, i.e. token shares or tokenized securities, utility tokens and cryptocurrencies. Due to their different designs, not all cryptographic tokens fulfill the key functions of money to the same degree. Bitcoin, for example, was created for the sole purpose of being a digital alternative to fiat currencies. Ether, on the other hand, serves as the basis for smart contracts on Ethereum, a Turing-complete platform created for decentralized applications. Other cryptocurrencies share some similarities to securities. The owners of the cryptocurrency OBITS, for example, are entitled to a share in the profits issued by the organization and to cast votes on decisions made by the issuer. Despite the variety of their designs and purposes, cryptocurrencies are treated as an individual class of technological innovation by regulatory bodies across the globe. In the United States, for example, the initial coin

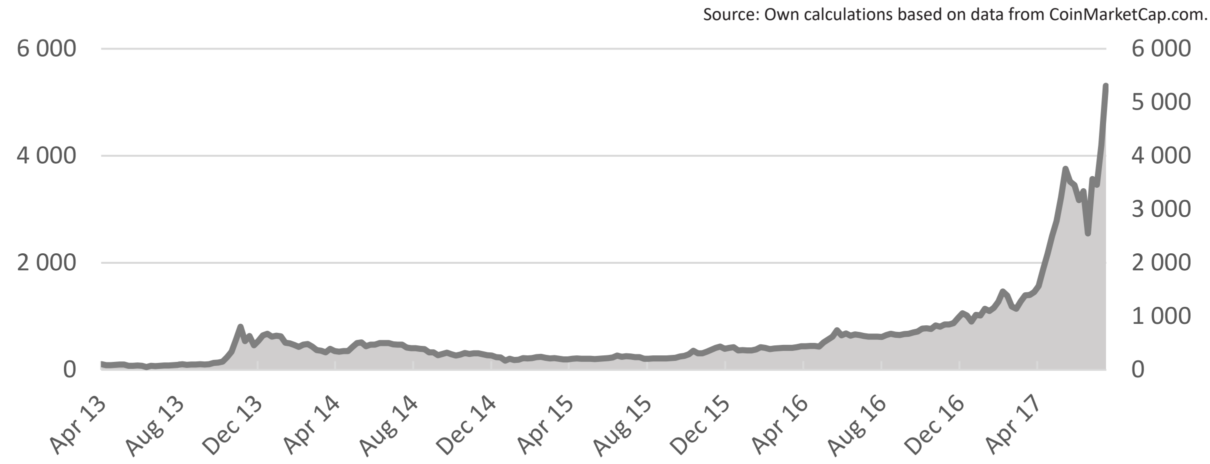

Figure 2. Cryptocurrency index from April 2013 to mid-August 2017, weekly basis

offering of The Dao has been investigated by the SEC. The commission concluded that ICOs are similar to the issuance of equities and therefore are subject to federal securities laws (Securities & Exchange Commission, 2017). In other countries such as Switzerland and Singapore, cryptocurrencies are not considered securities but assets. In the United Kingdom, cryptocurrencies are classified as private currencies and thus are not regulated as financial products, as opposed to Russia, where the debate points to a legal status of a financial instrument rather than a virtual currency (Sokolin, 2017). Despite the different regulatory approaches, cryptocurrencies have so far been regulated equally within the separate jurisdictions. To summarize, there seems to be consensus that cryptocurrencies as a class of financial innovation need some sort of regulatory guidance, but there is no consensus on how this regulatory environment should be designed. Based on the class-wise treatment from a legal point of view and on their decentralized and cryptographic nature, cryptocurrencies comply with the requirement of homogeneity, even though they might serve different purposes.

4.4. Externally heterogeneous

In addition to being internally homogeneous, cryptocurrencies have to clearly distinguish themselves from other established asset classes in terms of their characteristics as an investment in order to be considered an individual asset class. To conduct this assessment, a proxy for the overall development of the cryptocurrency market is needed. For this purpose, the authors first derive an index that tracks the performance of the cryptocurrency market as a whole, starting in April 2013. As described in subsection 4.1, the index is calculated on a weekly basis, following the Laspeyres approach by weighting the prices of the five largest cryptocurrencies with the corresponding share on their aggregated market capitalization at the given point in time. Since the cryptocurrency market is dominated by only few currencies, the limitation on the top five does not impair the validity of the index. This is underlined by the share of the five largest cryptocurrencies of the total market capitalization: as of August 9, 2017, the five largest cryptocurrencies, i.e. Bitcoin, Ethereum, Ripple, Bitcoin Cash, and Litecoin, account for more than 80 percent of the total market capitalization (CoinMarketCap, 2017). This share has even been significantly higher in the preceding months. Figure 2 shows the weekly development of the cryptocurrency index as of April 2013.

The figure reveals that the cryptocurrency index has developed very similarly to the price of Bitcoin, especially in the early years. This is not very surprising, since Bitcoin has been (and still is) the leading cryptocurrency as measured by market capitalization. As a result, the weighting of Bitcoin in the cryptocurrency index has been accordingly high. However, with the emergence of alternative cryptocurrencies, especially Ether, the dominance of Bitcoin in the index has decreased over time.

The cryptocurrency index enables a comparison of the aggregated cryptocurrency market and established asset classes from an investors' point of view.

Table 3. Annual risk/return profiles of established asset classes and cryptocurrencies, period from April 2013 to mid-August 2018

Asset class	Average return	St. dev.	Sharpe ratio[2]	Max. drawdown	Weeks to recovery
Stocks	10.72%	11.30%	0.86	–12.31%	21
Bonds	2.17%	3.34%	0.36	–4.52%	35
Commodities	–9.88%	11.57%	–0.94	–46.77%	No recovery yet
Forex	4.21%	4.72%	0.69	–7.16%	No recovery yet
Cryptocurrencies	130.81%	89.43%	1.45	–79.17%	96

In Table 3, the annualized risk/return profiles of stocks, bonds, commodities, foreign exchange and cryptocurrencies are presented.

It reveals that the cryptocurrency market achieves an average return of more than 130 percent per year. Cryptocurrencies hence performed by far better than stocks (10.7%), bonds (2.2%), commodities (–9.9%) and foreign exchange (4.2%). However, this comes at the cost of increased risk inherent in the cryptocurrency market whose returns reveal an annual standard deviation of roughly 90 percent. For comparison, the standard deviation of commodity returns amounts to 11.6%, making it the second riskiest investment in the investigated sample period, followed by stocks (11.3%), foreign exchange (4.7%) and bonds (3.3%). This empirical evidence is further underlined by the maximum drawdown, which measures the largest percentage peak-to-trough decline of an investment. Table 3 additionally shows the number of weeks until a new peek is reached after the maximum drawdown. The table shows that the cryptocurrency market entails the largest risk in comparison to the established asset classes, having a maximum drawdown of 79.2 percent and a time to recovery of 96 weeks. Again, commodities are identified as the second riskiest investment, followed by stocks, foreign exchange and bonds. The large maximum drawdown and its long period of recovery show that an investment into the cryptocurrency market is not suitable for short-term oriented investors, since significant losses are possible in the short run. Despite its volatility, the cryptocurrency market achieves the highest excess return per unit of risk, as measured by the Sharpe ratio. A Sharpe ratio of 1.45 confirms that the cryptocurrency market reveals the most favorable risk/return profile in comparison to the established asset classes in our sample period. Stocks (0.86) rank second, foreign exchange (0.69) third, bonds fourth (0.36), and commodities fifth (–0.94). The negative Sharpe ratio of the latter indicates that the risk-free investment, as proxied by the 3-month treasury bill rate, has performed better than an investment in the commodity market.

A key figure to evaluate the diversification potential of the cryptocurrency market is its return correlation to other asset classes, as shown in Table 4. It reveals that cryptocurrencies are highly uncorrelated to other established asset classes, with correlation coefficients ranging from –0.02 (bonds) to 0.05 (stocks). In particular, cryptocurrencies show lower correlations to stocks, bonds, commodities, and foreign exchange than the established asset classes among themselves. These results indicate a certain diversification potential by including cryptographic tokens into a portfolio based on a classical investment universe. The authors analyze this diversification potential in the next section in more depth.

Table 4. Correlation Matrix. Index proxies: S&P500 Index (Stocks), Bloomberg Barclays US Aggregate Bond Index (Bonds), Bloomberg Commodity Index (Commodities), Trade-weighted U.S. Dollar Broad Index (Foreign Exchange), and Cryptocurrency Index (Cryptocurrencies)

Asset class	Stocks	Bonds	Commodities	Foreign Exchange	Cryptocurrencies
Stocks	1.00	–	–	–	–
Bonds	–0.17	1.00	–	–	–
Commodities	0.26	–0.05	1.00	–	–
Foreign Exchange	–0.19	–0.38	–0.44	1.00	–
Cryptocurrencies	0.05	–0.02	0.00	0.02	1.00

2 The 3-month treasury bill rate has been used as proxy for the risk-free rate.

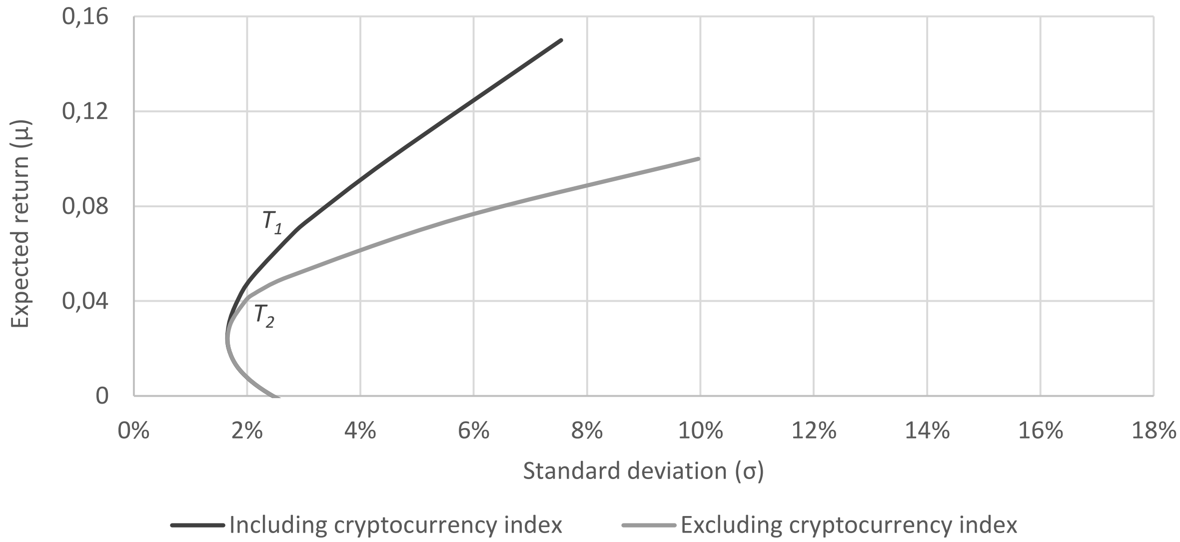

Figure 3. Efficient frontiers with and without the cryptocurrency market

4.5. Expected utility

As described in section 3, the characteristic of expected utility refers to the ability of an asset class to either increase a portfolio's expected return or to lower its risk. To evaluate this characteristic, two efficient frontiers are calculated and illustrated in Figure 3. The first one (light gray curve) is based on an investment universe including all proxies of established asset classes, i.e. stocks, bonds, commodities, and foreign exchange. The second one (dark gray curve) additionally includes the cryptocurrency index.

The two efficient frontiers underline the fact that an inclusion of the cryptocurrency market into the asset universe enlarges the set of optimal portfolios[3]. For the same amount of risk, investors are able to achieve a larger average return by incorporating cryptocurrencies in their portfolio allocation. To give a deeper look at the characteristics of the cryptocurrency market from an investor's point of view, Table 5 reveals the characteristics of the tangency portfolios (T_1 and T_2 in Figure 3), i.e. the ones that optimize the Sharpe ratio for a given asset universe. It confirms that an inclusion of cryptocurrencies into the asset universe increases the risk-adjusted average excess return of the optimal investment, as measured by the Sharp ratio. The tangency portfolio including cryptocurrencies achieves a larger Sharpe ratio of 2.10 in comparison to 1.58 of the reduced asset universe.

The portfolio allocation of the tangency portfolios shows that this significant increase in the Sharpe ratio can be achieved by investing only 2.1 percent of the total portfolio into the cryptocurrency market. Investors therefore could significantly improve their performance by only investing a small amount of their total investment into cryptocurrencies. Based on these findings, the requirement of an improved expected utility of an investor's portfolio by including cryptocurrencies is clearly met.

Table 5. Comparison of tangency portfolios, annual performance

Asset universe	Average return	Std. dev	Sharpe ratio	Portfolio allocation				
				Stocks	Bonds	Commodities	Foreign exchange	Crypto-currencies
Including cryptocurrencies	6.9%	2.8%	2.10	14.9%	45.1%	0.0%	37.9%	2.1%
Excluding cryptocurrencies	4.3%	2.1%	1.58	15.8%	45.0%	0.0%	39.2%	NA

3 Note that this is not relevant for investors seeking the lowest possible risk of an investment beyond the risk-free asset, since both minimum variance portfolios do not include cryptocurrencies.

4.6. Selection skills

In order to benefit from the increased expected utility from an incorporation of cryptocurrencies in a portfolio, investors should not need to possess specific selection skills. In particular, investors should be able to improve the risk/return profile of their portfolio without actively selecting specific cryptocurrencies. The analysis in the previous section has shown that a passive security selection by means of the cryptocurrency index is sufficient to increase the Sharpe ratio of a portfolio of established asset classes. Investors therefore do not need to include specific cryptocurrencies such as Bitcoin or Ether into their portfolio. A passive index product like an index fund or an ETF that does not need active management is suitable in order to benefit from the risk/return characteristics of the cryptocurrency market.

4.7. Cost-effective access

In order to be a potential investment opportunity, cryptocurrencies need to be accessible at reasonable transaction costs, i.e. bid-ask spreads and trading fees need to be sufficiently low. The former is addressed in Figure 4, showing the temporal development of Bitcoin's bid-ask spread on Bitfinex, the largest Bitcoin exchange as measured by trading volume (data.bitcoinity.org, 2017). It reveals that there have been two major incidents that caused a significant increase in the bid-ask spread of Bitcoin. In particular, the spread sharply increased in February 2014 when the Bitcoin exchange Mt. Gox announced that 850,000 Bitcoins, which was about USD 450 million at that time, were stolen.

A second sharp increase in the bid-ask-spread occurred in August 2016, when hackers stole 119,756 Bitcoins, worth roughly USD 72 million at the time, from Bitfinex, the largest Bitcoin exchange as of September 2014. Despite these two incidents, the increasing number of investment possibilities in Bitcoin has led to a continuous increase in the trading volume since October 2013, which again has led to narrower bid-ask spreads. In mid-August 2017, it amounted to 0.03 percent, a size which is comparable to the value-weighted spread of S&P500 stocks that laid between 1 and 3 basis points from 2013 to 2016 (Iercosan, Kumbhat, Ng, & Wu, 2017). Hence, the spreads in trading Bitcoin can be assumed to be cost-effective. The trading volume of other leading cryptocurrencies such as Bitcoin Cash, Ether, Litecoin, and Ripple has also grown over time, indicating a steady narrowing of their bid-ask spreads. As of September 2017, their bid-ask-spreads fluctuated around 40, 4, 10, and 25 basis points, respectively, indicating higher transaction costs than for trading Bitcoin (Kraken, 2017).

Trading fees constitute the second most important cost driver. Most cryptocurrency exchanges distinguish between maker and taker fees. Maker fees, on the one hand, apply when a requested order does not match against any other order and therefore is added to the order book. A taker fee, on the other hand, is raised when a request order matches against any other trade order and gets executed immediately. Maker fees are typically lower than taker fees, since the respective order increases the liquidity of the order book in contrast to its counterpart. For many cryptocurrency exchanges, both fee types are not held constant but depend on the amount traded.

Source: data.bitcoinity.org.

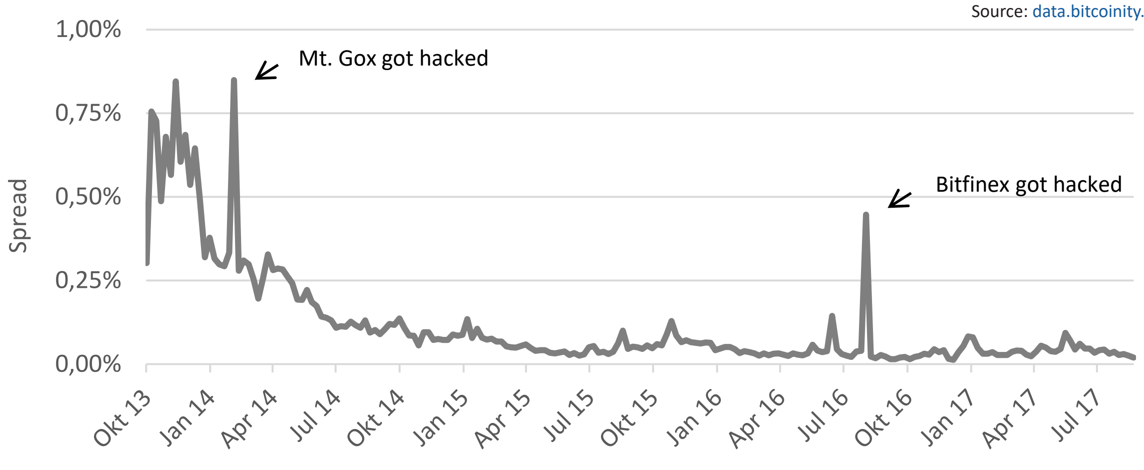

Figure 4. Bid-ask spread of Bitcoin on the Bitfinex exchange, weekly data

Bitfinex, for example, charges taker and maker fees between 0 and 0.1 and between 0.1 and 0.2 percent, respectively, depending on the investor's trading volume in the preceding 30 days (Bitfinex, 2017). Other leading cryptocurrency exchanges such as Poloniex or OKCoin.cn have similar fee structures. For comparison, Interactive Brokers LLC., the leading electronic brokerage firm in the U.S. (Golovtchenko, 2016), charges between 0.2 and 0.08 basis points, depending on the monthly trade amount (Interactive Brokers, 2017), and thus is significantly cheaper than the mentioned cryptocurrency exchanges. Overall, it can be concluded that the leading cryptocurrencies can be traded at reasonable costs, even if not as cost-effective as trading traditional asset classes such as foreign exchange. With the increasing maturity and accessibility of the cryptocurrency market, the costs are expected to decline further, pointing towards a positive assessment of this last requirement of an individual asset class.

CONCLUSION

Cryptocurrencies have increasingly come into the focus of investors. Although the market is still at an early stage, the authors have found evidence that cryptocurrencies meet most requirements as an independent asset class. In particular, cryptocurrencies clearly distinguish themselves from established asset classes in terms of their technological innovation, the distributed ledger technology, and their (mostly) decentralized governance, pointing towards a stable composition of the cryptocurrency market. Not only the design of cryptocurrencies but also their financial performance in terms of risk and return clearly differs from established asset classes: An investment in cryptocurrencies comes with a comparably high volatility, i.e. a high risk, which, however, is compensated by a high expected return. Additionally, its low correlation to stocks, bonds, commodities, and foreign exchange induces a diversification potential for investors. Hence, an expansion of the traditional asset universe by cryptocurrencies implies a superior risk-adjusted performance measured by the Sharpe ratio, even if only a small share of the total portfolio allocation is invested into the cryptocurrency market. Investors also do not need to pick specific cryptocurrencies, since an index fund or an ETF that does not need active management is suitable in order to benefit from the performance characteristics of the cryptocurrency market. However, such passive index products are still rather scarce. Also, the number of financial institutions that offer direct investments in cryptocurrencies is still relatively small. Therefore, the trading volume of cryptocurrencies is low in comparison to established asset classes, leading to less cost-effective access to the market. With the ever-increasing supply of products and services for cryptocurrencies offered by established financial institutions, the accessibility and trading volume is expected to rise, leading to lower costs in trading cryptocurrencies in the near future.

Based on these findings, the authors conclude that cryptocurrencies qualify as an individual asset class, despite their (yet) limited accessibility. It will be of importance to closely monitor the future development of the market, since the financial performance, and thus our evaluation, is largely driven by the sharp rise in prices in the first half of 2017. Future research therefore should investigate the boom-and-bust cycle of the cryptocurrency market to identify potential bubbles. The burst of such a potential bubble would largely affect our findings, as well as the future of the cryptocurrency market as a whole.

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