

RESEARCH ARTICLE

Developing a Cryptocurrency Assessment Framework: Function over Form

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Abstract. The rise of cryptocurrency as a new *sui generis* asset class creates a need for a new classification scheme to cover the wide range of functionality for which tokens can be used. By differentiating tokens based on their functional attributes, cryptocurrency tokens can be categorised into *crypto-transaction* tokens (which act as a cash substitute); *crypto-fuel* tokens (which underpin generic blockchain applications); and *crypto-voucher* tokens (which can be exchanged for a predefined asset). This classification is applied to identify important issues when considering whether to participate in a cryptocurrency system, such as the impact of potential forks, token supply expectations and the level of dependence on a few operators (*entity-dependence*). For crypto-transaction tokens (and crypto-fuel tokens if used in a similar or overlapping role) it shows the importance of the token being seen as a “better” form of money. For crypto-fuel tokens, the popularity of blockchain applications and the utility of the crypto-fuel system in application development is vital. For crypto-voucher tokens, the value of the underlying asset, the token’s exchangeability for that asset and the importance of a digital representation should be considered by participants. The interplay between fundamentals and speculation as drivers of price is considered. An erratum for this article has been published at <https://doi.org/10.5915/LEDGER.2018.151>.

1. Introduction

The number of cryptocurrencies has increased rapidly from one to over 1350 cryptocurrencies as of 18 December 2017.¹ This has been accompanied by increasing diversification, in terms of purpose, technology and governance, resulting in a highly variable range of applications. Whilst Bitcoin focused on providing an electronic cash substitute, subsequent cryptocurrencies and their underlying technology can now be used to raise funds through Initial Coin Offerings (ICOs), to underpin a decentralised network, and as a mechanism to facilitate other applications,² including those across the engineering space and for social purposes.^{3,4}

Whilst the variation in tokens facilitates a range of possible applications and benefits, it also leads to a lack of clarity in how to assess the suitability of a token for a particular purpose. This makes cryptocurrency harder to oversee for regulators and difficult for investors to evaluate. The resulting regulatory uncertainty has been cited as the main obstacle to adoption by application developers and network operators.²

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One of the first regulators to formally assess how cryptocurrency should be regulated was the Securities and Exchange Commission (SEC), which split tokens into fully regulated *security tokens* and lightly regulated *utility tokens*. Differentiating between these is not without difficulty;⁵ in particular, determining whether a token involves ‘reasonable expectation of profits to be derived from the entrepreneurial or managerial efforts of others,’ and so is a security.⁶ The Swiss regulator FINMA follows a similar approach except tokens that represent ‘assets’ are regarded as securities.⁷ The issue is further complicated by the Commodity Futures Trading Commission’s (CFTC) view that all virtual tokens are subject to their oversight as either commodities or derivatives.⁸ There are no lists provided to show how different cryptocurrencies are allocated into these groups, which makes it difficult for stakeholders to be sure as to which regulations apply to specific cryptocurrencies.

As a general rule, globally, regulators have so far tended to avoid making special rules or providing specific guidance to create a regulatory framework for operating cryptocurrencies.⁹ In the United Kingdom and Singapore, for example, regulators have explicitly stated that cryptocurrencies do not fall within a specific part of the regulatory framework, but that a cryptocurrency will be regulated if it takes on sufficient characteristics of another regulated asset to be treated as that asset.^{10, 11} This approach is also reflected in the new regulatory regime for regulated financial instruments which came into force across the European Union on 3 January 2018, which lists those asset classes which are regulated, but does not mention cryptocurrency.¹²

This ambiguity may also explain why, despite the number of cryptocurrencies, Bitcoin remains dominant, with over half of the market capitalisation as of 18 December 2017.¹ Participants may be deterred from exploring alternative cryptocurrencies (*altcoins*) that are poorly understood, particularly since, for example in the United Kingdom, the lack of a specific regulatory framework is often accompanied by regulators warning that there are increased risks when investing in cryptocurrency, compared to other asset classes.^{10, 13} This may also explain why some thought leaders have questioned whether cryptocurrency represents a legitimate form of investment that provides participants a genuine source of value,^{14, 15} why some regulators have chosen to ban ICOs,¹⁶ and the observed high volatility in cryptocurrencies (Appendix A), fuelled by speculation.^{17, 18}

The previous ‘ontological’ classification approach proposed by Herbert and Stabauer in 2016 encompassed three (Bitcoin, Ethereum and Ripple) out of the twenty-one cryptocurrencies currently considered the most financially significant (Sections 2 and 3), and does not take into consideration the proliferation of new token types since that study.¹⁹ It further does not cover recent developments fundamental to most new financially significant cryptocurrencies, *e.g.* the use of ICOs.

This article proposes a new classification approach based on the function of the token, rather than the underlying form of the protocol. This classification framework provides a tool for understanding and assessing a given cryptocurrency, which enables cryptocurrencies to be interpreted and understood by a broader, less-technical readership. This is particularly important given the continuing creation of new cryptocurrencies marketed to a public audience. It is consistent with the outcomes-focused approach deployed by regulators, for example the SEC characterising the operation of DAO tokens when determining them as a security, rather than commenting on the underlying Ethereum blockchain.⁶

The methodology used (Section 2) is to first identify the most financially significant cryptocurrencies, and to classify them by applying criteria which consider the underlying differential characteristics of their tokens. The resulting classification (Section 3) is then

applied as an assessment framework for identifying the underlying fundamentals for each cryptocurrency type, from which stem important questions around whether cryptocurrencies are a better type of money, the impact of forks, token supply, and entity-dependence (Section 4). Speculation is considered (Section 5) as this may produce high volatility, obscuring the impact of the underlying fundamentals which would normally constitute the basis for valuing an asset.²⁰

2. Methodology

Scope—The cryptocurrencies considered are those where the token is: (i) an entirely digital store of value, (ii) publicly available, and (iii) supported by a blockchain. Publicly available cryptocurrencies are likely to have the most available data, whilst the support of the blockchain has been seen as a differentiating characteristic of cryptocurrencies.^{21, 22} Using this scope, the most financially significant cryptocurrencies are selected for the dataset.

Determining financial significance—The metrics routinely available publicly are: market capitalisation, price, circulating supply, and liquidity.^{1, 23-28}

Comparisons based on price alone can be misleading because if token supply is low, buyers are forced to offer higher prices to acquire tokens even though there is a limited user base.

Market capitalisation is the price of a token multiplied by the circulating supply of tokens. It is favoured because it directly measures the amount held in each cryptocurrency, and so focuses on the most financially significant cryptocurrencies. Price is measured as the average price weighted by the different volumes traded in different markets, to account for variations in price. Circulating supply deducts from total supply the amount of publicly unavailable tokens, such that market capitalisation is the amount held by the general public in the cryptocurrency.²⁹ A limitation to existing metrics of market capitalisation is how to account for inaccessible tokens resulting from owners losing access to their wallets or hoarding.³⁰ Such scenarios could lead to market capitalisation giving a misleading impression of the amount invested in a given cryptocurrency.

Liquidity is important, as a low liquidity means that users can only move in and out of a cryptocurrency system slowly, at great cost, which can inhibit the adoption of a cryptocurrency.^{30,31} It is considered here because it is indicative of the prevalence of inaccessible tokens: the fewer tokens that are for sale, the lower the transaction volume is likely to be for a given market capitalisation. Liquidity is measured by the transaction volume over the last 24 hours.

For robustness, two metrics from three websites are examined at three timepoints.^{1, 23-28} Lists of the top ten cryptocurrencies by market capitalisation and liquidity were collected from coinmarketcap.com at 14:27 on 4 October 2017, 15:48 on 30 October 2017, and 10:27 on 18 December 2017. Examining coincap.io at 15:58 on 30 October 2017 and 10:28 on 18 December 2017 corroborated with coinmarketcap.com, whilst examining onchainfx.com led to similar results, except that this website did not include Tether in its rankings. Where two lists disagree, cryptocurrencies from both rankings are included.

The top five ICOs by amount raised as of 18 December 2017 are also included.³² To mitigate against the risk of cryptocurrencies failing to launch, coinmarketcap.com was used to

restrict the list to where either the tokens or futures exchangeable for the tokens could be bought.

Criteria—Applied to each cryptocurrency:

- (1) What is the purpose, the functionality, and the rights associated with the token?
- (2) How is the supply of tokens determined over time?
- (3) How is the cryptocurrency related to other cryptocurrencies?

These questions characterise the fundamentals of each cryptocurrency, *i.e.* the characteristics that bring value to owning a token other than anticipation of a price increase. This is analogous to Shiller’s (2003) argument that speculative bubbles form when irrational investors are drawn by rising prices.³³

Information on each cryptocurrency was sourced from whitepapers, official websites, and third-party commentary.

3. Results

Dataset—Bitcoin, Ethereum, Ripple, Bitcoin Cash, Litecoin, Dash, NEM, NEO, Monero, Ethereum Classic, Tether, Qtum, Zcash, Cardano, Bitcoin Gold, EOS, AirSwap, Filecoin, the Bancor Protocol, Qash, and Kin (Appendix B).

The veracity of the information released by BitConnect has been questioned,^{27, 34} and similarly Tezos is involved in accusations of dishonesty.^{35,36} Both are excluded.

Classification—The analysis identifies three groups (Table 1), as well as ‘hybrids’ and potential overlap between them (see below).

Table 1. Allocation of cryptocurrencies across the different groups.

Crypto-Transaction	Crypto-Fuel	Crypto-Voucher
Bitcoin	Ethereum	AirSwap
Bitcoin Cash	Ethereum Classic	Bancor Protocol
Dash	NEM	Filecoin
Litecoin	NEO	Tether
Monero	Qtum	
Ripple	Cardano	
Zcash	EOS	
Qash (currently)	Qash (planned)	
Bitcoin Gold		
Kin		

The development of crypto-fuel functionality for Qash is discussed in the associated whitepaper.³⁷

Crypto-transaction—is defined as cryptocurrencies that are designed primarily for transacting value, *i.e.* to be a form of ‘electronic cash’.³⁸

Crypto-transaction tokens are usually designed to be easily transferrable, with minimal barriers to acquisition. Value is not derived from some underlying asset, but rather it is determined by a network of users (see Section 4). Among the cryptocurrencies examined (except Monero), this value was further supported by fixing the total amount of tokens that will ever be created. Examining the websites of crypto-transaction systems suggests that the availability of exchanges and/or merchants who will accept the tokens is an important consideration. Electronic cash is only useful if it can be exchanged directly for goods or services, or if exchange can occur easily through some other currency.

Crypto-transaction tokens were the first form of cryptocurrency, beginning with Bitcoin in 2009. Despite this, new systems are still being created, such as Bitcoin Cash, Bitcoin Gold, Qash, and Kin in 2017. The development of a new codebase usually focuses on resolving perceived limitations in a previous attempt to create electronic cash (typically Bitcoin). The underlying code is often an amended copy of that of an older token, except for Qash and Kin. Even Bitcoin was developed to remove a perceived limitation, specifically the dependence of previous electronic cash systems on a central governing entity.³⁸

Improvements focus on speeding transactions;³⁹⁻⁴² changing the mining algorithm to prevent centralisation;^{40, 41, 43, 44} improving scalability;^{41, 45} and enhancing liquidity.³⁷ There is a distinct subgroup that is concerned with privacy (Dash,³⁹ Monero,⁴¹ and Zcash^{43, 46}), a finding corroborated by other researchers.^{31, 47, 48} There is a second subgroup where the crypto-transaction token was developed to support a specific platform that can provide a suite of financial (Ripple⁴⁹ and Qash³⁷) or social media (Kin⁵⁰) services. Dash is unusual in seeking to change the governance structure through enabling network participants to vote on governance and budgeting proposals.³⁹ How improvements are prioritised and the strategies pursued to implement a given enhancement is system-specific.

Crypto-fuel—This term applies to cryptocurrencies that intend to enable developers to create blockchain-supported applications. They are typically launched with a blockchain platform that is designed to enable the token to be used as a fuel for the created applications to operate. It is a term sourced from the Ethereum whitepaper.⁵¹

The blockchain platform often has *smart contract* functionality, which enables the creation of accounts that behave in a pre-programmed, rule-based way in response to changes in the network, and so forms the basis of decentralised applications.⁵¹⁻⁵⁶

The blockchain platform can be used to facilitate ICOs, explaining the popularity of basing ICOs on crypto-fuel systems, *e.g.* with Etherparty, the Bancor Protocol, and CoinDash all based on Ethereum, and Ecobit on NEM. The blockchain platform can, however, also be more broadly applied to create a new crypto-voucher system (*e.g.* the Bancor Protocol discussed in the next section), or some other type of network that runs independently of a central authority.

Crypto-fuel development usually starts as a fresh project (*e.g.* Ethereum or NEM) or as a fork from some other crypto-fuel’s codebase (*e.g.* Ethereum Classic). They rarely evolve just from a crypto-transaction system. The new codebase typically focuses on improving the process for creating blockchain applications over a prior cryptocurrency. This can mean simplifying the creation of applications;^{51, 53-58} raising flexibility;^{55, 58} improving scalability;^{53, 55, 56} easing regulatory compliance;⁵⁵ preventing subsequent changes to the code;⁵² or reducing the costs of usage.⁵⁶

The underlying architecture behind crypto-fuels varies significantly both from the perspective of the experience of the developer in creating an application to how the cryptocurrency is created and distributed. Developers may have to learn a new programming language,^{51-53, 55} or be able to use a preferred language,^{54, 56, 58} whilst cryptocurrency supply might be fixed,⁵⁸ increase indefinitely,⁵¹ or increase up to a fixed cap.⁵²

Crypto-voucher—This term is used to describe cryptocurrencies whose tokens carry the right to a predefined asset.

The asset to which the token-holder has rights varies. For example, USD Tether is exchangeable one-to-one with USD (or equivalent spot value in Bitcoin);⁵⁹ tokens on the Bancor Protocol are exchangeable at fixed ratios with other cryptocurrencies;⁶⁰ and Filecoin tokens will be transferrable for data storage space.⁶¹ In AirSwap, the token is temporarily locked up to register signals to peers of an intention to buy or sell Ethereum-based tokens.⁶²

As well as depending on the demand for an underlying asset, crypto-voucher tokens are also often dependent on one or more external blockchains. In the case of Filecoin, this dependence means the existence of bridges that enable participants to exploit the functionality of multiple other blockchains.⁶¹ In contrast, the Bancor Protocol and AirSwap are run on top of the Ethereum blockchain,^{60, 63} whilst Tether uses the Omni Layer protocol, which runs on the Bitcoin blockchain.⁵⁹

Crypto-voucher systems are usually not the most dominant cryptocurrencies from the perspective of liquidity or market capitalisation (except for Tether), but are more prevalent among recent ICOs (AirSwap, Filecoin, and the Bancor Protocol).

Hybridisation—The distinction between crypto-fuel and crypto-transaction cryptocurrencies can be complicated by market forces turning crypto-fuel tokens into a store of value, in this respect taking on the properties of a crypto-transaction token; conversely, in some cases, the creation of new protocols is used to give additional crypto-fuel functionality to a crypto-transaction cryptocurrency. The extent to which such ‘hybridised’ cryptocurrencies fulfil an alternative role determines the extent to which the considerations associated with that other role are relevant (Figure 1). For example, Bitcoin was designed for transacting value and thus put in the crypto-transaction group.³⁸ Subsequently, the Omni Layer was developed so that Bitcoin could acquire crypto-fuel functionality.⁶⁴ However, the primary function for the Bitcoin token continues to be in transacting value and so it remains in the crypto-transaction group. Ethereum is in the crypto-fuel group but market forces have sometimes used it to purchase goods and services from merchants, although, in practice, this is very difficult.⁶⁵ The Ethereum whitepaper continues to describe ether as a ‘crypto-fuel’.⁵¹

Overlap—Linked to hybridisation is the issue of overlap, in particular between crypto-fuel and crypto-transaction tokens. Determining which cryptocurrency falls within each of these categories will therefore require a determination of the primary function of the relevant cryptocurrency. The starting point for forming this judgement, used in this article, was how the functionality of the token was explained within its whitepaper, as this is the best evidence of the original design over the token. As tokens evolve, a value judgement may be required to determine the primary function of the cryptocurrency in question. This involves a consideration of how market participants are actually using the cryptocurrency, and the effect of changes to the design, for example as a result of votes on its use, or changes shown by later whitepapers. This capacity for evolution may be part of the original code used for a

cryptocurrency, for example OP codes were baked into the original Bitcoin design which, although not part of the original function, were later reactivated in Bitcoin Cash, making it both spendable and compatible with smart contracts. Activation events such as these may alter the classification of the cryptocurrency and reinforces the fact that different market participants may legitimately come to different conclusions of how a cryptocurrency is to be categorised, based on a different judgement of the primary function of a given cryptocurrency. These differences in view point will reflect the fact that, for some cryptocurrencies, the primary function changes depending on the scenario in which it is used and, therefore, a cryptocurrency may have multiple concurrent uses. However, in this case the distinction between crypto-fuel and crypto-transaction cryptocurrencies is still important to analysing a particular use.

4. Applying the Classification Scheme to Identify Fundamentals

Figure 1 (below) provides a framework for the main questions which might be relevant to assessing a given cryptocurrency. This is not intended to cover all the potential risks and opportunities that may be associated with a cryptocurrency. Instead, it demonstrates the value of the classification scheme in identifying the underlying fundamentals behind different types of cryptocurrency.

The application of questions highlighted in Figure 1 in assessing a cryptocurrency is mostly self-evident. However, some of the questions raised require further elucidation to ensure the applicability of the framework for a broad audience. These issues are discussed below.

Determining a “better” form of money—Two-thirds of cryptocurrency payment companies’ transactions were found to be between national currency and cryptocurrency,⁶⁶ underlining the importance of national currencies as a competing form of money. Hence, following Hileman and Bank of England Governor Mark Carney,^{22, 67} cryptocurrency and national currencies are compared regarding each of the economic functions of money, to determine whether a given cryptocurrency has the potential to truly represent ‘The Best Money in the World.’⁴⁵

- As a long-term store of value:
 - The paper notes underpinning the value of bank accounts deteriorate and must be replaced. The Federal Reserve is forecast to spend USD 726.6 billion on new paper notes in 2017,⁶⁸ about 85% of which replaces deteriorated paper notes,⁶⁹ which typically last about 6-7 years.⁷⁰ Cryptocurrencies’ digital form does not deteriorate over time.
 - Investors cannot be sure to recover the value invested in highly volatile cryptocurrencies; the continuous creation of new systems of cryptocurrency means there is a risk of previous systems becoming obsolete and so losing value; flaws in the underlying code may suddenly render the cryptocurrency valueless. For some cryptocurrency systems, such as Bitcoin, the process for verifying and recording transactions (*mining*) could in theory become dominated by a single entity, who could then spend the same token many times and/or block all transaction validation (though the risk of such a so-called ‘51% Attack’ is demonstrably smaller in established proof-of-work-based

cryptocurrencies due to their increased size).⁷¹ Hence, crypto-transaction systems often seek to prevent miner centralisation.

- As a unit of account:
 - A paper currency cannot measure value in fractions of a coin, whereas a digital currency is infinitely divisible, suggesting cryptocurrencies could be particularly valuable for micropayments.
 - The high volatility of cryptocurrencies undermines its use in the consistent measurement of the value of goods or services.²²
- As a medium of exchange:
 - Cryptocurrencies facilitate global transactions without an intermediary, potentially offering faster and more private transactions.
 - Paper currencies are more valuable as a medium of exchange because they have a much larger userbase than cryptocurrencies. This could explain why scalability is an issue for some crypto-transaction systems: lack of scalability constrains the potential userbase. This also suggests the importance of liquidity: the easier it is to enter and exit a cryptocurrency, the more useful it is as a medium of exchange.³¹

Forks—When the codebase of a cryptocurrency forks, it effectively splits into two versions: the original and a new version that implements perceived improvements. Unless all users and miners then switch to one version, the result is two distinct cryptocurrencies.⁷² If the original transaction data is copied across, the owners of the original cryptocurrency may receive free tokens of the new cryptocurrency. This occurred when Ethereum Classic forked from Ethereum, and when Bitcoin Cash forked from Bitcoin. A tendency for investors to purchase cryptocurrencies intending to benefit from such events has been observed.⁷³

Token Supply—There is likely to be an inverse relationship between the price and the expected supply of tokens in circulation. Potential participants should therefore consider how new tokens will be created over time and their distribution mechanism. For many cryptocurrencies,^{38-41, 51, 52} the total supply over time is determined formulaically by the codebase.

Entity-Dependence—Entity-dependent cryptocurrencies are characterised as when the system becomes dependent on a small number of operators.⁷⁴ This can be by design, such as with Tether controlling the creation and destruction of tokens,⁵⁹ or by evolution. For example, a few market participants could potentially hoard a significant proportion of a cryptocurrency in circulation, giving them power over its price. The importance of who controls the verification and recording of transactions has been particularly emphasised.⁷⁴ A widely held concern with Bitcoin is whether a miner could have sufficient computing power to instigate a 51% attack,⁷¹ enabling them to block all transactions and to spend the same tokens repeatedly.^{40, 41, 43} Participants should thus consider the implications of entity-dependence.

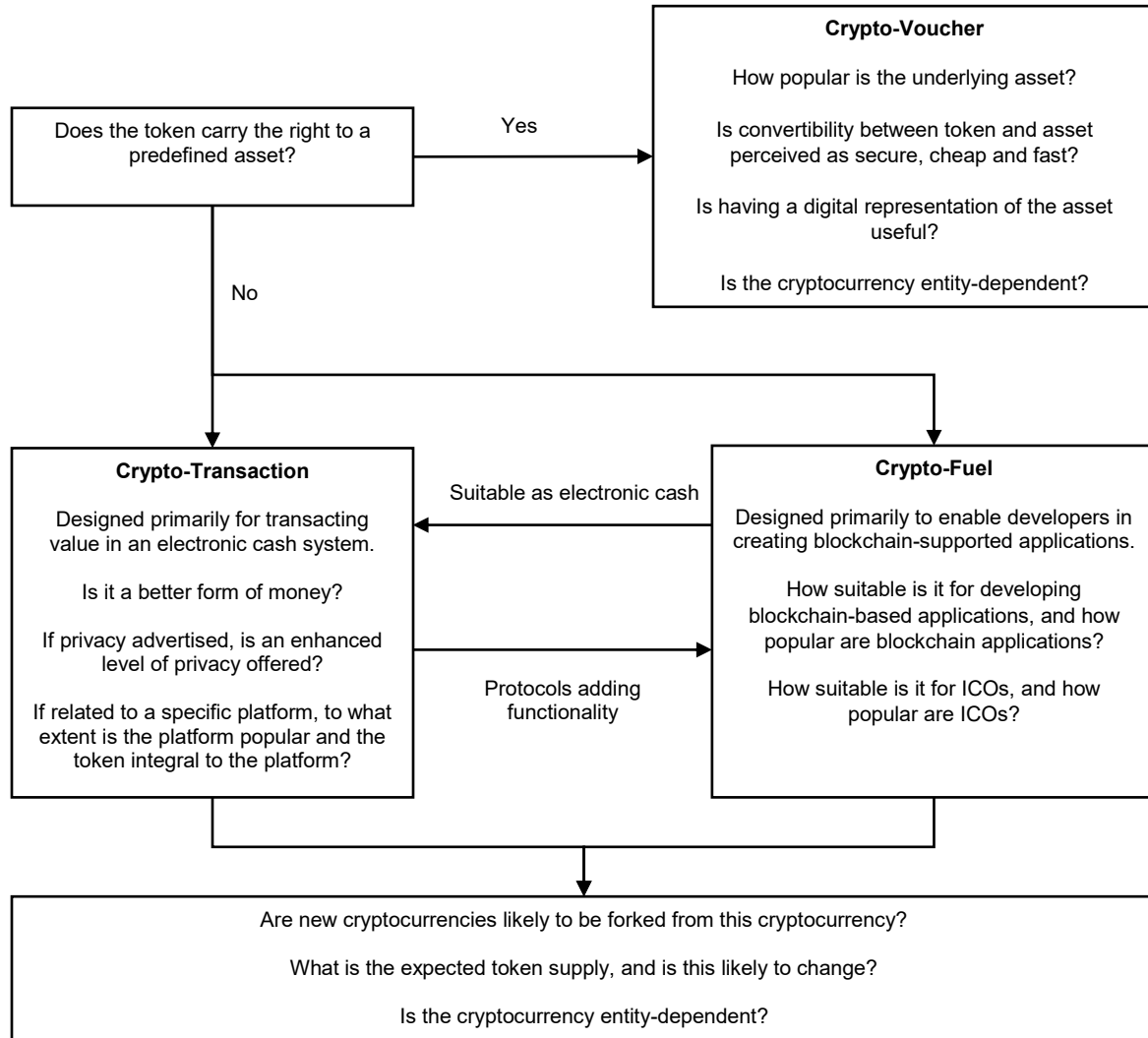


Fig. 1. An assessment framework for cryptocurrencies.

5. Problems with Fundamentals as Investment Criteria

The problem with using the identified fundamentals (Section 4) to price cryptocurrencies is that speculation can act as an important factor that obscures the effect of these fundamentals.³³ There is econometric evidence to support cryptocurrencies as an asset class affected by speculation.^{17,18} This makes it difficult both for participants and investors to anticipate future price dynamics using the fundamentals suggested by this article. A similar issue was observed with Internet companies during the “Dotcom Bubble” where valuations were often based on speculation rather than profitability. Demers and Lev (2001) found that when these valuations fell during the “Dotcom Bust”, those Internet companies with the strongest fundamentals were the most resilient.⁷⁵ This suggests that the fundamentals highlighted by this article may be particularly important for investors in identifying cryptocurrencies with mid- to long-term value.

The presence of less predictable speculation is particularly problematic given the high volatility in cryptocurrency prices, illustrated by the charts in Appendix A (Figures 2-6). Throughout 2017, extreme increases in prices have been observed, particularly with Bitcoin,⁷⁶⁻⁷⁸ in absolute terms, but also with the hundred-fold increases in Ethereum and Dash, and over three-hundred-fold increases in NEM and Ripple (Figures 3 and 5). This trend seems to be reversing with Bitcoin, Litecoin, Ethereum Classic, and Monero reducing to less than half, and Dash, NEM, Ripple, and Zcash reducing to less than a third of their value in 2018 up to 10 April (Figures 4 and 6). Figure 2 illustrates a similar pattern in 2014 when even more severe declines were observed. Litecoin's price fell to less than a tenth in less than a year. Investors and participants risk entering at the peak of a speculative boom to see their holdings greatly reduce in value.

Volatility is worsened by the nascent nature of the trading infrastructure, with exchanges facing difficulties in handling surges in demand, denial-of-service attacks, and theft.⁷⁹ The threat of losing access to cryptocurrency holdings may trigger investors to sell even if the cryptocurrency's fundamentals are strong, contributing to the high price variation. Infrastructure difficulties may explain why prices can differ across exchanges, with Bitcoin prices varying by USD 4000 on 8 December 2017.⁷⁹

6. Conclusion

A new classification has been developed which reflects the functional diversity of cryptocurrencies, by categorising them into three broad types: crypto-transaction, crypto-fuel and crypto-voucher tokens. Applying this classification can be used to identify the different fundamentals inherent to the different cryptocurrency types. This provides both a framework for investors and participants to assess whether a cryptocurrency could fulfil its purpose, and a basis for regulators to start to assess whether a cryptocurrency is properly designed to meet investor expectations, as part of fulfilling their investor protection function.

At the beginning of 2018, a severe reversal of cryptocurrencies' previous rise in value has been observed, possibly indicative of a sustained downturn that could have profound consequences for token-holders. The future of cryptocurrencies beyond this reversal is unclear. Their fate could follow that of equities after the "South Sea Bubble," where the new asset class became banned for 100 years and the money invested lost.⁸⁰ Alternatively, cryptocurrencies with strong fundamentals could parallel Internet companies with strong fundamentals, such as Amazon and Google who survived the collapse in equity prices in the Dotcom Bust and came to be dominant forces in the Internet world. An important difference between these bubbles is that equities in the South Sea Bubble were dominated by fraudulent claims,⁸⁰ whilst Internet companies often solved real, important problems.⁸¹

Contrary to much of the negative commentary around cryptocurrencies,^{14, 15} fundamentals can be articulated. The results of this article suggest that in this changing landscape, cryptocurrencies that serve a real purpose will dominate the cryptocurrency market, but whether this continues to be predominantly Bitcoin is yet to be determined. There are other forms of electronic cash (crypto-transaction) that offer perceived improvements; furthermore, crypto-fuel and crypto-voucher tokens offer additional functionality and thus potentially added value for the user.

This article has articulated the purposes of crypto-transaction, crypto-fuel, and crypto-voucher tokens, but whether these resolve real, important problems will be observed as these technologies and their use-cases mature. By analogy to the Dotcom Bubble, as the market

matures and speculation becomes less of a dominant force in driving up cryptocurrency values, cryptocurrencies with stronger fundamentals underlying them are likely to be the most resilient to any downturn in the market.

A limitation of this article's analysis is that cryptocurrencies are a rapidly developing asset class, and so how they are used could unpredictably change over time, requiring amendment to this classification. This is particularly a concern with crypto-fuel tokens, because their wide range of potential applications suggests that their primary use could vary substantially (as has been discussed for Ethereum). Cryptocurrencies also offer new sociological models, such as relating to political governance,⁸² and so participants may be more interested in joining a system to support a given philosophy, rather than based on speculation or the underlying fundamentals, in which case different issues may be relevant.

Future research could examine to what extent the identified fundamentals and/or speculation are the drivers of cryptocurrency values for each of the three different cryptocurrency types, as more data becomes available.

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Author Contributions

AB was responsible for drafting the manuscript, designing and conducting the research, and interpreting the data. JB and AH provided input on the current legal classification of cryptocurrencies, potential weaknesses of this classification and on the response of regulators to the growth of the new asset class, including ICOs.

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Appendix A

The below charts illustrate the variation in different cryptocurrencies' prices over time. Prices are divided by the price at the start of the series, such that a value of 2 indicates that prices have doubled since the beginning of the period. Baselines equalling one are included to ease comparison. Charts were created using R packages *ggplot2*⁸³ and *cowplot*,⁸⁴ using data sourced from www.coingecko.com, which had a broad coverage and provided historical data in CSV format.

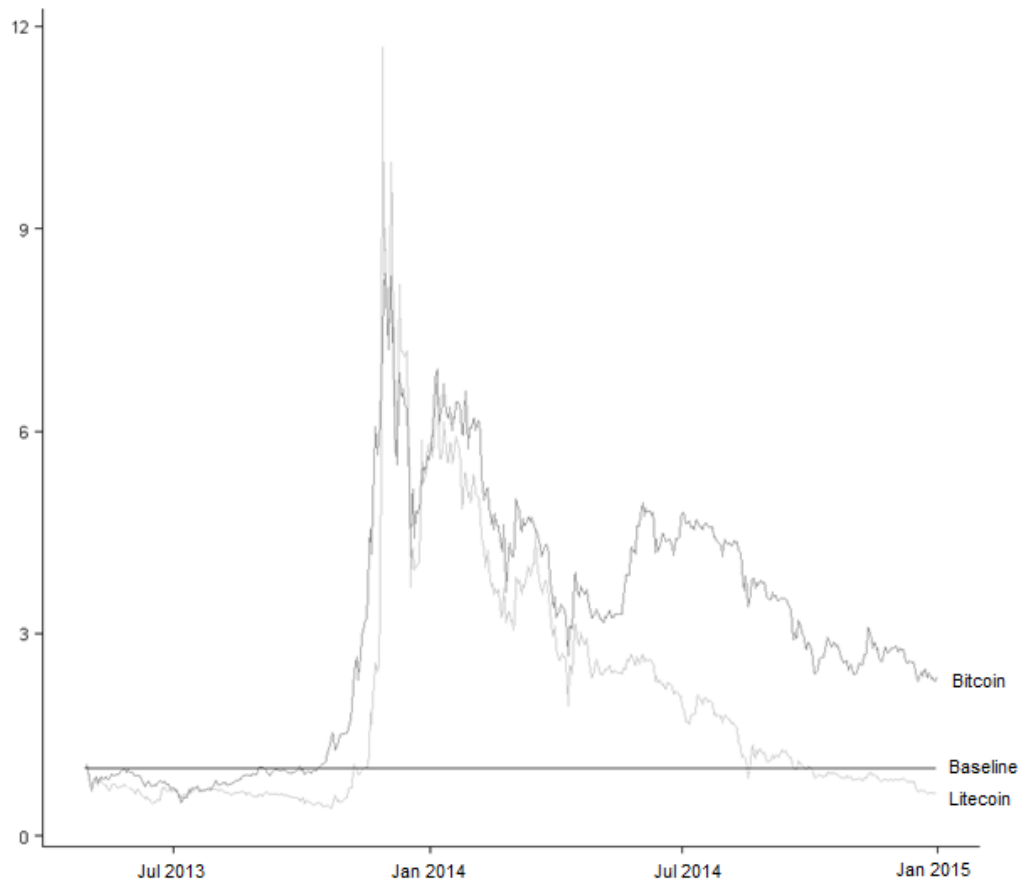


Fig. 2. Bitcoin and Litecoin prices from 28 April 2013 to 31 December 2014.

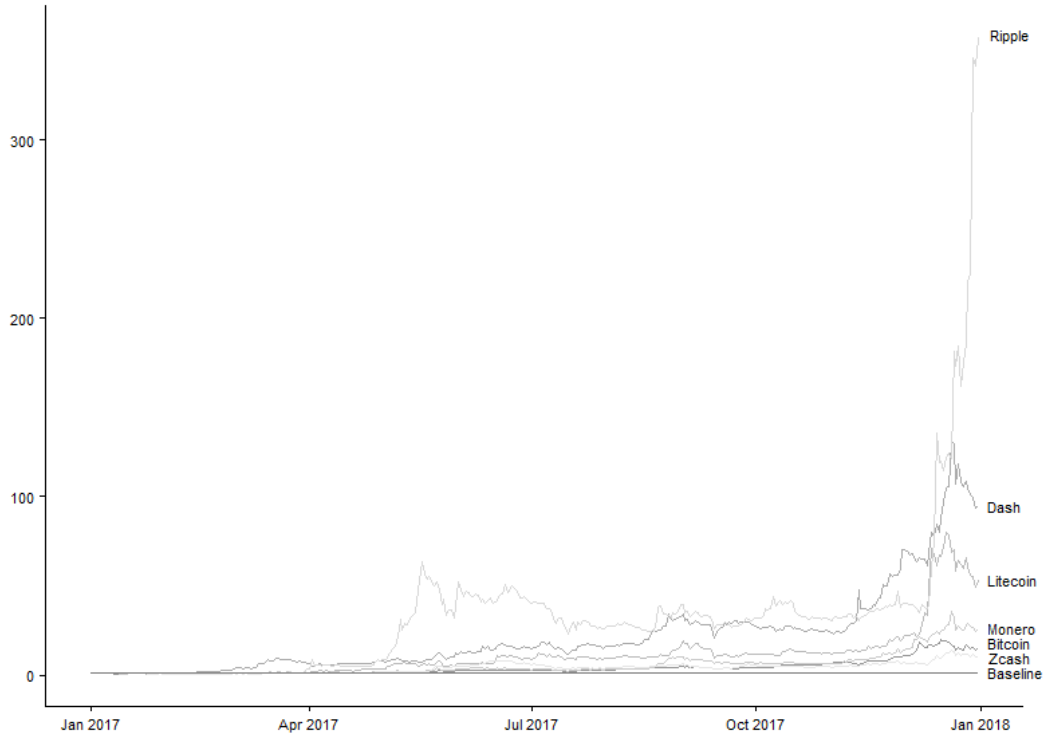


Fig. 3. Crypto-transaction cryptocurrency prices from 1 January to 31 December 2017.

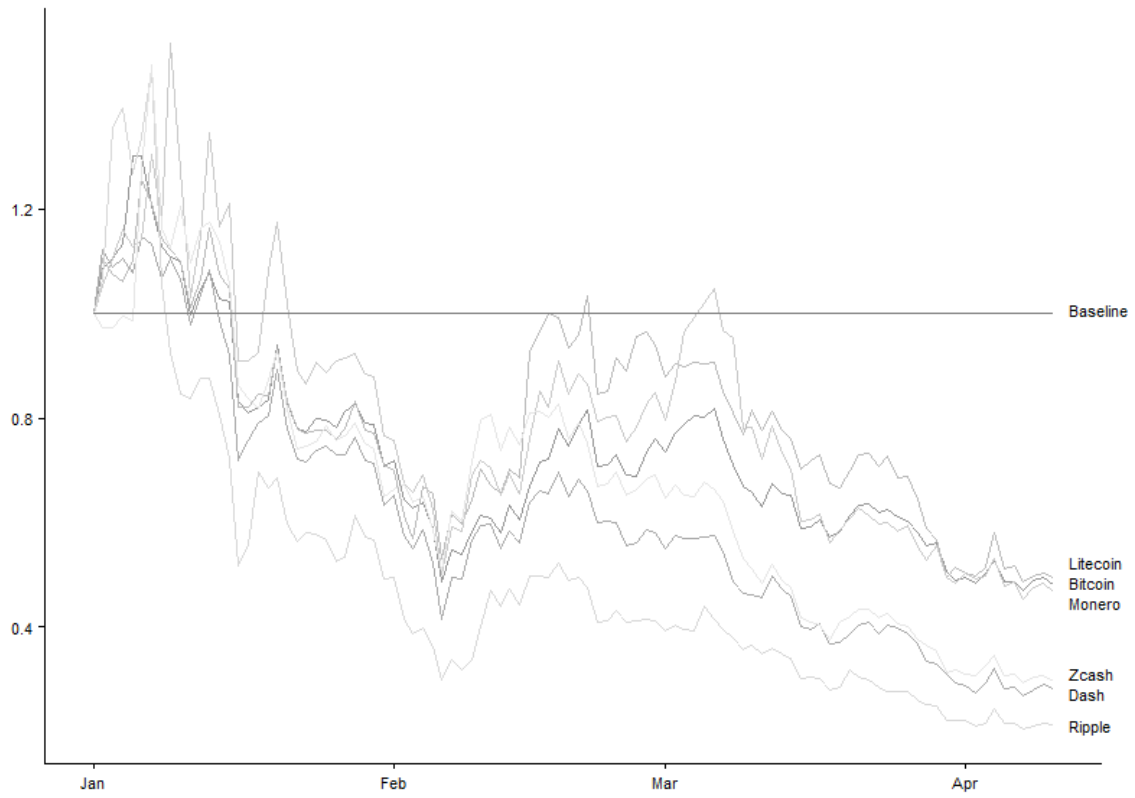


Fig. 4. Crypto-transaction cryptocurrency prices from 1 January to 10 April 2018.

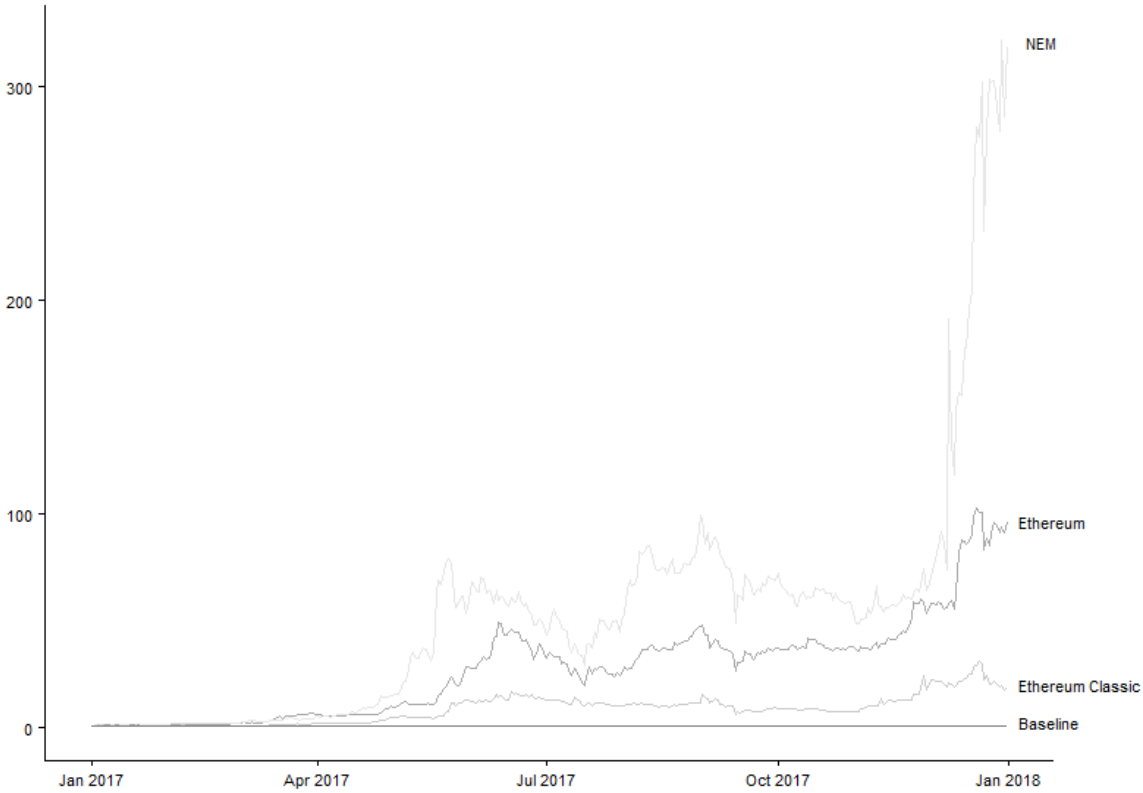


Fig. 5. Crypto-fuel cryptocurrency prices from 1 January to 31 December 2017.

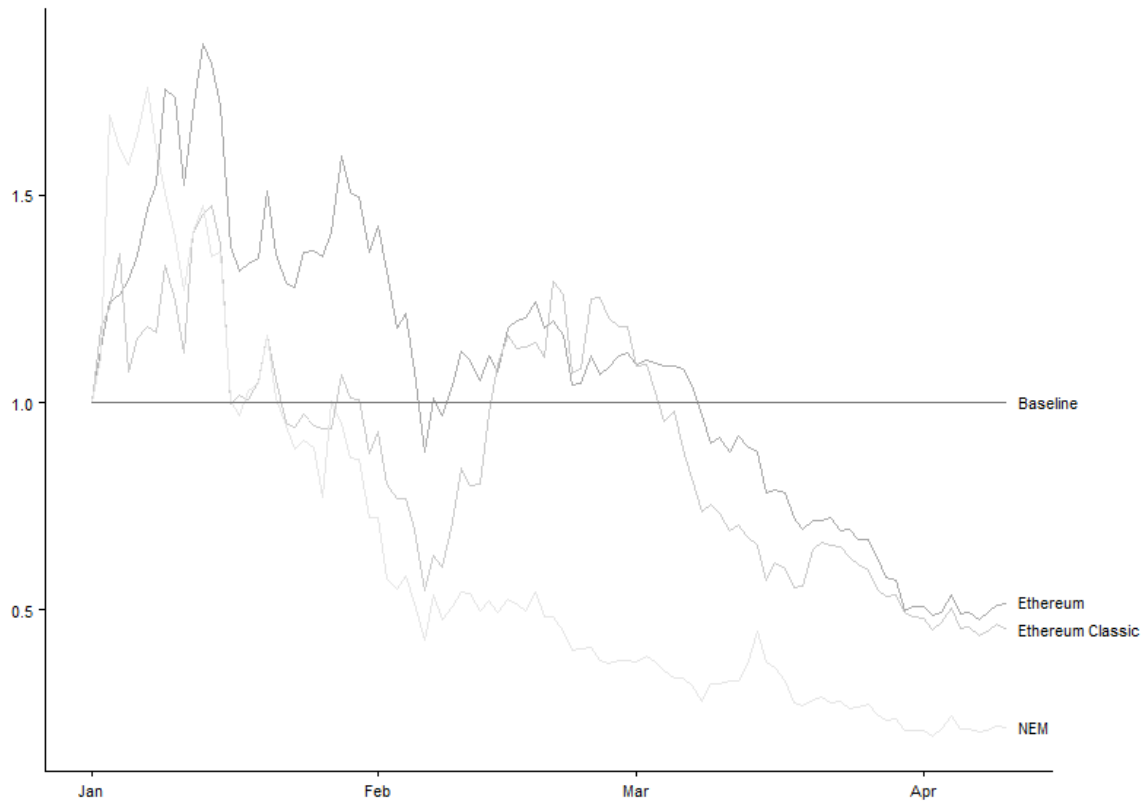


Fig. 6. Crypto-fuel cryptocurrency prices from 1 January to 10 April 2018.

Appendix B

Table 2. Market Capitalisation and Liquidity (transaction volume over last 24 hours) Measured in USD for the Cryptocurrencies Selected Based on These Metrics.*

Cryptocurrency	10:27 on 18 December 2017	
	Market Capitalisation	Liquidity
Bitcoin	318,567,613,388	13,070,000,000
Bitcoin Cash	31,514,053,090	877,377,000
Dash	8,456,546,893	250,788,000
Litecoin	17,294,853,905	1,198,410,000
Monero	5,411,241,508	182,633,000
Ripple	28,770,594,399	1,072,940,000
Zcash	1,531,318,793	331,762,000
Ethereum	69,594,352,659	2,062,100,000
Ethereum Classic	3,528,696,852	493,391,000
NEM	7,150,157,999	93,046,400
NEO	4,820,946,000	532,062,000
Qtum	3,163,793,147	1,147,910,000
Tether	1,128,439,474	2,070,980,000
Bitcoin Gold	5,190,273,036	199,003,000
Cardano	12,661,355,262	349,895,000
EOS	4,593,527,046	387,014,000

*Data sourced from coinmarketcap.com at 10:27 on 18 December 2017.

Table 3. Amount Raised in USD at ICO for the Top Five Cryptocurrencies Selected on This Basis.*

Cryptocurrency	Amount Raised
AirSwap	365,000,000
Filecoin	262,000,000
Bancor Protocol	153,000,000
Qash	108,170,000
Kin	97,500,000

*Data sourced from smithandcrown.com/icos at 14:46 on 18 December 2017.



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