Crypto Currencies

Strategies for short-term trading

Magellan MBA Final Project
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Executive Summary:

2017 marked a historic year for the crypto market, which experienced a cumulative growth of 2,700% year-to-date onset by economic circumstance, a larger adoption by a diversified group of users and the entrance of new crypto technologies. This has drawn attention from independent and institutional investors alike seeking to capitalize from the opportunities that are developing within this emerging market. As more and more people begin to rush into crypto, there is a concern about the lack of established methods for valuing crypto-assets and the speculation that drives it.

This paper explores methods of evaluating long-term and short-term value of crypto-assets by performing a market analysis of the industry and applying price-forecasting models to identify strategic investment opportunities.

A three-year projection shows that crypto-assets with large network effects will experience the highest growth. These assets include: Bitcoin, Ethereum, LiteCoin and Ripple. Although financial models for valuing the utility of a token network are being established (DVF), the value of crypto assets will continue to be driven by speculation. This is in large part due to the ambiguity of how to classify a crypto-asset (equity, currency, or utility). By benchmarking the aforementioned crypto-assets based on key economic drivers, a 3-year investment portfolio was formed. The portfolio consists primarily of Bitcoin (37%) followed by Ethereum (23%), Litecoin (22%) and Ripple (17%).

A data-driven approach for short-term price forecasting was then applied to capture marginal value from characteristically high price fluctuations of the aforementioned crypto-assets. The forecasting methods used include: Turtle trading and long-short term memory networks. The results from the turtle trading strategy were extrapolated to evaluate it as short-term investment strategy. The simulation yielded a 28.20% return on initial investment and was used to form a profitable 3-year investment strategy.

After further consideration, the trading strategy simulation should be extended to cover a larger data set before being considered as a financially sustainable instrument. Further simulation will yield more statistically significant financial projections and can be used to ensure the return on investment. The LSTM model was able to achieve an accuracy of 91% and should be considered for future implementation.

Technology:

The concept of electronic cash was first introduced in 1980 through the invention of an RSA encryption algorithm that would allow one user to pass data with a unique signature. [1, 2] This technological advancement inspired the idea of a decentralized online commerce platform enabled by a high level of privacy and security. The growth of the world-wide-web in the late 90's sparked interest in creating digital cash over the following decades. Although few methods of online markets (e-bay) and cash exchanges (paypal) were widely successful, efforts to produce crypto-currencies were impeded by banks and regulatory restrictions. This was mainly attributed to the anonymous and unmonitored flow of early third party based crypto-currencies (such as e-gold), which stigmatized digital currencies as a market place for illegal activities. Then, in 2009, an author by the name of Satoshi Nakamoto released a peer-to-peer electronic cash system called Bitcoin that was to operate on top of distributed and decentralized network of participants 'Blockchain [3]. Fueled by the economic crisis in 2008, Bitcoin quickly gained popularity and continued to grow to be the most valuable crypto currency on the market today (Market Cap: 70Bn USD). Since the creation of Bitcoin more than 850 other crypto-assets have been created; some of which provide additional utility beyond a medium of exchange.

Technological Summary

The underlying innovation that bitcoin (BTC) provides as a crypto currency is called the 'blockchain'. A blockchain is a public ledger listing the history of all transactions that propagate along bitcoin's distributed, peer-to-peer network of 'Miners'. Users in the market contain digital wallets (placed on an electronic device or online exchange service) with a unique signature where they can store unused bitcoins and private keys that enable them to conduct a transaction. When a new transaction is performed, it is broadcasted across the network of miners coupled with a difficult, computationally expensive puzzle (i.e. 'proof-of-work'). Miners serve as ad-hock nodes within the network that volunteer their computing resources. As the Network is decentralized, it is more resilient to node failures or targeted attacks. Miners are incentivized to volunteer their computing resources to the network through a process known as 'Mining'. Mining consists of generating a cryptographic proof-of-work and appending valid transaction data to the blockchain. As all transaction data is broadcasted across the network, every Miner in the BTC community has an opportunity

to compete against each other in producing the first valid proof-of-work thus authenticating a transaction and preventing fraudulent activity from diluting the money supply. At the conclusion of mining a transaction block, the 'Miner' is rewarded with new units of crypto currency (currently 25 BTC), which is added to the total money supply (like the mining of gold). In addition, Miner's are rewarded with the transaction fee from the buyers, which varies depending on the scale of transaction (typically less than 1%). Measures are put in forth to control the total supply of BTC in circulation by modulating both the BTC added per authentication and the difficulty of mining. The reward/added money supply is tapered off by half its previous value after the addition of 210,000 new blocks. Furthermore, the difficulty of the Proof-of-Work is adjusted to keep the number of authenticated blocks at a fixed rate of 10 blocks added per minute.

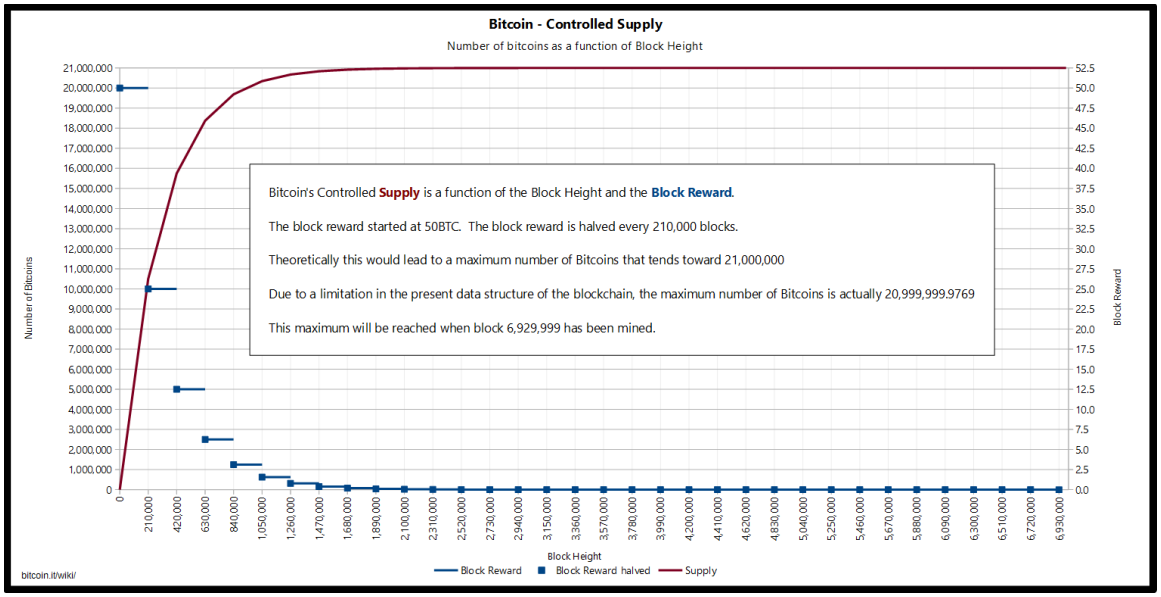


Figure 1: The structure of blockchain creates a controlled demand/supply curve

The Proof-of-work is a brute-force, random process of compressing the transaction data into a 4-byte hash via the SHA-256 hash algorithm. The difficulty of a proof-of-work is dictated by the ability to find a hash value within a pre-specified target range and is directly proportional to the required computational energy. After every 2016 blocks the difficulty level is adjusted based on the average time over or under 2 weeks it took to find the previous 2016 blocks. As the 'Hash-rate' (rate of mining new coins) is driven by difficulty level, which translates to hardware, energy and time costs: the supply of new bitcoins is set to increase linearly with time until it approaches a fixed total supply of 2.1 quadrillion BTC by approximately 2140. Now the inflation of BTC is 4% per

annum and is expected to approach 0% as the supply of BTC in circulation approaches its fixed target. At this point in time, the miner's will only be rewarded via transaction costs. As of now, Transaction fees are relatively low, but are driven by miners seeking revenue. As less BTC is added to the total supply and mining becomes more computationally expensive, the transaction fees are expected to increase.

Is Crypto a Currency?

The blockchain model has provided bitcoin and other alt-coins advantages that attract users to operate in the crypto market. Among the most appealing features that draw users to use crypto currencies is its accessibility, decentralized structure, low transaction fees. However, a concern of its stability has marked it as a speculative currency and have made people skeptical of its worth. The list of bitcoin properties are provided in the table below:

The State of Crypto Currency	
Property	**Notes**
Decentralized	Distributed network of Miners. No centralized bank.
Scarce	Bitcoin set to reach a fixed total Supply of 2.1 quadrillion BTC by 2140.
Divisible	Infinitesimally Divisible.
Storable	Minimal physical storage required (i.e. cloud wallet)
Irreversable Transactions	Irreversible after an hour. Transaction fees are cheap now, but expected to rise as mining becoming more computationally difficult.
UnFakeable	Stringent method (proof-of-work) in place to verify transactions.
Verifiable	Publicly audited through blockchain.
Speed	Takes longer for large transactions (~1 hours). Essentially instantaneous for small transactions.
Anonymous	Considered Psuedo-anonymous: bitcoin addresses can be traced through blockchain. However, third party services can be used to anonymize transactions.
Scalable	Can be circulated anywhere (barring computational resource restrictions)
Offline Transactions	There are physical bitcoins (i.e. Casascius, Bitbills). But, other computer must be used to complete transaction.
Stable	Highly Volatile. High price sensitivity to speculative trends and regulatory actions.

Figure 2: List of unique Crypto-currency properties

For deeper consideration, one must assess three classical functions of traditional currencies: 1) Medium of Exchange 2) Unit of Account 3) Store Value.

Medium of Exchange:

A reliable medium of exchange necessitates that both buyer and seller can agree on a value of a good/service. Crypto currencies have stalled in gaining wide acceptance since they have yet to shown the ability to sustain a dependable value. The most appealing feature that has driven up the value of crypto currencies so far is the low transaction costs (0-1%).[4] Due to the inherent properties of electronic currency and the structure of the blockchain, crypto currencies have been able to avoid third-party intermediaries to provide services (i.e. authentication, transport, security, storage) that would have otherwise increased the transaction costs (fiat currency: 4-5%). One negative ramification of bi passing a third party intermediary has pushed crypto currencies to become popular platform for illegal activities (i.e. 'Silk Road'[5]). For example, in 2014 Mt Gox, at the time the world's largest bitcoin exchange, fell victim to a ransom-ware attack and lost 800,00 BTC valued at 400 million USD[6] The news surrounding early stage crypto currencies make people suspicious, including federal authorities, and heightens its risk. Another disadvantage of this feature is that public or private businesses are not obliged to accept crypto currencies as a legal tender. This is an important barrier has limited the adoption rate of digital currencies. Although the number of merchants accepting bitcoins shows signs of increasing crypto currencies,[7], they still do not have a significant presence in a physical market place. Fiat money maintains a strong network effect that impedes its wide acceptance as a global currency. In 2016, the average daily volume of USD traded was estimated to be 5.1 trillion USD [8]; about 7,000 times that of bitcoin's average daily volume trade of 800 million USD. The market that facilitates a vast majority (~35% in the US) of the daily USD volume traded is the credit market[9]. Crypto currencies have a fixed total supply that prohibits the creation of new units for loans. This distinction limits the use of crypto currency from entering the credit market. Ultimately, the acceptance of various crypto currencies has experienced a steady growth, as is evident from the historical increase in transaction volume.

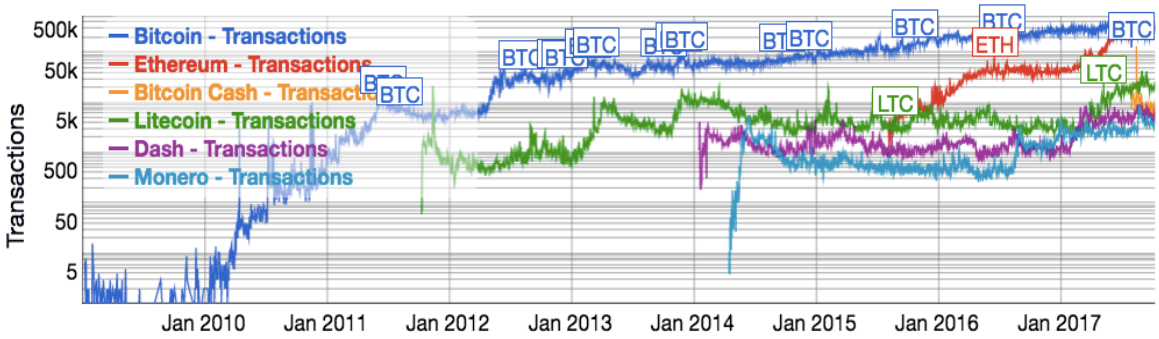


Figure 3: Trading Volume of Top Crypto Assets over Time

Unit of Account:

Crypto currencies are able to denominate any good or service within a precise value because they are infinitely divisible. It also enables large price fluctuations without adding crypto units to the fixed total supply. These Large price fluctuations have been problematic for businesses that need to constantly update their prices in order to avoid the risk of high volatility losses in a competitive market. This lowers crypto currencies' ability to capture the relative value of goods and services, making it confusing for consumers to deal exclusively in the crypto currency. As a result, businesses have relied on methods of mitigating price volatility (i.e. 'market exchange pricing' and 'instantaneous exchanges facilities'), which are based on fiat currency exchanges.

Store of Value:

The last critical component that will determine if crypto currency should be considered as a viable currency is if it can transfer value over time. The fixed total supply of crypto currency protects against inflation from third party intermediaries. As mentioned in the previous section, fiat currency circulates mostly in the credit market. Poor investments in the credit market leads to bad debt and default risk. A similar pattern of events where bad credit leads to irreversible debt and expansionary monetary policies can be seen through each financial crisis of the past four decades (i.e. stock market crash, junk bond crash, dotcom bubble, homeowners crisis) [10]. Over the past five years, the United States has a debt that is ~100% of its GDP [11] and an inflation rate that averages 2.5% per year [12]. Although the price of Crypto currency can fluctuate, it cannot be artificially inflated by the creation of new units. On the other hand, Crypto currencies are vulnerable to other external threats that can have large effects on the value of the currency (i.e. cyber attacks). Fiat currencies rely on centralized financial institutions to bare the responsibility of protecting assets from cyber attacks. While 40% of these institutions invest up to 10 million USD per year on information security to protect themselves and their clients[13], crypto currencies bypass centralized intermediaries. This passes the responsibilities onto users and smaller groups who may be ill equipped or ill prepared to deal with cyber attacks that are becoming more frequent and sophisticated (i.e. phishing, ransom-ware, malware). Furthermore, the blockchain structure that allows for near anonymity and irreversible transactions that makes crypto currency a popular target for malicious attacks. The negative impacts of these attacks are then often amplified by political and regulatory reactions.

Summary:

As the longest standing crypto-currency, Bitcoin has established a strong network effect that empowers it as the most appealing medium of exchange and unit of account on the crypto market. Although, its price volatility does not secure it with a reliable store value and prohibits it from holding intrinsic value, it has a strong potential to behave more as a commodity currency as it matures. For this reason it can be likened to a fiat currency backed by the de-centralized government (i.e. miners) who issues it.[14] Until the market matures, there are guaranteed to be a frequent cycle of large price fluctuations.

Industry Analysis:

As the overall market capitalization continues to follow an exponential growth [15] the market has become appealing not only for tech enthusiasts but also institutional investors seeking high margins [16]. This section explores the transformation of the crypto industry from a niche group of early adapters and tech hobbyists to a structured ecosystem of expanding business entities. This section proceeds by reviewing the Industry: 1) Sectors 2) Macro Factors 3) Projections.

Sectors

The use of crypto assets is not geographically constrained, however the operational entities are primarily concentrated within Asia, followed by North America and Europe. The areas of operation within the crypto market can be categorized into three sectors that often intersect: 1) Exchanges/Wallets 2) Payments 3) Mining.

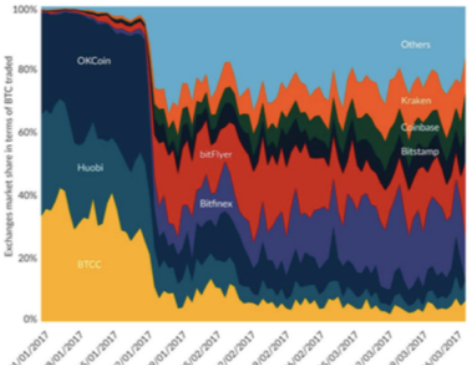


Figure 4: Crypto trading volume market share over major exchanges

Exchanges facilitate the purchase, trade and sale of crypto currencies thus dictating the liquidity and price of a crypto currency. Exchanges account for most of the operating entities in the crypto market (more than 140) and have recently become fragmented (see figure 5). This year, the crypto market exchanges were recorded to employ 1,876 full-time workers across the globe. Most of these companies are small (less than 50 people), but have provided services that have reached up to a 4.3 million unique users; a 540% increase from 4 years back.

Because 72% of exchanges hold custody of all funds, security becomes a primary concern. On average, exchanges allocate 17% of their budget on security by investing in

Total in this period

Exchange	Volume [BTC]	Market share
USD	17.6M	58.60%
CNY	4.32M	14.37%
EUR	3.69M	12.27%
JPY	3.09M	10.27%
GBP	408k	1.36%
others	331k	1.10%
PLN	250k	0.83%
CAD	127k	0.42%
IDR	118k	0.39%

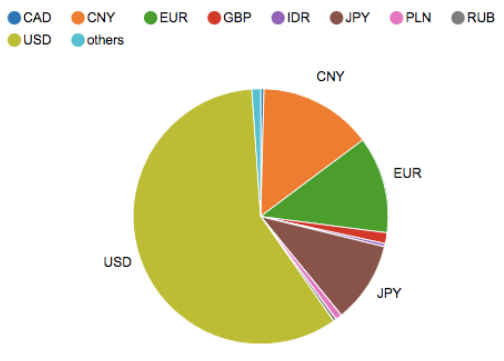


Figure 5: National Currency market share by Total Transaction Volume (6 months)

cold-storage systems (~90% of companies) and multi-signature architectures (~80% of companies). Although smaller companies are less prepared for security breaches, they tend to hold more formal government licenses (52%) than large exchanges (35%). Currently, the USD and the EUR are the most widely supported national currencies across exchanges at 65% and 49% respectively. This is in light of a series of recent regulations on Bitcoin in China, which has reduced the CNY's share of transaction volume in the market by 73% from January to September of 2017. As for crypto currencies, Bitcoin is still supported on 100% of exchanges followed by Ether (43%), Litecoin (23%), and Ripple (16%). Exchanges generally provide closed-source wallets as features for users to manage and track their holdings. Exchange models for wallets span peer-to-peer exchanges, currency exchange services and integrated 3rd party exchanges rate[8].

Payment services are platforms that enable value-transfer between crypto currencies and services/goods built on blockchain technology. Payment activities can be further deconstructed into four use cases that are positioned for national-currencies vs. Crypto-currencies and Businesses vs. Individuals. These sub-categories of payment services use are as follows:

- *Money Transfer services:* international money transfers denominated in national currencies (i.e. traditional remittances, Bill payments)
- *B2B payments:* Payments for cross-border businesses.
- *Merchant Services:* Payment methods for merchants such as shopping and point-of-sale terminals.
- *General-Purpose crypto currency platforms*: Instant payments to users using the same platform via payroll, crypto-currency and other services.

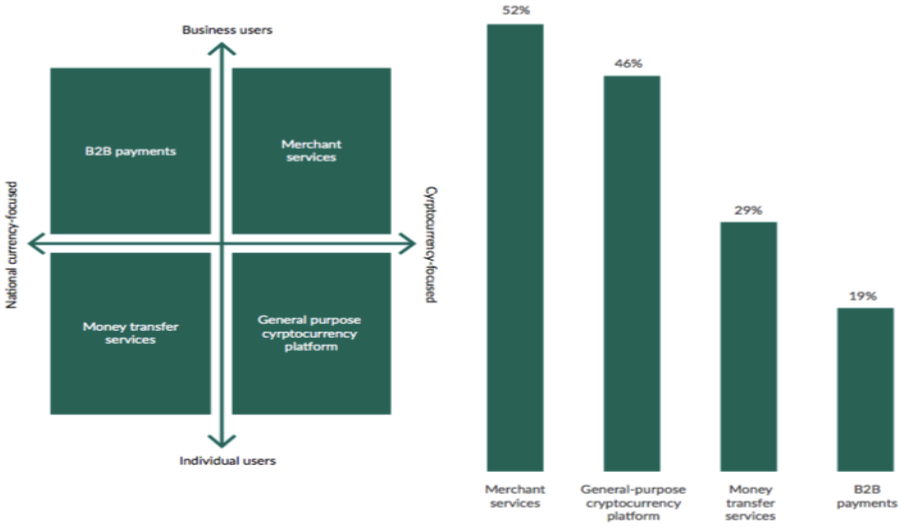


Figure 6: Positioning of Payment Services and User Activity Ratings

These services primarily serve local customers despite being a more popular choice for large cross-border transactions. Asian customers constitutes about one third of activity in every method of payment service with the exception of Money transfer services (82%). European and North American companies have the most geographically diverse set of customers as 44% and 52% of their respective customers are foreign. Most transactions (68%) are made as National currency to Crypto currency or vice-versa. For this, Bitcoin remains as the most dominant crypto currency being used in national currency based payment services (86%). Most of these services depend on Money transfer operations (MTO) partnerships that are formed with banks and local payment networks (79%). This, along with liquidity ratings in local currencies, is the largest challenge that payment services face moving forward.

Mining is an essential part of the crypto industry that is solely responsible for securing transactions and determining the supply of crypto currencies. As the market cap for crypto currencies like bitcoin has increased in an exponential fashion, so have the cumulative mining revenues: more than 2 bln of unappreciated USD in 2016. Based on the protocol models, the percent of mining revenues is expected to shift from crypto currency generation to transaction fees as time goes on (see figure 7) [17].

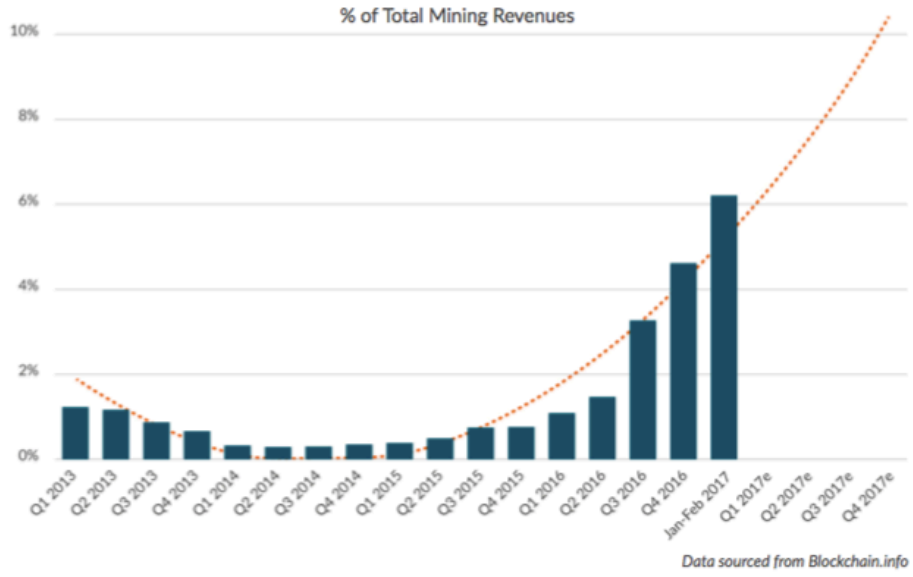


Figure 7: Transaction fees as percent of crypto mining revenues.

This has pushed mining to evolve from a computer hobbyist activity to a competitive, capital-intensive sector. The landscape of mining now encompasses businesses devoted to developing specialized mining hardware, providing cloud/remote mining

services and pooling mining resources. Due to their role in the economy, miners will continue to have a stronger influence on protocol development moving forward. This is an important consideration since mining resources has shifted into a smaller list of larger groups. The top four mining pools have sustained over half of the market share throughout 2016 and 2017 (the highest being AntPool at 25.2%). Furthermore, the mining companies are geographically congested into 2 regions, China (58%) and USA (16%). As a result, the risks factors that the mining sector face is amplified for the whole crypto industry. These risk factors include 1) Regulations 2) tax policies. A majority of the mining community across Europe, Asia and North America believe that the regulations are vague and require more clarity. Furthermore, the vast majority of miners in every region are opposed to value-added tax (VAT) laws (~90%). The crypto industry in general is concerned that these issues will be compounded by an increasingly centralized shift in power of mining companies in specific locations.

Macro Factors (PESTL analysis):

The future of crypto currency depends on a series of macro-economic trends that can be placed into three categories: Politics, Social/Culture, Technology and Legal. The major factors in each sub-category that will dictate the trajectory of crypto assets are listed in the diagram below.

Political	Social/Cultural	Technology	Legal
Instability in national currency drives the demand for digital currency	Preference of virtual versus physical transactions	Advances in technological alternatives that overcome less developed financial infrastructure in emerging markets wit	Adoption by Financial Institutions (FinTech)
Miners influence on protocol development	Stigma of crypto to support nefarious activity	Network Compromises (Hacks)	Government de/regulations
Economic Business cycles (high inflation)	Awareness/Adoption of crypto utilties	Mature/Saturated market	
		Increasing energy demand needed to validate future transactions	

Political

The advantages of crypto-currencies have been most promising for countries that operate around an unstable national currency (either due to high inflation or government manipulation). For example, venture investments in Bitcoin have taken off in Latin American (i.e. Argentina, Panama, Uruguay) countries where 60% of people do not have access to a bank. This trend is also exhibited in Kenya, where more than half of the GDP is linked to digital currencies. As smartphone technology become more accessible in developing countries, an estimated 5 billion people may be likely to adopt crypto currencies as well.[18] Additionally, as mining entities become more powerful, the crypto community will become more susceptible to their agenda. One of the major developments that threaten long-standing crypto-assets is ***Forks***. For Bitcoin's, this has been epitomized by recently created *Bitcoin cash* (BCH) and *Bitcoin Gold* (BTG). These crypto currencies were created as near copies of Bitcoin with minor changes and are expected to compete as substitutes. These hard forks diverge from Bitcoin based on minor protocol changes that are pushed by a network of miners seeking higher rewards from transaction costs.

Social/Cultural

Although crypto-assets are based off of a system of complex technologies and economic theory, its long-term sustainability hinges on its wide scale acceptance. Public sentiment surrounding crypto-assets remain to be the most notable driver of prices, as can be seen in Figure 8 below. This hypothesis has been supported by numerous studies that show strong correlation between various social media sentiments (Google[19], Twitter[20]) and crypto asset price. This phenomenon of 'emotional' trading is spurred on by the hype surrounding the disruptive blockchain technology, which is still not well understood. This creates a noisy, inefficient market that is difficult to decipher and leaves people susceptible to large gains/losses. This may be compounded with the activity of 'fake news' from people and/or machines that intentionally post inaccurate articles that ultimately influence the market [21]. Nefarious activity has surrounded crypto currencies since its inception (i.e. hacks and illegal transactions) and will continue to make people skeptical of its legitimacy. Despite the enticing appeal of a volatile market that experiences abnormal returns, it would be more beneficial in the long-term for the market to become more efficient and allay investor skepticism. Globalization and a

virtualized transaction platform encourage larger acceptance of crypto-platforms that are more suitable in a fully distributed markets.

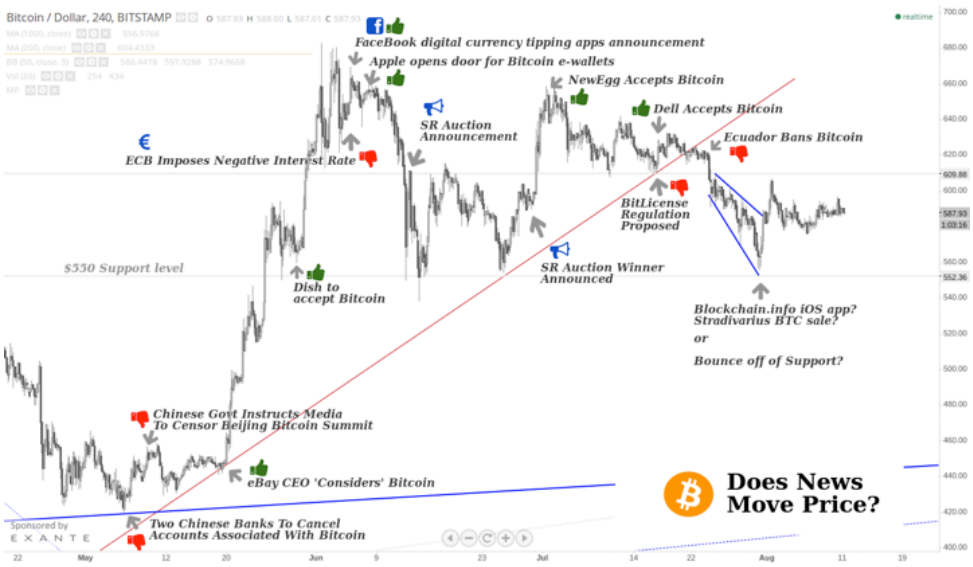


Figure 8: Timeline of notable news events and price action of Bitcoin

Technological

The world of crypto assets is evolving at an unparalleled rate that is intimidating for those who can't keep up with it (most people). As a new market experiencing the growing pains of establishing security and trust, there is much controversy about how a digital asset can be protected against exchange/wallet hacks. Bitcoin and other crypto-assets have a dark history of hacks that make people wary of its legitimacy [22]. This has led crypto-based businesses to invest a significant portion of their capitol (17%) in security systems that still can't guarantee the assurance of a centralized bank. However, crypto-currencies are well positioned to ride the e-commerce and fintech wave. The Blockchain protocol avoids touch point verification systems[23] that increase transaction costs and time. Still, Crypto assets would need to reduce their volatility in order to achieve a level of liquidity that can make them appealing for low-liquidity markets (such as micro-transactions).

Legal

There is a high level of legal ambiguity that surrounds crypto-assets including how it will be taxed and how it will be regulated. There is no universal standard for how to treat crypto assets, leading to regulatory policies that vary country to country. Most

countries interpret crypto assets as property that is subject to capital gains tax, however the degree of acceptance widely varies[24] Most recently, China displayed their stance against crypto-currency by declaring a ban on Bitcoin and shutting down number of exchanges in 2017.[25] Despite a temporary dip in the market, the prices of Bitcoin later surged and now China is reconsidering lifting the ban. [26] Establishing a standard for legal treatment of crypto-assets would help promote crypto-assets in the future.

Projections

In a recent report by RNR market research[27] predicted that the crypto currency industry to grow at a CAGR of 32.32% through 2023, reaching 2 trillion USD. [28, 29] This estimate was based off of the current adoption rate of wallets, which have doubled each year and the recent surge of asset-backed tokens that provide greater stability. The network sustaining crypto assets is expected to penetrate a broader audience (0.5-5%), resulting in more liquidity and driving up the market value. [22] This adoption will be highest in regions where the national currency is being devalued due to high inflation (Latin America, Africa, Middle East, Asia).

Among the crypto currencies that have benefited the most from a recent market growth is Ethereum. A 2016 interview conducted amongst blockchain experts predicted Ethereum to have a larger uptake within financial institutions, finTech, and E-commerce relative to bitcoin, which was only considered better suited for adoption in emerging markets. This resulted in a 5 year projected growth of 300% and 506% at the time in both BTC and ETH respectively [30]. The growth of Ethereum became evident recently as its price jumped to reach 3x its original value and eventually settled down in the later half of 2017.[31] The market has experienced bullish behavior that will likely be followed by a bear market in the near future. By 2020 BTC and ETH prices are expected to increase 2x and 3x respectively. These crypto assets are the clear market leader, where LiteCoin and Ripple exhibit lagging behavior.

Market Analysis

In the past years, crypto currencies have experienced high volatility indicative of a speculative market in its nascent stages. In spite of this, the market has experienced tremendous increase over a two-year span, shooting up from 12.7 Billion USD in July 2016 to a high of 112 billion in June 2017.[32] However, only select crypto-tokens have managed to create value where others quickly fizzled out or served as vehicles for pump-and-dump scams. This section explores key aspects of the crypto market including crypto: Segmentation, Benchmarking, Positioning.

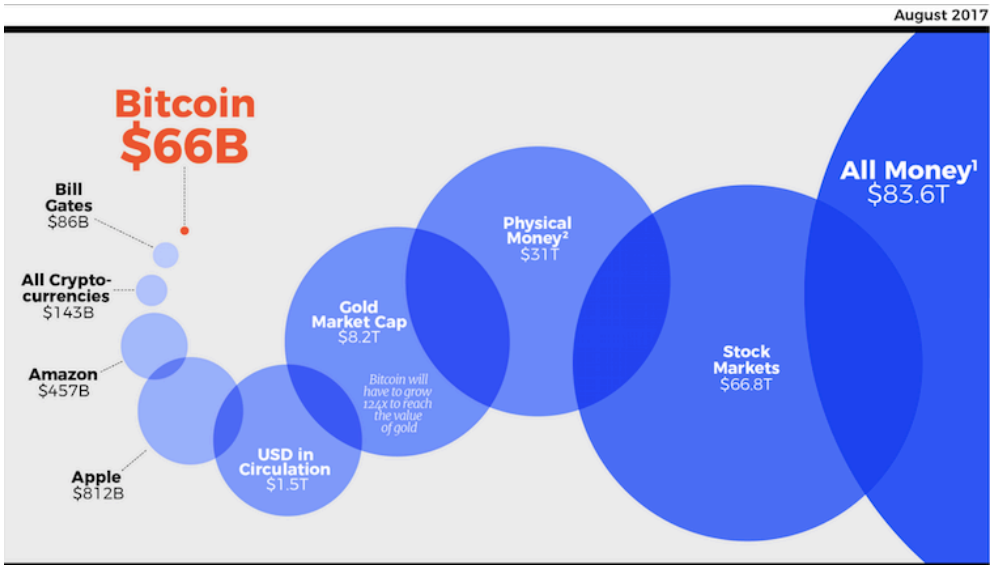


Figure 9: Relative scale of crypto market with other entities

Crypto-Segmentation:

Crypto tokens can be classified into four main classes: 1) Currency Tokens 2) Utility Tokens 3) Asset Tokens 3) Equity Tokens. Although crypto tokens can fit into multiple categories, these categories offer distinct models on how to promote user engagement and measure value generated. A framework for defining tokens and their functions can be seen below:

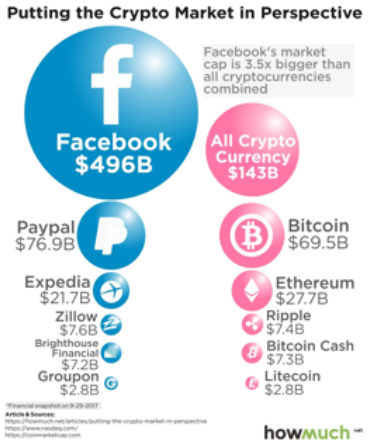
Token Class		
Role	**Goal**	**Features**
Currency	Smoothing transactions costs	Paying unit Buying unit
Utility	Providing Functionality and Accessibility	Network interface Markets interface Platform interface Usage Fees Product usage Product creation Active/Passive Work rewards
Equity	Creating user engagement	Voting Ownership Governance Profit Sharing Benefits Sharing

Currency Tokens: Tokens that serve as a medium of exchange for goods or services. The value of currency tokens is speculative, which is dictated by the amount of users and liquidity of the token.

Utility Tokens: Tokens that permit users to carry out actions on the network or provide users permanent or temporary control over a physical asset that is shared over the network. These encompass smart contracts and calls to application program interfaces. Services that have emerged around utility tokens include investment/prediction markets, gaming and social networks. Digital assets that are often coupled with a utility include computing power and storage space.

Equity Tokens: Tokens that imply ownership/control over the governance of the protocol. Companies that are strongly governed by equity tokens are known as decentralized authority organizations (DAO). Similar to stocks, it serves as a store of value and can be used to influence the direction of a company.

Crypto-Benchmark



The four most popular crypto currencies (as determined by market capitalization) on the market have account for over 90% of the crypto market. These crypto currencies include Bitcoin (BTC), Ethereum (ETH), Ripple (XRP), and Litecoin (LTC). [33]

Bitcoin is the original crypto currency and benefits from the network effect it has built since its eight years in operation.[34] In 2016, it was estimated that 54% of users use Bitcoin exclusively for investment purposes. However, Bitcoin has grown to provide non-monetary functions through the use of OP_RETURN, a feature to embed time-stamped metadata in transactions. Bitcoin is still the most popular crypto asset, but has yielded much of its market share to the other crypto currencies that have emerged over the years (~90% in 2016 to ~48% in 2017). Other crypto currencies have been able to cut into Bitcoin's market share by updating features from its blockchain protocol and branching out.

Ripple, created in 2012, was produced as a digital settlement network to enable real-time (4 seconds) and scalable payments across multiple currencies/commodities (i.e. USD, Bitcoin, Frequent Flier Miles, etc.).[17] Users can register gateways as trusted links between two parties making a transaction and become creditworthy intermediary for receiving and sending currencies. A public ledger is used to keep track of the credit, for any currencies that can be credited as a liability (fiat currency), and transaction flow for users/gateways on the system. The transaction fees for ripple are set at 0.00001 XRP. Ripple's payment network has already been adopted by 15 of the world's largest financial institutions as a global consensus ledger.

Litecoin, created in 2013,[35] essentially operates that same as bitcoin but differentiates itself via the mining protocol. Litecoin is designed to reduce the fixed block rate to 2.5 blocks per minute (4x faster than Bitcoin) and has a fixed supply of 84 million LTC. The reduction of the mining/hash rate lowers difficulty of mining and thus the barrier for users to participate in the mining process. As a result, litecoin has a much lower transaction cost (0.01% LTC) and can be traded much faster.

Rather than a currency, ***Ethereum*** is a software platform/programming language that operates on platform-specific token (ether) to compensate nodes for utilizing computations performed.[36, 37] Ethereum leverages the blockchain to run decentralized applications 'dapps' that eliminates fraud, downtime or interference by using 'Smart Contracts'. The crypto utility token that is used to access the Ethereum blockchain is known as Ether. In 2015, Ethereum partnered with Microsoft to create EbaaS "Ethereum blockchain as a service) a ethereum based development tool on the azure platform[1]. Other groups such as Intel, BP, UBS, and Accenture have also adopted Ethereum in what is known as the Enterprise Ethereum Alliance. Since then, Ethereum has been used to support more than 700 dapps that span across various industries (i.e. Vevue project, KYC-Chain and 4G capital), establishing itself as the most used blockchain for non-monetary applications.

Positioning

Based on the industry analysis and market, a list of the key financial indicators was compiled to evaluate the investment value of the aforementioned crypto assets. The highest weighted parameters were designated as public awareness/network effect, accessibility and utility, and transaction costs. At this point, a crypto-asset benchmark was performed to form a 3-year crypto portfolio (see Appendix 1). The portfolio consists of Bitcoin (37%), Ethereum (23%), Litecoin (22%) and Ripple (17%). A graphic of how the crypto assets are positioned in the weighted criteria is provided in figure 10 below.[38]

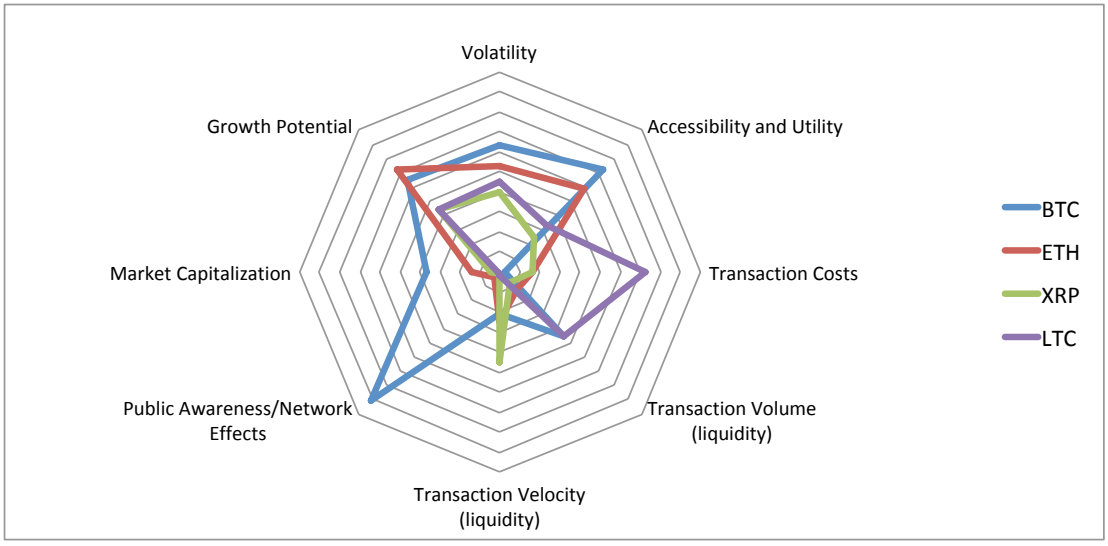


Figure 10: Positioning of Crypto-Assets (BTC, ETH, XRP, LTC)

Investment Perspective:

When the Internet took off in the late 1990s, the first generation of protocols (i.e. TCP/IP, HTTP, SMTP) used to transmit content generated a large amount of value. However, all of this value was captured by applications developed by companies that retained rights over the data (i.e. Google, Facebook, etc.). Dominant companies continued to grow, investing more resources to build their infrastructure, scale their services, and drive up the switching costs for its users. This led to the current state of the Internet, where the vast majority of the value generated by the Internet passes through a handful of companies based on an application. In a distributed protocol system, the value distribution is reversed because of two distinct reasons: 1) Shared Resources/Data 2) Cryptographic tokens.

1) Distributed protocol systems eliminate the need for capital investment in computing infrastructure via economically incentivized miners who supply the computing resources. Furthermore, data generated in a distributed protocol is freely available via the public ledger. These two characteristics drastically lower the barrier for entry of new application developers to launch a product operating on top of a suitable protocol. This results in a more competitive ecosystem for application developers that strengthen the network externalities of the underlying protocol.

2) Cryptographic tokens act as an extension of the protocol by providing users the right to access the network and its applications. In this structure, successful

applications built on top of well-designed protocols will appreciate the value of the crypto tokens, attract investors and drive up speculative value.

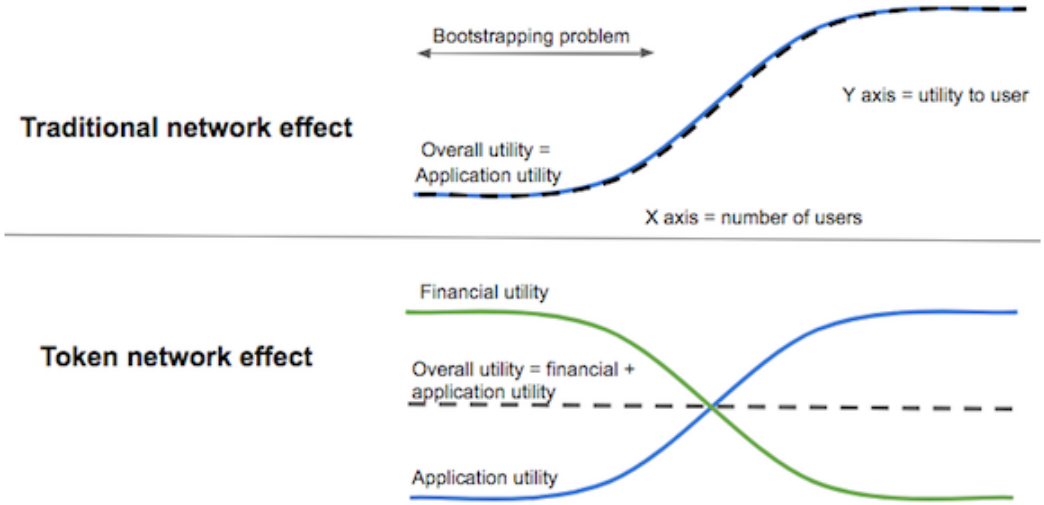


Figure 11: Crypto Tokens provide financial and application utility. This changes the dynamic of how an asset is adopted and gains in value.

With this model in place, it is beneficial to first classify a crypto-token as a digital asset in a distributed market place. Once this is designated, one can then build a more concrete understanding of a crypto-token's utility value within its network by using a tradition discounted cash flow model. Since all crypto tokens also serve as currencies, one must account for it's speculative value as its being traded on an exchange. Building from this three-step framework, one may place stronger confidence in a crypto equity investment.

Valuation Methods

As a new type of asset class that is continually evolving, methods of valuating crypto assets are still being developed. Based on the function and features of the different Crypto classes, two models can be applied separated to reflect the weighted intrinsic values of the asset (Utility Value/Economic Value).

Utility Value

Crypto tokens that exhibit strong utility value can be more readily treated as an economic entity. For these token the valuation method equate tokens to shares, reflecting value through buybacks, dividends and price appreciation. A discounted Cash Flow framework can be applied to understand price appreciation of crypto tokens, where the tokens represent digital good that hold a value. These digital goods (i.e. storage space, distributed computing, identify verification) represent a segment of a market with a projected growth. A fundamental analysis of the market growth and expected market share of a digital good can be used to compute the value flow (i.e. the value of the digital asset at discrete time steps).

(4) $$PV = \sum_{t=0}^{n} \frac{VF_t}{(1+r)^t}$$

In equation 4 above, the discounted cash flow equation can be used to compute the present value (PV) of crypto tokens based on the amount of time an investor chooses to hold onto the crypto asset (t).

(5) $$r = r_f + \beta_a(r_m - r_f)$$

The discount rate (r) is then estimated by either using a proxy or via the Capital Asset Pricing Model (CAPM) method. The CAPM equation, listed as equation 5 above, quantifies the relationship between systematic risk and the expected return. In the CAPM model for crypto tokens, the risk-free rate (r_f) is often measured in the form of a 10-year government bond yield and represents time value. The additional risk of investment is computed as the asset volatility (β_a) multiplied by the risk premium: the expected market return (r_f) – risk free rate). The expected market return is often approximated as the historic return rate of a crypto index (i.e. CAMCrypto30).

(6) $$\beta_a = \frac{cov(r_{a,}\square_b)}{var(r_p)}$$

The asset volatility for a crypto-asset is computed as the covariance of the historical returns of the crypto asset versus that of a benchmark over the variance of that benchmark. A common benchmark used to measure crypto-asset volatility is a fiat currency (i.e. USD).

Economic Value

Crypto currencies prove to be the most difficult class to model, as they do not reliably emulate traditional currencies or corporations with cash flow. A popular model that has been applied to model the price of crypto-currencies in the past was modifies Barro's (1979) model of the gold standard. [39] This model takes into account Supply-Demand, investor behavior and global financial indicators as the fundamental price drivers where the price equilibrium is derived from the relationships described below:

(1) $$M^S = P^{CC}B$$

The total Money supply of a crypto-currency (M^S) is computed as the exchange rate of the crypto currency (p^{cc}) multiplied by the total stock in circulation (B). This is shown as equation 1 above.

(2) $$M^D = \frac{PY}{V}$$

The demand in circulating crypto-currency of a crypto-currency (M^D) is computed in terms of the general price of goods and services (P), the size of the crypto currency economy (Y), and the velocity of crypto-currency use (V).

The price equilibrium of a perfectly efficient crypto-currency market (P^{CC}) is approximated as intersection of the supply and demand curves (i.e. $M^D = M^S$). From here, the **Investor behavior** (a), **global financial factors** (m), and noise representing other market inefficiencies (ε), are then incorporated into the model. Lastly, a logarithmic transformation is applied to the model (represented as lower case variables), resulting in the linearized price formula of crypto-currencies listed below:

(3) $$p_t{}^{CC} = \beta_0 + \beta_1 p_t + \beta_2 \gamma_t + \beta_3 v_t + \beta_4 a_t + \beta_5 m_t + \varepsilon$$

An empirical study published by the Economics and Econometrics research institute (EERI)[40] demonstrated that demand side variables and speculative investor behavior show the strongest impact on the price of Bitcoin. Furthermore, it shows that macro-financial indicators are statistically insignificant.

Summary:

These evaluation methods provide an intuitive guideline on how to conceptualize the prospective value of a crypto asset, but do not accurately capture the price. The problems that arise when applying traditional evaluation methods to crypto currencies are as follows:

1) The crypto market is nascent and does not provide enough data to form reliable models.
2) The nature of a crypto asset is difficult to define as it is based on a disruptive technology without clear boundaries.
3) The market is characterized by a feed-forward loop where speculative investment behavior creates high market inefficiencies.

The approach from the independent trading strategy is to use key trading indicators derived from equation 3 to create price action models. The models are fully parameterized in order to account for market inefficiencies and anticipate high-price fluctuations that frequently occur. The models for this approach are discussed in the next section.

Quantitative Methods:

This section takes a quantitative approach to extract economic and social indicators for monitoring crypto asset price action. The premise of this analysis is to support the development of a semi-automated trading bot that can achieve positive profit margins. The system schematics for the trading bot are shown below:

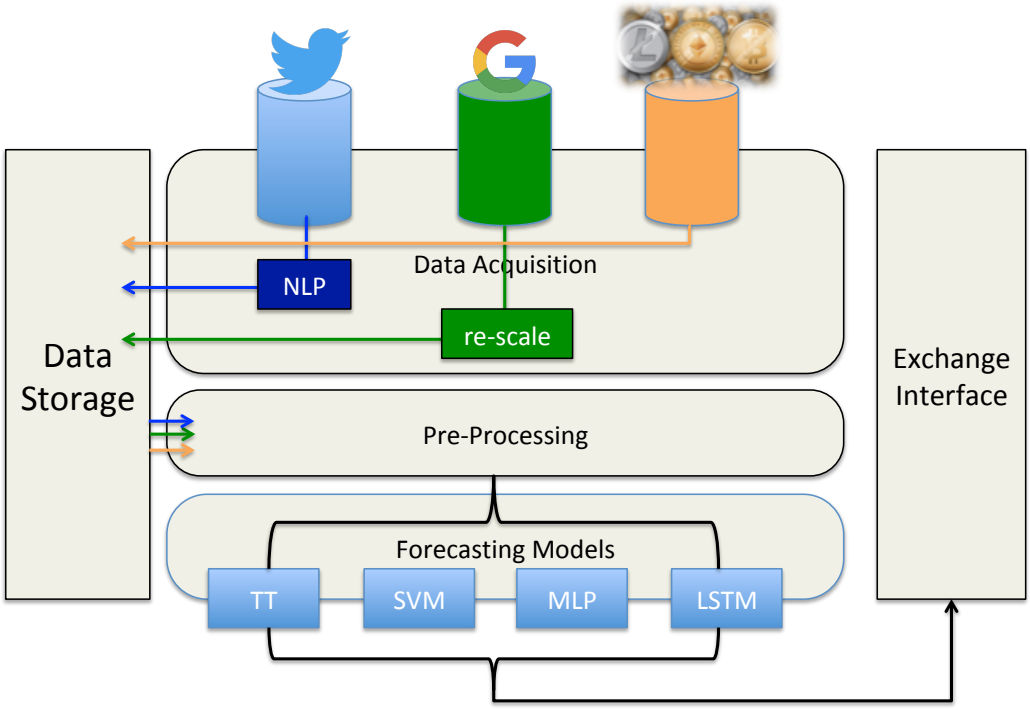


Figure 12: Schematic for semi-automated crypto trader

Data Collection and Pre-Processing

Data for this study has been collected via a multi-threaded web scraping application that streams financial and social data over a user-defined period of time. Data was obtained for the following crypto-assets:

1) Bitcoin (BTC)
2) Ethereum (ETH)
3) Ripple (XRP)
4) Litecoin (LTC)

Data retrieved from each source were logged in separate csv files for later analysis. The sources of the raw data are listed below:

Financial Data: A custom API wrapper running at a 15-second sampling rate was used to obtain trading data from an aggregate of all exchanges. The fields that were logged include:

- FROMSYMBOL: The ticker symbol for the crypto currency being recorded.
- LASTUPDATE: Timestamp of last trade completed across all exchanges.
- HIGH24HOUR: The highest price recorded across all exchanges in the past 24 hours.
- LOW24HOUR: The lowest price recorded across all exchanges within the past 24 hours.
- OPEN24HOUR: The opening price recorded across all exchanges at the beginning of the 24-hour timeframe.
- LASTVOLUMETO: The most recent trade value in USD.
- LASTVOLUME: The most recent trade volume in the unit of the crypto-asset.
- PRICE (C): Current Trading price of crypto-asset in USD.

Financial data was then post-processed during offline analysis in order to extend the feature set along a discretized timeline that could be synchronized with the social data. The additional financial features that were curated offline include:

- Change in Price (V)- The change in price over a 1-minute time increment (stationary).

$$V = P(t) - P(t-1)$$

- Weight-Price (W)- The weighted price implies a market clearing benchmark (P) and thus an underlying valuation (V) of the financial asset.

$$W = C(t) - C(t-1)$$

- Short-Term Rolling Average (rollS)- Closing price Rolling average over time = 6 hours

$$rollS = movavg(C, n)$$

- Long-Term Rolling Average (rollL) - Closing price Rolling average over time = 18 hours

$$rollL = movavg(C, n * 3)$$

- High-to-Open range (HO): this provides an indication of the positive price fluctuations that were observed in the previous 24-hour window.

$$HO = H_{24} - O_{24}$$

- Low-to-Open range (HO): this provides an indication of the negative price fluctuations that were observed in the previous 24-hour window.

$$LO = L_{24} - O_{24}$$

- Close-to-Open range (CO): this provides an indication of the net price fluctuations that were observed in the previous 24-hour window.

$$CO = C - O_{24}$$

- Weight-to-Open range (WO): this provides an indication of the net price fluctuations that were observed in the previous 24-hour window.

$$WO = W - O_{24}$$

- Stochastic Oscillator (K): Speed of momentum of the price.

$$K = 100 * \frac{C - Low_t}{High_t - Low_t}$$

- Price Rate of Change (PROC): Percentage change in price based on a previous data-point long term rolling average:

$$PROC = \frac{C(t) - rollL(t-1)}{\text{rollL}(\text{t} - 1)}$$

- Moving Average Convergence Divergence (MACD):

$$MACD = movavg(rollS(t) - rollL(t), n)$$

- Regional Strength Index (RSI): momentum indicator that denotes whether a stock is overbought or oversold

$$RSI = 100 - \frac{100}{1 + RS^*}$$

$$RS^* = \frac{avg\ gain\ over\ time\ (t)}{avg\ Loss\ over\ time\ (t)}$$

All data was obtained from the website cryptocompare: [41] an interactive platform to monitor real-time crypto data.

Social Data: Custom software modules were created to stream social data from Google trends and Twitter messages containing keywords.

Google Trend data was retrieved every 30 minutes to indicate the level of relative interest of a keyword query at 1-minute increments for the past 60 minutes. Data for a specific keyword is normalized to a scale of 100 for each search. Subsequent searches were scaled based on the offset relative interest of that keyword from the previous searches at matching time points. Keyword searches that were conducted to retrieve Google trend data include:

- Bitcoin
- Ethereum
- Ripple
- litecoin

The data was then post-processed during offline analysis in order to synchronize the social data along an absolute discretized timeline that could be shared with the financial data.

- Difference in Google Query (dG)- The change in normalized Google queries over a 1-minute time increment (stationary).

$$dG = G(t) - G(t-1)$$

All data was obtained using the python library pytrends[42] (a pseudo api for Google trends).

Twitter data was streamed to log tweet messages that contained keywords in real-time. Each tweet message was also processed using a Natural language processor (NLP) sentiment analyzer in order to compute the polarity of the message. The keywords that were used in retrieving messages about crypto data include [bitcoin, BTC, ethereum, ETH, ripple, XRP, litecoin, LTC]. The raw data fields that were logged include:

- Keyword: The keyword associated with the twitter message.
- id_str: The user who created the tweet.
- friends_count: The amount of friends associated with the user's account.
- followers_count: The amount of followers associated with the user's account.
- Negative: Negative polarity associated with the twitter message.
- Neutral: Neutral polarity associated with the twitter message.
- Positive: Positive polarity associated with the twitter message.
- Compound: Positive polarity associated with the twitter message.
- Text: Tweet message from user containing keyword.

The data was then post-processed during offline analysis in order to synchronize the social data along an absolute discretized timeline that could be shared with the financial data. The additional financial features that were curated offline include:

- Follower Compound Weight (FCW): this provides an indication of the weighted Compound score in 1-minute windows (weighted by the number of followers of user tweet). Compound is an aggregate of the polarity rating of a user's tweet.

$$FCW = \sum_{i=0}^{n} F_i * C_i$$

- Total Positive (P): this provides the total number of positive (Compound greater than 0) tweets that were sent over within a 1-minute time window.

$$P = \sum_{i=0}^{n} C_i > 0$$

- Total Negative (N): this provides the total number of negative (Compound less than 0) tweets that were sent over within a 1-minute time window.

$$N = \sum_{i=0}^{n} C_i < 0$$

All data was obtained using the python library tweepy[43] (a python library for accessing the Twitter API). Sentiment Analysis was conducted using the Valence Aware Dictionary and Sentiment Reasoner (VADER) [44] that is provided within the python natural language toolkit (NLTK) library.[45]

Forecasting models

The forecasting models that were used in creating a trading strategy include Turtle trading and long-short term memory

Turtle Trading[46] Richard Dennis and William Eckhardt established The Turtle trading system in 1983 to simplify trading based on objective rules and price signals. The system is defined to cover all trading decision criteria: Markets, trading Tactics, and

Position Sizing. The design of this crypto turtle trading strategy is intended to address each trading decision criteria in the following ways:

Markets: The turtle trading strategy should be implemented across a diverse set of markets with substantial trading volume. Although, the markets in this implementation are limited to Crypto-Assets, the assets being traded show steep trends and sufficient trading volume.

Trading *Tactics*: Trading tactics define rules on when to buy and when to sell. These rules are based on a Dual Moving Average Crossover (DMAC) algorithm that indicate strategic buy and sell points. As a difference between a long-term and short-term price action, the MACD signal line is used indicate positive and negative momentum swings. A threshold crossing is tuned to 10% of the previous data's maximum momentum value in order to designate a strategic time-point for buying or selling.

Position Sizing: The amount of units being bought and sold is gaited by the volatility of the asset over a short-term window. This reflects the confidence level of a strong trend raising the future value of an asset.

Alternatively, machine-learning algorithms can be used to incorporate a larger feature set (including social data) in order to predict future prices. Machine learning encompasses a broad category of self-learning algorithms that iteratively optimize prediction models by minimizing an objective function. The advantages of machine learning algorithms lie in their ability find unique and complex relationships in data without being explicitly programmed to find them. Instead, machine-learning algorithms can be designed as structured networks that are good at finding special patterns in the data. Machine learning frameworks can be powerful in high frequency crypto trading because of their ability to form accurate models from a sparse data-set in a market that is still under-defined. Once a reliable model is formulated, an independent can use anticipated price action from the model to make strategic trades (i.e. buy when the asset price is expected to rise significantly and sell when the asset price is expected to fall significantly).

A popular machine-learning algorithm that is designed to find temporal patterns data is called **Long-Short Term Memory networks (LSTM)**. LSTM's belong to a sub-category of machine learning algorithms called deep learning. The term is intended to

reflect the nature of how networks (composed of neurons and links) can be modularized to contain hidden layers, exposing complex relationships in the data. First proposed by Hochreiter Schmidhuber in 1997[47] LSTM networks are a version of recurring neural networks that have the ability of learning long and short-term dependencies. These deep learning frameworks are structured as cells associated with discrete time steps chained in sequence by the hypothesized output of the previous cell. Within each cell is a neural network that combines information from the previous state's output with the current state's feature set to form a new state hypothesis. LSTMs differentiate themselves from RNNs by containing a more detailed neural structure within their cells. An LSTM cell consists of neural stages that provide the ability to "forget", "add" and "remember" information.

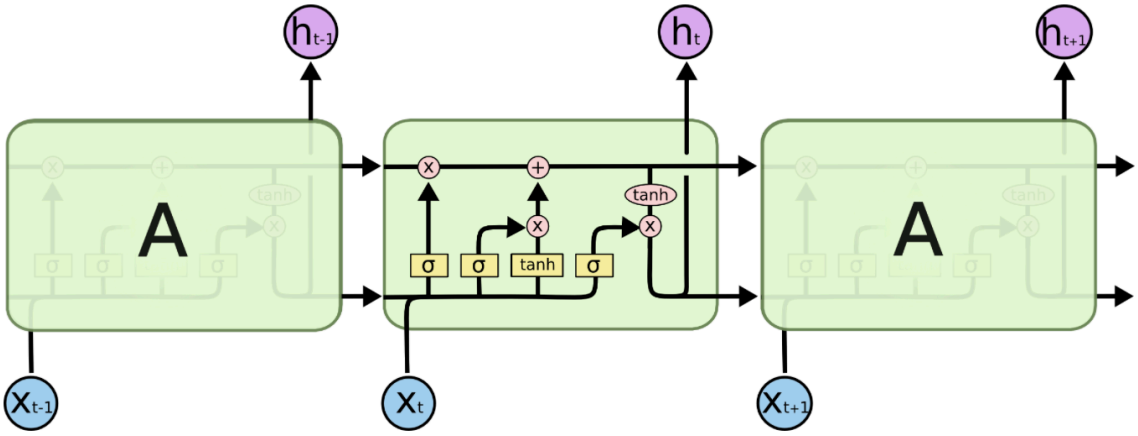


Figure 13: LSTM internal cell diagram

The Forget stage determines if the new data effects what we considered relevant (weight parameters) previously. If this is the case, the model scales the cell state down by how 'irrelevant' the old data has become.

$$f_t = \sigma(w_f[h_{t-1}, x_t] + b_f)$$

The Add stage determines which data values are most useful to update considering the context from weighted parameters from the previous states. Based on these values, it then scales the current hypothesized parameters.

$$i_t = \sigma(w_i[h_{t-1}, x_t] + b_f)$$

$$\widetilde{c_t} = tanH(w_c[h_{t-1}, x_t] + b_c)$$

The *remember stage* then computes a new weight parameters that will influence future states.

$$\theta_t = \sigma(w_o[h_{t-1}, x_t] + b_o)$$

$$h_t = O_t tanH(C_t)$$

Results

The ***turtle trading*** strategy was able to achieve a return on initial investment (ROI) of 28.2% over a 23-day period. A qualitative analysis indicates that the strategy was able to capture positive price swings while avoiding substantial price drops (See Figure 14). This finding is supported by the long tail distribution of the Profit-off-Sales (Pos) margins, following a gamma distribution with an expected PoS value of 2.71%. A more detailed report on the financial gains can be view in the Appendix 2.

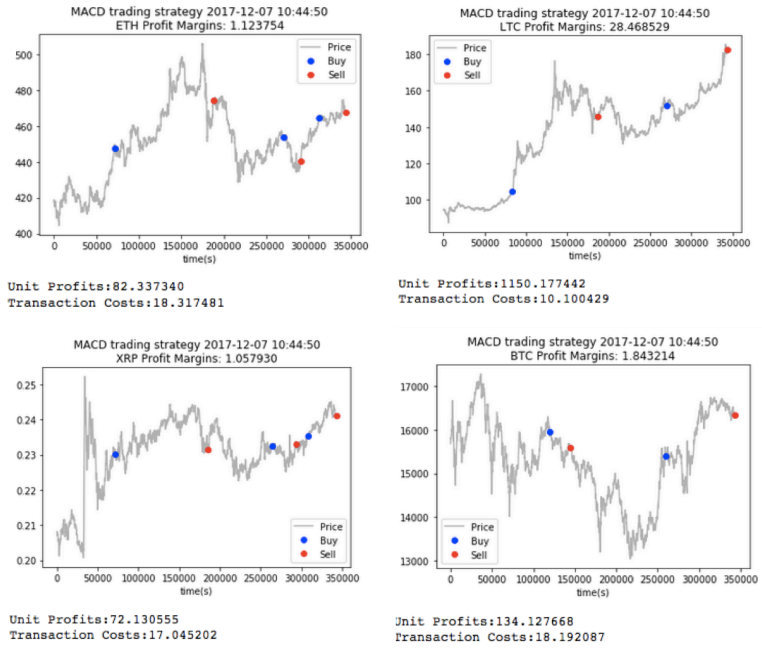


Figure 14: Trading results from DMAC turtle trading strategy implementation

In order to gage the success of a LSTM trading strategy, regression and classification models were trained to predict future price action at variable time-steps [1, 10, 30, 60, 180] minutes. Root-mean-square and mean absolute percentage error loss functions were used to measure the performance of in/out of sample regression models, while accuracy and F1 score were used for classification models. The ***LSTM*** models achieved peak performance while predicting 1-min future prices with an accuracy of 91%. Performance for both regression and classification models diminished for long-term future price predictions, which would need to improve in order to capture aggregate price gains. LSTM models show promise as potential trading strategies. However, due to a limitation in available computing resources, financial projections were only generated for the turtle trading strategy.

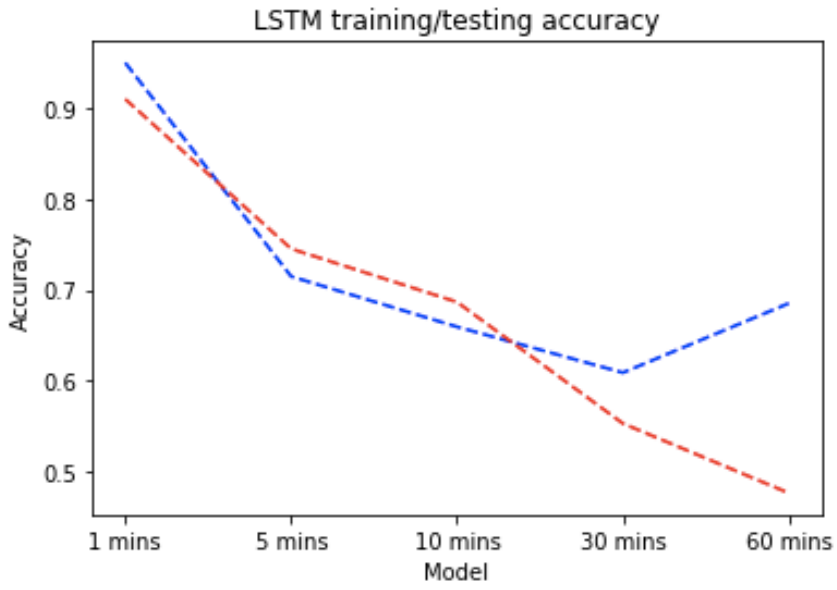


Figure 15: multi-class LSTM accuracy for future models

Financial Outcomes:

Provided the quickly evolving conditions that shape the crypto industry and asset value, a short-term financial projection is established to test the performance of each trading strategy. More than 23 days of data spanning 2 months was obtained via the acquisition module of the trading software in order to compute the out of sample success

of a MACD turtle trading strategy. The results were extrapolated to develop year-over-year financial projections over a 3-year period. This was then used to develop a free-cash-flow to value the business at the end of the 3-year time period (See Appendix 3-5). The decisions, assumption and deduction for on the financial projections are listed below:

Assumptions, Deductions and Decisions:

- Inflation is zero; ignore VAT-value added taxes
- The initial capital investment will have an annual depreciation rate of 33%.
- The algorithmic trading strategy is to be financed 100% by equity.
- Crypto assets are to be treated as a capital gain with a tax rate of 25% of profits. Tax savings from losses are received in the same year of their occurrence.
- GDAX Transaction fees equal 0.25% of takers price (Asset sold).
- Although this trading algorithm is fully automated and requires no employees, it will require maintenance to ensure financial security and R&D activities to develop higher performance algorithms for future use. I am willing to invest 20 hours per week at a rate of 30 USD per hour to fulfill this role.
- The cost for obtaining the software will be expensed as an initial investment leading-up to project launch. This is computed as the initial 3 months spent in research and development at a rate 30 USD per hour.
- The cost of reserving a personal computer to run the algorithmic trading bot throughout the first 3-years is 2000 USD.
- The algorithmic trading strategy is expected to function 365 days per year.
- Current trading algorithm performances will depreciate over a 4-year time-span due to trends in macro-economic climate, crypto market maturity and the entrance of more investors.
- For a debt-to-equity ratio of zero, I require a 10% on investment. Interest on personal loans considered for financing the project is expected to be 10%.
- A risk factor of 4.0 based on the relative volatility of Bitcoin to Gold is accounted for in estimating the WACC.
- Energy costs for running the trading software continuously for a year is expected to be a flat fee of 360 USD.

- Trade value per day will appreciate at the 5-year CAGR of the crypto industry.
- There is no limit on the amount of money that can be traded over a given period of time.
- Advanced receivable and advance payables are promptly paid.

Results

The revenue during a given period was calculated as the overall profit on crypto asset Sales during each trading period (PoS). During the period of testing, each crypto asset demonstrated a long-tailed PoS distribution with an overall mean profit margin of 2.71%. The total value of trades per day performed by the automated trader bot was 7,600 USD per day. Given the performance of the trading bot, a higher total value of trader per day would increase the profitability of the investment strategy. This is expected to occur during period of high price fluctuation.

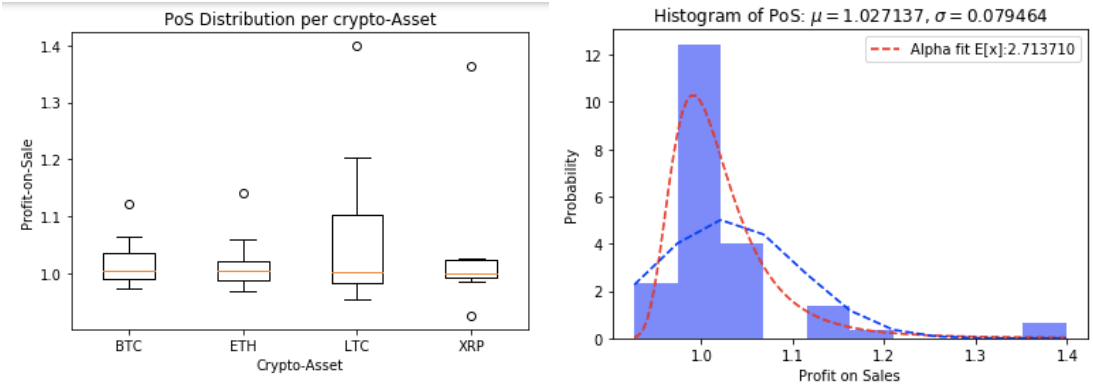


Figure 16: Profit-of-Sale (PoS) distribution for trading strategy (total number of trades = 63)

Coefficient values for unlevered Beta, risk free rate and market premium were obtained using benchmark values listed on damadora [48] in order to compute the weighted average cost of capitol (WACC) for the project. The equation to compute the WACC is as follows:

$$WACC = W_{dt} \times k_{dt} \times (1 - T) + (1 - W_{dt}) \times k_{st}$$

Once the initial WACC was computed, a risk multiplier based on the relative volatility of crypto assets to Gold [49] was applied to reflect the added risk of investing in the crypto market. The resultant WACC was 32.52%, which is a sufficiently high value reflecting

the risk of the market. The risk weighted average cost of capitol was used to find the discounted cash flow over each year of operation. Summation of these values was used to yield the Net present Value (16614 USD) with a discounted payback period of 1.46 years. Under the assumed conditions, the independent trading strategy results in a positive free cash flow over the 3-year investment period with a

Free Cash Flow	$ (30,000.00)	$ 30,010.30	$ 27,831.93	$ 18,899.27
WACC	32.522%			
Discount Factor	1	1.325218683	1.756204559	2.327355093
Discounted Free Cash Flow (DCF)	(30,000.00)	22,645.55	15,847.77	8,120.49
Net Present Value (NPV)	$ 16,613.81			
IRR	74.10%			

Figure 17: The independent Trading strategy is expected to yield a positive NPV

The WACC value is a function of the debt-to-equity ratio, tax rate and loan interest. Tax policies on earnings involving crypto assets are under-defined and vary from country to country. Adjusting the debt-to-equity ratio by taking on leverage to finance the project is a more assured way of gaining tax savings and lowering the WACC. However, the project is too risky and the assumed interest rate of 10% is too high to gain significant benefit from adding leverage.

Financial Assessment:

Tornado analysis was performed to identify the most significant factors that affect the output NPV of the project. The parameters used in this analysis were selected in order to understand the how to most effectively concentrate resources in order to mitigate financial risk. From this analysis, the most important factors that would contribute to the overall success of this project are the model performance and variable costs that lead to year-end EBITDA. See figure 18 below.

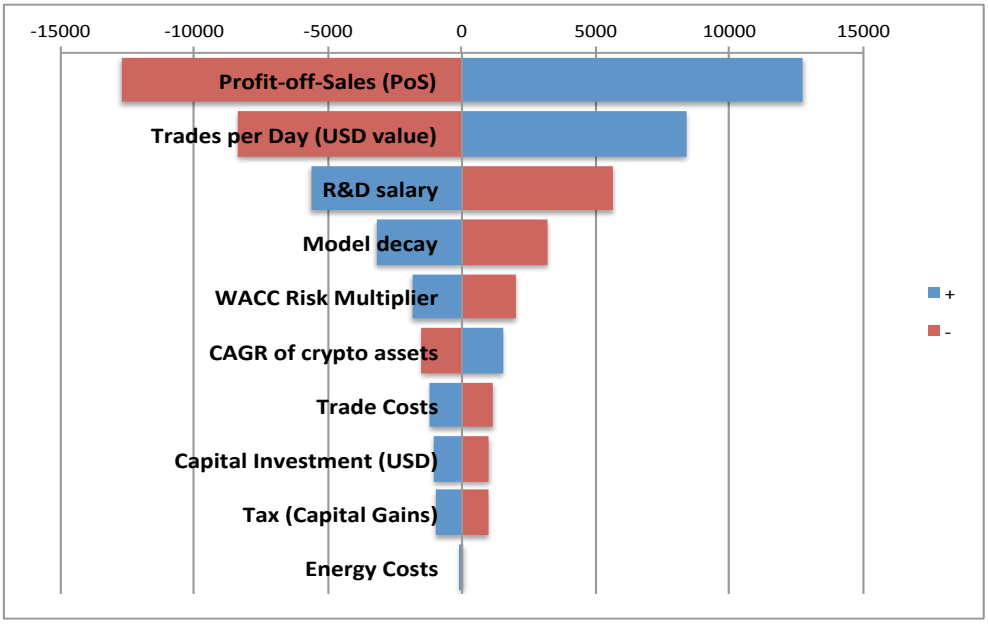


Figure 18: Tornado Chart to explore most influential factors

Improvements in the model performance are a result of Software R&D efforts for maintaining and improving the automated trader bot. These efforts are expensed based on the time (20 hour weeks) and rate (30 USD per hour) proposed as a personal opportunity cost. As a result, a key performance indicator (kpi) can be formed to measure productivity of software development throughout the 3-year project. This kpi would be useful to track and evaluate the value of resources allocated towards R&D. The kpi to track productivity is as follows:

$$Productivity = \frac{PoS}{R\&D\ salary}$$

Under the anticipated conditions, the Productivity level is set to be 9.03 e-4. By comparing the incremental changes in these two parameters, the appropriate salary level for achieving a profitable model can be determined, see figure 19 below.

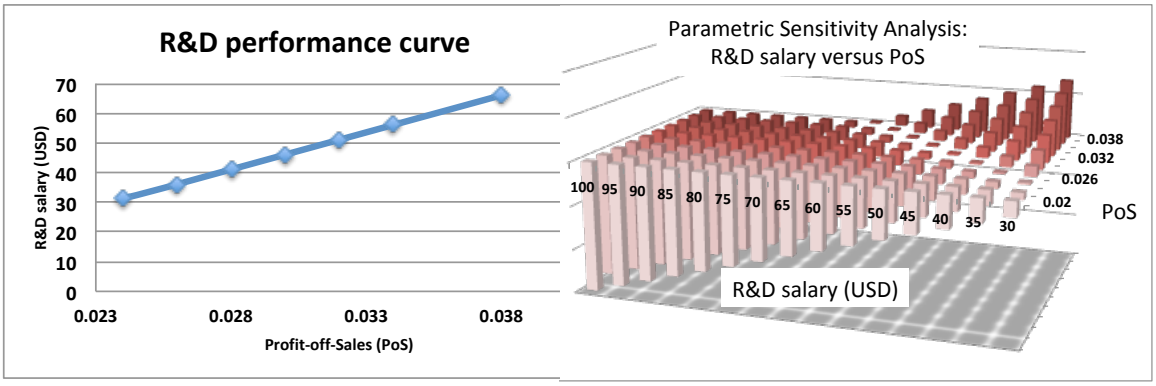


Figure 4: Salary levels required for sustaining a profitable project

Following this, a scenario analysis is conducted in order to gage of negative deviations in the financial projections can effect the outcome of the project. The parameters that were tuned during the scenario analysis Profit-off-sales, risk multiplier and model decay. In this analysis, the most influential weights are tuned as a percentage of their expected values to reflect pessimistic outcomes. The table for parameter tuning and results of the scenario analysis are provided below.

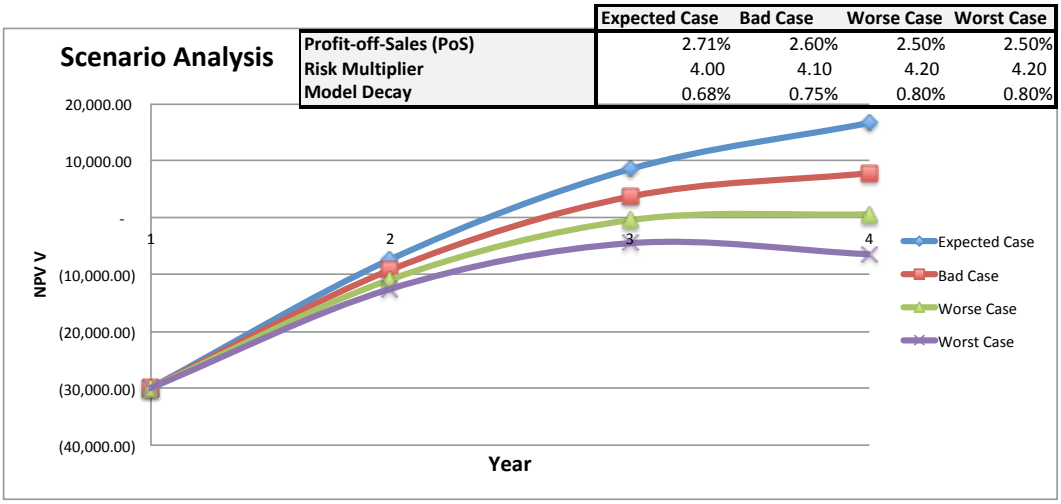


Figure 5: Scenario Analysis

Worst-case scenario analysis indicates that the project will not be profitable if a dependable model is un-assured. Profit-off-sales and model decay reflect the trading strategy's ability to capture evolving trends in the market. Measures may be taken to reduce the probability of pessimistic case scenarios by investing in more sophisticated model training (such as LSTM networks) based on larger data sets. The risk multiplier reflects exposure to uncertain conditions when investing in this premature, high-risk market. In order to avoid the conditions that would lead to worst-case scenario a risk analysis is performed in the next section.

Conclusion:

The independent trading strategy shows efficacy in capturing the positive price action that is exhibited in the crypto exchange market as can be seen in the long-tail distribution of profit margins (Figure 16). Based on the results obtain from the data, it would be a profitable investment moving forward. However, the data obtained for modeling the performance of the trading strategy is limited to under a month. Do to these limitation, the price signals in the data set do not comprehensively cover the historical price signals in the crypto exchange market. This creates statistical uncertainty that cannot be easily accounted for in the financial forecast analysis or the WACC risk multiplier.

With this in mind, I believe that an extra month of trading simulations would be appropriate to guarantee statistical significance of the independent trading performance. At the end of 2017, the crypto exchange markets exhibited abnormally high price gains causing the Bitcoin, Ethereum and Litecoin to be over-valued. This suggests that there will be a correction of the price levels for Bitcoin, Ethereum, and Litecoin at the beginning of 2018. This presents an opportune time to validate the trading model in a bearish market. If the model performs above break-even Profit-off-Sales levels while effectively avoiding negative price fluctuations, then it would be my recommendation to invest in the project.

References

1. Robinson, S (2003). "Still Guarding Secrets after Years of Attacks, RSA Earns Accolades for its Founders". *SIAM News 36 (5)* **36**: 5.
2. Nakamoto, S (2008). Bitcoin: A Peer-to-Peer Electronic Cash System.
3. Nakamoto, S (2008). Bitcoin: A Peer-to-Peer Electronic Cash System October 31, 2008 ed. Nakoto Institute.
4. Wiki, B. https://en.bitcoin.it/wiki/Proof_of_work.
5. (Dec 24, 2017). Silk Road (Marketplace) https://en.wikipedia.org/wiki/Silk_Road_(marketplace).
6. Brandom, R, and Jeong, S Why the feds took down one of Bitcoin's largest exchanges https://www.theverge.com/2017/7/29/16060344/btce-bitcoin-exchange-takedown-mt-gox-theft-law-enforcement.
7. Wong, JI CoinMap: Bitcoin-Accepting Merchants Increased 81% in November https://www.coindesk.com/surge-in-real-locations-accepting-bitcoin/.
8. System, BoGotFR How much U.S. currency is in circulation? https://www.federalreserve.gov/faqs/currency_12773.htm.
9. Bedell, D, and Pasquali, V Payments Volumes Worldwide https://www.gfmag.com/global-data/economic-data/26gzj8-payments-volumes-worldwide.
10. Anderson, S A history of the past 40 years in financial crises http://www.ifre.com/a-history-of-the-past-40-years-in-financial-crises/21102949.fullarticle.
11. (2016). United States National Debt https://countryeconomy.com/national-debt/usa.
12. (2010--2017). Historic inflation United States- CPI inflation http://www.inflation.eu/inflation-rates/united-states/historic-inflation/cpi-inflation-united-states.aspx.
13. Research, OoF (2017). Cybersecurity and Financial Stability: Risks and Resilience https://www.financialresearch.gov/viewpoint-papers/files/OFRvp_17-01_Cybersecurity.pdf.
14. Research, B. Bitcoin volatility will match major fiat currencies by 2019, 2016.
15. ElBahrawy, A, Alessandretti, L, Kandler, A, Pasto-Satorras, R, and Baronchelli, A (2017). Evolutionary dynamics of the cryptocurrency market https://arxiv.org/abs/1705.05334.

16. Williams-Grut, O (2017). GOLDMAN: It's getting harder for institutional investors to ignore cryptocurrencies http://www.businessinsider.com/goldman-sachs-cryptocurrencies-bitcoin-ethereum-icos-2017-8.
17. http://www.blockchain.info.
18. Magee, C (2015). Bitcoin Blazes New Trail in Emerging Markets. In: Network, C (ed).
19. Edwards, J (Sept 19, 2017). The price of Bitcoin has a 91% correlation with Google searches for bitcoin. *Markets Insider*.
20. Colianni, S, Rosales, S, and Signoroti, M. Algorithmic Trading of Cryptocurrency based on Twitte Sentiment ANalysis.
21. Aru, L (2017). How Bots and Black Marketers are Influencing Bitcoin Price, Altcoins Value https://cointelegraph.com/news/how-bots-and-black-marketers-are-influencing-bitcoin-price-altcoins-value.
22. Hern, A (18 Mar 2014). A history of bitcoin hacks. *Guardian News*.
23. Bulkin, A (May 3, 2016). Explaining blockchain—how proof of work enables trustless consensus.
24. Peaster, WM (November 29, 2017). Bitcoin, Cryptocurrency and Taxes: What You Need to Know. Blockonomi.
25. Rapoza, K (Nov 2 2017).
26. Gao, A (Oct 29, 2017). Chinese Might be Able to Trade Bitcoin Again Soon.
27. (Oct 13, 2017). Cryptocurrency Market to Grow at 32.31% CAGR to 2023. *Market Watch*.
28. http://www.economist.com/sites/default/files/the_future_of_cryptocurrency.pdf.
29. D'Alfonso, A, Langer, P, and Vandelis, Z (Oct 17, 2016). The Future of Cryptocurrency. pp 1-24.
30. D'Alfonso, A, Langer, P, and Vandelis, Z (2016). THe Future of Cryptocurrency http://www.economist.com/sites/default/files/the_future_of_cryptocurrency.pdf.
31. Bovaird, C (June 9, 2017). 3,000% Gains in 2017: What's Next for Ether Prices?
32. Cryptochurrency Market Capitalizations.
33. (2017). Visualing the Crypto Bubble. Are we headed for another Dot-Com Disiaster? https://howmuch.net/articles/putting-the-crypto-market-in-perspective.
34. Nakamoto, S. Bitcoin: A Peer-to-Peer Electronic Cash System.
35. (2011-2016). https://litecoin.org/.
36. (2015).

37. Shieber, J (2015). Microsoft partners with ConsenSys to use Ethereium to provide blockchain-as-a-service https://techcrunch.com/2015/10/28/microsoft-partners-with-consensys-to-use-ethereum-to-provide-blockchain-as-a-service/.
38. Microsoft partners with ConsenSys to use Ethereum to provide blockchain-as-aservice https://techcrunch.com/2015/10/28/microsoft-partners-with-consensys-to-use-ethereum-to-provide-blockchain-as-a-service/.
39. Barro, R (1979). Money and the Price Level under the Gold Standard. *Economic Journal* **89**: 13-33.
40. Ciaian, P, Rajcaniova, M, and Kanes, dA The Economics of BitCoin Price Formation https://arxiv.org/ftp/arxiv/papers/1405/1405.4498.pdf.
41. . https://www.cryptocompare.com/.
42. pytrends 4.1.1 https://pypi.python.org/pypi/pytrends/4.1.1.
43. . Tweepy: An easy-to-use Pythoon library for accessing the Twitter API.
44. Hutto, C, and Gilbert, E. VasderL A oarsunibuy=ous Rule-based model for Sentiment Analysis of Social Media Text.
45. . Natural Language Toolkit.
46. (2003). http://bigpicture.typepad.com/comments/files/turtlerules.pdf.
47. Hochreiter, S, and Schmidhuber, J (1997). Long Short-Term Memory. *Neural Computation* **9**: 1735-1780.
48. Danmodaran, A (2017). Damodaran Online http://pages.stern.nyu.edu/~adamodar/.
49. Bitcoin Volatility TIme Series Charts https://www.buybitcoinworldwide.com/volatility-index/.

Appendices:

Appendix 1: Crypto Asset Benchmark

Benchmarking Crypto-Currencies										
Key Trading Indicator (KTI)	BTC		ETH		XRP		LTC		Weights	
	Value	Norm	Value	Norm	Value	Norm	Value	Norm	Rating (1-10)	Norm
Volatility	5	1	6	0.83333	8	0.625	7	0.714	7	13.46%
Accessibility and Utility	116.6	1	95.1	0.81561	39	0.33019	53.4	0.458	8	15.38%
Transaction Costs	$ 2.70	0.03	$ 0.34	0.22	$ 0.34	0.22	$ 0.07	1.00	5	9.62%
Transaction Volume (liquidity)	30,000	1	8,000	0.26667	4,800	0.16	30,000	1	5	9.62%
Transaction Velocity (liquidity)	250,000	0.45455	300,000	0.54545	550,000	1	19,300	0.035	5	9.62%
Public Awareness/Network Effects	800	1	32	0.04	6	0.0075	6	0.008	10	19.23%
Market Capitalization	71.7	1	28.7	0.40028	9.9	0.13808	2.8	0.039	4	7.69%
Growth Potential	9	0.9	10	1	6	0.6	6	0.6	8	15.38%
Total	0.83863863		0.529166398		0.371933402		0.46		52	100%
	0.381409862		0.240662993		0.169153986		0.208773158			

Appendix 2: Turtle trading strategy results

Date	nSells (Count)	nSells (USD)					Transaction Fees (Parameters)	BTC margins	ETH margins	LTC margins	XRP margins	Original Portfolio (Decision)			
11-3,11-6	9	20,308	0.53%	-2.05%	-1.61%	-0.76%	0.25%	0.53%	-2.05%	-1.61%	-0.76%	BTC	36.8%		
11-15,11-20	16	42,384	7.74%	6.38%	3.93%	-5.98%		7.74%	6.38%	3.93%	-5.98%	ETH	23.7%		
11-23,11-27	9	22,945	11.56%	9.02%	9.58%	2.47%		11.56%	9.02%	9.58%	2.47%	LTC	16.8%		
12-7,12-11	10	25,462	3.65%	3.47%	68.29%	3.19%		3.65%	3.47%	68.29%	3.19%	XRP	22.6%		1%
12-12,12-20	19	62,733	2.06%	9.28%	7.73%	39.20%		2.08%	9.36%	7.80%	39.55%		100%	"=="	100.000%
Per Day	2.760719394	7,617													

Turtle Trading Strategy

Transaction Fee 0.25%

			BTC 36.8%				ETH 23.7%				LTC 16.8%				XRP 22.6%								
Total Investment	Date	Total time (s)	Initial Investment	USD profit	Trans Costs	profit margin	Initial Investment	USD profit	Trans Costs	profit margin	Initial Investment	USD profit	Trans Costs	profit margin	Initial Investment	USD profit	Trans Costs	profit margin	Total profits	Trans Costs	Net Profit	Profit margins (initial day's investment)	Profit margins (Value of sales)
$ 10,000.00	11-3,11-6	244,560	$ 3,679.72	$ 19.41	$ 9.20	0.527%	$ 2,372.91	$ (48.71)	$ 17.76	-2.053%	$ 1,684.31	$ (27.03)	$ 12.54	-1.605%	$ 2,263.07	$ (17.12)	$ 11.27	-0.756%	$ (73.46)	$ 50.77	$ (124.23)	-1.24%	-0.61%
$ 9,875.77	11-15,11-20	435,360	$ 3,634.01	$ 281.42	$ 47.61	7.744%	$ 2,343.43	$ 149.42	$ 23.71	6.376%	$ 1,663.38	$ 65.34	$ 12.29	3.928%	$ 2,234.95	$ (133.60)	$ 21.04	-5.978%	$ 362.58	$ 104.64	$ 257.94	2.61%	0.61%
$ 10,133.71	11-23,11-27	348,480	$ 3,728.92	$ 431.07	$ 18.59	11.560%	$ 2,404.64	$ 217.02	$ 18.76	9.025%	$ 1,706.83	$ 163.55	$ 9.16	9.582%	$ 2,293.33	$ 56.62	$ 11.62	2.469%	$ 868.25	$ 58.13	$ 810.12	7.99%	3.53%
$ 10,943.84	12-7,12-11	343,440	$ 4,027.03	$ 146.79	$ 19.91	3.645%	$ 2,596.87	$ 90.11	$ 20.05	3.470%	$ 1,843.28	$ 1,258.74	$ 11.05	68.288%	$ 2,476.66	$ 78.94	$ 18.65	3.187%	$ 1,574.57	$ 69.66	$ 1,504.91	13.75%	5.91%
$ 12,448.74	12-12,12-20	599,820	$ 4,580.79	$ 94.59	$ 56.78	2.065%	$ 2,953.97	$ 274.14	$ 36.37	9.280%	$ 2,096.75	$ 162.15	$ 20.44	7.733%	$ 2,817.23	$ 1,104.43	$ 43.24	39.203%	$ 1,635.31	$ 156.83	$ 1,478.48	11.88%	2.36%
$ 13,927.22		1,971,660		$ 973.27	$ 152.10	5.108%		$ 681.97	$ 116.64	5.220%		$ 1,622.74	$ 65.48	17.585%		$ 1,089.28	$ 105.83	7.625%	$ 4,367.26	$ 440.04	$ 3,927.22	28.20%	2.36%
		22.82	days of trading																$ 4,367.26	$ 440.04	$ 3,927.22		
																			-	-	-		

Appendix 3: Investment Strategy Financial Projections

Financial Projections				
		2018	2019	2020
	0	1	2	3
Profit-off-Sales (PoS)	2.71%	2.71%	2.03%	1.35%
Trades per Day (USD value)	$ 7,600.00	$ 7,600.00	$ 10,056.32	$ 13,306.52
CAGR of crypto assets	32.32%			
R&D salary	$ 30.00			
Trade Costs	0.25%			
Model decay	0.68%			
Energy Costs	$ 360.00	$ 360.00	$ 360.00	$ 360.00
Capital Investment (USD)	$ 12,000.00			
Tax (Capital Gains)	25%			
WACC	32.522%			
Risk Multiplier	4.00			
Equity	100%			
Interest Rate on Personal Loan	10%			
USD Inflation (2017)	1.90%			
Software + R&D	$ 18,000.00	$ 31,200.00	$ 31,200.00	$ 31,200.00
Computer Costs	$ 2,000.00			
Advanced Receivables	prompt payment			
Advanced Payables	prompt payment			
Debt	0%			
3-year loan (financial charges)	-			
Financial charges (interest on loan)		$ -	$ -	$ -

Appendix 4: Investment Strategy Profit & Losses

	Profit & Loss:				
			2018	2019	2020
		0	1	2	3
365	Trade per day (USD value)		$ 7,600.00	$ 10,056.32	$ 13,306.52
	Model performance (RoT)		2.71%	2.03%	1.35%
	Earnings		$ 75,175.40	$ 74,512.30	$ 65,567.89
0.25%	COGS (Transaction Costs)		6935	9176.392	12142.20189
1	Energy		$ 360.00	$ 360.00	$ 360.00
	Software R&D (Oportunity cost)		$ 31,200.00	$ 31,200.00	$ 31,200.00
$30,000.00	Depreciation		10000	10000	10000
	EBIT	$ -	$ 26,680.40	$ 23,775.91	$ 11,865.69
	Financial Charge (Personal loan)		$ -	$ -	$ -
	Profits before Tax		$ 26,680.40	$ 23,775.91	$ 11,865.69
25%	Taxes on EBIT		$ 6,670.10	$ 5,943.98	$ 2,966.42
	Net PROFIT		$ 20,010.30	$ 17,831.93	$ 8,899.27
0	Receivables	0	0	0	0
0	Stocks	0	0	0	0
0	Payables	0	$ -	0	0

Appendix 4: Investment Strategy Free Cash Flow

	Free Cash Flow				
	EBIT	$ -	$ 26,680.40	23775.91104	11865.68834
	Taxes on EBIT		$ 6,670.10	5943.97776	2966.422084
	Depreciation		10000	10000	10000
	- Ch Stocks		0	0	0
	- Ch Receivables		0	0	0
	+ Ch Payables		0	0	0
	- Investment	$ (30,000.00)			
	FCF (sources)	**$ (30,000.00)**	**$ 30,010.30**	**27831.93328**	**18899.26625**
100%	Equity issues	-30000.0			
0%	Debt	0.0			0.0
	Interest from Debt		0.0	0.0	0.0
	Tax savings from interest		0.0	0.0	0.0
	Dividends		10010	7832	0
	Ch in cash	0.0	20000.0	20000.0	18899.3
	FCF (applic)	**(30,000.00)**	**30,010.30**	**27,831.93**	**18,899.27**

Appendix 5: Investment Strategy Balance Sheet

Balance Sheets				
Gross Fixed Assets	30,000.00	30,000.00	30,000.00	30,000.00
Acc depreciation		10,000.00	20,000.00	30,000.00
Net Fixed Assets	30,000.00	20,000.00	10,000.00	-
Stocks		-	-	-
Receivables		-	-	-
Cash	-	20,000.00	40,000.00	58,899.27
Total Assets	**30,000.00**	**40,000.00**	**50,000.00**	**58,899.27**
Equity Capital	30,000.00	30,000.00	30,000.00	30,000.00
Retained earnings		(10,010.30)	2,168.07	20,000.00
Net income		20,010.30	17,831.93	8,899.27
Total equity	30,000.00	40,000.00	50,000.00	58,899.27
Loans	-	-	-	-
Payables		-	-	-
Total Eq+Liab	**30,000.00**	**40,000.00**	**50,000.00**	**58,899.27**
	0	0	0.0	0