HEC MONTRÉAL

ICOs Underpricing

par

Sormeh Dolati

Dr. Vincent Grégoire
HEC Montréal
Directeur de recherche

Sciences de la gestion
(Spécialisation Finance)

Mémoire présenté en vue de l'obtention
du grade de maîtrise ès sciences en gestion
(M. Sc.)

November 2022

Résumé

[Write your French abstract here (150 to 250 words).]
Mots clés: ICO, IPO, Underpricing, Whitepaper, Blockchain, Smart Contract, Information Asymmetry, Token, Fundraising

Méthodes de recherche: Étude empirique

Abstract

In this empirical work, steps are taken to study underpricing in ICOs and its determinants. Initial Coin Offerings (ICO) is a mechanism through which new ventures raise capital by selling tokens to a crowd of investors (Fisch, 2019.) Previous studies show that underpricing is a phenomenon that exists in IPOs (Initial Public Offerings), and IPOs are underpriced on average. The primary reason for underpricing is information asymmetry which can be reduced through information disclosure. In ICOs, this can happen through whitepapers, social media and source code availability. OLS regression models were used in this study to examine primary determinants of ICO underpricing. The study results show evidence that the inverse of fundraising goal, having a whitepaper, whitepaper length, using social media, and source code availability are associated with ICO underpricing. Whitepaper types, social media types and specific whitepaper topics were also studied. Some whitepaper topics can be used as signals for quality and mitigate information asymmetry. The study results show there is evidence of a significant relationship between these whitepaper topics and ICOs underpricing.

Keywords: ICO, IPO, Underpricing, Whitepaper, Blockchain, Smart Contract, Information Asymmetry, Token, Fundraising

Research methods: Empirical Study

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Acknowledgements

I want to express my gratitude to my thesis supervisor, Dr. Vincent Grégoire, for his fantastic support, deep insight, and patience. I would also like to thank my family, Mohsen, Dario and Jigzy, who have unconditionally motivated and supported me during my Master's.

1. Introduction

Initial Coin Offering is a method of financing projects through the Internet, in which new ventures sell tokens to a crowd of investors (Feng et al., 2019). Fisch (2019) indicates that ICOs represent a novel mechanism of entrepreneurial finance that has substantially gained popularity since 2017. Blockchain technology is at the core of the business models of these ventures (Fisch et al., 2021).

While ICOs and IPOs (Initial Public Offerings) have similarities, they also have important differences. The main ones are: Regularity frameworks and documentation requirements differ. ICO duration is concise compared to IPOs (Felix, 2018), and ICOs are primarily young, risky projects, while IPOs are well-settled companies (Zetzsche et al. 2017.)

Ibbotson, J (1975), and Ritter (1984), among others, provide convincing evidence that initial public offerings are, on average, underpriced (Beatty and Ritter, 1986). Beatty and Ritter (1986) believe that even though initial public offerings are underpriced on average, an investor submitting a purchase order cannot be sure about an offering's value once it starts publicly trading. They call this uncertainty about the value per share "ex-ante uncertainty." They argue that the greater the ex-ante uncertainty, the greater the expected underpricing.

Underpricing is a consequence of the information asymmetry between the agents involved in an IPO event. The first systematic information asymmetry model by Rock, k (1986) predicts that some investors have better information about the IPO valuation than the issuers and underwriters(Marcato et al., 2018.)

ICOs are controversial. Since they are loosely regulated, they enable startups to raise large amounts of capital while avoiding compliance costs and intermediaries. Conversely, the absence of regulation leads to increased investment risk due to misconduct (Fisch et al., 2021.) In addition, Florysiak & Schandlbauer (2022) believe the market is generally characterized by high degrees of asymmetric information between ICO issuers and ICO investors; they need to easily separate high-quality from low-quality ICO issuers compared to the IPOs. Meoli & Vismara (2022) discuss that because of high information asymmetries, investors find it particularly challenging to assess

companies' prospects of raising funds through ICOs. Interestingly, the ICO whitepaper is the only somewhat reliable source of information for investors to ground their investment decision (Adhami et al., 2018.)

Whitepaper as a voluntary disclosure is a mechanism that can reduce information asymmetry (Florysiak & Schandlbauer, 2022.) Campino et al. (2022) believe the whitepaper is also a measure of the project's credibility, as it contains technical information, business information, and information regarding the team. In this context, Thewissen et al. (2022) believe that some topics in the whitepaper are associated with the success of ICO projects. This content structure mitigates information asymmetry and signals quality.

Extending IPO research to the context of ICOs, we use similar independent variables in the current study to explore the impacts of these variables on ICO underpricing and success. In this study, the main questions are as follows: Are ICOs as underpriced as IPOs are, and what are the main determinants of ICO underpricing and ICO success? To answer these questions, this study surveyed 320 ICOs ended between August 2021 and April 2022 to identify underpricing in ICOs and determinants of ICO underpricing and success in different aspects. These determinants are divided into ICO characteristics determinants and high-quality signal determinants. ICO characteristics determinants are the size of the ICO (inverse of fundraising goal), ICO duration, being listed in an exchange and industry. At the same time, high-quality signal determinants include providing a whitepaper and its characteristics (such as whitepaper length, type and topics), social media channels and source code availability.

From a theoretical perspective, this study uses Beatty & Ritter (1986) research findings on IPOs to replicate the data to study underpricing of ICOs. The IPO underpricing is measured by the difference between its first-day closing price and its offering price. For the ICOs in this study, the initial return is calculated based on the same concept in IPOs.

The following indicators in ICO studies are used to examine the questions of the survey:
Used the inverse of the gross proceeds as an indicator for ex-ante uncertainty, while in this study, the inverse of the fundraising goal of ICOs was used. Loughran and Ritter (2004) used "Age" and "Industry" as IPO underpricing indicators. Similarly, this study uses ICO duration and industry as ICO underpricing determinants.
Fisch (2019) and Adhami et al. (2018) identify potential signals of ICO project quality. We use "Whitepaper" and "Available source code" in this study. "Whitepaper length" presents another determinant of underpricing, as a whitepaper characteristic, based on Samieifar & Baur (2021) and Bourveau et al. (2022.)

Zhang et al. (2019) and Thewissen et al. (2022) discuss ways to signal the quality of a project through specific topics in the whitepaper. This particular content leads to reduced information asymmetry and increases successful fundraising. The main topics are "Product description," "Token information," "Fund usage," "Roadmap," "Team," "Team size," "Blockchain application," "Smart contract," "Risk Factors," and "Legal Disclaimer."

To summarize our empirical results, we find that ICOs are, on average underpriced, which is in line with IPO underpricing studies. Results show that the size of an ICO, having a whitepaper, information disclosure through social media and accessible source code have a significant relationship with ICO underpricing. However, ICO duration is not significantly associated with ICO underpricing and success. In the second OLS regression model, having a whitepaper variable was replaced with whitepaper types. Gitbook, PPT, HTML, pdf, and protected formats are significantly associated with the ICO underpricing. In the third model, social media types were examined, and results show that "Discussion Sites," "Social Blogging," and "GitHub" are significantly associated with ICO underpricing. However, "Video Sharing" does not have a significant relationship. In the fourth model, "having a whitepaper" was replaced by the "whitepaper topics" variable. The results show a significant relationship between "Product Description," "Token Information," "Fund usage," "Team," "Team Size," and "Legal Disclaimer" topics in the whitepaper and ICO underpricing.

This study is organized as follows. The second part of the study describes the related literature and discusses the information asymmetry problem, the ex-ante uncertainty and signalling theory content. At the same time, this section provides relevant determinants in previous studies. Section 3 introduces the data and provides descriptive statistics. Section 4 presents the methodology of this study, while section 5 provides the main results. Section 6 concludes.

2. Literature Review

2.1 Theoretical Background

2.1.1 Cryptocurrencies, Tokens and Blockchain

With the global recession that followed the 2007-2008 crash due to the subprime lending crisis, the issues with systemic risk became and continue to be of crucial importance for finance professionals. One of the outcomes of the financial crisis is the creation of a new cryptocurrency called bitcoin that provides a trusted peer-to-peer payments network to move value around that does not rely on the current financial system but is maintained by the users of the network or the 'nodes.'(Boreiko & Sahdev, 2018)

The advent of Bitcoin in 2008 by Satoshi Nakamoto started a new episode of the digital era. Bitcoin is a combination of a cryptocurrency (bitcoin) and a blockchain (Bitcoin, with capital B). Nakamoto (2008) was able to design a peer-to-peer, decentralized, public ledger of transactions. Over time several improvements to the bitcoin protocol were developed. The Ethereum network is one of them. Ethereum was built on a Turing Complete, a language that allowed more complicated transactions to get executed through so-called "smart contracts."

"Smart contracts" allow the performance of credible transactions without third parties and make the transactions tractable and irreversible. One such "smart contract" that is deployable on the Ethereum network is a Dapp (decentralized app) called ERC20, which allows a single entrepreneur to raise a native currency from multiple investors, a process commonly known as an Initial Coin Offering (ICO) (Sharma & Zhu, 2020.) One critical emerging use case of blockchain technology involves "smart contracts." "Smart contracts" are computer programs that can automatically execute the terms of a contract. When a preconfigured condition in a "smart contract" among participating entities is met, the parties involved in a contractual agreement can automatically make transparent payments as per the contract (*AIR (Applied Innovation Review)*, 2016 p.8).

SEC classifies digital tokens into three main categories. First, the security token represents assets such as participation in actual physical underlying companies, earnings streams or an entitlement to dividends or interest payments. Second, the utility token provides access to goods and services that the entrepreneur and the platform provide. These tokens can then be used as discounted and premium access to goods and services. The third type of digital tokens is classified as cryptocurrencies. Usually, the tokens of this category are not directly linked with underlying assets or cash flow; neither do they have other functions or links to exchange for exclusive goods or services (Sharma & Zhu, 2020.) In this study, most of the ICO tokens are in the utility category, and some are security tokens.

2.1.2 ICOs

ICOs are a very recent phenomenon. The first ICO was conducted in July 2013 by Mastercoin, a digital currency built on Bitcoin's blockchain. Since then, hundreds of ICOs have followed. An ICO is a mechanism through which 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 distributed ledger technology (DLT). ICOs enable startups to raise large amounts of funding with minimal effort while avoiding compliance and intermediary costs. (Fisch, 2019)
An entrepreneur explains his or her business idea in a whitepaper. For many projects, funding starts with a so-called pre-ICO, in which a selected group of investors are given exclusive rights to purchase tokens, typically at a discounted price, before the token sale opens up to the public. (Li & Mann, 2021)

Most ICOs are accompanied by the release of a “whitepaper,” similar to the IPO prospectus. In principle, a whitepaper contains a description of the platform, its core business, and details about the issuance and usage of the digital token. It is meant to act as a formal way of information disclosure for the general public, potential investors and future customers. The issuer can reduce asymmetric information and create incentives for the investors to ensure the success of the token offering (Sharma & Zhu, 2020.) Florysiak & Schandlbauer (2022) believe whitepapers are the initial, essential, and arguably most comprehensive disclosure channel that sets the path and benchmark for any following business developments. Whitepapers are the primary tool to signal

the quality of the project through information disclosure. However, since they are unstructured and unaudited and providing them is voluntary, it is difficult to measure if they are standard and not subject to adverse selection. Some projects use Lite papers instead of whitepapers, which are shorter.

2.1.3 The Underpricing Phenomenon in IPOs

IPO underpricing occurs when the offering price is less than the closing price on the first trading day. Ibbotson, J (1975) and Ritter (1984) provide convincing evidence that initial public offerings are, on average, underpriced (Beatty and Ritter, 1986). Beatty & Ritter (1986) believe that even though initial public offerings are underpriced on average, an investor submitting a purchase order cannot be sure about an offering's value once it starts publicly trading. Beatty & Ritter call this uncertainty about the value per share 'ex-ante uncertainty. They argue that the greater the ex-ante uncertainty, the greater the (expected) underpricing.

Ljungqvist (2007) classifies theories of underpricing under four broad headings: asymmetric information, institutional reasons, control, and behavioural. Information asymmetry approach argues that underpricing is a consequence of the information asymmetry between the agents involved in an IPO event. The first systematic information asymmetry model by Rock (1986) argues that some investors have better information about the IPO valuation than the issuers and underwriters. Underpricing is used as compensation for investors with information disadvantages. Who are otherwise reluctant to participate in IPOs. Beatty & Ritter (1986) show that uninformed investors are discouraged by the "winner's curse" risk, and issuers use underpricing to attract investors who believe that shares are only available because they are mispriced or unwanted. Finally, signalling models present underpricing as a strategy adopted by issuers to signal the company's quality. In this setup, only well-performing companies can afford the initial cost of underpricing, which can be recovered in the subsequent seasoned equity offerings (Marcato et al., 2018.)

Under asymmetric information models, ex-ante uncertainty has been used in this study for ended ICOs. For this purpose, project characteristics, offering characteristics, prospectus disclosure and aftermarket variables are being considered the key features (Ljungqvist, 2007.)
As company characteristics, the leading indicators are:

- Age of the project (Ritter, 1984), (Ljungqvist & Wilhelm, 2003)
- The measure of a size such as a log sales (Ritter, 1984)

Offering characteristics:

- The inverse of the gross proceeds (Adhami et al., 2018)

Prospectus Disclosure:

- Number of uses of IPO Proceeds as disclosed in the prospectus (Beatty & Ritter, 1986)
- Number of Risk factors listed in the prospectus (Beatty & Welch, 1996)

2.1.4 The Underpricing in ICOs: how ICOs are different from IPOs

Aside from similarities between IPOs and ICOs as public offerings, exchange listing, and fundraising phases, there are essential distinctions between IPOs and ICOs. First, the regulatory framework for an ICO is different from an IPO. At the time of writing, the regulatory framework for ICOs is weak and inconsistent. If an ICO falls under security regulation, the issuer must follow a path like IPOs. An IPO requires lawyers, and banks, whereas an ICO requires programmers (Felix, 2018.) Documentation requirements are different. While a company that launches an IPO faces disclosure and registration requirements imposed by the securities regulator, ICOs' disclosure requirements are unclear and depend on their function and the governing jurisdiction. Most ICOs generally publish a whitepaper that outlines the business model of the project, a technical whitepaper that features the project's technological aspects, and the project's source code. Unlike IPOs' documentation, ICOs' documentation format is not standard (Ofir & Sadeh, 2019.)

Second, the phases an ICO goes through are the same as IPOs but differ in length. The start of the ICO is when the issuer sells cryptocurrencies to investors. Due to its heavy regulatory environment, setting up an IPO takes around 4 to 5 months. ICOs take less than a month. Some projects hold a pre-ICO, an opportunity for investors to invest and receive a discount. This is comparable to a pre-IPO, where a portion of the stocks is placed with private investors right before the IPO is scheduled to hit the market. Similar to IPOs, the post-ICO period is the phase of the first

listing day. The listing day is when an exchange adopts a cryptocurrency for the first time (Felix, 2018.) ICOs' marketing process is significantly different from IPOs' marketing process. While in an IPO, an underwriter conducts a book-building process, ICO marketing is done primarily through social media channels. In contrast with IPOs, which generally use social media to raise awareness for the project, ICOs use social media to publish vital information like launch announcements or the start of trading. Additionally, ICOs use social media platforms to communicate directly with potential investors, thus decreasing the ex-ante uncertainty associated with the platform (Ofir & Sadeh, 2019.) Third, IPOs are usually for well-settled companies, whereas an ICO is more for young and risky companies (Boreiko & Sahdev, 2018.) An IPO is only possible if it concerns an established company and complies with ethical business standards. As seen in the past, companies could raise capital while committing fraud. The unregulated ICO environment results in an additional risk factor for an investor: being a victim of fraudulent activity. For example, investors could be exposed to insider trading and pump-and-dump schemes. A pump and dump scheme is often set up by a large cryptocurrency holder or 'whale.' Furthermore, an IPO is often an exit strategy, where the owner's cash on selling their company. Conversely, an ICO is an entry strategy to finance the start-up. It is a difference in the track record. The differences between an IPO and an ICO cause an ICO to be considered substantially riskier. As a result, the type of investors active in the cryptocurrency market tends to be more risk-seeking than regular stock market investors (Felix, 2018.) In order to initiate an IPO, a potential issuer will have to "demonstrate a certain level, and stability, of revenues – which can only be achieved through a certain maturity in the issuer's operations." This is partially due to the listing requirements of exchanges and investment banks (which act as underwriters) tendency to select IPOs that have the potential to perform well after. ICOs, on the other hand, are typically launched very early. A 2017 study finds that most ICOs are in the idea stage, and their platforms/services are expected to be launched a year or more after the ICO. This difference suggests that ICOs are riskier and are associated with a higher degree of information asymmetry (Ofir & Sadeh, 2019.)

2.1.5 Main determinants of ICO underpricing

Some studies focus on which variables increase fundraising and decrease information asymmetry in ICOs. Fisch (2019) argues that signalling high quality refers to signalling theory in the ICO context. Higher technological capabilities reflect signalling. In particular, he explores three indicators that qualify as potential signals of technological capabilities: patents, technical whitepapers, and high-quality source code. Spence (1978), with signalling theory, argues that high-quality ventures can attract higher amounts of funding by sending signals to potential investors. Fisch (2019) also uses this idea to develop the ICO and whitepaper concept.

The informativeness of whitepapers and information disclosure is another variable studied in different papers. Beatty & Welch (1996) found that greater disclosure (uses of proceeds and number of prospectus risk factors) results in a higher initial return. Beatty & Ritter (1986) found important information in the number of use of proceeds, increasing underpricing (Beatty & Welch, 1996) Feng et al. (2019) results indicate that providing technical details in the whitepaper can effectively signal the quality of an ICO project. However, the primary source of information, the whitepaper, is an unstructured document without any standardization. (Meoli & Vismara, 2022)

Adhami et al. (2018), based on information asymmetry theory, believe that whitepaper and code availability are among the success determinants of an ICO. (Meoli & Vismara, 2022.) However, regarding the code availability, there are also concerns such as risks related to disclosing the code to hackers.

Samieifar & Baur (2021) find that the length of the whitepaper is positively correlated with the amount raised during the ICO and the likelihood of completing the ICO. In contrast, the readability grade of the whitepaper is only positively correlated with the amount raised.

In order to reduce information asymmetry, investors try to use different available channels. Projects, websites, and social media platforms help investors access information. Accordingly, Bourveau et al. (2022) find that lengthier and more technical whitepapers that disclose information about the team, token incentive structures, and governance measures positively predict successful

capital raising, which suggests that these whitepaper disclosures are relevant to the investment decision.

Zhang et al. (2019) identify the following topics in the whitepaper: introduction, definition, description of the problem, product description, token information, fund usage, roadmap, team, and references. Thewissen et al. (2022) results also show significant diversity in the topics covered in ICO whitepapers, ranging from technical descriptions, such as underlying blockchain structure, smart contracts, and data protection, to business-related concerns, such as future roadmap, market size, and risks. This study questions whitepapers' main topics and which are associated with ICO funding success. This study's main topics are Initial sale, Liquidity, Roadmap, Blockchain application, Smart contracts, Governance, Regulations, Human Resources, Service profile, Risk Disclosure and Legal disclaimers.

3. Data

In this study, the data was collected from two leading websites that are commonly used in ICO literature: icodrops.com website Figure A was used to collect the initial sample of 320 ended ICOs between August 2021 and April 2022, and since icodrops.com does not provide historical data, coinmarketcap.com Figure was used to complete the closing price information. These two websites have one of the most accurate data related to ICOs.

In order to construct the dataset, the following steps were taken. Since icodrops.com does not allow automated scraping, the data was collected manually, and the remaining data missing from this website (closing price) was retrieved from the coinmarketcap.com website. Screenshots of the websites are presented in the appendix to give a better image of how the needed information is listed on these two websites.

On the icodrops.com website, ended ICOs list in Figure A provides a table with the following information: Project name, category, financing received, financing goal, end date and the market traded (if the ICO is listed on exchanges).

If you click on each project (Figure A and

Figure A), in addition to a brief introduction to the project, the following information is accessible on the page: Token sale start and end date, Ticker/Symbol, token type (Standard), Role of the token (utility, payment, security, and stable coins), Fundraising Goal, percentage of fundraising completion, total token sold, ICO offer price, if the ICO is on the "whitelist" (KYC information on ICO which can make it more trustworthy), list of countries that cannot participate, personal cap, which platforms are acceptable, trading volume, market cap, return since ICO compared to USD, ETH and BTC. In addition, you can find the project's website, whitepaper (if available) and links to social media, including Facebook, LinkedIn, and GitHub for accessing source code, Twitter, discord, telegram, etc.

On the ICOdrops.com website, a link to the whitepaper for each project is provided, from which you can download or access the whitepaper. Whitepapers are available in different formats, such

as pdf files, PPT files, GitBook and HTML format with links to different parts of the whitepaper. There are also protected whitepapers; you must use your credentials for access. In a whitepaper which is an informational document about the project, you can find out who are the team members, what solution the project will be creating, how it would be interesting for the investors of the ICO to invest in the project, what are the features of the offered solution and how the project will deliver the product or service, what would be the payment process, and what are the promises. Generally, you can access industry overview, technical overview, roadmap, token details and, in some cases, "smart contract" information.

Based on data provided on the ICOdrops.com website, ICOs with no start and end date have been disregarded first. The next step, ICO duration, has been calculated in days from ICO's start and end date plus one. In addition, source code availability information has been provided. If GitHub information is available for the project, the source code availability dummy value is true.
In addition, each project provides information on the social media they use to communicate with investors, such as Facebook, Twitter, etc.

Moreover, the industry has been categorized into tech and non-tech considering the type of industry listed (Blockchain Service, Social Network, Gaming, Platform, Protocol, Dapp, DEX, DeFi, Network, Marketplace, Data Service, Trading, Predictions, Market, Business).

As mentioned above, closing price information was gathered from the coinmarketcap.com website. This website is one of the most accurate websites on cryptocurrency data. On the first page of each project, an overview graph is available that can provide a snapshot of one-day to one-year performance (price and volume). On the historical data tab (Figure), you can also find the closing price of the ICO. This study did not use other information available, such as ratings, news, and price estimates.

3.1 Data Limitations

Despite the wide variety of information provided by these two websites, there are limitations on the provided data that need to be considered. The most important limitation is that only some projects have complete data on every aspect this study needs. There was an outlier in the data that was eliminated to have more accurate results. The eliminated outlier was from the ICO duration column due to missing starting.

Another limitation is that the data of ICOs are constantly being updated. It means the results can be different unless we update the data constantly. In addition to these limitations, there are few studies related to the ICOs' whitepaper details, and the lack of previous studies is one of the potential limitations. IPO previous studies and prospectus-related information have been used to study the role of the whitepaper in ICO return by using critical factors of a whitepaper. However, the sample's heterogeneity of whitepaper data can also be another limitation. In some cases, the degree of technicality of the whitepaper topics is different. For example, two ICO whitepapers have a "Blockchain Application" topic; however, in one, there is a technical explanation of what the blockchain is and how it works, while the other only mentions the type of Blockchain and its brief application. Sometimes topics might not be on the whitepaper but instead listed on the website itself. Moreover, some ICOs remove whitepapers after the ICO duration ends, and the information will not be available afterwards.

In order to check if the ICO project is a scam, some studies use "being listed on an exchange" information as a control variable. Yen et al. (2021) consider the post-ICO survival measure of success, whether the tokens issued by the ICOs are subsequently listed on an exchange.

3.2 Descriptive Statistics

This sample includes 320 ended ICOs. Among all ICOs in the initial sample, 248 provided an accessible whitepaper during data collection. Table 1 presents the summary statistics for the observations included in the analysis, focusing on the sample of completed ICOs with available whitepapers. Table is provided in the appendix for accessing all study variables' definitions.

Table 1: **Descriptive statistics.** This table presents the descriptive statistics of the variables related to ICOs. 320 ICOs were listed on ICODrops.com between August 2021 and April 2022, for which all relevant variables are available. For each variable, the table contains the number of non-missing observations and the mean, standard deviation, 1st, 10th, 25th, 50th, 75th, 90th and 9th percentile values. All variables are defined in *Table A1:*

	Count	Mean	Std. Dev.	Min	1%	10%	25%	50%	75%	90%	99%	Max
ICO Return	303	12.49	22.80	-1.00	-0.88	0.13	1.37	5.01	12.71	32.73	106.22	218.10
Size	314	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Whitepaper Pages	251	23.42	12.78	1.00	3.50	11.00	15.00	21.00	29.00		67.00	82.00
ICO Duration	298	3.60	2.47	1.00	1.00	1.00	2.00	3.00	5.00	8.00	10.00	11.00
Whitepaper type	320	0.83	1.62	-1.00	-1.00	-1.00	0.00	0.00	3.00	3.00	3.00	4.00
Social Media Type	320	1.99	1.45	0.00	0.00	0.00	0.00	2.00	3.00	4.00	4.00	4.00

The sample used includes 320 ICOs in a period from August 2021 to April 2022. The mean underpricing is 9.54 percent, meaning that the ICOs are underpriced on average.

The typical duration of an ICO is 3.6 days. Moreover, the most commonly used social media for projects are discussion sites, with 82 projects using them. In addition, the most used type of whitepaper is GitBook, with 120 observations.

Figure 1 presents the frequency of whitepaper types, frequency over time and whitepaper pages over time. Whitepapers' length varies from one to eighty-two pages, and the average is 23.42 pages.

Figure 1: Whitepaper type frequency, Whitepaper type frequency over time and Number of whitepaper pages over time

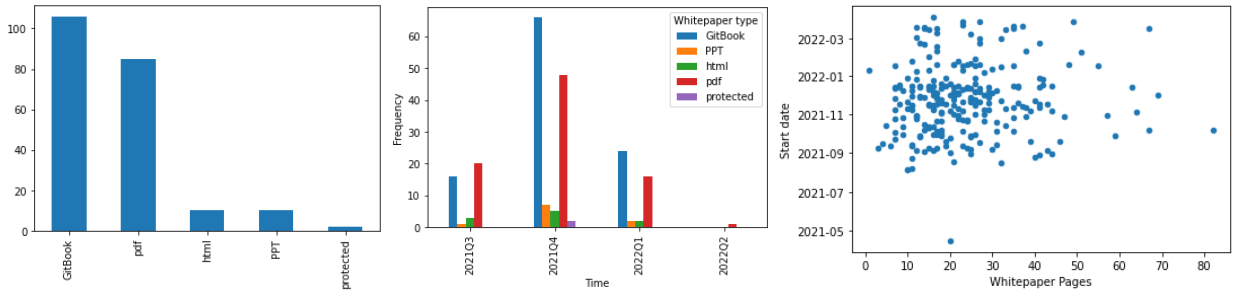
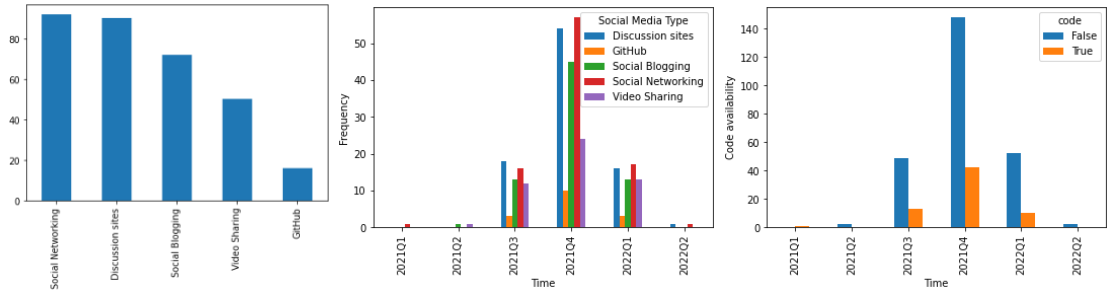


Figure 2 presents social media type frequency, frequency over time and code availability over time.

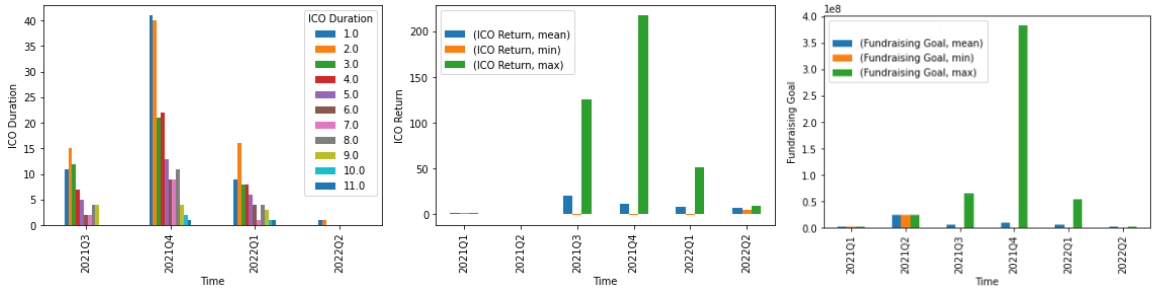
Figure 2: Social Media type frequency, Social Media type frequency over time and Code availability

Social Media Types: Social Networking (including Facebook, LinkedIn, and Twitter), Source code (GitHub), Discussion sites (including Discord and Telegram), Video Sharing (including YouTube) and Social Blogging (including Medium and Reddit).



To sum up time trends, ICO duration over time, ICO returns over time, and the fundraising goal of the ICOs over time are shown in Figure 3.

Figure 3: ICOs Duration over time in days, ICOs Returns over time and Fundraising Goal over time



To check multicollinearity, Pearson and Spearman correlation between models' variables are shown in Table 2 and Table 3. Both Pearson and Spearman correlation coefficients indicate that the only two variables with a positive association with the Pearson correlation of 0.612851 and Spearman correlation of 0.755076 are whitepaper and whitepaper type, which are not used in any of the models together.

*Table 2: **Pearson Correlation**. This table presents the Pearson correlation table of our main variables of interest.*

	Size	Whitepaper Pages	ICO Duration	Whitepaper	Whitepaper type	Social Media Type	Code
Size		0.00	-0.11	0.02	-0.01	0.01	0.04
Whitepaper Pages			0.03	-0.02	-0.18	-0.11	-0.12
ICO Duration				-0.03	0.02	-0.01	0.01
Whitepaper type						0.05	0.07
Social Media Type							0.05
Code							

*Table 3: **Spearman Correlation.** This table presents the Spearman correlation table of our main variables of interest.*

	Size	Whitepaper Pages	ICO Duration	Whitepaper	Whitepaper type	Social Media type	Code
Size		-0.038705	-0.139392	0.023361	0.002322	-0.008603	-0.080476
Whitepaper Pages			0.022682	0.003422	-0.142075	-0.157051	-0.145505
ICO Duration				-0.014774	0.010558	-0.012877	0.037309
Whitepaper type						0.065597	0.098635
Social Media type							0.047029
Code							

4. Methodology

In the first step, Beatty & Ritter's (1986) study was used to replicate the data to study underpricing of ICOs and its relationship with the ex-ante uncertainty.

The IPO is considered underpriced by the difference between its first-day closing price and its offering price. For the ICOs in this study, the initial return was calculated based on the same concept in IPOs as follows:

Initial return = $(P_{closing} - P_{offering})/P_{offering}$

$P_{closing}$ is the first-day closing price, and $P_{offering}$ is the offering price of the ICOs. The One-sided t-test was used to test underpricing in ICOs to determine if returns differ significantly from zero. P-value close to zero shows that our result is statistically significant, and it could be concluded that ICOs are underpriced on average.

4.1 Independent variables

To address the questions of this study, having a whitepaper, the age of the ICO project (ICO duration), whitepaper length and inverse of the fundraising goal (size) were used as independent variables. In addition, information disclosure indicators such as code availability, using social media, social media type and whitepaper type were used. We classify the industry of IPOs into tech-related and non-tech as a control variable. Moreover, being listed in an exchange is used to measure post-ICO performance and to ensure the ICO project is not a scam. For informativeness and technicality of the whitepaper, “topics used in whitepapers” were used to study the association of different topics with ICO success and underpricing. “Product description,” “Token information,” “Fund usage,” “Roadmap,” “Smart contract,” “Risk Factors,” and “Legal Disclaimer” were used as topics for whitepaper technicality.

4.2 Control Variables

Industry and quarter-year indicators are used as time-invariant variables. In addition, the length of the whitepaper is used as a whitepaper characteristic control variable.

Moreover, because many ICO projects turn out to be scams, studies consider post-ICO survival a measure of ICO success, such as whether the tokens issued by the ICO are subsequently listed on an exchange and whether the tokens are actively traded (Yen et al., 2021). High-quality projects signal their quality by the whitepaper content. However, low-quality projects might try to change the content to signal the quality. Measuring post-ICO survival can help address the issue.

Table presents a description of each variable used in the models of this study.

4.3 Fixed effects

To account for time-invariant effects, a quarter fixed effect is used. Daily date information has been converted to quarterly format and used with industry as multiple indices.

4.4 Study Hypotheses

In this section, the study hypotheses are provided as follows:

Hypothesis 1: ICOs are underpriced.
Hypothesis 2: The level of ICOs' underpricing is associated with the inverse of fundraising goals.
Hypothesis 3: The level of ICOs' underpricing is associated with the project's duration.
Hypothesis 4: The level of ICOs' underpricing is associated with information disclosure. ("Having whitepaper" and "whitepaper technicality" - specific topics –, "whitepaper length," "presence of social media," and "source code availability")

The “one sample t-test” and four Panel OLS regression models were used to address these questions. The “one sample t-test” was used to answer the first question and study if ICOs are underpriced.

In the first model, ICO returns were used as the dependent variable. In addition, independent variables used in this model are as follows: “size,” “whitepaper length,” “ICO Duration,” “having a whitepaper,” “code availability,” “having a social media,” and “being listed in an exchange.”

In the second model, the “having whitepaper” variable was replaced with “whitepaper type.” Whitepaper types show the whitepaper format and are as follows: pdf format, PPT format, HTML format, GitBook and protected format, which needs credentials to access. After creating subsamples for each format category, a separate OLS model was used to study the relationship of variables. The purpose of replacing “having Whitepaper” with “Whitepaper type” is to study if the whitepaper format would affect the information disclosure and the ICO underpricing.

We replace the “having social media” variable in the third model with “social media type.” It contains five dummy variables as follows: Social Networking (including Facebook, LinkedIn, and Twitter), Source code (GitHub), Discussion sites (including Discord and Telegram), Video Sharing (including YouTube) and Social Blogging (including Medium and Reddit). In order to run the model, a subsample was created for each social media type category, and a separate OLS model was used to study the relationships between dependent and independent variables.

In the fourth model, “having a whitepaper” was replaced by the “whitepaper topics” variable. The whitepaper topics include “Product Description,” “Token information,” “Fund usage,” “Roadmap,” “Team,” “Team size,” “Blockchain application,” “Smart contracts,” “Risk Factors,” and “legal disclaimer.” In this model, subsamples were also created, and for each topic, a separate OLS model was used to study the relationship between dependent and independent variables.

5. Empirical Findings

One sample t-test was used to analyze the underpricing in ICOs. The results obtained from this test show an average underpricing of 9.54 percent, which is statistically significant and in line with IPO underpricing studies.

Table 4 presents the results of the first OLS regression model used for studying the relationship between ICO underpricing and independent variables, including "size," "whitepaper length," "ICO Duration," "having a whitepaper," "code availability," "having a social media" and "being listed in an exchange." The second study question examines the relationship between the inverse of fundraising goals (size) and ICO underpricing. The results in Table 4 show the p-value close to zero, which is a significant statistical relationship. Moreover, the third question examines the relationship between underpricing and having a whitepaper in an ICO project. Again, the result is significant at the p-value close to zero, which indicates a negative relationship. In addition, the fourth question studies the relationship between ICO underpricing and the duration of the ICO project. The result shows no significant p-value of 0.1049, meaning there is no evidence of a significant relationship between ICO underpricing and ICO duration.

The last question studies the relationship between information disclosure and ICO underpricing, examined by two variables of available source codes in GitHub and having social media for interacting with investors. The p-value for both variables is close to zero and shows a significant relationship between information disclosure and ICO underpricing.

Table 4: Panel OLS Regression results for the first OLS Regression Model.

This table presents the OLS regressions for determinants of ICOs Underpricing in 220 ICOs, where the dependent variable is ICO Returns. The regression includes quarter-year fixed effects. Size variable values were divided by 100k.

	Model 1	
Variables	Coeff.	(SE)
Dep. Variable	ICO Return	
Size	-2.00	(0.13)***
Whitepaper Pages	-0.02	(0.00)***
ICO Duration	-0.51	(0.31)
Whitepaper (dummy)	9.84	(0.04)***
Code (dummy)	-8.38	(0.32)***
Social media (dummy)	5.45	(1.17)***
Exchange (dummy)	1.54	(0.12)***
R-squared	0.03	
F-statistic	1.06	
P-value (F-stat)	0.39	
No. observations	220	
Estimator	PanelOLS	
Cov. Est.	Clustered	
Effects	Entity	

$$ICOReturn_i = \alpha_0 + \beta_1 size_i + \beta_2 WhitepaperPages_i + \beta_3 Duration_i + \beta_4 whitepaper_i + \beta_5 code_i + \beta_6 SocialMedia_i + \gamma ControlVariables + \epsilon_i$$

Notes: *, **, *** indicates significance at 0.10, 0.05 and 0.01
Standard Errors are reported in parentheses.

Table 5 presents the results of the second OLS regression model. The "having whitepaper" variable was replaced with "whitepaper type." Whitepaper type shows the whitepaper format, including PDF, PPT, HTML, GitHub and Protected format. After creating subsamples for each format category, a separate OLS model was used to study the relationship of variables. This model studies if whitepaper type would affect the quality of information disclosure and consequently affect the ICO underpricing.

The first subsample regression model studies the relationship between the GitBook format and ICO underpricing. The results show a significant relationship between all the independent variables and ICO underpricing when the whitepaper is in GitBook format.

Table 5: Panel OLS Regression results for the second OLS Regression Model

This table presents the OLS regressions for determinants of ICOs Underpricing, where the dependent variable is ICO Returns. The model has four sub-samples of whitepaper types. The regression includes quarter-year fixed effects. Moreover, size variable values were divided by 100k.

	Model 2							
	GitBook Sub-sample		PPT Sub-sample		Html Sub-sample		PDF Sub-sample	
Variables	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)
Dep. Variable	ICO Return		ICO Return		ICO Return		ICO Return	
Size	-4.15	(0.02)***	-8.05	(0.13)***	-7.75	(0.00)***	6.44	(0.01)***
Whitepaper Pages	0.08	(0.00)***	-0.23	(0.02)***	0.20	(0.00)***	-0.12	(0.04)***
ICO Duration	-1.46	(0.01)***	-1.61	(1.68)	-0.69	(0.00)***	0.47	(0.09)***
Code (dummy)	-5.47	(0.01)***	-19.12	(8.17)**	3.78	(0.00)***	-10.32	(0.51)***
Exchange (dummy)	-7.53	(0.01)***	19.48	(1.96)***	-16.71	(0.00)***	6.93	(0.77)***
R-squared	0.12		0.12		0.25		0.03	
F-statistic	1.96		0.51		1.51		0.31	
P-value (F-stat)	0.10		0.76		0.23		0.90	
No. observations	81		25		29		59	
Estimator	PanelOLS		PanelOLS		PanelOLS		PanelOLS	
Cov. Est.	Clustered		Clustered		Clustered		Clustered	
Effects	Entity		Entity		Entity		Entity	

$$ICOReturn_i = \alpha_0 + \beta_1 size_i + \beta_2 wpPages_i + \beta_3 Duration_i + \beta_4 whitepaperType_i + \beta_5 code_i + \beta_6 SocialMedia_i + \gamma ControlVariables + \epsilon_i$$

Notes: *, **, *** indicates significance at 0.10, 0.05 and 0.01
Standard Errors are reported in parentheses.

The second subsample results show that if the whitepaper is in PPT format, there is a significant relationship between ICO underpricing and size, whitepaper pages, code and being listed in an exchange. In the third subsample, which is HTML format, results show the p-value close to zero and a significant relationship between all independent variables and ICO underpricing. In the PDF format, also results show a significant relationship between endogenous variables and ICO underpricing.

In the third model, we replace the "having social media" variable with "social media type," including Social Networking, Source code (GitHub), Discussion sites, Video Sharing and Social Blogging. In order to run the model, a subsample is created for each social media type category. Table 6 presents the results of the third OLS regression model for five different subsamples. Results show that in the Social Media type of "Discussion sites," code availability is significantly

associated with ICO underpricing. In the "Video Sharing" and "GitHub" types, only ICO duration does not show enough evidence of significant association with ICO underpricing. Results in the "Social Blogging" and "Social Networking" types show that all independent variables have a significant relationship with ICO underpricing.

Table 6: Panel OLS Regression results for the third OLS Regression Model

This table presents the OLS regressions for determinants of ICOs Underpricing, where the dependent variable is ICO Returns. The model has five sub-samples of social media types. The regression includes quarter-year fixed effects. Moreover, size variable values were divided by 100k.

	Model 3									
	Discussion sites		Video Sharing		Social Blogging		Social Networking		GitHub	
Variables	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)
Dep. Variable	ICO Return		ICO Return		ICO Return		ICO Return		ICO Return	
Size	0.04	(0.10)	-4.49	(1.44)***	4.48	(0.03)***	-3.12	(0.98)***	-6.05	(0.18)***
Whitepaper Pages			-0.10	(0.03)***	0.06	(0.00)***	0.21	(0.00)***		
ICO Duration	-0.11	(0.15)	-0.08	(1.09)	1.43	(0.01)***	-1.81	(0.07)***	-0.19	(0.16)
Whitepaper(dummy)	0.25	(0.26)	18.57	(3.46)***					6.29	(0.58)***
Code (dummy)	-7.27	(0.09)***	-13.66	(5.57)**	-6.74	(0.47)***	-6.47	(0.03)***	-7.15	(2.25)**
Exchange (dummy)	1.90	(1.24)	7.75	(1.77)***	17.74	(0.05)***	-3.61	(0.11)***	-6.78	(0.85)***
R-squared	0.03		0.10		0.03		0.11		0.14	
F-statistic	0.51		0.54		0.29		1.24		0.29	
P-value (F-stat)	0.77		0.77		0.92		0.31		0.91	
No. observations	82		37		49		59		16	
Estimator	PanelOLS		PanelOLS		PanelOLS		PanelOLS		PanelOLS	
Cov. Est.	Clustered		Clustered		Clustered		Clustered		Clustered	
Effects	Entity		Entity		Entity		Entity		Entity	

$$ICOReturn_i = \alpha_0 + \beta_1 size_i + \beta_2 WhitepaperPages_i + \beta_3 Duration_i + \beta_4 whitepaper_i + \beta_6 SocialMediaType_i + \gamma ControlVariables + \epsilon_i$$

Notes: *, **, *** indicates significance at 0.10, 0.05 and 0.01
Standard Errors are reported in parentheses.

In the fourth model, "having a whitepaper" is replaced by the "whitepaper topics" variables, including "Product Description," "Token information," "Fund usage," "Roadmap," "Smart contracts," "Risk Factors," and "legal disclaimer." In this model, subsamples are created as well. This model studies the relationship between ICO underpricing and independent variables in different whitepaper topics, representing the technicality of whitepapers and the quality of information disclosure.

Table 7 presents the results of the fourth OLS regression model for seven subsamples. The results show significant relationships between ICO underpricing and independent variables.

Table 7: Panel OLS Regression results for the fourth OLS Regression Model

This table presents the OLS regressions for determinants of ICOs Underpricing, where the dependent variable is ICO Returns. The model has seven sub-samples. The regression includes quarter-year fixed effects. Moreover, size variable values were divided by 100k.

	Model 4													
	Product Description		Token Information		Fund Usage		Roadmap		Smart Contracts		Risk Factors		Legal Disclaimer	
Variables	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)	Coeff.	(SE)
Dep. Variable	ICO Return		ICO Return		ICO Return		ICO Return		ICO Return		ICO Return		ICO Return	
Size	43.20	(0.00)***	23.37	(0.00)***	6.22	(0.00)***	6.10	(0.18)***	-4.23	(0.23)***	-1.28	(0.00)***	-5.28	(0.00)***
Whitepaper Pages	-0.30	(0.00)***	-0.14	(0.00)***			-0.03	(0.01)***	-0.15	(0.00)***				
ICO Duration	0.09	(0.00)***	-3.77	(0.00)***	-0.15	(0.00)***	0.02	(0.10)	-0.01	(0.00)**	-0.44	(0.00)***	-1.77	(0.00)***
Code	-14.42	(0.00)***	-22.12	(0.00)***	-5.87	(0.00)***	-3.09	(0.10)***	-4.56	(0.12)***	0.03	(0.00)***	6.13	(0.00)***
Exchange	0.45	(0.00***	16.11	(0.00)***	6.95	(0.00)***	1.78	(0.16)***	0.62	(0.01)***	-0.04	(0.00)***	10.50	(0.00)***
R-squared	0.06		0.21		0.15		0.32		0.09		0.01		0.18	
F-statistic	0.39		1.35		0.85		2.31		0.22		0.05		1.08	
P-value (F-stat)	0.85		0.28		0.51		0.08		0.94		0.99		0.40	
Observations	39		33		26		31		18		22		25	
Estimator	PanelOLS		PanelOLS		PanelOLS		PanelOLS		PanelOLS		PanelOLS		PanelOLS	
Cov. Est.	Clustered		Clustered		Clustered		Clustered		Clustered		Clustered		Clustered	
Effects	Entity		Entity		Entity		Entity		Entity		Entity		Entity	

$$ICOReturn_i = \alpha_0 + \beta_1 size_i + \beta_2 wpPages_i + \beta_3 Duration_i + \beta_4 whitepaperTopics_i + \beta_5 code_i + \beta_6 SocialMedia_i + \gamma ControlVariables + \epsilon_i$$

Notes: *, **, *** indicates significance at 0.10, 0.05 and 0.01
Standard Errors are reported in parentheses.

5. Conclusion

This study uses a sample that includes 320 ended ICOs. Among all ICOs in the initial sample, 248 provide an accessible whitepaper during data collection.

One-sample t-test was implemented, and the OLS regression models were used to examine the underpricing of ICOs and study their main determinants. The results of this study confirm the underpricing of ICOs as it is already verified in IPOs.

According to the results, some ICO characteristics are significantly associated with ICO underpricing. These characteristics include the size or inverse of fundraising goals, having a whitepaper, whitepaper length, code availability and using social media to communicate with investors.

As we discussed earlier, information disclosure is the primary tool to reduce information asymmetry, sustain market efficiency and increase underpricing. Information disclosure is a way to signal the quality of the project and helps investors' decisions. Based on the results, there is evidence that information disclosure tools such as using social media, different social media types, having a whitepaper, different whitepaper types, providing source code, and specific topics in the whitepaper, are associated with ICO underpricing and success.

To summarize, whitepapers' Gitbook, PPT, HTML and PDF formats are significantly associated with ICO underpricing. In addition, results show that "Video Sharing," "Social Blogging," "Social Networking," and "GitHub" in social media types are significantly associated with ICO underpricing.

The study shows a significant relationship between almost all listed topics in the whitepaper and ICO underpricing.

Since low-quality projects might try to change the whitepaper content to signal the quality, measuring post-ICO survival can help address the issue. Therefore, being listed in an exchange was used as a control variable to ensure the ICO project was not a scam.

This study shows the importance of voluntary disclosure and its tools to mitigate information asymmetry. However, standardizing whitepaper formats and contents might help effectively measure the whitepaper content's technicality.

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7. Appendix

7.1 Tables

Table A1: Variables Definition included in the mode

Variable	Definition	Source
ICO Return	$(P_{closing} - P_{offering})/P_{offering}$ Where $P_{closing}$ is the first day closing price and $P_{offering}$ is the offering price of the ICOs	Calculated
Size	Fundraising goals	ICOdrops.com website
ICO Duration	ICO duration as difference between ICO's starting date and ending date plus one	Calculated
Whitepaper	If the project has a whitepaper available	ICOdrops.com website
Code	If the Source code is available in GitHub platform	ICOdrops.com website
Social Medial	If project is using social media	ICOdrops.com website
Whitepaper Type	Formats in whitepapers are available (five formats including: pdf, PPT, html, GitBook and protected format)	ICOdrops.com website
Social Media Type	Five categories of social media including: Social Networking, GitHub, Video Sharing, Social Blogging and Discussion Sites	ICOdrops.com website
Whitepaper Topics	10 main topics including: Product description, Token information, Fund usage, Roadmap, Team, Team size, blockchain application, Smart contract, Risk factors, Legal disclaimer	Projects Whitepaper

7.2 Figures

Figure A1: ICODrops.com website.

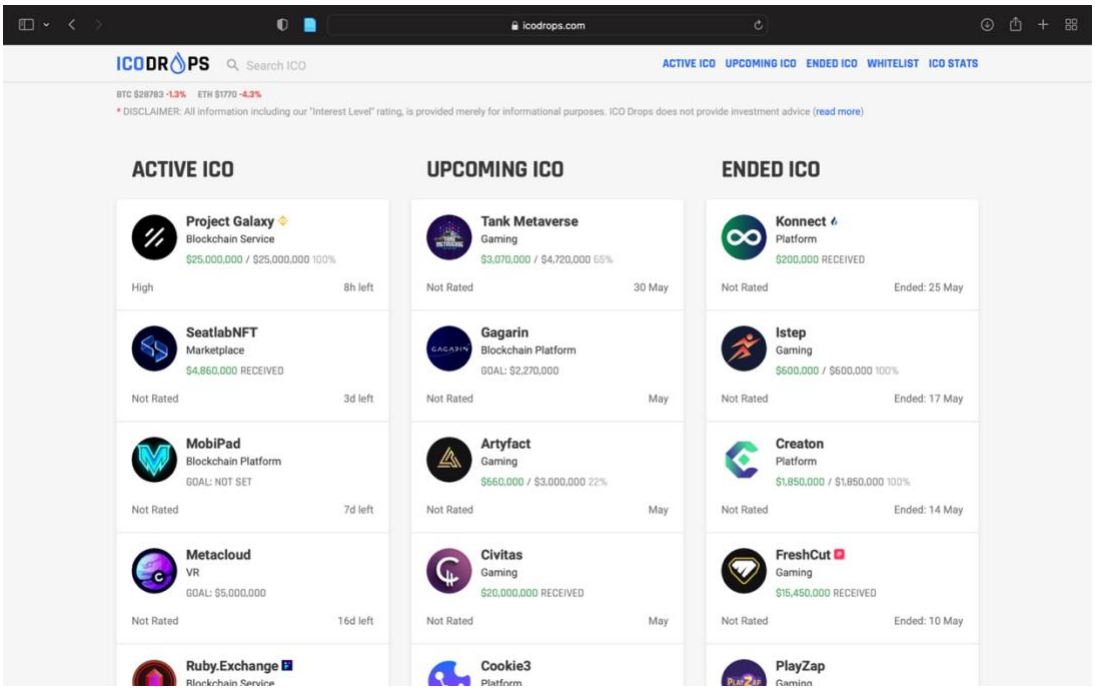

Figure A2: Coinmarketcap.com website. This snapshot shows the information on each ICO listed on this website.

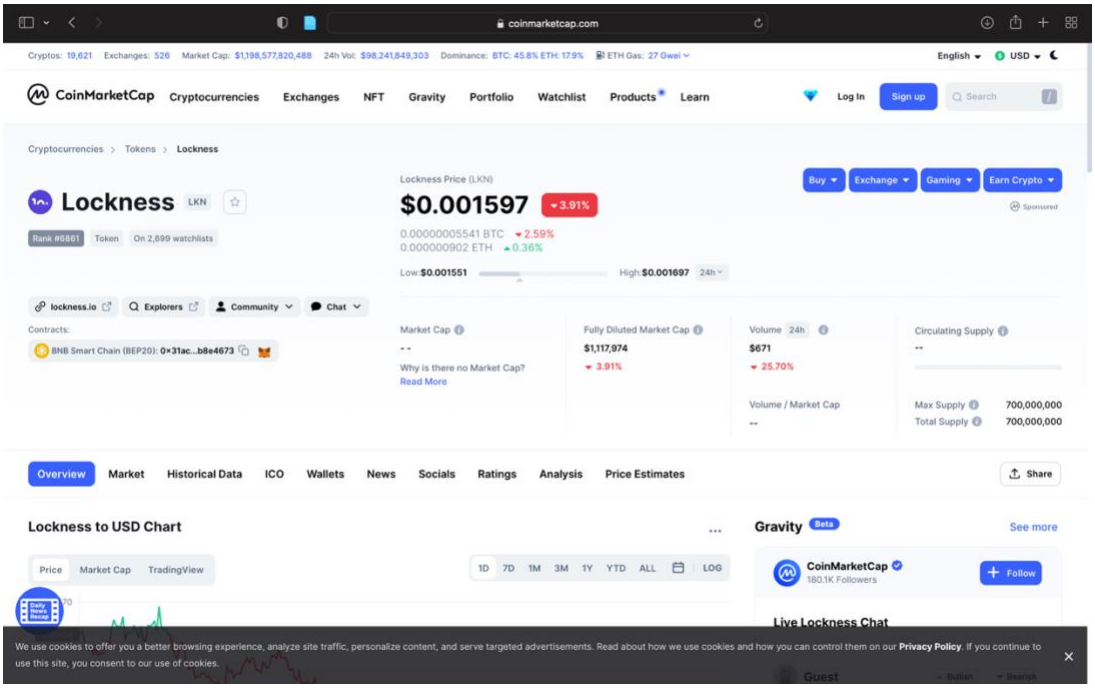

Figure A3: ICODrops.com website, list of ended ICOs.

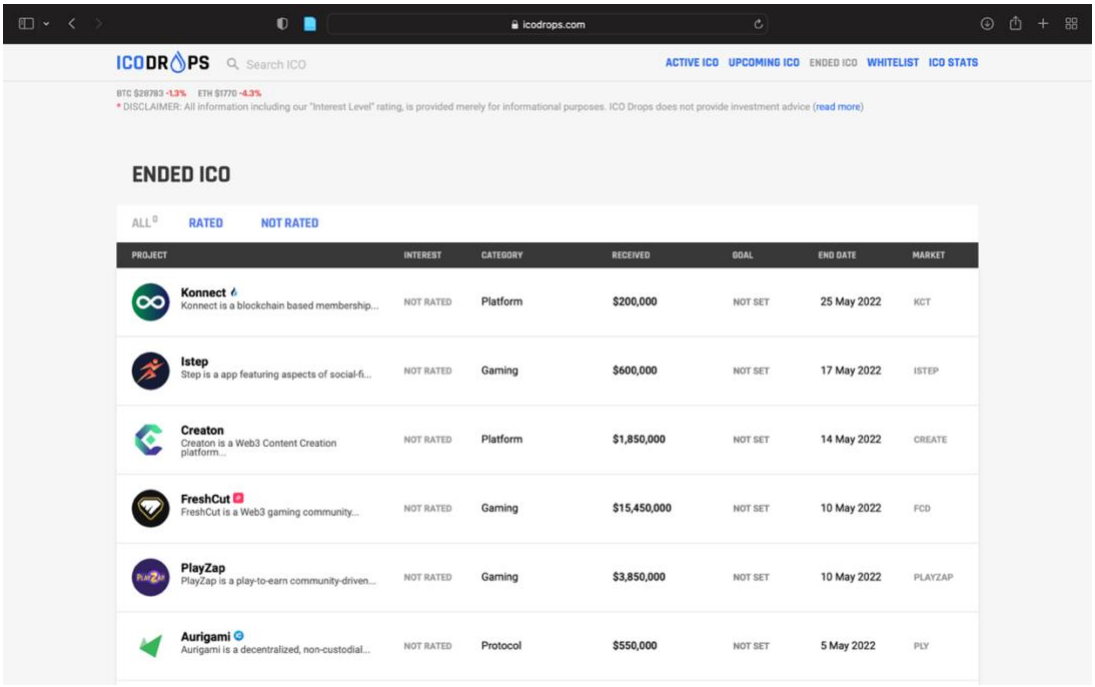

Figure A4: ICODrops.com website. The first snapshot of how each ended ICO page looks and what information is listed on this page.

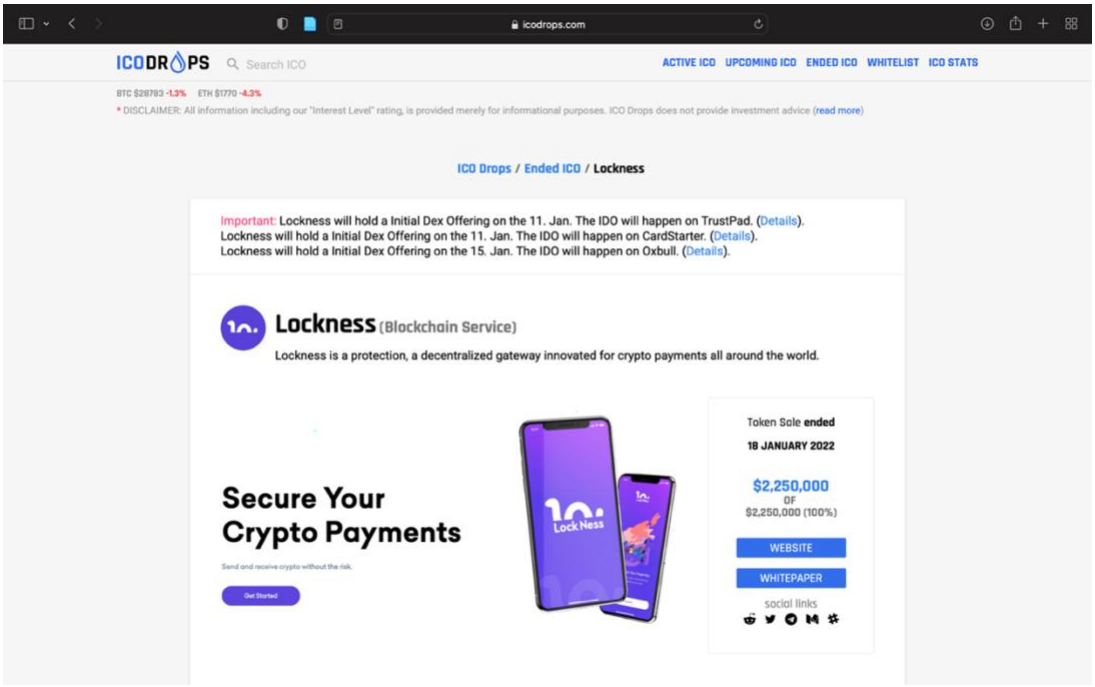

Figure A5: ICODrops.com website. The second snapshot of how each ended ICO page looks and what information is listed on this page.

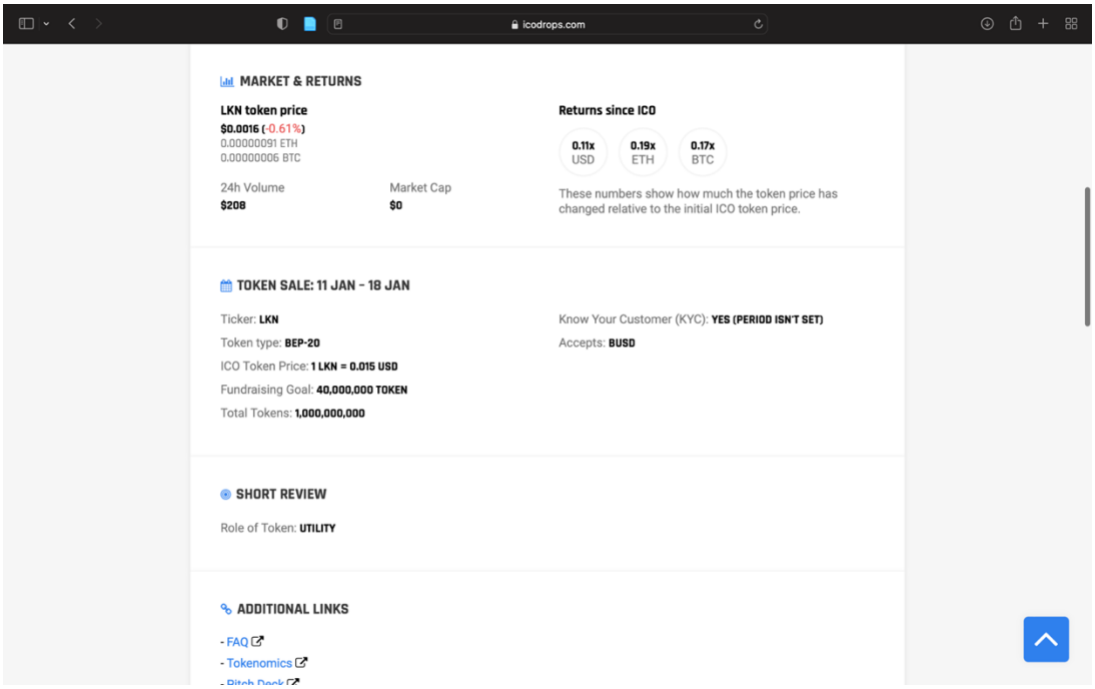

Figure A6: Coinmarketcap.com website. Historical data, such as price information on each ICO.