Ex-ante uncertainty as a determinant of Initial Coin Offering underpricing

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OF TWENTE.

Abstract:

This thesis examines the influence of ex-ante uncertainty determinants on the underpricing of Initial Coin Offering (ICO) in a hand collected sample in 2017-2018. The proxies used for ex-ante uncertainty are adapted from the models of IPO underpricing, specifically Beatty and Ritter (1986). ICOs differ from IPOs in numerous ways and this research utilizes an established model for IPO underpricing for ICOs. The proxies used are issue size, whitepaper pages and project age. The results suggest that ICOs, on average, are underpriced and that underpricing is greater if ex-ante uncertainty is greater.

Keywords: Underpricing, ex-ante uncertainty, ICO, Initial Coin Offering.

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1. Introduction:

Cryptocurrency is a digital currency that uses cryptography in order to make online transactions more secure. Most of the cryptocurrencies consist of decentralized systems that are essentially based on blockchain technology, which is a distributed ledger imposed by a diverse network of computers. An ICO (Initial Coin Offering) is the first public offering of a cryptocurrency and can be viewed as an IPO (Initial Public Offering) for cryptocurrency. During the IPO / ICO, there can be a difference in the offer price and the market price of the stock / cryptocurrency.

"Underpricing is the phenomenon whereby the price of an asset is on average set too low during an issue." (Felix, 2018) This concept leads to the process where the price of the tokens adjusts to the market value over the course of the listing day. ICO underpricing is poorly documented, while IPO underproducing is well-documented. The first goal is to determine whether or not ICOs are underpriced and secondly why?

"One extension of Rock's (1986) model is the ex-ante uncertainty theory; this suggests that higher ex-ante uncertainty requires a higher level of underpricing, and that underpricing serves as compensation for this problem (Beatty and Ritter, 1986)." Beatty and Ritter (1986) state that if the ex-ante uncertainty is higher, an investor is willing to pay a lower price for the asset. Since ICOs are new and poorly regulated, there is a high level of information asymmetry as there may be only a few people knowing the actual characteristics of the venture's plans. This leads to my hypothesis that the amount of ex-ante uncertainty is positively related to the level of underpricing for ICOs.

Because of the differences between IPOs and ICOs, this research will add to the existing literature by testing which determinants influence ICO underpricing. There is a substantial research gap since little research has been done about ICOs because it's a relatively new phenomenon. Thus this research will add to the existing literature by providing further empirical outcomes for a theory which is taken in high regard for the underpricing in IPOs. The research question is the following:

Is the underpricing greater if the ICO has a greater ex-ante uncertainty?

2. *Cryptocurrency:*

This chapter will first describe cryptocurrency in general, then stipulate the ICO process and end with key differences / similarities between ICOs and IPOs.

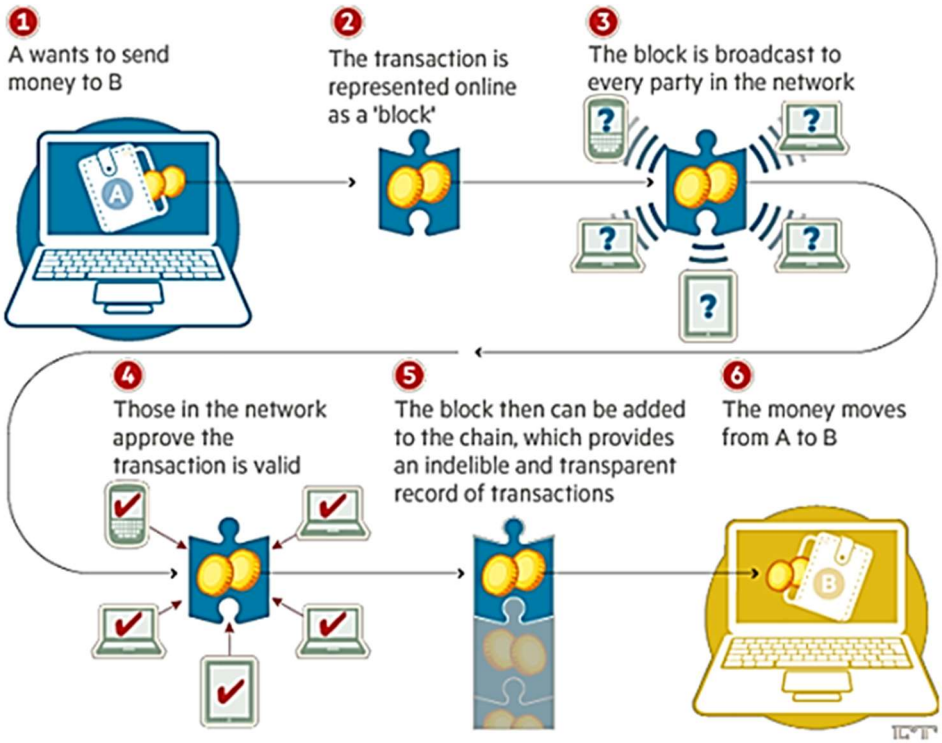
2.1 Cryptocurrency overview

A feature that is the absolute trademark of cryptocurrency and at the same time its biggest allure is the organic nature it possesses. There is no centralized authority issuing it, which in theory renders the whole concept immune to any form of (undesired) governmental manipulation or interference.

2.1.1 Blockchain

Blockchain is at the heart of cryptocurrency, and first an introduction of this technology will be given. Blockchain is a specific subset of the Distributed Ledger Technology (DLT), which is a method to record and share data between several data stores (or the so-called ledgers). These ledgers each have exactly similar data records and are regulated by a dispersed network consisting of computer servers, or also known as 'nodes'. The figure below shows how a blockchain works.

Fig. 1 The blockchain



("Technology: Banks seek the key to blockchain | Financial Times", 2019)

A key advantage of this blockchain technology is the fact that the implementation of a bunch of transactions that would usually require intermediation of a third party (e.g. a bank, a broker, a custodian etc.) can be simplified in such a way that those parties are no longer needed. Fundamentally the main importance of blockchain is that the trust is decentralized as well as the authentication of transactions. This makes the middleman dispensable.

Cryptocurrencies can be seen as virtual systems allowing for secure payments of online transactions, those systems are called 'tokens', which represent ledger entries internal to the system itself. The reason they are starting with "crypto" is that it refers to numerous algorithms used to encrypt the transactions as well as "cryptographic techniques, such as elliptical curve encryption, public-private key pairs, and hashing functions, are employed." ("Cryptocurrency", 2019)

2.1.2 Cryptocurrencies

The most well-known cryptocurrency is Bitcoin, and for this particular example, the terminology is applicable. However, after the creation of Ethereum, which has enabled the market to create all kinds of coins due to smart contracts, the term currency does not fit most coins.

Next, to the widely familiar Bitcoin there are hundreds of alternative coins or so-called altcoins. A lot of the initial altcoins are built using Bitcoin's open-source protocol with a few adaptations to the code, resulting in a brand-new coin that possesses different characteristics. Then there are also the altcoins that are not using Bitcoin's open-source protocol and have their own ledger and open protocol. A good illustration is Ethereum.

"Illustrative is that the total market capitalization of the 100 largest cryptocurrencies is reported to exceed the equivalent of EUR 330 billion globally by early 2018." ("Cryptocurrencies and blockchain", 2018)

The popularity of cryptocurrencies has increased tremendously over the past few years and as stated in the quote above, the fiat circulation is immense. If one looks at the total market capitalization, the number doubles to an astonishing 728 billion US dollars by early 2018.

2.1.3 ICOs

Projects have started to use an ICO (initial coin offering) with the goal to raise capital. This funding is then used to build the features which facilitate a function for which the coin will be used as payment. To some extent, the process of an ICO is similar to an IPO (initial public offering). The differences are that no equity is being sold, but instead, the ability to utilise an application. Moreover, when companies go public via an IPO, they have a proven track record and must comply with legislation and the set of rules from exchanges. There is a middleman in the form of an underwriter who sets the price after book building. An ICO is a much leaner process with little to no regulation. In simple terms, this means that person x has an idea for a coin, creates a project, website, whitepaper and sets an ICO date and price. Person y finds out about this idea, sends funds to a contract, gets his coins, and person x just raised capital and can continue to build the use behind the coin.

"In an initial coin offering (ICO), new ventures raise capital by selling tokens to a crowd of investors. Often, this token is a cryptocurrency, a digital medium of value exchange based on the distribution ledger technology." (Fisch, 2019)

As stated in this quote, new ventures aim to raise capital to kickstart and properly execute their operations by issuing their tokens to a crowd of investors. The most common section in which these initial coin offerings (ICOs) happen, is at ground-breaking ventures using distributed ledger technology (DLT) and in particular the blockchain technology. The so-called tokens are often used as currency in the venture's niche. Those tokens have a particular value that is decided by the venture, and it has the potential to cover a wide range of applications. Commonly, the tokens provide either a utility or they function as securities. Those two are frequently seen as two different types of tokens. (Sameeh, 2018) The main constitutor of ICO tokens are the utility tokens, which are linked to a virtual medium and used to exchange a particular utility that the venture offers. "Cryptocurrency refers to a digital medium of value exchange and is also referred to as a coin (hence the term "initial coin offering")." (Fisch, 2019)

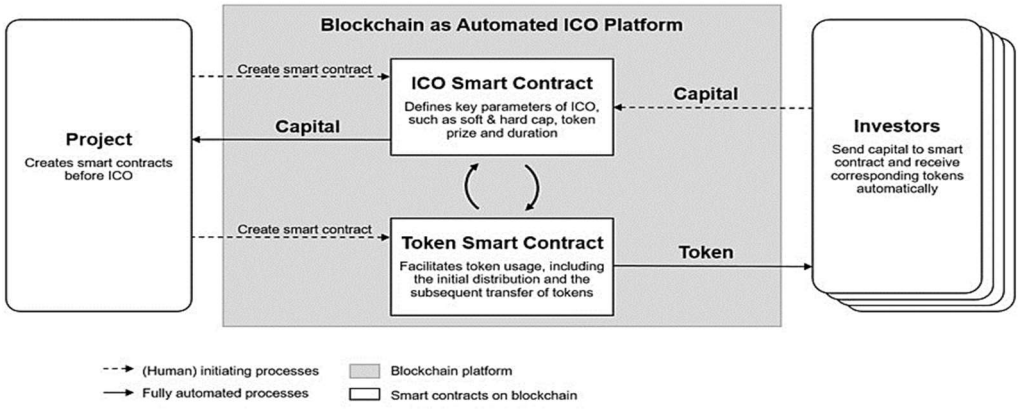
Security tokens get their value from a tradeable asset and on top of that are often seen as investment vessels. They can be seen as equity tokens, basically resembling traditional stocks or traditional

securities like a share in the venture or dividends. After the ICO has ended, most tokens can be traded for each other in the secondary market. Even though there has gone a lot of attention towards cryptocurrencies and in particular ICOs in recent years, there is little information about the dynamics of ICOs and for example which variables determine the height of the raised capital. On top of that, it is unclear if ICOs show similar behaviour in terms of dynamics if compared to other fields of entrepreneurial finance. The main difference between this method to raise capital and other sectors is the use of DLT, which is needed for the issuance of tokens and the fundament of these ventures. A whitepaper is usually created to offer more information about the venture's project, the requirements for the project to succeed, the aimed number of tokens they hope to sell during the ICO and how much of the total supply the founders are going to keep.

2.2 The ICO process

An ICO stands for "Initial Coin Offering". The goal of an ICO is to raise as much capital as possible in exchange for coins. The coins are created by means of a Smart Contract (see diagram below). Capital is sent to the Smart Contract and after the completion of the ICO, the coins (tokens) are distributed to investors. The Project which raised the capital will utilize this to create the promised features for which the coin can be used in the future. The capital is sent in the form of well-established cryptocurrencies with larger market caps such as Ethereum. The investor exchanges his dollars/euro's or other conventional currency for cryptocurrency and digitally sends this to the Smart Contract.

Fig. II Smart contract



(Chanson et al., 2018)

The ICO process vs the IPO process

IPO Process

Step 1: IPO team
The firm will hire a legal counsel, an auditor and an investment bank for underwriting during the offering

Step 2: Evaluation by the intermediary
The firm will be evaluated on whether or not it is ready for an IPO by intermediaries. The quality of management, corporate governance, cash flows and business plan is assessed.

Step 3: Regulatory review
A preliminary prospectus is filed, and with the help of intermediaries, any questions regarding the prospectus are answered.

Step 4: Marketing
The marketing of an IPO consists of the management and underwriting team conducting book building by presenting their IPO to brokers and institutional investors. The investors and brokers give information regarding what they think about the offering. In this way, the interest is gauged.

Step 5: Clearance
Clearance is obtained from the securities regulators, and a final prospectus is prepared for all interested investors.

Step 6: Underwriter
The investment bank accepts orders of the amount of shares investors want to have. The investment bank (underwriter) prices the shares based on fundamentals and feedback from interested parties. After clearance, the underwriter buys all shares from the firm.

Step 7: IPO sale
The IPO sale starts and the security is distributed from the underwriter to the purchasers. Investors have the opportunity to accept the offered amount of shares for a price set by the underwriter.

ICO Process

Step 1: Idea generation
A person or a team will create an idea for a project/application which will be built on the blockchain and has a unique value as opposed to the idea without the blockchain. A website will be made regarding the general idea.

Step 2: Technical research
The management and developers make decisions about the technology required, business approach, governance, which token platform will be used, the structure of the sale and pricing.

Step 3: Whitepaper disclosure
The team writes a whitepaper that explains the essence of the concept, technology used, novelty, team, business plan, ICO process and legal disclosure

Step 4: Backing
Key investors, individuals with a large audience, industry insiders and technical advisors are asked for feedback and for a set amount of money/tokens they can become official advisors of your project. This can be seen as the groundwork for the marketing

Step 5: Pre-sale (optional)
A pre-sale is done for a limited amount of capital in order to raise awareness, raise fund for the marketing, operation, legal and development cost.

Step 6: General marketing
The marketing of the ICO is started, and investors are targeted mainly via digital channels such as social media.

Step 7: ICO sale
The ICO sale starts and (whitelisted) participants can send cryptocurrency to a smart contract and receive the new token after the sale ends.

By posting a well-organized whitepaper, ventures hope to increase their chances of receiving more funds. Companies usually work closely together with underwriters to make sure they get a good estimate of how much the IPO can raise and to determine what kind of securities they want to sell.
A major difference between the two is the legal regulations. Ventures performing IPOs have to follow strict rules. While in comparison, ICOs are not limited by specific regulations or related government agencies. (Bovaird, 2017)

On top of that, IPOs are commonly conducted by more mature ventures, while ICOs are commonly used by young and risky ventures. An IPO is not possible if the company isn't fully established and doesn't comply with standards ruling in the corresponding business. ICO investors with little regulations have a relatively high risk of being a victim of fraudulent activity.
Furthermore, IPOs are regularly seen as exit strategies for ventures, where the owners get capital for selling their company. On the other hand, ICOs are (as previously described) entry strategies to initiate the operations of the venture.

Critical differences in the processes arise mainly from the fundamentals that (i) IPOs are generally well established companies with steady cash flows and a proven track record, (ii) IPOs are being regulated and several official (government) parties have to approve of it before an IPO can take off, (iii) ICOs don't require an underwriting team, the marketing can be done via new channels such as social media and backed proponents whereas the actual distribution is done on the blockchain by a smart contract. (iv) The IPO is often just a part of the total equity that will be offered to outside investors; after an IPO, there are one or several SEO's. However, in contrary, the ICO is the last event (if there is a pre-sale) where the cryptocurrency will be offered to investors.

2.3 ICO and IPO disparity

Since its inception, ICOs have captured global attention as a new and promising phenomenon of raising capital for businesses. A process which is based on mechanisms of decentralisation and cryptography, ICOs have broken several barriers and are less influenced by the pre-existing regulatory framework associated with IPOs.

2.3.1 High risk capital

ICOs varies from IPOs in some ways. An ICO is a way of raising capital in a project through the selling of tokens that investors buy through fiat currency or already established cryptocurrency (often Ethereum) with the payoff for investors being future gains if the project turns out to be successful (due to an increase in demand, price increases). In essence, the process still lacks a centralised regulatory platform. An IPO is the process of selling stocks through regulated exchange platforms and unlike ICOs, confers ownership rights to the investors (*Kaal & Dell'Erba,2017)*. There are specific differences between ICOs and IPOs regarding the process, risks and governance. The emergence of ICOs has come out as a threat to classic high risk venture capital. The total capital accumulated through ICOs and tokens surpassed the traditional form of venture capital *(Chourou et al., 2018)*.
By investing in ICOs, investors get cryptocurrencies and sometimes, although this is rare, a right of ownership or royalties to a project. On the contrary, IPO sells equity; the share in the ownership of the company *(Chohan, 2017)*. Furthermore, the equity holders are also entitled to dividends. The regulatory framework is dramatically different in case of IPOs and ICOs, where the latter has decentralised the overall process of fundraising and thus played a vital role in fundraising projects since its inception. ICOs or token sales has changed the way people think of investing by making it possible for a person from the USA to invest in a startup formed by partners living in various parts of the world with office in the UK which is legally registered in Switzerland and ICO process operated under the legal jurisdiction of Singapore *(Boreiko & Sahdev, 2018)*. With the proliferation of social media, internet channels and blogs, it has become possible for companies to explore untapped age cohorts most active on such platforms in order to collect more funds for the project.

2.3.2 Risks

IPO and ICO have certain similar risks that need to be taken under consideration before the investment decision. The first and foremost risk is that investors are not guaranteed to get a share. Due to oversubscription, small investors sometimes hardly get an allotment. Moreover, investors' money gets stuck for a period which could have been used for another purpose (opportunity cost). This is more stringent for ICOs as the time it takes to get listed and thus being tradeable tends to be higher than IPOs. However, the most significant risk factor is losing principal if the listed price becomes lower than the offered price.

For cryptocurrencies, the following risks are idiosyncratic. The most controversial issue surrounding ICOs is the towering number of scams, phishing scandals and Ponzi schemes. Also, the propensity to fall under the victim of hacking is very high, and as the investors' identities are not always known, the issue of compensation is vague *(Momtaz, 2018)*. The issue of the regulatory framework is another major threat still in existence. Although some countries have tried and succeeded in bringing ICO under proper jurisdiction, the majority of the countries are lagging regarding regulatory issue guidelines. Apart from these, cryptocurrencies are extremely volatile, and the tradability of a digital token on any exchange is not guaranteed. Last but not the least; token holders do not enjoy any liquidity preference, and upon bankruptcy when the debt holders and outside creditors are satisfied, token holder usually has no recourse at all *(Kaal & Dell'Erba, 2017)*.

Underpricing is significantly affected by trading volume, issue size, market sentiment and pre-ICO, and the first-day trading volume is congruent with the level of underpricing. By judging many other factors and their relationship with underpricing, it is stated that factors that affect IPO underpricing can even be related to ICO underpricing. ICO underpricing is considerably affected by proxies, which measure, influence or assume information asymmetry *(Felix, 2018)*.

A unique feature of ICO is that investors invest significant amounts of wealth but have no legal right to claim a fair return and it contradicts with many kinds of the literature of law, finance and corporate governance (Chohan, 2017). The lack of investor protection can be attributed to the absence of underwriter, corporate governance and proper regulation.

3 IPO Underpricing

The main theory used in this research (ex-ante uncertainty) will be applied to the ICOs. First, a short introduction to underpricing is given, then several theories regarding underpricing are explained. After this, the main theory (ex-ante uncertainty) is elaborated upon. Finally, empirical findings regarding underpricing are discussed.

3.1 Underpricing

Firms approach the public capital market searching for additional funds in order to grow. Traditional and less stringent forms such as owner's equity and bank loans are not sufficient or not as efficient as offering shares to the public. Underpricing is a common phenomenon that happens when firms offer stock through an IPO. This anomaly is defined as the offered price is lower than its intrinsic value (Beatty & Ritter, 1986). The objective of a firm which goes public is to raise the maximum possible amount of equity. If the offered price is lower than the intrinsic value, the company has underpriced their shares (Saunders, 1990). If the offered price is higher than the intrinsic value, the company raised a short-term premium. However, investors who have taken a risk buying the IPO have lost money, creating friction between the investor, underwriter and the firm. On the first trading day, traders respond to the (slight) mispricing of the stock and the price increases or decreases based on demand until it moves to its intrinsic value (Tian & Megginson, 2007). For stocks, it is paramount that the initial offer price of the shares reflects the intrinsic value of the assets of the company in order to raise the maximum possible amount of equity for the shares (Jenkinson & Ljungqvist, 2001). If prices are too high, they will be less optimal in the long run due to SEOs. A price lower than the perfect reflection of the intrinsic value of the assets means that the shares are underpriced.

3.2 Information Asymmetry

This section focusses on ICO underpricing via theories from IPO underpricing. Most of these theories fall under a greater concept: information asymmetry. When a firm goes public, there are multiple parties involved. Theories based upon information asymmetry argue that one of the parties has more relevant information than another party. In this research, the asymmetry that will be focused upon is between the issuer and the investor. In this case, the investor has less information than the issuer.

3.3 IPO underpricing explanations

There are several explanations behind the occurrence of underpricing. The theories include legal liability, book building, signaling, winner's curse and ex-ante uncertainty.

3.3.1 Legal liability

In the case of legal liability, underpricing can be explained by the risk which investors take if the share would fall short and thus create a gap which could result in a lower first-day closing price than the IPO offering price. Shareholder lawsuits for omissions in the IPO prospectus could then be filed, which would cost the issuing firm a significant amount of money (Ibbotson 1975). Other forms of legal liability aside from monetary settlement include reputational costs and opportunity costs due to the time extensiveness of a lawsuit (Lowry & Shu, 2002). Alexander (1993) found that the likelihood of being sued has a strong correlation with negative first-day returns (overpricing). Tinic (1988) found that IPOs were less underpriced before the implementation of the Securities Act of 1933, which enabled lawsuits, which gives strength to the hypothesis that firms use underpricing as a means to decrease the probability of a lawsuit. However, the relationship was not supported by the empirical evidence of other research (Drake & Vetsuypens, 1993). Their conclusion is that underpricing is too expensive as a lawsuit avoidance strategy and doesn't work effectively in avoiding lawsuits.

3.3.2 Book-building

Book-building is a task of the underwriter in which they attempt to determine the price for a share offering, based on demand from institutional investors. This process of price discovery involves generating and recording investor demand. By aggregating the pricing data discovered during this process, the final price is calculated. “The offerings are priced and technically underwritten only the night before selling starts, upon the completion of the extensive marketing effort commonly known as bookbuilding.” (Busaba, 2006)

The option to withdraw once the issuer has found out the investor valuations represents a potential option to the particular issuer. This particular option can be seen as a ‘put’ on the (uncertain) price investors are willing to pay, with a so-called ‘exercise price’ equal to a venture’s reservation price, which is the maximum price that a buyer is willing to pay.

Bookbuilding is a concept that provides an extra value to that option by translating ex ante uncertainty in the market value of the venture directly into the discrepancy in the (initial) offer price itself.

The fact that an increased extent of uncertainty enhances the impact of investor intel on the (initial) offer price leads to at first an increase in the discount required to call for this information.

The book-building hypothesis examines the relation between information generation and underpricing. When there is little need for accurate pricing, the expected gain from underpricing offsets the investors’ cost of acquiring information regarding the company (Sherman and Titman, 2002), however, when price accuracy is essential, the IPO is oversubscribed, and thus, the underpricing is greater, and investors can earn economic rents.

The asymmetric information which is at the source of book-building assumes that one of the parties knows more than the others. Subsequently, the resulting information friction gives rise to underpricing in equilibrium. Empirically however, the relationship between book-building and underpricing through the reduction of uncertainty has not been significant, albeit close (12% level) (Bubna & Prabhala, 2011).

3.3.3 Signalling

The signalling model (Allen & Faulhaber, 1989) reasons that IPOs are underpriced since IPOs are just a small part of the total amount of equity offered throughout the years. The first offering is underpriced to signal the quality of the stock as the performance is enhanced by intentional underpricing, to be able to offer equity in an SEO for a higher price which would counteract the underpricing cost. Signalling theory for underpricing can be viewed in the following manner: Underpricing at the initial offering is a credible sign that the firm is doing well since only good firms can recoup the initial loss after their performance has been realised (Allen & Faulhaber, 1989). Bad firms will not underprice since they expect that they cannot recoup the initial loss with their performance. This theory suggests that firm owners themselves know their firm best. This model suggests that firms underprice to leave a good taste in the mouth of investors (Ibbotson & Jaffe, 1975).

3.3.4 Winner's curse

There is one main model regarding uncertainty and investor groups. The base of this model is the winner's curse model (Rock, 1986), and this model is later extended by the ex-ante uncertainty hypothesis (Beatty & Ritter, 1986). The winner's curse model is known as the adverse selection theory of underpricing. Information asymmetry among investors is the reason for underpricing in this model. The two investor groups are (i) a small informed group and (ii) a large group of uninformed investors. The winner's curse is that uninformed investors partake in IPOs regardless of the quality, while informed investors only enter the IPOs which give them positive returns based on the value of the shares is higher than the price being offered. Some uninformed investors will exit the market because of reoccurring losses if they lose too often. The uninformed investors that are unlucky and experience reoccurring losses a few times in a row will leave the market, which leads to a decrease of available capital. This problem is solved by underwriters by starting with a lower opening price such that the amount of unlucky uninformed investors is reduced and thus more of them stay in the market. Due to the limited nature of shares in IPOs, uninformed investors tend to invest in negative ROI IPOs and are more likely to get share in these IPOs (informed investors crowd the uninformed investors out

in positive ROI IPOs). If uninformed investors exit the market, available capital would decrease and thus underwriters solve this problem by starting with a lower opening price such that uninformed investors stay in the market. This is a reward for uninformed investors due to the winner's curse.

3.3.5 Ex-ante uncertainty

The winner's curse model is extended by ex-ante uncertainty about the intrinsic value of the issue as this increases the level of underpricing. If ex-ante uncertainty increases, the winner's curse problem increases (Beatty and Ritter, 1986). Informed investors will stay away from negative investments, and uninformed investors will invest regardless. If ex-ante uncertainty about the intrinsic value of the stock increased, investors would want to pay a smaller amount for them. The issuer then has to decrease the initial offer price to meet the demands of the buyer. Underpricing can be seen as a premium for uncertainty. The final valuation is done by the market, and this could differ from the valuation made by the underwriter for stocks if the valuation was too high, the margin which underpricing provides acts as a safety net for the investors.

One of the most well-known models concerning the phenomenon is the winner's curse model by Rock (1986), which is expanded by the models of Beatty and Ritter (1986) and Baron (1982) by their ex-ante hypothesis. According to Rock (1986) and Beatty and Ritter (1986), companies tend to underprice their IPOs because of information asymmetry that exists between informed and uninformed investors. Baron's (1982) model reasons that underpricing is caused due to the information asymmetry that exists between the underwriter and the company that issues stocks. Ex-ante uncertainty is a product of the estimation of the intrinsic value while a company issues shares (Clarkson et al., 1994). The central proposition from these studies is that the degree of underpricing is increased as a result of the ex-ante uncertainty about the intrinsic value of stocks.

The theory put forth by Rock (1986) is known as Adverse Selection Theory of Underpricing and argues information asymmetry as the reason behind underpricing. Uninformed investors tend to be affected because they lack the expertise to assess if the shares are overpriced and will eventually leave the market later on after suffering severe loss and as a result, underpricing in such situation is a

competitive tool to counter the adverse consequences. This hypothesis is the staple of this research and will now be discussed regarding ICOs.

Beatty and Ritter (1986) argue that an issuing firm, which will go public only once, cannot make a credible commitment by itself that the offering price is below the expected market price once it starts trading. An investment banker is positioned to enforce the equilibrium because of the necessary continuity of equilibrium, which keeps them in business. For ICOs however, many founders are in turn advisors for different ICOs. If their ICO fails to underprice, they are personally affected by being reputationally penalized as advisors or founders for other ICOs in the future.

Hanley and Hoberg (2010) find that greater informative content in an IPO prospectus acts as premarket due diligence and thus results in more accurate offer prices and less underpricing. More information in public documents, thus helps reduce ex-ante uncertainty for IPOs, thus reduces underpricing. For ICOs, there is no standardised paper which is used to inform the public (prospectus), but an alternative is used: A whitepaper. The whitepaper contains public information regarding the ICO. The difference between the two documents merely is that whitepapers are not standardised, and although whitepapers are very common, ICOs do not necessarily have one.
P. Clarkson and J. Merkley (1994) conducted their study on IPO in Canada in the 80's and determined three proxies as a substitute of ex-ante uncertainty being: the size of the issuing company, the market climate and the reputation of the underwriter.

Yu and Tse (2006) took the Chinese market from 1995 to 1998 as a case to test the ex-ante uncertainty hypothesis of Beatty and Ritter (1986) and the winner's curse hypothesis of Rock (1986). The three proxies of their study were the offer size of the IPO, the standard deviation of the after makrter returns and the age of the firm. A basis regression with ex-ante variables was developed. A t-test was formulated to confirm the interaction of variables with the crisis dummy.
All these proxies could be categorised as characteristics of the company and offer the disclosure of prospectus and aftermarket variables.

However, Jenkinson & Ljungqvist (2001) reasoned that the standard deviation of aftermarket return cannot always be marked as a robust ex-ante proxy because a higher standard deviation might be due to the risk and return. Muscarella and Vetsuypens (1989) and Cheung and Krinsky (1994) both used Baron's (1982) model and examined investment banks that issued their own stock. This would result in no information asymmetry because there is no third party underwriter. However, contrary to the hypothesis of Baron's (1982) model, more underpricing was found.

Ritter and Beatty (1986) found a positive relation between ex-ante uncertainty and underpricing. It is worth noting that the R squared is low at 0.07. If the R squared was high, it would imply that the actual initial return on an offering is predictable.

Momtaz (2018) examines how virtual currency projects acquire external finance through ICOs. Raw and abnormal first-day returns range from 6.8% to 8.2%. This is consistent with the market liquidity hypothesis of ICOs, which states that issuers have an incentive to underprice in order to generate market liquidity, which, in turn, increases the inherent value of their currency.

The lack of investor protection in ICOs is because ICOs are unregulated, have a lack of CG and also do not have an underwriter, which you would find in an IPO. Token prices increase due to a higher demand than supply for a specific platform. Since the amount of tokens is fixed in most cases, a currency that is used more often will appreciate in value. Gross proceeds for ICOs are lower when a Pre-ICO is conducted and decrease throughout the actual ICO. When a project accepts the legal tender, gross proceeds rise. Money left on the table decreases when an ICO involves a KYC process, in which the project team gets to know its investors and hence can better gauge its real value. ICO size and country restrictions increase money left on the table.

In the case of ICOs, Momtaz (2018) identified the quality of the management team, platform vision, and ICO profile as three proxies for underpricing. He further found an empirical basis for the proxies by the regression result of first-day return, especially the quality of the management team.

Felix (2018) argues that established literature proxies for IPOs can even be applied to ICO, although the level of underpricing varies.

Apart from the findings of Rock (1986) and Beatty and Ritter (1986), other studies have also concluded information asymmetry as the reason behind underpricing. Allen and Faulhaber (1989) related asymmetric information and underpricing by assuming that the information related to the quality of investment projects that are unavailable to the external investors and companies expecting better profit use underpricing as a tool to attract attention to their better quality.
In Baron's model (1982) information about potential demand and market, the state is mainly possessed by underwriter but not the issuer. In cases like this, the optimal offering price differs from the first best solution, which is proposed in the absence of asymmetric information and lack of observability of the workings of the underwriter.

Numerous studies have been conducted in the hope of building a relationship between underpricing and book-building and fixed-price auction methods. Almost all the papers found that the book-building method has a lower impact on underpricing. Compared with the fixed-price method, book-building method has its strength in collecting information and full disclosure of share allocation by underwriters. As a result, the book-building method has an information advantage. It does not matter if it is because of the allotment of favourable shares or long-term benefit aimed at drawing in investors to reveal true demand interest, a book-building method in pricing is commonly well thought-off to have reduced under-pricing due to its nature of information-gathering.

3.4 Empirical findings

Underpricing is not only a phenomenon observed in the developed economies but is widespread in the emerging markets as well. The variations of underpricing concerning developed and emerging economies are worth taking under consideration, given the difference in fundamentals. Several studies have been conducted regarding underpricing in both developed and emerging markets. Empirical findings from more than 40 countries prove underpricing to be a worldwide phenomenon. However, these findings also show that there is a variation in the level of underpricing across countries. For instance, calculated average initial return of countries such as France 3-14%, Greece 48-64%, Taiwan

30-47%, Australia 11-30%, Brazil 74-78.5 and China 127-950% add strength to the prior statement (Engelen et al., 2010).

Among the first few prominent studies is the one by Rock (1986) and its extension by Beatty and Ritter (1986). Both the studies were conducted based on data from the developed countries and concluded that the information gap that exists between informed and uninformed buyers could act as an ex-ante uncertainty and increase the probability of the occurrence of the winner's curse. For this reason, to protect the level of participation of the uninformed buyers for a healthy IPO market, issuers of shares use underpricing as a useful tool. This model also suggests that when ex-ante uncertainty increases, underpricing should increase. The underlying reason put forth in support of this by Beatty and Ritter (1986), who used gross proceeds and the number of proceeds as proxies, is that increasing ex-ante uncertainty is directly tied to intensifying the winner's curse problem. The prediction of these studies was a focus to some later empirical studies, and among those, the one by Koh and Walter (1989). They used new issues from Singapore as a sample due to the unique institutional arrangement of the Singaporean market and found that the winner's curse is strongly associated with underpricing in the sample.

Clarkson et al. (2009) researched the Canadian market to research ex-ante uncertainty and underpricing using similar proxies. Results of the univariate tests in the study were consistent with prior empirical studies conducted with data of both the USA and Canada market. An important point to be noted is that the findings of the paper suggested that the underpricing decreased with the increase in annual sales. Other factors were auditor quality, gross proceeds from the offer and underwriter's status. Further findings were that underpricing was higher in tech-based companies and low for firms in other industries. Underpricing was the lowest for firms that included earnings forecast in the prospectus. Kennedy et al. (2006) found that the high-tech sector faces greater ex-ante uncertainty, and thus, their IPOs are more underpriced.

According to Ghosh (2005), uncertainty played a role in underpricing in India based on data obtained from 1993-2001. The study further concludes that when IPO issue size is large, underpricing was less and in contrast to the international market, India also experienced less underpricing during the high-

volume boom period. The paper also found the results to support signalling theory for IPOs for companies during 1993-2001.

Empirical evidence suggests that the level of average underpricing in the Netherlands from 1984 to 1990 was 5%, but it was 250% for China between 1990 and 2000 (Sinha et al., 2004). The issue of strong governance to promote investor (both informed and uninformed) rights has long been resonating from the work of Rock (1984). Information asymmetry and the reality of the participation of uninformed investors as downright necessary for a healthy IPO market is often the conclusion. The role of governance regarding the level of underpricing in countries around the world is studied rigorously by La Porta et al. (1997). A country's legal structure can be said the reason behind the development of different financial markets and a company's ability to increase finance either by debt or equity is supported when a good legal environment is present (La Porta et al., 1997). Investors are better protected in common law countries, and the financial market is more developed in comparison to French civil law countries where investor protection rules are at a minimal level. The position at the middle is held by structures originating from Scandinavian and German civil law systems. Later on, Engelen et al. (2008) theorized that economic growth accelerates in common law countries in comparison to civil law countries. The reasons are better property security and contact rights.

Corporate governance has a straightforward relationship with underpricing. By collecting and analyzing data on IPOs of 25 countries around the world (Loughran et al. 1994) concluded that with more government interference, the average initial returns from IPOs were higher. Other governmental decisions also play a role in the level of underpricing. For example, as evidenced by GCC (Gulf Cooperation Council) countries, the regulation to prohibit foreign underwriter and foreign investors as a whole, underpricing becomes more severe (Hopp and Dreher, 2013). The same thing happens to underprice when the capital market authority necessitates the assessment of the firm by star analyst (Liu and Ritter, 2011). Alanazi, & Al-Zoubi (2015) found from 139 IPOs in the GCC region that governance regulation usually promotes better protection to the investors in IPOs market, even in economies with weak regulations.

4. *Hypotheses*

The following section elaborates upon the hypotheses in this research. The first hypothesis is regarding the general level of underpricing. Hypotheses 2 to 5 are regarding the influence of ex-ante uncertainty on ICO underpricing. Ex-ante uncertainty is a concept which is unobservable and unmeasurable. Therefore, several proxies have been formulated and will be elaborated upon in this section. The hypotheses are based upon the model of Rock (1986) extended by Beatty & Ritter (1986).

4.1 The average underpricing of ICOs

Based on the presented findings of previous studies regarding IPO underpricing, it can be argued that ICOs would be underpriced on average as well. From previous research, it is clear that IPOs in various countries have been underpriced on average. Loughran and Ritter (2002) found that the average first-day returns of IPOs in the US in the 1980s was 7%, in 1990 to 1998 it was 15% and during the internet bubble in 1999-2000, it was around 65%. Momtaz (2018) found that the raw and abnormal first day returns range from 6.8% to 8.2%. There are significant similarities between the ICO process and the IPO process. Furthermore, the empirical findings that IPOs in which the issuer is the underwriter are more underpriced of Muscarella and Vetsuypens (1989) and Cheung and Krinsky (1994) suggest that underpricing of ICOs may be more than IPOs. The higher risks of ICOs due to various reasons such as weak laws, corporate governance, absence of shareholder rights and the position in a high tech field would also support this notion.

Hypothesis 1: ICOs in 2017-2018 are on average underpriced.

4.2 Issue size

Beatty and Ritter (1986) state that investors consider IPOs with a low issue price to be more uncertain because they are considered to be more speculative. Therefore, the gross proceeds of an issue are used as a proxy for ex-ante uncertainty. Beatty and Ritter (1986) found that small offerings are more underpriced than large offerings. Dorsman et al. (2013) explained this relationship by arguing that information regarding the value of larger issues is more valuable than information regarding the value

of smaller issues. As a result, more information is gathered about larger issues thus, the ex-ante uncertainty is higher for smaller issues. This translates straightforwardly to ICOs. Projects with a larger issue size on average should experience less ex-ante uncertainty.

Hypothesis 2: The issue size of an ICO has a negative effect on the level of underpricing.

4.3 Project Age

The age of a company is widely used as a proxy for ex-ante uncertainty. The rationale behind this use is the following: Older companies have a longer track record; this proves their ability to survive and they are therefore less risky. Furthermore, more information is available about the company. Ritter (1984) argues that an older company is more established and that on average less uncertainty exists regarding an IPO of an older company. Therefore, younger companies are riskier and need to leave more money on the table during an IPO. In terms of ICOs, if a project has been worked on for a longer period of time, the developers have had more time to create a track record for their project. Furthermore, on average, more information has been created and communicated.

Hypothesis 3: The age of a project has a negative effect on the level of underpricing.

4.4 Whitepaper

Hanley and Hoberg (2010) find that greater informative content in an IPO prospectus acts as premarket due diligence and thus results in more accurate offer prices and less underpricing. More information in public documents, thus helps reduce ex-ante uncertainty for IPOs, thus reduces underpricing. For ICOs, there is no standardised paper which is used to inform the public (prospectus), but an alternative is used: A whitepaper. The whitepaper contains public information regarding the ICO. The difference between the two documents merely is that whitepapers are not standardised, and although whitepapers are very common, ICOs do not necessarily have one. Given that more information in public documents helps reduce ex-ante uncertainty and thus underpricing, the following hypothesis is made in line with Hanley and Hoberg (2010):

Hypothesis 4: The extensiveness of the whitepaper has a negative effect on the level of underpricing.

5. Methodology

In this chapter, the research methodology will be described. This consists of the measurement of the variables, data collection method and sources and the regression model used to test the hypotheses will be discussed.

5.1 Research method:

The goal of this research is to find if ICOs are on average underpriced and if proxies based on ex-ante uncertainty affect underpricing of ICOs. In this subchapter, the research methods used in previous research will be stipulated.

Beatty and Ritter (1986) use weighted least squares regression in order to reduce heteroscedasticity that is present in an OLS regression. This is the case because a higher ex ante uncertainty should be reflected in a greater dispersion of initial returns. However, as they note, their results are nearly identical using OLS rather than WLS. The weighting term used in WLS is multiplying both left-hand and right-hand side variables by log[1000 + sales]; however, for ICO underpricing such a term is not available. Thus, given that results for OLS and WLS were nearly identical, OLS will be used in this research. The construction of the variables in this research reduces the heteroscedasticity by taking the natural logaritm for some of the variables.

Momtaz (2018) tests for several determinants against underpricing and utilizes an OLS regression for the determinants. To test average underpicing for ICOs a t-test is used. The underpricing is regressed for three measurements of the dependent variable: Raw first-day returns, Abnormal value weighted and Abnormal equally weighted. In which equally weighted has a poor fit due to the introduction of a significant amount of noise.

In previous research regarding ICOs, the following methodologies have been used. *Adhami et al. (2017)* used a logit regression model to find which determinants influence ICO success / failure. The logit version is used due to the dependent variable being binary. Felix (2018) uses the same measurements

for the dependent variable, and some of the independent variables overlap. In his paper, an OLS regression is used. Fisch (2019) uses an OLS regression for his research regarding the role of signalling theory on the amount raised in ICOs.

For hypothesis 1 a one-sample student t-test will be used in order to determine if the underpricing of ICOs is statistically different from zero.

For hypotheses 2-4 an OLS regression will be used and is formulated as follows:

$$Underpricing_i = \alpha + \beta 1\ Issue\ size_i + \beta 2\ Project\ age_i + \beta 3\ Whitepaper_i + \beta 4\ ERC20_i + \beta 5\ Presale_i + \beta 6\ Bonuss_i + \beta 7\ TTX_i + \beta 8\ Git_i + e_i$$

In which α represents the constant in the regression, β represents the respective coefficient of the three independent variables and control variables. The variable e represents the error term (residual).

5.2 Measurement of variables

In this section, the measurement of the variables will be discussed. First, the measurement of the dependent variable (underpricing) is further elaborated upon. Then the independent variables Issue size, Project age and Whitepaper are stipulated and finally the control variables.

5.2.1 Dependent variable

$$Underpricing = \left(\frac{(P_{i,t} - E_i)}{E_i} - \frac{(M_t - M_{t,0})}{M_{t,0}} \right)$$

Underpricing refers to the discrete difference between the first day closing price and the issue price (Ritter, 1984). However to make it comparable to other ICOs it needs to quote the initial return (IR) in relation to the ICO price: In which IRi is the initial return of token (i), Pi,t is the closing price of token (i) and Ei is the issue price of token (i). The market adjustment (second quotient) is in line with Momtaz (2018) and Felix (2019) ICO research and is necessary due to the longer time untill coins are

listed and higher volatility of the market. For the movement of the market, a composite index will be taken. In this way, the market-adjusted underpricing can be calculated. Mt is the price of the index at the closing price time of token (i). Mt,0 is the index price at issue date of the token (i). Since exchanges for cryptocurrency do not close, a closing price is not available. However, a similar timing will be used for the variable. The price at the end of the next day will be used. This is slightly longer than the original construction of the variable. However it is necessary due to uncertainty regarding at which time tokens are listed at various exchanges. Because the underpricing is a relation to the market, the selection of the market portfolio is of utmost importance because it must match the token in such a way that the price would on average react the same to external market events. The market portfolio created is elaborated upon in the Data section. Two market portfolios have been created to increase robustness. The first one consists solely of Bitcoin, whereas the second market portfolio is consists of every cryptocurrency except Bitcoin. A further explanation can be found in Appendix B.

5.2.2 Independent variables

The independent variables used in this research will first be discussed, after which the measurement of other (similar) variables found in literature is elaborated upon.

$$Issue\ size = \ln(gross\ proceeds)$$

This variable is in line with the variable used by Beatty and Ritter (1986) and captures the empirical regularity that smaller offerings are more speculative, on average, than larger offerings. The natural logarithm is taken because of the large expected dispersion in this measurement.

$$Project\ age = \text{Announcement date} - ICO\ date$$

If a project has been worked on longer, the developers have had more time to create a track record of their project. This measurement is the days between the announcement date of the project and the ICO date.

$Whitepaper = \text{Number of p}ages\ in\ whitepaper$

The number of pages in a whitepaper captures the uncertainty retail investors who cannot asses the code. More extensive whitepaper results in more information being present and thus less uncertainty and less underpricing.

In the existing literature, the main proxies that are used to test the influence of ex-ante uncertainty on underpricing are:

- The log of one plus the number of uses the proceeds listed in the prospectus.
- The inverse of the gross proceeds.

The number of uses of proceeds listed is a proxy for ex-ante uncertainty due to the SEC regulation. Firms appear to be reluctant to give highly detailed specifications of what they will do with their net proceeds for two reasons: increased exposure to legal liability, and disclosure of proprietary information to competitors. The SEC requires more speculative issues to provide more detailed enumerations regarding the uses of proceeds.

Proxies used in other studies in order to capture ex-ante uncertainty are:

- The market capitalisation
- The reputation of the underwriter
- The age of the company
- R&D expenditure of a company
- Issue Price and size of an IPO

5.2.3 Control variables

Control Variables:

The majority of the following control variables are in line with Momtaz (2018):

$ERC20 = \text{Coin uses the ERC20 protocol (Dummy variable)}$

This variable takes standardization into account. The ERC20 protocol is used by Ethereum and can be seen as the standard for ICOs.

$Presale = \text{ICO had a presale (Dummy variable)}$

This variable is either can either be a 0 or a 1 if the ICO had a presale.

$Bonuss = \text{Bonusses available during ICO (Dummy variable)}$

This variable is either a 0 or 1 if there was a bonuss structure during the ICO (e.g. first X participants get a better rate).

$\text{TTX} = \text{Duration in days from ICO end to listing on the exchange}$

TTX measures the duration in days from ICO end to listing on the exchange. Since this time window varies per ICO, this variable is used.

$\text{Git} = \text{Github repository available during ICO (Dummy variable)}$

This variable measures if there is a code repository available during the ICO. The code repository can give insight into the status of the project and the quality of the code.

5.3 Sample and data collection

Data has been collected and double checked for validity from various websites and databases:

- www.cryptocompare.com
- www.coindesk.com/ico-tracker
- www.icomarks.com
- www.icobench.com
- www.icodrops.com
- www.cryptoslate.com
- www.github.com

The price at t=0 for ICOs has been triangulated across multiple sources because of the lower validity. Websites have been removed from the source list if they consistently gave false information. The data has been winsorized with 10%. After starting with a sample of 1300, the ICOs with lacking price data were removed, after which 800 remained. Of these 800, 300 lacked multiple other variables and thus were removed. Of the 500 remaining 200 were removed due to inherently low validity among reputable sources. The sample size of 300 is enough for regression to be statistically significant. Since the data came from public sources, the removal of 200 out of 500 ICOs was to be expected. Of the 300 outliers, clear sampling errors and other outliers based on the residuals from the regression were removed. This leaves this sample with an N of 280.

In order to get a clear overview of the ICOs of the present cryptocurrencies and their values, a list of variables has been collected. This includes the ICO price, the date of the ICO listing, date of closure, the ICO closing price and the amount of funds raised. On top of these variables their Github project creation date, announcement date, Github line of codes, number of pages in the whitepaper, whether or not they had a presale and a bonus and lastly if they are ERC20 (used for smart contracts on the Ethereum blockchain for implementing tokens) based or not.

5.4 Data Analysis

The influence of the proxies for ex-ante uncertainty on ICOs is assessed using linear regression. A t-test was used to assess if ICOs on average, are underpriced. IBM SPSS Statistics version 25 was used to analyse the sample. With a one sample t-test, the underpricing is assessed with a test value of 0. The test value of 0 means that a null hypothesis would expect no underpricing and thus that the first-day return would be 0. This test is done for all three models (raw underpricing and the two market adjusted models).

For the influence of ex-ante uncertainty on ICOs, the dependent variable in all three models is translated and transformed for the regression. This is due to the skewness of the underpricing variable. The variable is first translated because of the negative numbers in the sample (some ICOs have negative first day returns). For raw underpricing, all observations are first rounded up by two in order to have a minimum of 1. For market models, the same approach has been used. The variable was then transformed using a log with a base number of 10.

Data was checked for sample errors, which were removed and extreme outliers were double checked and if the error terms were not normal distributed removed from the data set. However, the number of outliers removed was less than 2% of the total sample.

6. Empirical findings

In this section, the empirical findings will be discussed. In table 1, the descriptive statistics are presented for the dependent, independent and control variables. Table 2 provides the correlation statistics between the variables. Table 3 presents the one sample T-test for Underpricing. Table 4 presents the results of the OLS regression for the three dependent variables. Table 5 presents a split sample based on the cryptocurrency market, with every ICO before the 17th of December 2017 is categorized as "hot market" while every ICO after the 17th of December 2017 is categorized as a "cold market".

6.1 Descriptive statistics

In Table 1, the descriptive statistics of the total sample are presented. The total sample is 287 ICOs. For reference in 2017 and 2018 combined, there were roughly 550 ICOs.

Table 1: Descriptive statistics

Variables	Total sample (N = 287)							
	#Obs.	Mean	Median	Std.dev	Min	Max	Q1	Q3
Dependent variables								
Underpricing	287	1.45	0.06	4.49	-1.00	34.34	-0.37	1.20
MA Underpricing BTC	287	1.32	0.02	4.46	-3.66	34.41	-0.39	1.00
MA Underpricing Index	287	1.15	0.01	4.37	-4.11	33.61	-0.41	0.73
Independent variables								
Funds Raised (x $1.000)	287	18,377	10,000	33,755	15	320,000	3,600	20,000
Whitepaper	287	28	27	21	0	127	14	38
Project Age	287	87	62	138	0	1,148	21	101
Control variables								
Time Till Listing	287	29	14	46	0	379	4	36
ERC20	287	0.79	1.00	0.41	0.00	1.00	1.00	1.00
Presale	287	0.77	1.00	0.42	0.00	1.00	1.00	1.00
Bonuss	287	0.58	1.00	0.49	0.00	1.00	0.00	1.00
Github	287	0.08	0.00	0.28	0.00	1.00	0.00	0.00
Hot Market	287	0.71	1.00	0.45	0.00	1.00	0.00	1.00

Dependent variables:

Raw underpricing is the raw first-day return. Market-adjusted underpricing (BTC) is the market adjusted underpricing with the BTC price taken as the market benchmark. Market-adjusted underpricing (index) is the market adjusted underpricing with the index (every coin except BTC) as a benchmark. The dependent variables have not been transformed yet, as the descriptive statistics are harder to interpret once translated and transformed.

The mean of raw underpricing is 1,45, which means that ICOs have gained 145% during the first day of listing. This is a staggering amount, and the median is a 6% gain. This means that the data is skewed to the right. Which occurs inherently since underpricing has a natural minimum of -1. The maximum in the sample is 3434%.

Results of the market adjusted underpricing with BTC as a benchmark is very similar to raw underpricing. The difference is that the minimum can be lower than -100% and is -556%. This is possible since BTC can increase in price while the ICO decreases in price. The median (2%) is lower than it is in raw underpricing.

Market-adjusted underpricing (index) differs from the other two dependent variables. The mean underpricing with the index taken as a benchmark is 115%, the median is in line with the BTC model.

Independent variables:

The average capital raised in ICOs in the sample is $ 18 million. This is in line with the population in this time frame, as the average raised capital is $ 24 million. The median is lower with $ 10 million. Which means that date is skewed to the right and there are some ICOs which outperform most others. The worst performing ICO raised € 15 thousand and the best one $ 320 million.

The average number of pages in a whitepaper is 28, and this is reasonably close to the median number of 27. The maximum number of pages in this sample is 127.

The average project is 87 days old before it launches an ICO. The median, however, is 62. Which means the data is skewed to the right. The maximum is 1148 days.

Control variables:

The dummy variables give insight that most ICOs are ERC20, have a presale, have no git, and roughly 50% of the time have a bonus structure. The average time till listing is 29 days and the median is 14. Some ICOs list the same day and others have waited for 379 days. Furthermore, roughly 71% of all cases are before the 17th of December 2017, while 30% occurred after this date.

Discriptives comparison:

When the variables are compared with Boreiko and Sahdev (2018), mean underpricing is in line with their discriptive data in the 2017-2018 timeframe. Control variables vary from theirs but are not presented per year, so this is possibly due to ERC20 / Pre-sale being more used in 2017-2018 than in earlier years. Chanson et al. (2018), find a mean underpricing of 110% and a median of 42% The mean is somewhat lower than ours but in the same ball park. The median differs the most and could possibly be due to a different measure for underpricing as the first-week close is taken in this research instead of the first-day. Fisch (2019) finds the mean amount raised to be 19.6 million and the median 11.8 million. This is in line with our sample. Control variables for pre-sale and ERC20 are in line with the proportion in our sample. Momtaz (2018) finds a median raw underpricing of 2,6% while the mean is 8,2% for a sample size of 302 ICOs. The mean funds raised is 15 million in this sample, while the median is 5,8 million. Time to listing has a mean of 93 days in this research while the median is 42. This is higher than what was found in our sample. For the control variables, Momtaz (2018) finds that 43,9% of ICO's have a Pre-ICO, and 67,3% is based on ERC20.

6.2 Correlation matrix

In Table 2, the correlation matrix is presented for the dependent, independent and control variables. Using the Pearson correlation measure, the goal is to detect the correlation between the independent variables.

Table 2: Pearson Correlation matrix

Variables	1	2	3	4	5	6	7	8	9	10	11
1. Underpricing (Log)											
2. MA Underpricing BTC (Log)	.891**										
3. MA Underpricing Index (Log)	.815**	.941**									
4. Funds Raised (Ln)	-.157**	-.136*	-0.099								
5. Whitepaper	-.191**	-.140*	-.131*	.345**							
6. Project Age	-0.065	-0.020	-0.012	0.054	.124*						
7. Time Till Listing	0.038	-.167**	-.198**	-0.018	-0.044	0.013					
8. ERC20	-0.054	-0.028	-0.029	.288**	.224**	-0.081	-0.083				
9. Presale	-0.061	-0.085	-0.093	0.048	.207**	0.008	0.097	.126*			
10. Bonuss	-0.054	-0.058	-0.043	-0.086	-0.001	.121*	0.093	0.012	-0.014		
11. Github	0.111	0.063	0.073	0.005	-0.036	.175**	.127*	0.031	-0.074	0.003	
12. Hot Market	.139*	-0.014	-0.064	-.224**	-.274**	-0.066	-0.060	-.158**	-.166**	-0.047	0.109

*** Correlation is significant at the 0.01 level (2-tailed).*

** Correlation is significant at the 0.05 level (2-tailed).*

The dependent variables are all significant with each other due to a portion of the construction being equal; this has no further meaning.

There is some significant collinearity between the independent variables whitepaper and funds raised, as well as the project age and whitepaper. This result seems logical as more professional ICOs would likely have (a more extensive) whitepaper and would thus raise more funds by attracting more investors. The project age and whitepaper are positively correlated as well, which suggests that writing a more extensive whitepaper takes more time, which seems logical as well. However, the coefficients among these predictors are quite low with 0.345 and 0.124 on which basis multicollinearity is not suspected. There is some collinearity between the control variables and the independent variable. However, the coefficients are low and based on the variance inflation factors, which are all lower than 1.3, there is no multicollinearity.

6.3 T-test for underpricing

Table 3 presents a one sample T-test that has been conducted for all three measures for underpricing. In this table, a T-test is done for raw underpricing and market adjusted underpricing for BTC and Index. The student T-test is used to find out if the dependent variables are statistically signifanctly different from zero. Zero is taken because if there would be no underpricing, random effects would cause the mean, on average, to be zero. The T-test is suitable because the transformed independent variables are taken, which are more normally distributed. Furthermore, a violation of normality is acceptable when the sample size is large enough. The sample size is 287, and thus, the T-test is suitable for the distribution of the data.

Table 3: One Sample T-test for Underpricing

Variable	Mean	St.Dev	df	t
Raw Underpricing	1,45	4,49	286	5.48*
Market Adjusted Underpricing (BTC)	1,32	4,46	286	5.02*
Market Adjusted Underpricing (Index)	1,15	4,37	286	4.46*

* *Significance at the 0.01 level*

Underpricing is statistically significantly higher (Mean = 1.45, St.Dev = 4.49) than 0, $t(286) = 5.48$, $p < 0.01$. This means that the mean of 145% raw underpricing is significantly different from zero at the 0.01 level. The T score is 5.48, which indicates that the raw underpricing is roughly five times different from zero. The market adjusted models are significant at the 0.01 level as well and still have high T scores, albeit a little lower than the raw model. This means that the result is robust for the marked adjusted models as well. The results are similar to Felix (2018), who also rejects the null hypothesis based on the t-test (positive).

Hypothesis 1: ICOs in 2017-2018 are on average underpriced.

We found that ICOs, in line with IPOs, are on average underpriced. This is significant at the 0.01 level for raw and market adjusted underpricing benchmarked with BTC and an Index. Thus the null hypothesis can be rejected. The average raw underpricing for ICOs is more severe than IPOs, with 145% versus 5% (Netherlands).

6.4 Regression analysis

On the next page, table 4 is presented. The results of the OLS regression are depicted. This Table consists of three panels. The first three models are of the individual independent variables. Followed by model four, in which all independent predictors are incorporated. The coefficients are flagged if they are significant. The significance of the F test implies that the independent variables are significantly a better fit than a model without them. The adjusted R^2 measures the percentage of the total variability in the dependent variable that is explained by the independent variables adjusted by the number of variables used in the model. A low R^2 implies that a small part of the variance can be predicted by the model.

Panel A shows that Funds Raised and Whitepaper Pages significantly (at the 0.01 level) decrease raw underpricing. Project age is not significant and does not influence underpricing. Model four incorporates all variables, and the findings are similar to the individual models. The adjusted R^2 is 3,8% compared to 7% Beatty and Ritter (1986), which means that the explanatory power of the model is weak, as should be expected.

Panel B and Panel C have similar results as Panel A. Funds Raised and Whitepaper are significant in the individual models with the correct sign. Although the signs are correct in model four, whitepaper loses significance in Panel B while Funds Raised loses significance in Panel C. Model four correctly predicts 4,2% and 4,7% of the variance respectively and is significant at the 0.01 level. Market adjusted models introduce noise to underpricing, which could explain the difference between panels.

Table 4: OLS Regression of the influence of ex-ante uncertainty on underpricing

	Panel A. Raw Underpricing								
Variables	Expected	Model 1		Model 2		Model 3		Model 4	
	sign	B	S.E.	B	S.E.	B	S.E.	B	S.E.
Independent variables									
Funds Raised (Ln)	-	-0.031***	0.012					-0.022*	0.012
Whitepaper	-			-0.003***	0.001			-0.002**	0.001
Project Age	-					0.000	0.271	0.000	0.000
Control variables									
Time Till Listing		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ERC20		-0.001	0.045	-0.009	0.044	-0.041	0.044	0.005	0.045
Presale		-0.035	0.042	-0.013	0.042	-0.034	0.042	-0.016	0.042
Bonuss		-0.043	0.035	-0.034	0.035	-0.028	0.036	-0.036	0.035
Github		0.111*	0.063	0.108*	0.063	0.129	0.065	0.119*	0.064
Constant		0.922***	0.186	0.490***	0.053	0.469***	0.053	0.821***	0.190
#Obs.		*287*		*287*		*287*		*287*	
R^2		*0.045*		*0.051*		*0.028*		*0.065*	
Adjusted R^2		*0.024*		*0.031*		*0.008*		*0.038*	
F - value		*2.194***		*2.515****		*1.367**		*2.410***	
	Panel B. Market Adjusted Underpricing (BTC)								
Variables	Expected	Model 1		Model 2		Model 3		Model 4	
	sign	B	S.E.	B	S.E.	B	S.E.	B	S.E.
Independent variables									
Funds Raised (Ln)	-	-0.020***	0.008					-0.0154*	0.009
Whitepaper	-			-0.001**	0.001			-0.001	0.001
Project Age	-					0.000	0.000	0.000	0.000
Control variables									
Time Till Listing		-0.001***	0.000	-0.001***	0.000	-0.001***	0.000	-0.001*	0.000
ERC20		0.002	0.032	-0.005	0.031	-0.021	0.031	0.008	0.033
Presale		-0.029	0.030	-0.017	0.030	-0.029	0.030	-0.019	0.030
Bonuss		-0.024	0.025	-0.018	0.025	-0.017	0.026	-0.023	0.025
Github		0.062	0.045	0.060	0.045	0.067	0.046	0.061	0.046
Constant		1.023***	0.133	0.744***	0.038	0.661***	0.015	0.972***	0.136
#Obs.		*287*		*287*		*287*		*287*	
R^2		*0.060*		*0.059*		*0.043*		*0.069*	
Adjusted R^2		*0.040*		*0.039*		*0.022*		*0.042*	
F - value		*3.004****		*2.914****		*2.095**		*2.576****	
	Panel C. Market Adjusted Underpricing (Index)								
Variables	Expected	Model 1		Model 2		Model 3		Model 4	
	sign	B	S.E.	B	S.E.	B	S.E.	B	S.E.
Independent variables									
Funds Raised (Ln)	-	-0.012*	0.008					-0.008	0.008
Whitepaper	-			-0.001**	0.001			-0.001*	0.001
Project Age	-					0.000	0.000	0.000	0.000
Control variables									
Time Till Listing		-0.001***	0.000	-0.001***	0.000	-0.001***	0.000	-0.001*	0.000
ERC20		-0.006	0.029	-0.007	0.028	-0.020	0.028	0.000	0.029
Presale		-0.027	0.027	-0.017	0.027	-0.027	0.027	-0.019	0.027
Bonuss		-0.013	0.022	-0.009	0.022	-0.008	0.023	-0.011	0.023
Github		0.066	0.040	0.064	0.040	0.070*	0.041	0.065	0.041
Constant		0.984***	0.118	0.813***	0.034	0.800***	0.034	0.937***	0.122
#Obs.		*287*		*287*		*287*		*287*	
R^2		*0.064*		*0.070*		*0.056*		*0.074*	
Adjusted R^2		*0.044*		*0.050*		*0.036*		*0.047*	
F-value		*3.217****		*3.511****		*2.779***		*2.765****	

*** *Significance at the 0.01 level*

** *Significance at the 0.05 level*

* *Significance at the 0.1 level*

Hypothesis 2: The issue size of an ICO has a negative effect on the level of underpricing.

We found that for ICOs, in line with IPOs, issue size has a negative effect on the level of underpricing. This is result is robust for almost all different models and significant at the 0.1 or 0.05 level. Thus the null hypothesis can be rejected. This result is in contrast to the finding of Momtaz (2018), which found no significant result between issue size and first-day returns. Since both variables are log transformed, this relationship is elastic, and the interpretation of the result is as follows: If the issue size increases by 1%, raw underpricing decreases by 0.05%. If the issue size increases by 10%, raw underpricing decreases by 0.48%. If the issue size increases by 100%, raw underpricing decreases by 3.45%. While at first, this seems very little, given the vast spread in funding for ICOs (min $ 15k, max $ 320m) this coefficient can have a significant impact.

Hypothesis 3: The age of a project has a negative effect on the level of underpricing.

We found that for ICOs, the maturity of a project has no effect on the level of underpricing. This variable has no significance in any model, and thus, the null hypothesis cannot be rejected.

Hypothesis 4: The extensiveness of the whitepaper has a negative effect on the level of underpricing.

We found that for ICOs, more extensive information results in less underpricing. This result is robust in individual models across all dependent variables. Since in 5 out of 6 of the models which incorporate whitepaper pages it is significant and the right sign, the null hypothesis can be rejected. However, this result is less robust than the result of issue size. This result in line with the findings of Hanley and Hoberg (2010), who find that greater informative content in an IPO prospectus acts as premarket due diligence and thus results in more accurate offer prices and less underpricing. Since the dependent variable is log transformed, the interpretation of the result is as follows: For each additional whitepaper page, raw underpricing decreases with 0.2%.

6.5 Split sample

Table 5 presents the OLS regression with a split sample across three panels based on whether the ICO was conducted before or after 17 December 2017 (top of the market). The sample has 204 observations for the hot market while there are 83 observations for the cold market.

Table 5: Split sample OLS Regression of ex-ante uncertainty on underpricing

		Panel A. Raw Underpricing				*Panel B. Market Adjusted*				*Panel C. Market Adjusted*			
Variables	Expected	Hot market		Cold market		Hot market		Cold market		Hot market		Cold market	
	sign	B	S.E.	B	S.E.	B	S.E.	B	S.E.	B	S.E.	B	S.E.
Independent variables													
Funds Raised (Ln)	-	-0.009	0.013	-0.079**	0.032	-0.010	0.010	-0.050**	0.021	-0.004	0.009	-0.043**	0.018
Whitepaper	-	-0.002	0.001	-0.001	0.002	-0.002**	0.001	0.000	0.001	-0.002**	0.001	0.000	0.001
Project Age	-	0.000	0.000	-0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Control variables													
Time Till Listing		0.001*	0.000	-0.003**	0.001	-0.001***	0.000	-0.002**	0.001	-0.001***	0.000	-0.001**	0.001
ERC20		-0.019	0.047	0.074	0.118	-0.013	0.036	0.044	0.080	-0.026	0.032	0.046	0.069
Presale		0.006	0.043	-0.148	0.115	-0.008	0.033	-0.106	0.077	-0.012	0.029	-0.080	0.067
Bonuss		-0.018	0.038	-0.094	0.077	-0.024	0.029	-0.046	0.052	-0.014	0.026	-0.033	0.045
Github		0.154**	0.064	-0.245	0.197	0.096**	0.049	-0.100	0.133	0.104**	0.044	-0.080	0.115
Constant		0.600***	0.193	1.934***	0.549	0.896***	0.149	1.669***	0.369	0.837***	0.133	1.601***	0.320
#Obs.		204		83		204		83		204		83	
R^2		0.080		0.202		0.084		0.166		0.107		0.161	
Adjusted R^2		0.043		0.116		0.046		0.075		0.070		0.071	
F-value		2.131**		2.340**		2.222**		1.837*		2.913***		1.780*	

*** *Significance at the 0.01 level*
** *Significance at the 0.05 level*
* *Significance at the 0.1 level*

Across all three panels, funds raised are only significant during the cold market. Whitepaper loses its significance for raw underpricing in comparison to the non-split sample regression. The signs stay as expected for all independent variables across all panels. Time till listing is significant for both samples across all panels, however, flips to a positive sign for raw underpricing. Whitepaper is significant in Panel B and Panel C, but only in the hot market. Github is significant, but only in the hot market as well. The models have a higher predictive power during the cold market but are more significant during a hot market.

The split sample regression functioned as a robustness test, but also as an interesting comparison to which independent variables hold power in what type of markets. Funds raised was only significant in cold markets, while white paper pages were mainly significant in hot markets. The coefficient for issue size was much stronger in cold markets than in the total sample. If the issue size increases by 1%, raw underpricing decreases by 0.18%. If the issue size increases by 10%, raw underpricing decreases by 1.71%. If the issue size increases by 100%, raw underpricing decreases by 11.85%.

7. Conclusion

In this section, the empirical findings from the T-test and OLS regressions are discussed. The goal of this research was to find out if ICOs were underpriced and if a well-established theory for IPO underpricing had predictive power for ICOs as well.

This research was set out to fill the research gap by applying an established IPO underpricing model to ICOs. Proxies for ex-ante uncertainty were translated to the field of ICOs, and known variables for ICOs were taken into account as control variables. Our research question was:

Is the underpricing greater if the ICO has a greater ex-ante uncertainty?

To answer this question, several hypotheses were developed. First, we needed to establish that ICOs on average, were underpriced. Second, based on potential proxies for ex-ante uncertainty, the relationship between ex-ante uncertainty and underpricing could be assessed. For this research, we used a T-test to establish if underpricing was, on average different from 0. An OLS regression was used to find out if there was a significant relationship between the independent variables for ex-ante uncertainty and underpricing. The sample included 287 ICOs with the time frame being 2017 and 2018 for almost all of them. The data stemmed from various public sources and was checked across sources to enhance validity.

We find that ICOs, on average, are underpriced. Additionally, this is robust for raw underpricing, and both markets adjusted underpricing models. We find that one proxy for ex-ante uncertainty, issue size, significantly reduces underpricing in such a way that ICOs which raise more funds are less underpriced. Additionally, this is robust for non-transformed models. The number of whitepaper pages also significantly reduces underpricing, but this result is less robust. Given that two proxies are significant to underpricing and the sign, as well as the model strength, is in line with IPO research, this indicates that underpricing is greater if ex-ante uncertainty is greater.

7.1 Academic implications

The contribution of this research to the existing literature is threefold. First of all, the outcomes of the T-test confirm that ICOs are indeed on average underpriced. This is not only for raw first day returns, but market adjusted returns as well. This result adds to existing underpricing literature and calls for more academic research regarding utilizing established IPO theories for the prediction of underpricing of ICOs.

Second, the OLS regression of ex-ante uncertainty proxies on underpricing has confirmed that at least some of the proxies for ex-ante underpricing are consistently able to predict the level of underpricing. This is not only for raw first day returns, but market adjusted returns as well. This result adds a vital finding regarding issue size to ex-ante uncertainty and underpricing literature and calls for more research regarding the relationship between other ex-ante uncertainty proxies and ICO underpricing.

Third, the results regarding the split sample are consistent between different measurements for the dependent variable and call for further academic research. This is not only for the differences between hot and cold markets for ICOs but for IPOs as well.

7.2 Practical implications

The practical implication of this research is that investors in ICOs now know that the issue size and whitepaper pages play a major role in short term returns on investment. If an investor would prefer a short term return on investment and capitalize directly after listing, ICOs with a smaller (expected) amount of funding would, on average, provide a larger return (probability not taken into account). This works the same way for whitepaper pages, in which short term investors would prefer ICOs with the least number of whitepaper pages (probability not taken into account).

Furthermore, this research gives insight to ICOs as to which variables to focus on in what type of market (hot vs cold). During a hot market, CEOs should focus on creating a more extensive whitepaper while during a cold market, underpricing is reduced by a larger issue size.

8. Limitations and future research

The most significant limitation of this research is the difficulty to assess if the data is valid. The data has to be hand collected and combined from various public online sources. During the collection and cross-checking, it came to light that data is not reliable. In order to address this, data was removed when this was seen.
Given that the data collection has been done manually for some variables and had to be checked manually. Although the data had been cross-checked, some clear data errors were still present (e.g. billions of USD funds raised). Once there is a database containing verified data, the repetition of this research might be interesting.

Data available mostly consists of successful ICOs, since unsuccessful ICOs (which went to zero) have no motive to keep their information available online. This means that a specific subsample is underrepresented in this research. This may also be the reason why Momtaz 2018 found the mean underpricing to be much lower, as this research managed to incorporate failed / died ICOs.

Given the early stage of research for ICOs, certain variables could be added as control variables to increase the robustness. Founder Age and experience are examples of variables which may contribute to underpricing.
Other established underpricing theories for IPOs could be translated to ICOs as well, such as the signalling model.

Furthermore, in this research, the first available listing price was taken. In future research, it would be interesting to see if underpricing, and the effect of ex-ante uncertainty on underpricing is observable for other measurments (+x days after listing) as well.

Finally, further research regarding the differences for specific variables during hot/cold markets would be beneficial to understanding why certain variables are only significant during one type of market and if the result of this study is robust.

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10. Appendices:

Appendix A: an example of an ICO

Civic's (CVC) ICO issued 1 Billion tokens with a maximum cap of 33 million USD. 33% of all tokens were sold in the ICO. Civic is an application which allows for on-demand, secure and lowers cost access to identity verification via the blockchain. By sending BTC or ETH to the smart contract, investors could buy CVC tokens. A whitepaper was available before the sale, and more information can be found on www.tokensale.civic.com

Appendix B: Market adjusted indices

Market Index:

Most importantly, a proper index should be seen as a benchmark and is an indicatory point for investments based on the index. There are several types of indices, for example, the DAX index from Germany evaluates the performance of the 30 largest companies which are also the most liquid on the German stock market. This means that the DAX represents approximately 80% of the total market capitalization of the ventures in Germany that are listed on the stock exchange. The broader an index is, the less often the composition has to be readjusted, as it will naturally readjust.

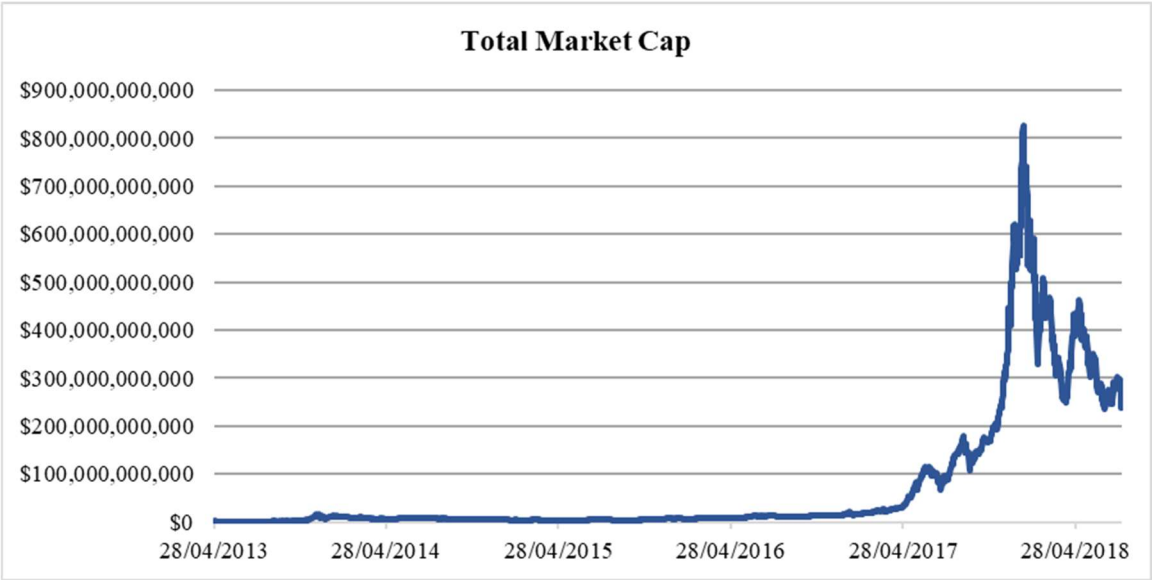
Some of the first cryptocurrency indices are retrieved by the TaiFu index family, set up by the Americans Tai Zen and Leon Fu. One of their indices consists of tracking the top 30 cryptocurrencies daily, based on their market capitalization. The other is their Altcoin index which does the same but excluding Bitcoin or any hard forks of Bitcoin. The final index is where they focus on Bitcoin and all hard forked cryptocurrencies based on Bitcoin.

The reason I think this is not an appropriate way to index the cryptocurrencies is that an index should be an indicator of the increase in the price of specific cryptocurrencies compared to the general market fluctuation. By changing the tracked currencies based on what is in the top 30 daily, the index misses the point reweights too often. In this case, the market fluctuation is ruling the index, instead of acting as an indicator.

On top of that, there is extreme volatility in prices and liquidity in the cryptocurrency market. This can result in a significant market fluctuation, leading to a deceptive index. To illustrate the indices I created, there are two different types of graphs. The first shows the actual data over a set time, while the second type is a logarithmic version of the data. The reason I chose this is because it is easier to notice a particular trend in logarithmic data than in the regular data.
Felix 2018 uses the largest cryptocurrency index, the so-called CCI30, but for reference, he also uses the Morgan Stanley Capital International World Index (MSCI). Keeping in mind that different indices are potentially set up with very different standards, it is of paramount importance to use more than one reference. The CCI30 is similar to the TaiFu index; it tracks the top 30 cryptocurrencies in terms of market capitalization. This was set to 30 because they claim it is the minimum number necessary to be statistically relevant.

In the book, Lee, D., & Deng, R. Handbook of blockchain, digital finance, and inclusion, Volume 1, the so-called CRyptocurrency IndeX (CRIX) is used for reference. The CRIX is constructed based on approximately 30 cryptos, and it is focused on high coverage of the accessible market capitalization. The reallocation period is one month, at which the liquidity will be checked. Every three months, the number of constituents and the constituents themselves are checked. Momtaz (2018) has created an index in a similar manner as I do with the same data source: coinmarketcap. However, there is one difference in approach: all cryptocurrencies are used in his index instead.

To illustrate the indices I created, there are two different types of graphs. The first shows the actual data over a set time, while the second type is a logarithmic version of the data. The reason I chose this is because it is easier to notice a particular trend in logarithmic data than in the regular data.



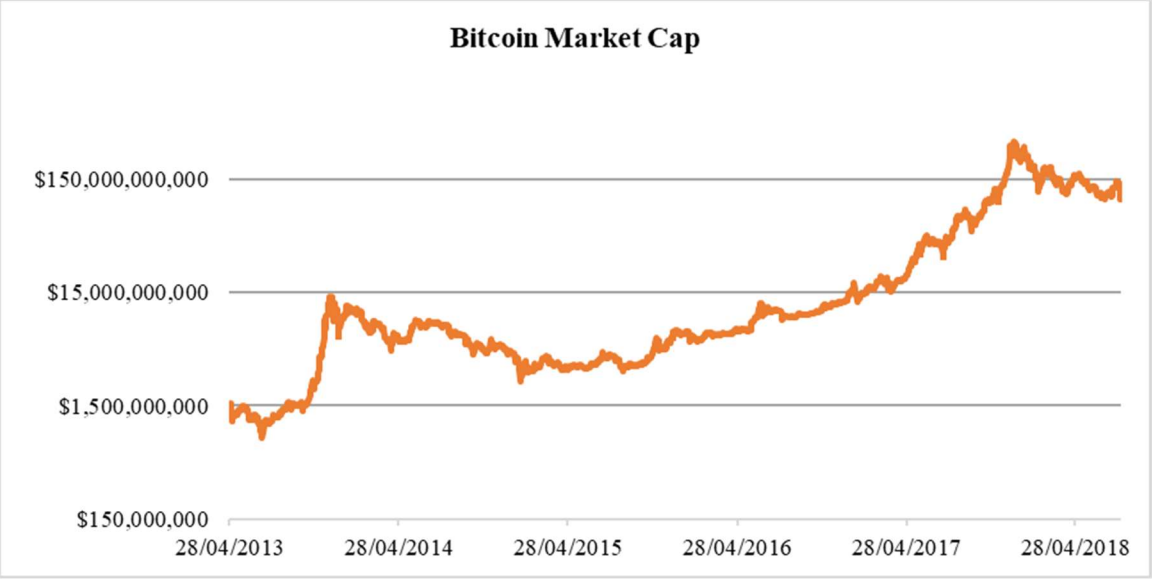
The graph presented above is the total market cap of all cryptocurrencies. As you can see, a clear parabola is noticeable from 2017 until the start of 2018. At the start of 2018, the "bubble" pops, and the market cap deflates. This is interesting since the sample can be split into two groups, one group before the bubble popped and the other afterwards.

The graph presented above is the logarithmic version of the previous graph. This graph is provided because two indexes have been created from the Total Market Cap. The first one is the Bitcoin Market Cap, which consists solely of BTC. The second one is the Index Market Cap, which is constructed by subtracting the Bitcoin Market Cap from the Total Market Cap.

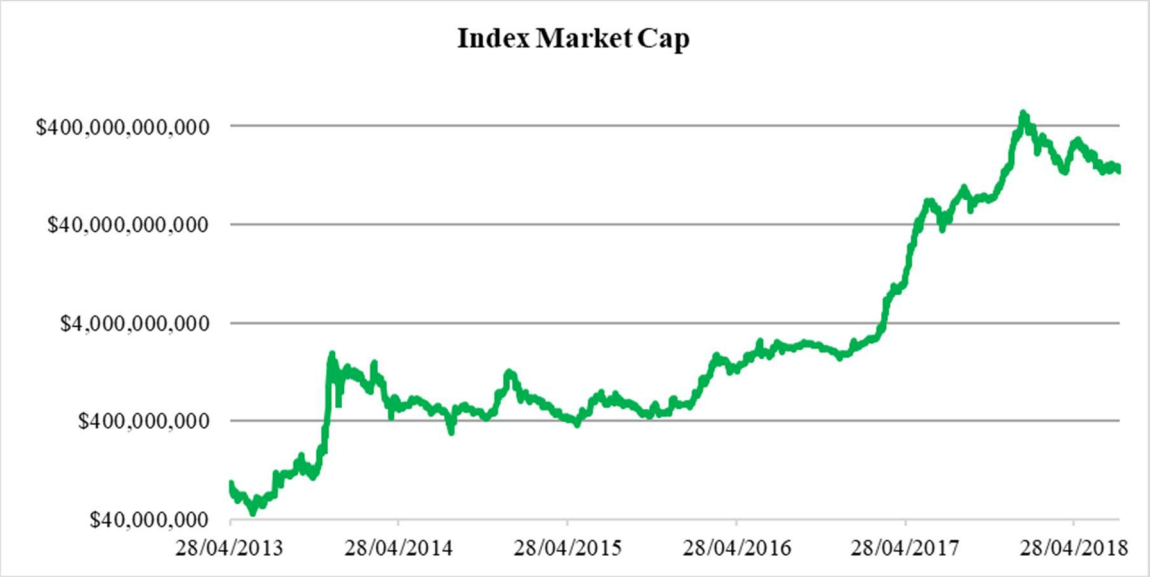
The reason that the Market Cap is used is that the relative increase of the market cap is equal to the relative increase in the price if no new tokens are being issued. For the Bitcoin Market Cap, this is valid since most BTC has already been mined and the issue rate is too low to be significant. The Index Market Cap gives a fair view of the influx of currency into alternative cryptocurrency during a period because it sums all cryptocurrency except BTC per data point.

The rationale behind the use of the Index Market Cap is that ICOs, in essence, are alternative cryptocurrencies. Although Bitcoin is a cryptocurrency, this is an important distinction. The use of two measures will be that of robustness.

The Bitcoin Market Cap is not reweighted, due to the fact that it solely consists of BTC. The Index Market Cap is not reweighted as well because it consists of all cryptocurrencies except BTC. Since the market cap is taken, the Index Market Cap does not need to be reweighted either.



When comparing the Bitcoin Market Cap to the Total Market Cap on the previous page, the graphs look very similar. This is deceptive, since the market movements of alternative coins are different than BTC.



When comparing the Index Market Cap to the Bitcoin Market Cap, a clear difference in market movements can be identified. For our sample which is in 2017-2018, the parabola is much steeper at the beginning of 2017 after which it flattens and then continues. Bitcoins parabola is much more gradual. The deflation after the top also differs.