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Navn:	Thi Nhu Yen Nguyen og Jose Luis Almanza Hurtado

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Navn på veileder *:	Amir Sasson

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Jose Luis Almanza Hurtado

Thi Nhu Yen Nguyen

BI - Norwegian Business School

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Abstract

Initial Coin Offerings (ICO) have been studied through the lens of signaling theory from various perspectives, including factors influencing ICO success and short-term post-ICO performance. However, only a few researchers have examined how quality signals impact the long-term post-ICO performance. We investigate blockchain technology-based firms' (BTBFs) long-term post-ICO performance in terms of buy-and-hold returns by assessing the impact of four signals: ownership retention rate, underpricing, ICO rating, and organization of presale, while controlling for factors that could bias our results. Among the four factors, our results suggest that ICO rating and the organization of a presale by a BTBF are positively related to the venture's long-term aftermarket performance. However, the impacts of ownership retention rate and underpricing on ICO aftermarket performance are inconclusive. Nevertheless, the study lays the foundation for future research on long-term post-ICO performance and carries practical implications for both BTBFs and investors in using and interpreting signaling factors effectively.

Table of contents

List of Figures and Tables

List of Abbreviations

ICO	Initial Coin Offering
BTBF	Blockchain technology-based firm
IPO	Initial Public Offering
NFT	Non-fungible token
DAO	Decentralized Autonomous Organization
PoW	Proof of Work
BAT	Basic Attention Token
SEC	The U.S Securities and Exchange Commission
ESMA	The European Supervisory Markets Authority
CRAs	Credit Rating Agencies
PP	Private placement
BTC	Bitcoin
BHR	Buy-and-hold returns
KYC	Know-your-customer

I. Introduction

Signaling theory has been proven useful in explaining how parties behave to reduce or mitigate information asymmetry (Spence, 2002). The theory plays a vital role in management research such as strategic management, human resource management and entrepreneurship with an increasing momentum over the years (Connelly et al., 2011). In the venture financing landscape, the role of quality signals, such as top management team quality (Lester et al., 2006), institutional investment (Ahlers et al., 2015; Colombo et al., 2019; Fisch & Momtaz, 2019), or the underwriter reputation (Colombo et al., 2019), in reducing information asymmetry between ventures and investors has been widely studied.

According to Leland & Pyle (1977), firms must find a way to transfer information via different signals to the market because "without information transfer [between ventures and investors], markets may perform poorly" (Leland & Pyle, 1977, p.1). More specifically, the sender (or venture), must choose whether and how to communicate (or signal) its quality to the receiver (or investor), who must choose how to interpret the signal (Connelly et al., 2011). This helps to "resolve information asymmetries about latent and unobservable quality" (Connelly et al., 2011, p.4), becoming more relevant in contexts of under-regulation and low transparency. Thus, signaling theory has been helpful in explaining the relationship between ventures and investors in financial markets where the senders of signals are or are not required to disclose information due to the higher or lower information asymmetry that the context entails.

Enterprises, more specifically, startups, are disrupting the market at an unprecedented pace with a myriad of radical innovations and new technologies (Manyika et al., 2013). Among all the "next big things" in the 21st century, blockchain is expected to change the future of the world economy (Tapscott & Tapscott, 2016). The technology is paving the way for widespread adoption in a number of areas, among which Bitcoin and cryptocurrencies represent one of the most remarkable use cases with the cryptocurrency market valuation of more than USD 2 trillion by March 2022 (Reynolds, 2022). Together with the growing popularity of blockchain technology, venture capitalists have shown tremendous enthusiasm for blockchain-technology-based firms (BTBFs). In 2021, venture funding into BTBFs achieved a 737% Year-on-Year (YoY) growth, hitting USD 25 billion and accounting for 4% of the total venture funding of the year (CB Insights, 2022).

Additionally, the venture financing landscape for BTBFs has also witnessed the emergence and development of a revolutionary fundraising method named Initial Coin Offering (ICO). Via ICOs, BTBFs that are looking to raise money for their projects can create and offer tokens to public investors in exchange for either cryptocurrencies such as Bitcoin or Ether, and/or fiat currencies (Momtaz, 2018). The issued tokens are normally listed on crypto exchange markets, allowing token holders to trade the tokens and earn quick returns (Momtaz, 2018). The investors can also hold the token and use it when the ICO products or services are developed in the future.

The first ICO was launched in 2013, however, it started to gain a wider popularity in 2017. With more than USD 31 billion raised by 2019 and more than 5700 ICOs conducted (data retrieved from https://icobench.com/ on April 20, 2022), the ICO market is evolving from "too small to care" to "too big to ignore" (OECD, 2011). In the research context, ICO has been attracting increasing attention, resulting in a fast-growing literature body covering a wide range of topics from ICO success factors to ICO regulations and post-ICO performance.

ICO has enormous advantages for firms and high return for investors thanks to the democratization of access to funding, the perceived ease of access for investors, low transaction costs and high liquidity (Clements, 2018; Momtaz, 2018). However, it is also a point of debate due to the related investment risks such as frauds or scams, price volatility, and lack of legal protection (ESMA, 2017). One of the main reasons leading to such a high level of risk is the information asymmetry in the ICO context, which results from the lack of information disclosure and the information gap between ventures and investors at the early stage of the ICO projects. To overcome this issue, good-quality firms need to rely on different signals to differentiate themselves from their lower-quality counterparts.

Similar to existing management literature, a significant number of ICO researchers focus on the role of signals, such as information disclosure, ownership retention rate or team quality, in alleviating the information asymmetry. However, due to data limitation and the newness of this funding mechanism, ICO literature has been mostly focusing on ICO success (measured by the amount of fund raised) and short-term post-ICO performance, commonly 1 month, 6 months, or 1 year, leading to a limited amount of research on long-term post-ICO performance. Consequently, there is little known about whether the impact of quality signals on post-ICO performance is noticeable in the long run. Acknowledging this research gap, we introduce the research question: "To what extent does signaling theory explain long-term post-ICO performance? An empirical research into the impact of quality signals including ownership retention rate, underpricing, rating and presale availability".

ICO literature is still growing and limited compared to the extensive literature about Initial Public Offering (IPO). Moreover, the two concepts have some proven similarities and thus it is common for ICO researchers to consult IPO research. Adopting a similar approach, we study a set of recurring factors in the ICO and IPO literature related to quality signals and how they impact post-offering performance. The selected factors do not cover all existing quality signals, however, they are among the most thoroughly examined by IPO researchers and show a strong relation with ICO success and aftermarket performance in both ICO and IPO contexts.

We contribute to the ICO literature by utilizing IPO research about signaling theory and long-term post-IPO performance to study the ICO context, thus filling the gap of the impact of BTBFs' quality signals in the long run. We provide both entrepreneurs and investors with more information on the long-term performance of BTBFs, which is valuable in managing ventures or making investment decisions respectively. Our contribution is also relevant for further research on other emerging fundraising mechanisms using blockchain technology, such as non-fungible tokens (NFTs), which share many similarities with the ICO and have gained considerable popularity in 2021.

This master thesis is structured as follows: Section II introduces an overview of the context of blockchain technology, cryptocurrency, ICO and ICO market; Section III contains the literature review about how signaling theory has been used in ICO and IPO research; based on which hypotheses are formulated and introduced; Section IV describes the research methodology, how the data was gathered, how it is analyzed to answer the research question; Section V discusses the findings and conclusion of the paper. The limitations of this paper are presented and discussed in Section VI, along with some suggestions for future research. Finally, a conclusion with our major knowledge claim will be provided in Section VII.

II. An overview of ICO and ICO market

Due to the novelty of ICO and the cryptocurrency industry, we will introduce its context and market overview at the beginning of the master thesis. Firstly we will present blockchain technology as well as cryptocurrency and tokens, concepts that will provide a technical background about the technology that ICO firms use. Then, we will provide more details about ICO and the industry, including a definition of ICO and its characteristics, ICO related regulations and an overview of the ICO market and the ICO process.

1. Blockchain technology and cryptocurrency

1.1. Blockchain technology

Essentially, a blockchain is a public, digital, and immutable ledger which facilitates the recording of transactions and is distributed in a decentralized manner across an entire network of computer systems (Fisch, 2019; Yaga et al., 2018). Its name comes from the fact that transactions are stored in data packages or blocks. Each block contains identifiers such as timestamps, a unique hash value serving as identifier of the previous block, and a random verification number (Nofer et al., 2017). In addition, blocks can be validated by the network using cryptographic means and if the network reaches a consensus on a verified block, that block is added to the chain of previous blocks, which grows as more transactions occur.

In 2008, the blockchain concept was combined with other technologies, which gave birth to modern cryptocurrencies, the first one being Bitcoin in 2009 (Böhme et al., 2015). It became widely popular among technology enthusiasts as it was the first blockchain network facilitating a virtual currency allowing users to either hold it or make peer-to-peer electronic payments and transfers between the distributed network of users. Despite this being an important technological breakthrough, it was not until the mid 2010s that new use cases for blockchain started to emerge. The most important one to-date being the inception of the Ethereum network, co-founded by Vitalik Buterin. Ethereum allows computer programs or smart contracts to run on the network when called upon. These programs are executed on every node of the chain and are executed based on conditions of its own. This marked the beginning of an accelerated development of new cryptocurrencies and promising use cases ranging from decentralized exchanges to DAOs (Decentralized Autonomous Organizations).

Despite Bitcoin and Ethereum paving the way for mainstream adoption of blockchain technology, this space has received a great deal of criticism for environmental and economic reasons. First, Bitcoin's consensus protocol is based on a Proof of Work (PoW) mechanism that requires considerably high energy consumption to verify transactions by the network. Essentially, the verifiers in the network have to decipher a complex mathematical equation that requires substantial amounts of computational power (Nakamoto, 2008). In 2016, the resource-expensive PoW mechanism accounted for more than 90% of the total market capitalization of existing digital currencies (Gudgeon et al., 2020). Thus, putting into question the feasibility of further development and adoption of blockchain technology as a whole given the efforts to slow down climate change. Second, the nature of blockchain technology can ensure an almost perfect anonymity of transactions, thus making it an important facilitator of criminal activities in both developed and developing countries (Badea & Mungiu-Pupăzan, 2021; Härdle et al., 2019). Regulation is expected to play a key role in cryptocurrencies in the coming years, with certain governments raising barriers to adoption and others embracing it. Moreover, another security concern is an attack on the network itself, where cryptocurrencies can be untraceably stolen.

As Bitcoin and other blockchain technology-based concepts such as DAOs, NFTs, and other cryptocurrencies reach the mainstream market, policy makers are starting to catch up by establishing regulations. In addition, technology enthusiasts are creating more environment-friendly alternatives such as different consensus protocols, side chains that ease off workload in the main network, and different blockchains altogether (Gudgeon et al., 2020; Wang et al., 2019).

1.2. Cryptocurrencies & tokens

1.2.1. Definition and token clasification

A cryptocurrency refers to a type of digital asset that uses blockchain technology to enable transactions acting as digital money (Boreiko et al., 2019). Put differently, cryptocurrencies are the native currencies utilized in a certain blockchain to make transactions, e.g. Bitcoin within the Bitcoin blockchain. Since the inception of Bitcoin in 2009, thousands of cryptocurrencies and other blockchain applications have been created. The rise of cryptocurrencies has been considered to pose a threat to traditional banking institutions as they enable peer-to-peer transactions, making the role of intermediaries unnecessary (Härdle et al., 2019). This also means that the integrity of the network replaces the need to trust human operators and participants. However, cryptocurrencies have no intrinsic value, and can only function if the market accepts them and believes they hold the value attributed to them by the rest of the network.

Tokens are essentially programmable cryptocurrencies that are built on top of an existing blockchain infrastructure. This means that the token can serve a different purpose or use case from only a transactional one and the developers do not have to create a new blockchain but rather utilize an existing one as a host such as Ethereum (Boreiko et al., 2019). The Basic Attention Token (BAT) is an example of a token built on the Ethereum network that is programmed to allow advertisers to purchase advertising space in the Brave browser, which in turn rewards users for their attention to ads with BAT.

There is no universal classification of tokens (Härdle et al., 2019), however, four types of tokens are popularly identified, including utility tokens, security tokens, equity tokens and pure currency tokens (Momtaz et al., 2019).

- Utility tokens can be defined as programmable blockchain assets. This kind of token is unique to its specific ecosystem and allows the users to trade and utilize it within that ecosystem for certain use cases such as payment or rights to participate in the network (Boreiko et al., 2019). However, utility tokens can also be conceptualized as "mini-currencies" and as investments, due to the possibility of tokens increasing in demand and value as the platform or ecosystem becomes more widely known. Thus, most utility tokens can also be traded on crypto exchanges, where holders can exchange their tokens for other cryptocurrencies and tokens such as Bitcoin or Ether or fiat currencies. This is the reason why typically all tokens are broadly called cryptocurrencies. However, utility token holders do not have any ownership and control rights over the firms, hence lacking legal protection.

- Security tokens are digital forms of traditional securities such as stocks, bonds, derivatives, or other financial assets, that live on a blockchain. In other words, security tokens are tokenized securities. Thus, security tokens' value depends on the performance of the underlying assets. These tokens may or may not transfer the ownership and control rights of the firms, depending on predefined policies by the issuers.

- Equity tokens are security tokens that transfer ownership and control rights to the token holders.

- Pure currency tokens are digital currencies such as Bitcoin. These tokens serve as a commodity and their value comes from regular market forces.

1.2.1. Blockchain technology-based firms

Blockchain technology is at the core of token-based business models with which BTBFs operate (Fisch & Momtaz, 2019). A BTBF shares most of the same components of a non-BTBF, where a team of founders aim to create a project that can become a profitable business. For instance, similar to a business plan, the founders can create and publish a whitepaper disclosing details of the project to be developed, their future plans, their team description, and other information (Hackober & Bock, 2021). One of the main differences between traditional startups and BTBFs comes when the founders of BTBFs create and sell the tokens of their respective ecosystem as the currency to get access to the project's platform and to spend for services within that specific ecosystem (Härdle et al., 2019).

Tokens are typically offered in a similar manner as crowdfunding, where they represent future benefits for holders when the platform and services are eventually developed. Additionally, token offerings can also serve as a form of fundraising for early-stage projects as supporters can purchase the tokens during an ICO, which will be explained more in-depth in the next section.

2. ICO and ICO market

2.1. ICO definition and characteristics

2.1.1. ICO definition and token classification

ICO, also referred to as token sale or token offering, is one of the most nascent and innovative practices of raising money to fund a project or a venture. Currently, there is no unique definition of ICO (Aslan et al., 2021; Fisch, 2019; Momtaz, 2018; Zetzsche et al., 2018). Fisch (2019) defines ICO as "a mechanism through which new ventures raise capital by selling tokens to a crowd of investors". More technically, Momtaz (2018, p.1) describes ICO as a "smart contract(s) based on blockchain technology that are designed for entrepreneurs to raise external finance by issuing tokens without an intermediary". By issuing the token offerings on a blockchain, the firms have all transactions made in the ICOs recorded.

Ethereum is by far the most popular blockchain that BTBFs choose to issue ICO tokens, with around 90% of ICOs issued on it (Fromberger & Haffke, 2019; Haffke & Fromberger, 2018, 2020). The process to create a token on the Ethereum blockchain is quite straightforward. Firms may download the code for smart contracts from the public webpages such as Openzeppelin.com or Github.com which are accessible via the Ethereum webpage and modify the code based on their own settings of token names, token symbols, the total amount of tokens, or other related functionalities such as token transfer, token balance, or total token availability. After that, the code will be deployed on the Ethereum blockchain, and tokens are created (Ethereum, 2022a, 2022b; Momtaz, 2018). In the ICOs, tokens will be sold to investors in exchange for either a specific cryptocurrency such as Bitcoin or Ether and/or fiat currency, which is pre-defined by the issuers. Once the transactions are made in the ICOs, the token holders will have unique keys, allowing them to use, redeem or transfer the tokens. In general, regardless of the differences in their focus, most researchers agree on ICOs' role to finance ventures by offering tokens or cryptocurrencies to the investors using blockchain technology (Aslan et al., 2021; Fenu et al., 2018; Fisch, 2019).

Coins or tokens distributed in ICOs are " a digital representation of value that can be digitally traded and functions as a medium of exchange, unit of account, or store of value" (SEC, 2017a). As aforementioned, there are four main types of tokens including utility, security, equity and payment tokens. According to Momtaz et al. (2019), regardless of the public perception of tokens as stocks, utility tokens account for 90% of total value raised in ICOs, while it is only 3-5% security tokens and very few are equity tokens. On ICObench.com, 5,700 out of 5,712 ICOs listed are utility tokens and there is no security or equity token (data retrieved from https://icobench.com/ on April 20, 2022). Due to the popularity and dominance of utility tokens, in this paper, we will only look into ICOs that issue utility tokens.

2.1.2. ICO in comparison with IPO

ICO is considered a novel alternative to more traditional sources of start-up funding (Delivorias, 2021) and represents "an innovation in entrepreneurial finance" (Fisch, 2019, p.1). ICO has been popularly perceived as the cryptocurrency equivalent of IPO (Lyandres et al., 2020). This understanding is derived from the similarities between ICOs and IPOs regarding ventures' purposes and processes. By launching an ICO or IPO, ventures offer their tokens or stocks, respectively, for the first time to the public market to raise money. Another similar feature of ICOs and IPOs is that after the offering ends, the issued tokens or stocks are tradable on secondary markets (Chen, 2019).

The two concepts also differ, especially in the venture's development stage, related regulations, information disclosure, and investor accessibility (De Andrés et al., 2022). To launch IPOs, ventures are normally at a later stage with well-developed products and established business models. In contrast, firms launching ICOs are generally in a very early stage of their development, often without minimum viable products and long-term business models established (Collomb et al., 2018; Ofir & Sadeh, 2020). According to Haffke & Fromberger, (2020), less than 50% of the ICOs conducted in 2019 claimed to have a product on the market. Regarding the legal requirements, while IPOs have a well-constructed system of applicable laws related to registration, due diligence, and standardized launching processes, the applicable laws for ICOs vary a lot depending on the market where ICOs are launched. Additionally, IPO issuing firms have to provide information about financial performance, management team or potential risks, firm valuations, and related stock functionalities. In contrast, information disclosure is voluntary and unaudited in the ICO context (De Andrés et al., 2022). Lastly, with regards to investor accessibility, there is hardly any barrier for ICO investors apart from technical constraints, while the access to IPO investment is more "limited by the scarcity of the securities issued and by the actions of gatekeepers such as investment banks and brokers" (De Andrés et al., 2022, p.5).

2.2. ICO benefits and investment risks

2.2.1. ICO benefits

The fast growth and increasing popularity of ICO can be explained by the benefits it can bring to the table to both entrepreneurs and investors (Clements, 2018; Momtaz, 2018). Compared to IPOs and other traditional fundraising methods, ICO is still an underregulated fundraising process. Such a loose legal structure creates a certain level of flexibility and attractiveness for both ICO issuers and investors while also making it riskier for the latter as there are fewer legal mechanisms to protect them.

From an entrepreneur's perspective, ICO is an excellent alternative to raise funds (Clements, 2018; Momtaz, 2018). Thanks to the application of blockchain technology, firms can raise money via ICOs on a global scale with little restrictions (Chen, 2018). Compared with the lengthy and costly process of IPOs, ICOs appear to be a faster and less expensive fundraising mechanism. Not only the role of intermediaries (underwriters in IPO context) is eliminated, but there are also fewer agents and groups of stakeholders involved in the token offerings. This enables BTBFs to raise large amounts of money in a shorter amount of time without the costs related to administrative and legal compliance and intermediaries. It also allows investors and ICO issuers to make the transactions easily and directly (Momtaz et al., 2019). The growing popularity of blockchain technology creates network effects for BTBFs. With a wider adoption of blockchain-based products and services, technical constraints in ICO are lowered when new applications are developed. Consequently, ICO projects can draw more attention from the markets and have higher chances of receiving investment. Last but not least, if the startups decide to offer utility tokens (which 90% of them have done), the founders do not need to transfer their ownership and control rights, making ICOs more attractive to the entrepreneurs as they can retain control over their firms.

From an ICO investor's perspective, the biggest advantage of investing in ICOs over other types of investment in early-stage startups is the rapid exit option that only ICOs can provide (Momtaz, 2018). In traditional early financing by venture capitalists or angel investors, it is hardly possible for investors to exit until the invested projects achieve a certain level of development or maturity, other acquirers appear, or IPOs are conducted. Meanwhile, investors in ICOs can make a quick exit thanks to the token liquidity once the tokens are listed on the cryptocurrency exchanges, normally within three months (Clements, 2018; Momtaz, 2018). Additionally, as aforementioned, there are hardly any restrictions on who can buy in an ICO, making it easier for a wider public to participate (De Andrés et al., 2022).

2.2.2. ICO risks

Even though ICO offers a myriad of benefits to both firms and investors, it has received significant criticism because of the high risks to investors. Based on the Crypto Report (Dowlat, 2018, p. 23), 80% of ICO projects were identified as scams because they "did not have/had intention of fulfilling project development duties with the funds, and/or was deemed by the community". However, it is worth considering that the report also shows that 70% of funds raised via ICO went to "higher quality projects" (Dowlat, 2018, p. 1). On the other hand, Liebau &

Scheuffel (2019) find this magnitude of ICO scam questionable, arguing that the poor economic performance should be disentangled from scam projects. Using a sample of 46 ICO projects conducted by 2016, the authors only identified one project as a scam, accounting for 2.2%. Even if they consider 22 projects whose data on issuing and/or current price is missing as scams, the maximum failure rate was 49%. This worst-case failure rate, according to Liebau & Scheuffel (2019), is close to the 40% failure rate of new technology ventures examined by Song et al. (2008), emphasizing that the actual rate of scams in the ICO market is much lower than the 80% anticipated. Although Liebau's sample is considerably small compared to other ICO research, the result is worth considering as it lays a foundation for future study of scams in the ICO context.

Despite the inconsistency in the results that research on ICO scams might yield, it is undeniable that ICOs entail a certain level of risks, varying from price volatility, and lack of legal protections, to fraud and money laundering (ESMA, 2017). Information asymmetry and the absence of regulations are major reasons behind these ICO risks. In the venture financing context, information asymmetry arises when there is an information gap between investors and ventures about the true quality of the products (Komalasari & Nasih, 2020). Compared to IPO investors, their ICO counterparts face a much higher level of information asymmetry (Ofir & Sadeh, 2020; Burns & Moro, 2018).

Firstly, ICOs are not subject to any legal requirements regarding information disclosure, meaning that the information disclosure is voluntary, unstandardized and unaudited. Consequently, there is less sufficient reliable information for the public to assess the quality of the issuers. According to Zetzsche et al. (2018), 24.71% of ICO projects do not provide information about their financial performance. More importantly, information about who is liable for the projects is missing in a large number of ICOs. As Zetzsche et al. (2018) argue, it is typically in ICOs context that very little information about the issuing entities and their backers is revealed. This makes it hard for regulators to apply private law liability in case of ICO frauds or scams Zetzsche et al. (2018).

Secondly, ICO projects are blockchain-technology based, which are typically highly technical (Fisch, 2019). This makes it harder for investors to evaluate the projects, even when the source code is public. Thirdly, ICOs normally happen at a very early stage of the projects. Consequently, the investors lack historical data and track records based on which the projects can be assessed. This contrasts with IPOs where issuing firms are required to disclose information related to "the terms of the securities being offered as well as [...] the company's business, financial condition, management and other matters that are key to deciding whether the offering is a good investment" (SEC, 2013, p.3)

2.3. ICO regulations

Because of its increasing popularity, high market value as well as the risks associated, ICO has been subject to more scrutiny. Countries have imposed a wide range of regulations with the main purpose of protecting investors from ICO scams (Zetzsche et al., 2018).

On the one hand, South Korea and China declared that ICOs were illegal and prohibited all companies from raising money through ICOs (Choudhury, 2017; Kim, 2017; Meyer, 2017a, 2017b). The Chinese government warned all banks and financial institutions against any business activities related to ICOs. Additionally, for all ICOs that had been successfully completed, the issuers were demanded to refund all the money to the investors (Choudhury, 2017; Meyer, 2017a). Similarly, South Korea banned all fundraising activities involving cryptocurrencies with a warning of "stern penalties" on any individuals or parties that continued to participate in ICOs (Kim, 2017).

On the other hand, the U.S Securities and Exchange Commission (SEC) considers ICO tokens and technology as "a new and efficient means for carrying out financial transactions" but entail an "increased risk of fraud and manipulation" due to a lack of regulations (SEC, 2021). Instead of forbidding ICOs and cryptocurrencies, the SEC has put more effort into regulating the new market. In 2017, the SEC issued the Investor Bulletin "to make investors aware of potential risks of participating in ICOs" (SEC, 2017a) and Investor Alert to warn investors about the potential ICO scams (SEC, 2017b, 2017c). The European Commission has a similar approach toward ICOs, "evaluating ICOs and regulations that might be applied to them" (European Commission, 2018). In 2017, the European Supervisory Markets Authority (ESMA) published two statements about ICO. One statement warns investors of the risks of ICOs such as price volatility, lack of legal protections, risk of fraud, and money laundering for investors. The other highlights the applicable laws to firms participating in ICOs (ESMA, 2017).

Some other countries such as Singapore and Germany have adopted more friendly approaches to the innovative fundraising method (Karpenko et al., 2021; Mendelson, 2019). Singapore's government considers blockchain technology to have “the potential to empower an industry infrastructure for more efficient clearing and settlement of payments and securities” (MAS, 2021). Since 2016, Singapore has started developing “Project Ubin” in an attempt to tokenize the fiat currency (Dylan, 2017), paving the way for further development of a Blockchain-based settlement system (MAS, 2021)

2.4. ICO market overview

The first ICO, Mastercoin, was launched in 2013 (Shin, 2017), but it was until 3 years later that ICOs became widely popular. By the end of October 2019, more than USD 31.14 billion was raised via ICOs (PwC, 2020).

In terms of funding volume and number of successful ICOs, the U.S, Singapore, Hong Kong and The U.K. are the leading ICO hubs globally. More specifically, in 2017, there was over USD 6.5 billion raised via ICOs. 2018, named “the year of the climax”, saw nearly USD 20 billion raised via ICOs, accounting for a YoY growth in volume raised of 440% (Fromberger & Haffke, 2019; PwC, 2020). After the impressive growth in 2017 and 2018, 2019 marked a slower growth rate for the ICO market. There were 981 ICOs issued in 2019, decreasing 60% compared to 2018 (Haffke & Fromberger, 2020). The total volume of ICOs also decreased to USD 4.1 billion (PwC, 2020).

The slowdown in new ICOs launched is partly explained by Tiwari et al. (2020), who point out that, as of December 2017, there was no regulatory framework focused exclusively on ICOs, which provided an opportunity for people with ill intentions. Amid the unregulated and volatile market conditions, the growing popularity and surge in volume of ICOs led to a rise in fraudulent instances by issuers who took advantage of investors. Fraudulent activities were related to pump-and-dump schemes, pyramid and Ponzi schemes, and even money laundering. This prompted regulatory authorities around the world to take action, with 2019 marking the year when regulatory measures were either introduced or rolled out in many countries such as Australia, France and Hong Kong (Tiwari et al., 2020). Consequently, after regulations were in place, it became less attractive both for ill-willed issuers to launch ICOs and for investors to overlook due diligence processes.

In terms of volume raised by ICOs, by 2019 the digital currency ecosystem had 15 "mega-ICOs" that raised in total USD 9.686 billion. "Telegram Open Network", the first "mega-ICO", was conducted in 2018. In three months, it raised USD 1.7 billion by selling 2.9 billion tokens to 171 initial investors (Shieber, 2019). The project was to build a platform and coins to enhance the messenger ecosystem of 400 million users at that time (Singh, 2020). 2018 also witnessed the biggest ICO so far – EOS by start-up Block.one, raising more than USD 4.1 billion during its year-long ICO (Rooney, 2018). Despite not having a live product yet, the startup raised more money than the volume of the three biggest venture funding rounds in 2018, including Epic Games, Uber and Juul Labs (Clack, 2018). BITFINEX conducted in 2019 was the third-largest ICOs, raising more than USD 1 billion for the project of developing tokens for fee discounts in the iFinex ecosystem (PwC, 2020).

Despite the decreasing number of ICOs and the amount of money raised, ICOs have evolved from "too small to care" to "too big to ignore" (OECD, 2019). With USD 31.14 billion raised by 2019, ICO is a disruptive financing mechanism in the venture financing landscape and still is among the ongoing research topics in finance studies (Moxoto et al., 2021). In addition, as Holden and Malani (2022) point out, regulation may have slowed ICOs down but the BTBFs found yet another investment vehicle in NFTs. Many researchers have drawn similarities between ICO and this other emerging blockchain-based financing mechanism, where sales involve digital art attached to the tokens. ICOs resemble NFTs in many aspects, including that both are based on blockchain technology, tokens can be traded on secondary markets after first issuance thus creating a speculative aspect, tokens entitle owners to additional services later, and both mechanisms share common steps from the ones presented in the next section describing the ICO process (Ante, 2021; Chalmers et al., 2022; Holden & Malani, 2022). The main difference between ICOs and NFTs is that the former involves trading fungible tokens, i.e. interchangeable value instead of unique value. Due to their novelty, NFTs face a similar lack of regulation as ICOs did before, with a growing popularity in 2021 comparable to ICOs in 2018. However, just as countries with existing cryptocurrency regulations were quicker to regulate ICOs, it is likely that a similar scenario will happen with NFT regulation. Further similarities can be found in the literature, as Ante (2021) questions to what extent can quality signals in ICOs be applicable or transferred to the NFT market.

2.5. ICO process

The ICO process is commonly divided into three stages including pre-ICO, ICO or ICO launch, and post-ICO (Masiak et al., 2020; Ofir & Sadeh, 2020). During the process, relevant information about the projects is disclosed to the public (Bourveau et al., 2021) .

2.5.1. Pre-ICO

In the pre-ICO stage, ventures develop their strategic plans about where, how and when to launch the ICOs. The goal at this stage is to raise as much awareness about the projects as possible. Important documents such as whitepapers or source codes are typically prepared and published. ICO launch announcements, social media marketing, and incentivizing expert reviews are the keys to drawing attention to the projects. A presale is normally conducted in this stage to raise funds for intensive marketing activities as well as to build the credibility of the projects (Bourveau et al., 2021; Howell et al., 2020).

- *Whitepaper:* Whitepaper is a primary document that provides investors with detailed information about the ICO projects such as IT protocol, how the token sale works, what are token holders' benefits, or how the blockchain architecture operates (Adhami et al., 2018; Howell et al., 2020). It can also include the startup's history, milestones, or background of the management team, or even the business plan (Fisch, 2019; Florysiak & Schandlbauer, 2021, 2022).
- *Source code:* Source codes provide information about the projects' programming activities, algorithms or protocols, etc. Compared to whitepaper, source code is more technically oriented and is considered the core component of a venture (Cohney et al., 2019). Source codes are normally published on Github (Github.com) – an open-source platform for software development for developers and programmers. Due to its importance, most ICO aggregator websites and ventures' communication channels reference the source codes (Belitski & Boreiko, 2021). However, the availability of source code does not guarantee the success of an ICO but the quality of the source code does (Cohney et al., 2019; Fisch, 2019).
- *Marketing activities:* Projects' websites and social media platforms such as Telegram, Reddit, Twitter, or Facebook, are popular channels for ICO issuers to announce their projects and promote themselves in hopes to raise as much awareness of the project as possible (Alchykava & Yakushkina, 2021).

- *Presale:* Prior to the main ICO launch, BTBFs can conduct ICO presales, either privately to a selected group of investors or to the general public (Liu & Wang, 2019). Investors who participate in presales will get either discounts, bonuses or both for taking the risks of early investment. There are two main purposes of ICO presale. Firstly, presale helps BTBFs to raise funds to cover the costs of intensive marketing activities or strategic hires before the ICO launch. Secondly, through presale, ICO issuers can gather the very first information about the market response towards their project, based on which they can design the ICO launch, i.e. setting token price, soft cap, hard cap, among other factors (Howell et al., 2020; Momtaz, 2018).

2.5.2. ICO launch

In the second stage, the ICOs will be officially launched on the projects' websites and announced on any ICO aggregator websites they are registered in, such as ICObench (ICObench.com) or ICOdrops (ICOdrops.com). This is to increase project visibility by concentrating investor attention and traffic.

An ICO can be either uncapped or capped. In an uncapped ICO, the amount of funding that can be raised is unlimited or the price of the token is not published in advance. A capped ICO is the one that provides either a hard cap or a soft cap or both. Soft cap is the minimum amount that needs to be raised for an ICO to be considered successful. In contrast, hard cap works as the maximum threshold of money or amount of tokens that an ICO can raise or distribute. The majority of ICOs are capped. According to Roosenboom et al. (2020), 91.3% of their sample (630 ICOs from 2015 to 2017) were capped. A similar result is found on ICObench.com – one of the most popular ICO aggregator websites, with 4331 out of 5712 ICOs (accounting for 75.8%) capped.

The duration of the ICOs is decided by the issuers and varies significantly from days to even years, with an average of 40 days (Howell et al., 2020). After the token sale period, if the soft cap is reached, the ICO ends successfully and the ICO issuers can keep the money raised for further development of the projects. If the soft cap is not reached, the ICO is considered failed and the investors will get their money back. In case the ICO has a hard cap, whenever the hard cap is reached, the ICO ends, even if the time limit for the ICO has not ended yet.

2.5.3. Post ICO

In the post-ICO stage of a successful ICO, the token is listed on cryptocurrency exchanges and are tradeable on secondary markets. Each cryptocurrency exchange has its own listing criteria and methodology (Dean et al., 2020). For instance, CoinmarketCap (CoinmarketCap.com – one of the most popular cryptocurrency exchanges) has a 5-step process to evaluate whether a crypto asset, including an ICO token, can be listed and remain active on their platform.

Getting tokens listed on a cryptocurrency exchange plays a crucial role in ICO projects. It serves as an important indicator of ICO success (Amsden & Schweizer, 2018) and greatly impacts the liquidity of the tokens (Howell et al., 2020; Momtaz, 2018). Unlike IPOs in which the stocks are listed on the secondary exchange market on the next day after IPOs, it can take from 7 days up to 180 days for the tokens to be listed on a cryptocurrency exchange after the ICOs end (Feng et al., 2019). This time for the majority of the ICOs is within 3 months (Momtaz, 2018). According to Dean et al. (2020), the shorter the time until the listing is, the better the ICO's strategy and support team are. After the ICOs are finished, BTBFs are expected to deliver on their promises to investors by developing and launching the product or service they have raised money for.

III. Literature review and hypotheses

1. Post-ICO performance

Post-ICO performance is a popular topic in the field of research (Aslan et al., 2021, 2020; Fisch & Momtaz, 2020; Jain & Kini, 1995). Different factors have been used to evaluate ICO aftermarket performance, such as working websites, available applications and live platforms (Davydiuk et al., 2018), or future employment and its growth rate (Howell et al., 2020). In empirical research, the most commonly used way to measure a project's aftermarket outcome is the return on investment measured by the changes in token prices on cryptocurrency exchange markets (Fisch & Momtaz, 2020; Momtaz, 2019). The majority of firms try to have their tokens listed on crypto exchanges after ICO completion because it largely impacts their possibility to trade the tokens. This feature of ICOs is important for both firms and investors as it increases liquidity and reduces friction for exit (Momtaz, 2019). From a research standpoint, post-ICO trading enables the measurement of firms' performance after the initial offerings take place and for as long as the tokens are publicly listed on the exchanges. Thus, token values reflect investors' expectations of both future performance growth of the projects and of user adoption (Florysiak & Schandlbauer, 2022).

However, long-term post-ICO performance has been explored only by a handful of researchers. For instance, Aslan et al. (2021) argue that offer price and market sentiment are important for long-term post-ICO performance, however, their impacts vary based on the market periods. Lyandres et al. (2020), based on Gan et al. (2020), address how "entrepreneurs' skin in the game" determines the success of venture post-ICO performance.

As briefly mentioned before, most ICO researchers are confronted with a limitation when collecting data on post-ICO performance due to the short timeframe available for this novel fundraising alternative. As a result, most of the research about post-ICO performance is limited to the short-term or mid-term performance of one month to under 1 year (Aslan et al., 2021; Benedetti & Kostovetsky, 2021; Lyandres et al., 2020). The ones that do study long-term post-ICO performance, have only considered the ICO funding amount (ICO size) and other ICO success factors. (Momtaz, 2019, p.1), for instance, finds a size effect emerging from his empirical research about the pricing and performance of cryptocurrency, stating that "large ICOs are more often overpriced and underperform in the long run". Lyandres et al. (2020) share the same finding on the negative relationship between long-term post-ICO performance and ICO size.

2. Signaling theory in the ICO context

Information asymmetry is a remarkable phenomenon in financial markets, where ventures know more about their true quality than external investors or lenders (Leland & Pyle, 1977). As in Leland & Pyle's words (1977, p.1), "without information transfer [between ventures and investors], markets may perform poorly". However, it is difficult for entrepreneurs to directly share information about their projects with the investors for two reasons (Leland & Pyle, 1977). Firstly, if the shared information is crucially related to their competitive advantages, ventures face the risk of not being able to gain all the benefits if the investors share and/or resell it to competitors or other parties. Secondly, because of the information asymmetry, ventures may have the motivation to exaggerate the quality of their projects to receive higher funding. Given that the market will reflect the average quality of information, ventures with low quality have incentives to sell more poor quality information while ventures with high-quality information will not be willing to share their information, knowing that the market average for information quality is lower than theirs. This in turn can lead to market failure when the average quality continues to decrease to the point that there is only low quality information (Leland & Pyle, 1977). Based on Spence's Signaling theory (1993), the authors argue that for ventures to overcome these problems, signals of quality must be sent and interpreted through their actions.

2.1. Signaling theory in ICO success research

As previously mentioned, information asymmetry in the ICO market is even higher than in traditional ones, hence, signals of quality play a crucial role for the ICO market to function properly. Signaling theory, therefore, has been widely used in ICO research, covering both ICO success and post-ICO performance.

An ICO is commonly considered successful if the funding target is reached (Boreiko & Sahdev, 2018; Charlotte et al., 2019; Liu & Wang, 2019). Through the lens of signaling theory, many ICO researchers investigate the determinants of ICO success and how ICO issuers can send quality signals to the market to reduce the information asymmetry in order to achieve the financing target (Belitski & Boreiko, 2021; Burns & Moro, n.d.; Callejo, 2019; Momtaz, 2021; Ofir & Sadeh, 2020). One major stream of research investigates the role of voluntary disclosure such as whitepaper and source code to find out whether these are signals of high-quality ventures. Using a sample of 423 ICOs, (Fisch, 2019) finds that startups with more informative technological whitepapers and published code on GitHub are more likely to raise higher funds via ICO. Another stream of research looks into the impact of rating websites in the success of ICOs. A third one relies on signaling theory to explain underpricing in the ICO context.

2.2. Signaling theory in post-ICO research

Despite being constrained by the data limitation, researchers have examined various aspects of post-ICO performance in both the short term and long term. In this area of research, signaling theory is still widely used. Ownership retention rate, level of underpricing, ICO rating, and the availability of presale are four of the most noticeable factors that researchers have studied regarding how ventures signal their quality to the markets (Adhami et al., 2018; Boreiko & Vidusso, 2019; Florysiak & Schandlbauer, 2021; Gan et al., 2020). ICO researchers have emphasized the impact of these factors on both ICO success and post-ICO performance. However, ICO research is still rather limited and fragmented. Hence, many researchers explore the ICO phenomenon and related issues by consulting other fundraising research, especially IPOs' extensive literature due to their similarities in their underlying principles and processes (Benedetti & Kostovetsky, 2021; Collomb et al., 2018; Dean et al., 2020; Fisch & Momtaz, 2020; Howell et al., 2020; Lyandres et al., 2020; Momtaz, 2018). In the IPO context, the signaling impact of these equivalent factors is thoroughly examined in relation with post-IPO performance (Allen & Faulhaber, 1989; Belghitar & Dixon, 2012; Engelen & van Essen, 2010; Gumanti & Niagara, 2022).

Following a similar approach, in this master thesis we will study the research question: "To what extent does signaling theory explain long-term post-ICO performance? An empirical research into the impact of quality signals, namely ownership retention rate, underpricing, rating and presale availability". To do so, we develop testable hypotheses to examine whether the relations between the selected quality signals and IPO long-term performance exist and/or work similarly in the ICO context.

3. Hypotheses

3.1. Ownership retention rate

In the IPO context, ownership retention is the portion of shares held by the original issuers after the IPOs and is examined as an IPO quality signal (Gumanti & Niagara, 2022). Based on agency cost theory, Leland & Pyle (1977) state that owners and/or managers, after selling a portion of their ownership of the firm, will lose incentives to optimize the firm's performance. The decrease in management efficiency is explained by the differences in the interests and benefits that the owners and/or managers can have when they own 100% ownership rights of the firms and after issuing IPOs. As aforementioned, entrepreneurs know the firms' quality better than investors. Therefore, only the good issuers can and are willing to retain a high percentage of firms' ownership, knowing that they will gain profits in the future (Jensen & Meckling, 1976). Bad-quality firms find it difficult or cannot afford such costs to retain an equally high rate of retention. In this way, the good issuers can differentiate themselves from their bad counterparts in the market. Hence, high ownership retention is a signal that good-quality IPO issuers send to the market. Jain & Kini (1995, p. 1) agree with this finding, saying that "there is a significant positive relation between [long-term] post-IPO operating performance and equity retention by the original entrepreneur”.

In the ICO context, the ownership retention rate has also been examined as a signal for ICO success and post-ICO performance. Adopting a game-theoretic approach, Gan et al. (2020) highlight that the more tokens sold in an ICO, the fewer tokens left for the owners to sell on the secondary market or less “skin-in-the-game” left, which may reduce the incentives and efforts put into the ICO projects by the issuers to increase their value after ICOs finish. Davydiuk et al. (2018) state that ICO issuers who retain more tokens stand higher chances to achieve successful ICOs and generate better post-ICO performance. However, the post-ICO performance measures were recorded in June 2019 while their data sample consists of ICO conducted from 2016 to 2018, so it is hard to disentangle the impact of ownership retention on short-term and long-term performance. Similarly, Lyandres et al. (2020) argue that entrepreneurs’ retention rate has a positive relation to 6-month post-ICO performance.

Expecting a similar positive impact of ownership retention rate on long-term post-ICO performance as observed in the IPO context, our first hypothesis is as follows:

Hypothesis 1: There is a positive relationship between ownership retention in an ICO and its long-term performance.

3.2. Underpricing

Underpricing is the difference between the issuing price and the closing price on the first day after listing on the secondary market (Engelen & van Essen, 2010). Underpricing has been documented in both IPO and ICO contexts. Analyzing 8,668 IPOs going public from 1960 to 1987, Ritter (1991) finds a 16.4% average initial return from the offering price to the to the price at the end of the first day of trading. Engelen & van Essen (2010) found significant differences in the level of underpricing in the IPO markets among countries. Similarly, the abnormal initial return has been frequently researched in ICOs. Momtaz (2019) observes a positive underpricing in all sample years from 2013 to 2018. Meanwhile, Hu et al. (2018) look into the strong correlation between the secondary market return on cryptocurrencies and Bitcoin price.

Underpricing is popularly considered a quality signal for IPO firms (Allen & Faulhaber, 1989; Grinblatt & Hwang, 1989; Welch, 1989). After the IPOs, private firms will become public, meaning more information about the firms is disclosed. This will adjust the market expectation and evaluation of their performance, reflected via their stock prices. Therefore, it is too costly for bad-quality issuers to underprice their offerings, knowing that it may be not possible to recoup that money in the future when the information asymmetry is reduced and the investors know more about their quality. On the other hand, the good-quality issuers can use underpricing as a quality signal as they know in the future they can gain back the money thanks to their quality and performance (Allen & Faulhaber, 1989). Consequently, the higher the underpricing, the more money the good-quality IPO issuers leave on the table during their first offering. In the analysis of the Spanish IPOs, Álvarez & González (2005) obtain the same finding, showing that post-IPO long-term performance demonstrates a positive relationship with initial underpricing. Considering the ventures' incentives behind underpricing, we predict that there is a similarity between IPOs and ICOs in underpricing's impact on the issuer firms' long-term performance. More specifically, relying on the positive relation between underpricing and long-term post-IPO performance, we propose the second hypothesis as follows:

Hypothesis 2: There is a positive relationship between ICO underpricing and its long-term performance

3.3. ICO Ratings

Another way of reducing information asymmetry between issuers and investors is through expert ratings (Agoraki et al., 2021). In financial markets, Credit Rating Agencies (CRAs) develop reputational capital derived from evaluating the solvency of firms and the creditworthiness of debt securities. In other words, a CRA evaluates the issuers' credit quality, which is their ability to repay investors. In the IPO context, investment banks seek credit ratings when they are in the process of an IPO. A favorable rating is expected to lead to a more successful IPO issuance because it sends a good quality signal to the investors (Chan & Lo, 2011). Chan and Ling Lo (2011) find that the provision of credit ratings prior to IPOs reduces information asymmetry between IPO firms and the general public and improves market efficiency in the short term. This may also lead to less underpricing, shrinking the adjustment of the first day of trading leading to market value. Chan and Ling Lo (2011) also argue that while favorable credit ratings lead to the most positive market reactions in the short term., regardless of how favorable they are, they generally do not lead to abnormal long-term performance, Moreover, IPOs without credit ratings at all receive the worst market reactions. This indicates that an increased information availability through a favorable or lack of a credit rating brings about complete price correction in the short term.

However, Agoraki et al. (2021) point out some critiques that are worth mentioning on CRAs and the ratings they provide. First, market discipline has not developed enough to reduce its overreliance on ratings' activities. Second, regulators have repeatedly failed to address conflicts of interest deriving from CRAs' business model and a lack of transparency, as made known by the media during the financial crisis in 2007-2008, where several CRAs were criticized for misleading investors. Despite the criticism, Chan & Lo (2011) state that the provision of credit ratings reduces information asymmetry and improves market efficiency. They also find that the market reactions are immediate when information asymmetry is reduced but the impact on long-term performance is insignificant.

Similarly to credit ratings in the IPO context, ratings on ICO listing websites, including algorithmic and expert ratings, provide a third-party perspective to reduce information asymmetry for ICO investors. According to Belitski & Boreiko (2021), third-parties' rating is an important predictor of both the ICO projects' outcome and the quality of the information disclosed in the whitepaper. Momtaz (2018) states that the quality of the management team and ICO profiles, which are measured by ICObench, are reliable predictors of ICO success. Bourveau et al. (2018) discover a similar result, arguing that the analysts' rating on ICObench enhances the positive correlation between ICO voluntary disclosure and ICO success. As explained, most of the existing ICO research on ICO rating focuses on its short-term impact on post-ICO performance rather than in the long run.

Many researchers, however, have raised concerns about the unreliability of third-party ICO ratings. Boreiko & Vidusso (2019) recommend investors to treat such ratings with caution as they seem to vary considerably across rating websites and data seems to be of mediocre quality. Florysiak & Schandlbauer (2022) suggest that self-appointed experts with unknown monetary incentives such as the ones behind the ratings on ICObench can potentially increase information asymmetry instead of reducing it. The unreliability of experts' opinions may generate adverse selection costs, misleading investors. This concern is similar to the one raised in the IPO context regarding CRAs.

Criticism aside, IPO research has shown that third-party ratings have an impact on short-term post-IPO performance but the impact decreases in the long run as more information about the firms is published and the information gap is reduced. In the ICO context, third-party ratings also have an impact in the short term for ICO success, and as more information on BTBFs becomes available, we expect similar results to IPOs in the long term. Hence, we propose the third hypothesis as follows:

Hypothesis 3: There is no relationship between ICO ratings and long-term post-ICO performance

3.4. ICO Presale

A form of presale exists in both ICO and IPO contexts, acting as a mechanism to reduce information asymmetry while signaling quality to potential investors. ICO presale allows investors to buy tokens at a discounted price before the ICO launch in the same way that conventional early-stage equity investors take on more risk for a lower share price (Howell et al., 2020). In the IPO context, pre-IPO private placement (PP) is a form of external funding that allows privately held firms to introduce themselves to the institutional investor community before their IPOs (Cai et al., 2011). Despite the similarities, this process differs from the ICO presale which is usually accessible to any type of investors, whether they are institutional or not (Howell et al., 2020). Information about the completed pre-IPO PP is usually available to other investors via media coverage and reduces the information asymmetry on the issuing firm's quality. Cai et al. (2011) examine 500 PP IPO firms in comparison with IPOs that did not have PPs during the period of 1981-2002. Their findings show that IPOs with PP experience significantly less underpricing than their peers due to the reduction of information asymmetry. However, as for long-term stock return performance, the study indicates that IPOs with or without PPs do not show abnormal returns over an extended three-year horizon.

Adhami et al. (2018) and Roosenboom et al. (2020) state that, among other ICO success factors, the organization of a presale results in more successful ICOs. In terms of post-ICO, however, Ahmad et al. (2021) find that ICOs with presales and bonus schemes have a negative relation to successful post-ICO performance measured during a period of under a year. Similarly, Hsieh & Oppermann (2021) show that, among other factors, not holding a presale was positively associated with an ICO's early return. Ahmad et al. (2021) argue that a reason for this can be that projects that organize a presale could signal low quality due to an overly aggressive promotion strategy to sell out, discouraging some investors from buying tokens due to the risk perceived in a still new, unregulated segment of the financial market.

While there are no abnormal long-term returns for PP IPOs, we found no literature on the long-term performance of ICOs that organized presale. We expect that, similar to the IPO context, the impacts of presale in the ICO context will not be significant in the long run. Thus, our hypothesis is as follows:

Hypothesis 4: There is no relationship between ICO presale and its long-term performance.

IV. Methodology

1. Data

It is widely accepted in ICO empirical research to collect and match data from different sources to get the final complete dataset (Boreiko & Sahdev, 2018; Dean et al., 2020). Missing data, absence of unique ICO IDs, and ICOs listed on multiple sources are some of the issues that researchers have encountered when gathering data. Facing similar issues, we try to mitigate their effects as early as possible during the phase of data collection.

Firstly, we retrieve our ICO project data from ICObench (ICObench.com), a commonly used database for ICO research due to its wide coverage and long-standing reputation in the core literature (Boreiko & Sahdev, 2018; Dean et al., 2020; Fisch & Momtaz, 2019; Momtaz, 2018). ICObench is also known for discarding data points of failed ICOs, but given that we are studying the long-term performance of ICOs that were successfully funded, this does not affect our data sample and quality. The initial dataset from ICObench comprised 5728 projects (data retrieved on 17 February 2022) with information on ICO price, retention rate, presale activity, rating, presale price, launch location, blockchain utilized, and whitelist/KYC requirements, among other variables. Because our paper studies the long-term performance of startups 3 years after their ICOs and the token price data (as explained below) was retrieved on the 15th of April 2022, we exclude ICOs launched after April 15th, 2019, reducing the dataset to 3423 projects.

As aforementioned, missing data is another common issue in ICO empirical studies (Fisch, 2019). To mitigate this lack of information, we manually cross-check with other relevant sources of ICO historical data such as etherscan.io, icodrops.com, icomarks.com and icorating.com for cases that have missing information. These ICO aggregator websites are among the most widely used in ICO empirical research (Lyandres et al., 2020). However, it was not possible for us to gather all missing data points as 70% of ICOs conducted before 2017 are poorly covered by ICO listing websites (Boreiko & Sahdev, 2018). Therefore, after removing the ICO projects with missing data, the dataset was reduced to 1253 projects.

Secondly, we obtain the post-ICO performance data from CoinmarketCap (CoinmarketCap.com), which is one of the most comprehensive sources of ICO aftermarket data and is widely used for ICO research (Aslan et al., 2021; Benedetti & Kostovetsky, 2021; Fisch & Momtaz, 2019; Momtaz, 2018). From CoinmarketCap, we extracted a set of 9350 actively tracked tokens (data retrieved on 22 March 2022). We merged the datasets from ICObench and CoinmarketCap to generate a dataset of 318 ICOs that were active until the day we retrieved the data. We then manually gathered token prices of these 318 ICO projects from CoinmarketCap to include tokens' closing prices on both the first listing day and after 3 years of trading as well as listing dates for each token. Based on this, we obtained ICO underpricing and three-year post-ICO performance which will be described in the following section. We finalized our dataset by collecting Bitcoin prices from Nasdaq (Nasdaq.com) for dates corresponding with each token's first day of listing on the trading exchange and the three-year holding period, allowing us to calculate the Bitcoin performance over three years.

A significant reduction in ICO data samples is commonly seen in post-ICO empirical research. Aslan et al. (2021) reduce their initial dataset of 5579 ICO projects to 802 after matching with ICO aftermarket data from CoinmarketCap. Looking into the impact of venture capitals on post-ICO performance, Fisch & Momtaz (2019) have their dataset decreased from 2095 to 565 ICOs. Similarly, Benedetti & Kostovetsky (2021) have only 283 out of 2390 ICO projects when examining ICO cumulative post-listing returns. Therefore, the shrinking of our dataset is expected and will be discussed in the limitations of this master thesis.

2. Variables

A summary of all variables with description and data sources is presented in **Appendix 1.**

2.1. Dependent variable: Three-year post-ICO performance

The three-year post-ICO performance dependent variable is calculated based on buy-and-hold returns (BHR). According to Agathee et al. (2014), buy-and-hold returns are among the most popular methods used to measure long-term post-IPO performance. It is "a strategy where a stock is purchased at the first closing market price after going public and held until its T [time] anniversary" (Agathee et al., 2014, p.6). In ICO research, BHR is also widely used to calculate ICO post-market performance (Benedetti & Kostovetsky, 2021; Fisch & Momtaz, 2020; Momtaz, 2019). Three-year post-ICO performance is measured as BHR with the holding period of 3 years as following:

$$BHR_i = \frac{P_{iT} - P_{i0}}{P_{i0}}$$

In which, T is the holding period. P_{i0} is the closing price of token *i* on the first trading day, while P_{iT} is the 3-year trading closing price.

The three-year performance variable presents several extreme values, with the highest one being 101,060%, an unusual percentage even for the volatile and unpredictable cryptocurrency market. Because of such high numbers, these outliers can greatly impact our analysis. Consistent with how other ICO researchers attenuate the influence of outliers (Lyandres et al., 2020; Momtaz, 2019), we winsorize returns at different levels of 10%, 5%, 2.5%, and 1%. In essence, winsorization replaces the highest x% of the scores with the next smallest score, and replaces the smallest x% of the scores with the next largest score (Hellerstein, 2008). For instance, in the case of 10% winsorization, we replace the top 16 (5%) and the bottom 16 (5%) values with the next smallest and largest values, respectively.

2.2. Independent variables

We look into how quality signals impact long-term post-ICO performance, namely ownership retention rate, underpricing, presale availability, and ICO rating. These constitute the independent variables used in our analysis.

- **RetentionRate**

In the IPO context, ownership retention is the portion of shares held by the original issuers after the offerings (Gumanti & Niagara, 2022). Davydiuk et al. (2018) and Lyandres et al. (2020) used a similar approach to calculate the ownership retention of tokens in their ICO research. It is measured by deducting the percentage of tokens distributed in ICOs from the total 100% of tokens. According to Davydiuk et al. (2018), this information must be made available to the investors before the ICOs start and can be verified on the blockchain. This is to ensure that the data can reflect the owners' belief in the ventures' good performance in the future based on their better understanding of the projects' quality. Similar to Davydiuk et al. (2018), we retrieved the data concerning the percentage of tokens distributed in ICOs from ICObench and other ICO listing websites such as ICOdrops.com and ICOmarks.com.

- **Underpricing**

It is a widely accepted assumption in IPO research that in order to maximize their IPO gross proceeds, issuing firms are subject to fulfill the requirements of stock exchange markets, one of which is to establish "a liquid market in the shares" (Chambers & Dimson, 2009, p.7). Similarly, we assume that being listed on the secondary cryptocurrency exchange market is essential for the ICO firms to build the liquidity of their tokens. According to Ritter (1991, p.1), IPO underpricing is "measured from the offering price to the market price at the end of the first day of trading". This measurement of underpricing is widely used in both IPO and ICO research (Álvarez & González, 2005; Engelen & van Essen, 2010; Momtaz, 2019). Similarly, we calculated the underpricing of token *i* (Ri) in the same way:

$$R_i = \frac{P_{i1} - P_{i\_ICO}}{P_{i\_ICO}}$$

In which, P_{i_ICO} is token *i*'s price in its ICO while P_{i1} is token *i*'s closing price on the first day of trading on the secondary cryptocurrency exchange market.

- **Rating**

ICObench has been widely used as a major and reliable source of data to extract ICO third-party ratings (Boreiko & Vidusso, 2019; Bourveau et al., 2021; Fisch & Momtaz, 2019; Florysiak & Schandlbauer, 2021). Ratings are provided by ICObench as an attempt to gauge the quality of the ICOs and provide more information to their audience. The ICO aggregator website calculates the rating based on Benchy rating and expert rating (ICObench, 2017). The former is the rating given by ICObench's algorithm taking into account the team, disclosed information, product presentation, and marketing and social media activities of the

ICO projects. Meanwhile, the latter is voluntarily given by experts and is a weighted average of ratings on a project's team, vision, and product. ICO rating has been used either as an independent variable or control variable in a wide range of ICO research (Amsden & Schweizer, 2018; Boreiko & Vidusso, 2019; Lyandres et al., 2020). In this paper, ICO rating will be treated as an independent variable which ranges from 0 to 5, with a higher rating indicating a better quality ICO.

- **Presale**

The organization of a presale enables investors to buy tokens at a lower price than the one offered during ICOs. Presale is considered a common practice in ICOs among researchers. According to Howell et al. (2020), 43% out of 1,200 ICO taking place from mid-2017 through mid-2018 conducted presales. It is normally used as a dummy variable in ICO research (Adhami et al., 2018; Belitski & Boreiko, 2021; Fisch & Momtaz, 2020; Lyandres et al., 2020). Similarly, we assign a dummy variable to the organization of a presale, which equals to 1 if a presale was conducted before the ICO's official launch, and 0 otherwise.

2.3. Control variables

Relevant control variables are introduced to eliminate the confounding impact on post-ICO performance. We do not include a control variable (dummy) for whether the issuing firms publish whitepapers due to the lack of variation of whitepaper presence with 98% of the ICOs in our dataset having whitepapers.

- **YearListed**

The cryptocurrency market is significantly impacted by the overall market sentiment, which can include variables such as the amount of ICOs issued, market trends and other time-related differences and macroeconomic effects. According to Burns & Moro (2018), market sentiment affects the four-month return on investment of ICOs. The market sentiment has been measured in different ways such as Twitter statistics (Benedetti & Kostovetsky, 2018; Fisch, 2019), Google trends (Polasik et al., 2015) or media coverage (Burns & Moro, 2018). Taking another direction, Howell et al. (2020) and Lyandres et al. (2020) use Time (Quarter or Year) as a variable to reflect the market sentiment in their ICO research. Different from the year when the ICOs start which might impact the ICO success, the market sentiment of the year when the tokens get listed on CoinmarketCap (YearListed) will influence the tokens' aftermarket performance. Hence, we include the

YearListed variable to control for the impact of the market sentiment on the post-ICO performance.

- **Location**

According to Charlotte et al. (2019), country-level characteristics such as level of digitalization, financial systems and especially regulations on ICOs have a significant influence on the enactment of ICOs and ICO performance (Benedetti & Kostovetsky, 2021). As discussed in section II, each country has a different approach towards the establishment and development of the ICO mechanism and the cryptocurrency market, thus having different impacts on the performance of ICO projects. While countries such as Singapore and Switzerland have more ICO-friendly legal regulations to facilitate the growth of ICO and the cryptocurrency market as a whole, countries like China and South Korea took opposite measures to ban the emerging phenomenon entirely. As a result, firms issuing ICOs in the former group of countries may attract more investment and have more advantages and incentives to develop in the long run (Fisch & Momtaz, 2019; Lyandres et al., 2020; Momtaz, 2019). A dummy variable was assigned a value of 1 for all ICOs located in the top five most popular countries for cryptocurrencies according to the Coincub ranking (2022), and a value of 0 otherwise. This variable is included to control for the impact stemming from country-specific characteristics impacting ICO long-term aftermarket performance.

- **ListingTime**

Unlike shares in IPOs, ICO tokens are not automatically listed on the cryptocurrency exchange market after the initial offerings. There is an application process involved, which requires token issuers to meet specific requirements to get the tokens listed after the ICOs end. According to Dean et al. (2020), the projects whose tokens are more quickly listed on the cryptocurrency exchange market meet fewer obstacles along the process and are considered as having better quality. Consequently, the shorter the time for issuing firms to get their tokens listed, the better their post-ICO returns are. Therefore, to control for the effect of time to listing on long-term post-ICO performance, we include this control variable which is measured in number of days.

- **ERC20**

With around 90% of ICOs built on it, Ethereum is the most popular blockchain for ICO projects (Fromberger & Haffke, 2019; Haffke & Fromberger, 2018, 2020). As a result, the Ethereum standard "ERC20" is the most used token standard so far. This creates great advantages for ERC20 tokens built, including better interoperability, a leading infrastructure, and more externalities provided, leading to stronger network effects for the tokens (Fisch, 2019; Howell et al., 2020). According to Howell et al. (2020), the usage of ERC20 positively influences ICO aftermarket performance in 5 months. Amsden & Schweizer (2018) argue that adopting ERC20 helps to increase the tradability success of the tokens. ERC20 adoption has been popularly used as a dummy variable in ICO aftermarket performance research (Amsden & Schweizer, 2018; Burns & Moro, 2018; Howell et al., 2020). Following this approach, we assign a value of 1 to ICOs that are based on ERC20 and 0 otherwise to control for the impact of the ERC20 standard adoption on tokens' long-term performance.

- **InvestorRestriction**

Information asymmetry impacts both investors and issuing firms. However, it is harder for ICO firms to identify and verify their investors than in the IPO context, where most investors are institutional and are more publicly accountable. The implementation of whitelist and/or know-your-customer (KYC) processes requires investors to either register or complete a verification process before participating in an ICO. On the one hand, this may reduce the number of investors investing in the ICOs, but on the other hand, may increase the transparency of the ICO and allow ICO ventures to identify their investors and build a long-term relationship with them (Li & Mann, 2018; Lyandres et al., 2020). Lyandres et al. (2020) find that investor restrictions are significantly related to ICO success. Hence, to control the effects from investor restrictions, we include a dummy variable where a value of 1 is assigned to ICOs that issued either or both whitelist and/or KYC, and 0 otherwise.

- **BTCPerformance**

Bitcoin (BTC) has been the most remarkable use case of blockchain technology since its inception and has a great impact on the evaluation of the global cryptocurrency market (Rohr & Wright, 2017). An increase in BTC price may increase the price of other cryptocurrencies or tokens as investors are more optimistic, leading to high market sentiment (Dean et al., 2020). As the long-term post-ICO performance is measured based on price changes, BTC performance is an important control variable. BTC price changes over three years are calculated as follows:

$$BTCPerformance_i = \frac{BTC_{i0} - BTC_{iT}}{BTC_{i0}}$$

In which, BTC_{i0} is the Bitcoin price on the first day token *i* was listed on the trading exchange, while BTC_{iT} is Bitcoin price on the 3-year holding period of token *i*.

- **Size**

The main goal of ICOs is to raise funding for the development of the BTBFs' projects. Thus, ICO size has been widely used as a measurement of ICO success and has been researched for correlation with post-ICO performance (Lyandres et al., 2020; Momtaz, 2019). Momtaz (2019) finds a size effect in his analysis, as ICO projects with larger funds raised underperform in the long-run. To account for a possible related size-effect on long-term ICO aftermarket performance, we include the ICO size as a control variable, measured in USD raised via the ICOs.

3. Method

We use Ordinary Least Squares (OLS) regression to estimate the impact of independent variables on the dependent variable. In social sciences, OLS is one of the most popular statistical methods to interpret the relationship between independent variables and dependent variables (Hutcheson, 1999). It is also one of the common methods used among ICO researchers. Fisch and Momtaz (2019) used OLS to investigate the relationship between venture capital investment and post-ICO performance. Benedetti & Kostovetsky (2021) utilized the OLS regression to examine the factors that may impact tokens' buy-and-hold abnormal returns.

It is frequent to see the R-squared in post-ICO performance research range from 0.1 to 0.3 (Dean et al., 2020; Fisch & Momtaz, 2020; Lyandres et al., 2020). This means the models can typically explain from 10% to 30% of the dependent variable. Regardless, the research still yields important findings in the ICO context.

4. Model

Using OLS regression to examine the impact of underpricing, retention rate, rating, and presale on three-year-post-ICO performance (BHR), we construct the model equations as follow:

Full-sample analysis:

$BHR = Intercept + \beta\text{-}_1 Underpricing + \beta\text{-}_2 RetentionRate + \beta\text{-}_3 Rating + \beta\text{-}_4 Presale + \beta\text{-}_5 YearListed + \beta\text{-}_6 ListingTime + \beta\text{-}_7 BTCPerformance + \beta\text{-}_8 Location + \beta\text{-}9ERC20, + \beta\text{-}_{10} InvestorRestriction + \varepsilon$

In addition, a subsample analysis was also conducted to study the research question with *Size* as an additional control variable. This is because there were 36 observations that were missing ICO size data. Hence, to avoid reducing the dataset significantly, instead of removing those 36 observations, we conduct both a full-sample analysis for 318 observations without taking into account the ICO size variable, and a subsample analysis for 282 observations with ICO size variable.

Subsample analysis:

$BHR = Intercept + \beta\text{-}_1 Underpricing + \beta\text{-}_2 RetentionRate + \beta\text{-}_3 Rating + \beta\text{-}_4 Presale + \beta\text{-}_5 YearListed + \beta\text{-}_6 ListingTime + \beta\text{-}_7 BTCPerformance + \beta\text{-}_8 Location + \beta\text{-}9ERC20, + \beta\text{-}_{10} InvestorRestriction + \beta\text{-}_{11} ICOSize + \varepsilon$

V. Results

1. Descriptive Statistics

Figure 1 shows the total number of ICOs started within our chosen time frame (by 2019), as initially retrieved from ICObench (excluding ICOs that lack data about the starting year).

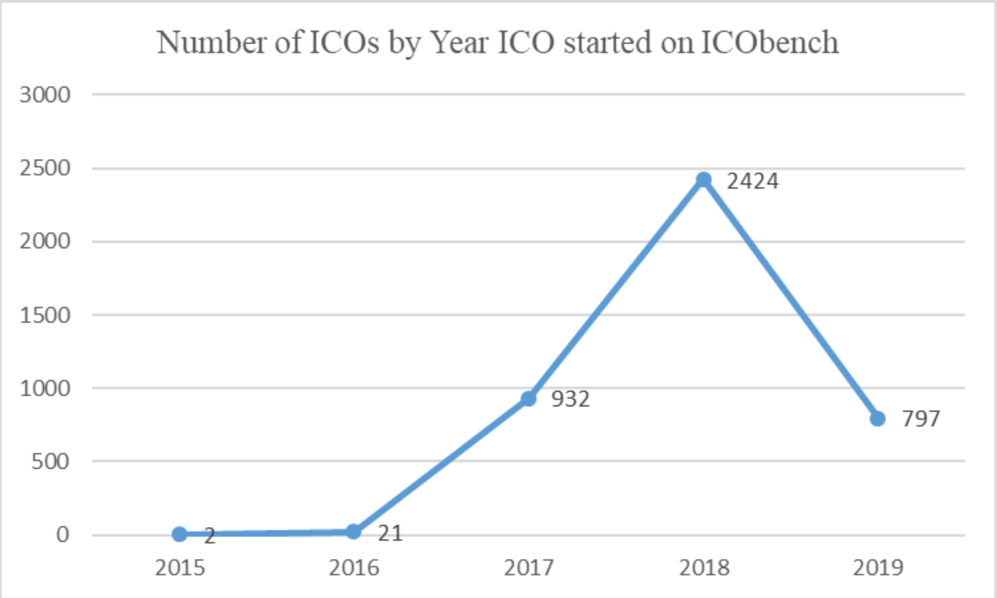

Figure 1: Number of ICOs by Year ICO started on ICObench

(Source: ICObench.com)

It is evident that 2019 saw a drop in the number of projects, contrasting the apparent upwards trend from previous years. This can be explained by the introduction and implementation of ICO-specific regulations as explained in Section II. Hence, issuers, investors, and regulators may have been more wary about this novel mechanism, likely driving the ICO numbers down in 2019.

The distribution of ICO projects launched each year is depicted below in Figure 2. The earliest ICO in our full-sample dataset was launched in 2015, while the latest one did in 2019. Similarly, the highest number of ICOs started in 2018..It must be noted that the number of ICOs started in 2019 for our full sample is disproportionately lower than the number of ICOs launched in the same year for the ICObench dataset. This is because we excluded ICOs launched after April 15th, 2019 to measure ICOs operating at least 3 years after ICO completion when compiling our full-sample dataset.

Figure 2: Number of ICOs by Year ICO started - Full sample dataset

(Source: ICObench.com)

As shown in Figure 3, the most ICOs launched in a single country in our dataset is 61 in the U.S.A., followed by 50 in Singapore.

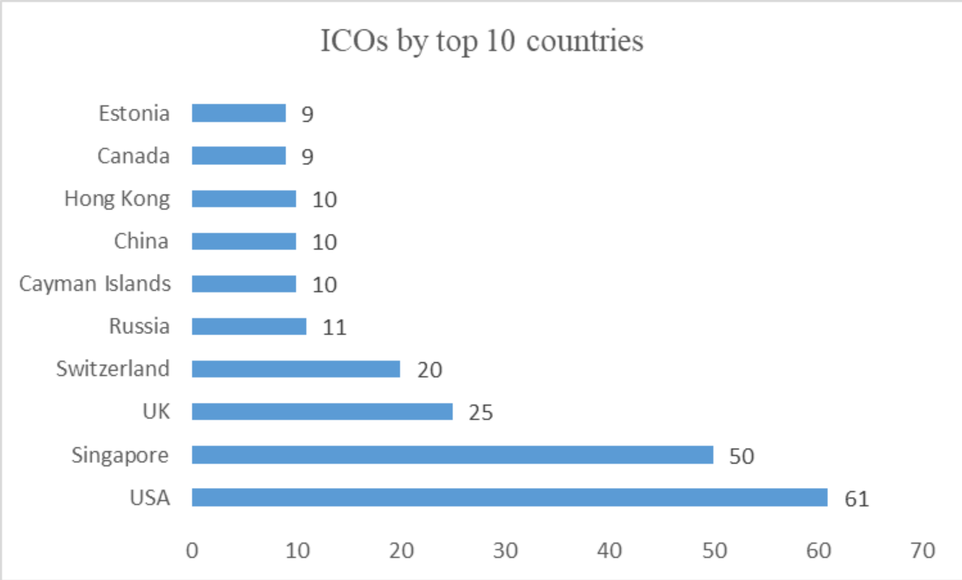

Figure 3: Number of ICOs by top 10 countries - Full sample dataset

(Source: ICObench.com)

The descriptive statistics of our full sample and subsample dataset are presented in Table 1 and Table 2 respectively. The tables present key measures of three-year post-ICO performance as well as the independent and control variables, and the summary when winsorizing returns at different levels.

The descriptive statistics of Three-year performance after winsorization is displayed in **Appendix 2**. As winsorization level increases, lower means and standard deviations are expected, mitigating the impact of extreme values but being more meaningful for top values, which are not capped at 100% as do negative performance values. For instance, the mean performance of the full sample is 70.32% (5.181 std) and 40.69% (3.584 std) at 2.5% and 5% winsorization respectively while for the subsample the mean is 56.3% (5.069 std) and 28.32% (3.539 std) respectively.

The mean and median ICO rating have similar values for both the sample and subsample, which suggests a symmetrical distribution. The average underpricing for the sample is 13,183.55% (2323.425 std), while for the subsample it is significantly lower at 167.8% (6.421 std). The median underpricing for the sample is -1.5%, while for the subsample it is 2.5%. The positive underpricing average and almost 50% of values being positive for both cases may suggest that, as expected, information asymmetry played an important role in the investors' perception of ICO projects, increasing the value corrected by the market once the tokens were listed. In addition, such a substantial decrease in average underpricing for the subsample may be associated with abnormally high underpricing values for the ICOs that were missing ICO size data.

Table 1: Descriptive statistics - Full-sample

	Year Listed	Location	Listing Time	ERC20	Investor Restriction	BTC Performance
count	318	318	318	318	318	318
mean	2017.767	0.415	46.917	0.701	0.311	4.777
std	0.690	0.494	112.942	0.458	0.464	3.100
min	2015	0	-556	0	0	0.33
25%	2017	0	3	0	0	2.205
50%	2018	0	23	1	0	4.24
75%	2018	1	80	1	1	6.5675
max	2019	1	457	1	1	15.68

	Presale	Rating	Retention Rate	Underpricing	Three-year Performance
count	318	318	318	318	318
mean	0.154	3.227	0.550	131.836	1.616
std	0.362	0.656	0.221	2323.425	12.933
min	0	1.5	0.05	-1	-1
25%	0	2.8	0.4	-0.58	-0.96
50%	0	3.2	0.51	-0.015	-0.86
75%	0	3.7	0.7	1.0375	-0.29
max	1	4.6	0.98	41434	150.31

Appendix 3 shows the correlations between all variables, which are no higher than 0.444 except for the correlation between BTC performance and the year listed. However, its 0.550 correlation can still be considered an acceptable value for low correlation and thus, not biasing our results. The Variance Inflation Factor (VIF) for both underpricing and presale show low collinearity, while retention rate and ICO rating show a VIF slightly higher than 5, thus falling under acceptable levels of moderate collinearity and still to be considered reliable for our analysis

Table 2: Descriptive statistics – Subsample

	Year Listed	**Location**	**Size**	**Listing Time**	**ERC20**	**Investor Restriction**
count	282	282	282	282	282	282
mean	2017.720	0.397	34812415	44.184	0.688	0.305
std	0.667	0.490	250245551	94.260	0.464	0.461
min	2015	0	114145	-467	0	0
25%	2017	0	5816580.5	3	0	0
50%	2018	0	14215000	19	1	0
75%	2018	1	25375000	69.5	1	1
max	2019	1	4197956135	457	1	1
	BTC Performance	**Presale**	**Rating**	**Retention Rate**	**Under pricing**	**Three-year Performance**
count	282	282	282	282	282	282
mean	4.483	0.149	3.237	0.553	1.678	1.175
std	2.993	0.357	0.645	0.219	6.421	10.431
min	0.33	0	1.5	0.1	-1	-1
25%	1.98	0	2.8	0.4	-0.53	-0.97
50%	4.05	0	3.2	0.505	0.025	-0.88
75%	6.09	0	3.7	0.7	1.2375	-0.44
max	15.68	1	4.6	0.98	64	117.96

2. Full-sample analysis

The results of our OLS regression on the full sample of 318 observations are presented in Table 3. Model 1 was run to test the impact of all control variables except "Size" on long-term post-ICO performance, Models 2 to 5 show the regression results with all control variables and one independent variable. Finally, Models 6 to 10 show the results with all independent variables and control variables but differentiating themselves in the level of dependent variable's winsorization at 0%, 1%, 2.5%, 5% and 10% respectively. This is to find the best data winsorizing level which helps reduce the biased impact of extreme outliers while not sacrificing data variability.

Table 3: Full sample analysis: Model 1 - Model 10

Model	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Dependent variable	**Three-year post-ICO perfromance (BHR)**				
(Winsorization Level)	0%	0%	0%	0%	0%
YearListed	0.885	0.806	0.943	0.957	0.944
	(1.377)	(1.371)	(1.377)	(1.387)	(1.383)
Location	-0.227	0	-0.12	-0.167	-0.174
	(1.472)	(1.468)	(1.474)	(1.479)	(1.477)
ListingTime	-0.011	-0.012*	-0.011	-0.012*	-0.011*
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
ERC20	0.646	0.485	0.497	0.574	0.689
	(1.653)	(1.646)	(1.657)	(1.661)	(1.656)
InvestorRestriction	0.012	-1.003	-0.794	0.078	-0.097
	(1.800)	(1.858)	(1.930)	(1.807)	(1.813)
BTCPerformance	0.615**	0.618**	0.595**	0.606**	0.629**
	(0.289)	(0.287)	(0.289)	(0.290)	(0.290)
Presale		4.340**			
		(2.122)			
Rating			1.409		
			(1.224)		
RetentionRate				-1.634	
				(3.328)	
Underpricing					0.000
					(0.000)
Number of observations	318	318	318	318	318
R-squared	0.031	0.044	0.035	0.032	0.032

Standard erros in parentheses: * p<.1, ** p<.05, ***p<.01

Model	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**
Dependent variable	**Three-year post-ICO perfromance (BHR)**				
(Winsorization Level)	0%	1%	2.50%	5%	10%
YearListed	0.927	0.392	-0.197	-0.391	-0.297
	(1.388)	(1.207)	(0.543)	(0.367)	(0.215)
Location	0.124	0.347	0.223	0.124	0.16
	(1.482)	(1.288)	(0.580)	(0.392)	(0.230)
ListingTime	-0.012*	-0.009	-0.005*	-0.004*	-0.001
	(0.007)	(0.006)	(0.003)	(0.002)	(0.001)
ERC20	0.395	0.263	0.695	0.641	0.416
	(1.663)	(1.446)	(0.651)	(0.440)	(0.258)
InvestorRestriction	-1.55	-1.043	-0.895	-0.838	-0.710**
	(1.992)	(1.732)	(0.780)	(0.527)	(0.309)
BTCPerformance	0.609**	0.546**	0.457***	0.441***	0.306***
	(0.291)	(0.253)	(0.114)	(0.077)	(0.045)
Presale	4.055*	3.996**	1.596*	0.717	0.262
	(2.154)	(1.873)	(0.843)	(0.570)	(0.334)
Rating	0.978	1.09	0.794	0.634*	0.458**
	(1.261)	(1.097)	(0.494)	(0.334)	(0.196)
RetentionRate	-0.688	-0.18	0.409	0.255	-0.121
	(3.372)	(2.932)	(1.320)	(0.892)	(0.523)
Underpricing	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	318	318	318	318	318
R-squared	0.047	0.051	0.091	0.132	0.166

Standard erros in parentheses: * p<.1, ** p<.05, ***p<.01

As depicted in Table 3, models run with winsorization of 2.5%, 5%, and 10% return better R-squared of 0.090, 0.132, and 0.166 respectively, while models with 0% and 1% of winsorization return 0.047 and 0.051 respectively. Model 8 and Model 9, with a winsorization of 2.5% and 5%, show an acceptable regression result and level of variability in our dataset when compared with the existing ICO research.

Looking deeper into the results of Model 8 and Model 9, Hypothesis 1 is not supported as *RetentionRate* has a fair coefficient estimate of 0.409 and 0.255 but the p-values from both models are not statistically significant (higher than 0.1). This means that even though the ownership retention rate has a strong implication on the ventures' quality and performance in the short run (Davydiuk et al., 2018; Lyandres et al., 2020), its impact is not confirmed in the long run based on our models. In addition, Hypothesis 2 is not supported as *Underpricing* has a coefficient estimate equal to 0 and a p-value higher than .05 in both models. Thus, similarly to the retention rate, the impact of underpricing on the long-term aftermarket performance of ICO firms does not last in the period of three years, regardless of its already proven significant relationship with ICO short-term performance in existing research.

Regarding Hypothesis 3, *Rating* has a significantly positive impact on ventures' long-term post-ICO performance with a coefficient estimate of 0.634 and p-value smaller than .1 according to Model 9. This means that if the rating for an ICO increases by 1 point (rating ranging from 0 to 5), its long-term performance may be 63.37% better. Consequently, Hypothesis 3 is unsupported, as the regression results show a remarkable positive relationship between *Rating* and long-term post-ICO performance. Regarding Hypothesis 4, in Model 8, *Presale* has a considerably high positive coefficient of 1.596 with a p-value lower than .1. Hence, contrary to Hypothesis 4, Model 8 shows a positive relationship between the organization of a presale before an ICO and three-year long-term performance, suggesting that an ICO with a presale may have a 159.58% better long-term post-ICO performance than those without a presale.

As for the control variables, Model 9 shows a strong positive impact of Bitcoin price changes on long-term post-ICO performance, with *BTCPerformance* having a coefficient of 0.441 and a p-value of 0, meaning that if Bitcoin price increases 100%, the token price will increase by 44.13%. Meanwhile, *ListingTime* has a coefficient of -0.005, translating into a negative relationship with long-term ICO aftermarket performance. This means 1 day longer in listing time would decrease long-term post-ICO performance by 0.5%. These findings are in line with previous research by Dean et al. (2020) and Rohr & Wright (2019).

3. Subsample analysis

As previously mentioned, a subsample analysis was conducted with an additional control variable "Size". This analysis was run on the sub-dataset of 282 observations with the results presented in Table 4. To make a more meaningful comparison between the two analyses, we kept the winsorization of three-year post-ICO performance at 0%, 1%, 2.5%, 5%, and 10% as done with the full dataset (Models from 11 to 15 respectively).

Table 4: Sub sample analysis: Model 11 - Model 15 (Inclusing *Size* variable)

Model	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**
Dependent variable	**Three-year post-ICO perfromance (BHR)**				
(Winsorization level)	0%	1%	2.50%	5%	10%
YearListed	-1.455	-1.419	-0.864	-0.829**	0.567***
	(1.190)	(1.148)	(0.567)	(0.385)	(0.214)
Location	1.231	1.271	0.656	0.422	0.361
	(1.266)	(1.221)	(0.603)	(0.409)	(0.228)
ListingTime	0.001	0	-0.004	-0.004*	-0.001
	(0.007)	(0.007)	(0.003)	(0.002)	(0.001)
ERC20	-0.564	-0.408	0.676	0.726	0.419*
	(1.408)	(1.358)	(0.670)	(0.455)	(0.253)
InvestorRestriction	0.666	0.602	-0.28	-0.404	-0.378
	(1.693)	(1.633)	(0.806)	(0.547)	(0.305)
BTCPerformance	0.448*	0.447*	0.471***	0.469***	0.311***
	(0.253)	(0.244)	(0.120)	(0.082)	(0.045)
Size	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Presale	5.305***	5.107***	2.026**	0.942	0.381
	(1.861)	(1.794)	(0.886)	(0.601)	(0.335)
Rating	1.931*	1.867*	1.095**	0.825**	0.610***
	(1.074)	(1.036)	(0.512)	(0.347)	(0.193)
RetentionRate	2.225	2.141	1.373	0.897	0.374
	(2.914)	(2.810)	(1.388)	(0.941)	(0.524)
Underpricing	-0.07	-0.069	-0.042	-0.032	-0.026
	(0.099)	(0.096)	(0.047)	(0.032)	(0.018)
Number of observations	282	282	282	282	282
R-squared	0.08	0.081	0.116	0.163	0.207

Standard erros in parentheses: * p<.1, ** p<.05, ***p<.01

Comparing the regression results between the two analyses, the subsample analysis produces moderately higher results. For instance, at 1% winsorization (Model 12), the subsample analysis returns an R-squared of 0.081, explaining 3% more of the dependent variable. At 5% (Model 14) and 10% (Model 15) winsorization, we obtain similar improvements of 3% and 4% respectively. Additionally, the subsample analysis creates positive changes in the coefficient and p-values. For example, at 5% winsorization (Model 14) the coefficient of *Rating* increases to 0.825 at 1.8% significance. However, it is noticeable that regardless of the changes, the predicted signs (+/-) of the variables remain the same in both analyses.

Table 5: Sub sample analysis: Model 16 - Model 20 (Excluding *Size* variable)

Model	**(16)**	**(17)**	**(18)**	**(19)**	**(20)**
Dependent variable	**Three-year post-ICO perfromance (BHR)**				
(Level of Winsorization)	0%	1%	2.50%	5%	10%
YearListed	-1.462	-1.425	-0.868	-0.834**	0.572***
	(1.187)	(1.145)	(0.565)	(0.383)	(0.214)
Location	1.244	1.283	0.665	0.431	0.372
	(1.259)	(1.214)	(0.600)	(0.407)	(0.227)
ListingTime	0.001	0	-0.004	-0.004*	-0.001
	(0.007)	(0.007)	(0.003)	(0.002)	(0.001)
ERC20	-0.561	-0.405	0.679	0.729	0.423*
	(1.405)	(1.355)	(0.669)	(0.454)	(0.253)
InvestorRestriction	0.66	0.597	-0.284	-0.408	-0.383
	(1.689)	(1.629)	(0.804)	(0.546)	(0.304)
BTCPerformance	0.447*	0.447*	0.471***	0.469***	0.310***
	(0.252)	(0.243)	(0.120)	(0.082)	(0.045)
Presale	5.297***	5.101***	2.021**	0.937	0.375
	(1.856)	(1.790)	(0.884)	(0.600)	(0.334)
Rating	1.944*	1.879*	1.104**	0.834**	0.620***
	(1.067)	(1.029)	(0.508)	(0.345)	(0.192)
RetentionRate	2.193	2.112	1.351	0.874	0.348
	(2.895)	(2.792)	(1.379)	(0.935)	(0.521)
Underpricing	-0.07	-0.069	-0.042	-0.032	-0.026
	(0.099)	(0.096)	(0.047)	(0.032)	(0.018)
Number of observations	282	282	282	282	282
R-squared	0.08	0.081	0.116	0.163	0.206

Standard erros in parentheses: * p<.1, ** p<.05, ***p<.01

To explain the impact of this slight improvement in the regression models of the subsample analysis, we ran the regression on the subsample without size. The results are shown in Table 3, Models 16 to 20. These test regressions produce the same R-squared and coefficients at all winsorization levels (the difference is 0.001) as the subsample analysis. Additionally, *Size* has very low coefficients in all models, almost 0. This points to the conclusion that the *Size* is not informative in this regression model and the improvement in the regression models comes from the removal of some extreme observations in the omitted observations.

VI. Discussion

1. Summary

We find a positive relationship between the rating given on ICObench and ventures' post-ICO performance in the period of three years (measured as BHR). These findings are in line with Belitski & Boreiko (2021) and Bourveau et al. (2021) on the role of third-party ratings in reducing information asymmetry. Similarly, there is a positive relationship between the availability of ICO presale and long-term post-ICO performance. This contradicts the findings by Ahmad et al. (2021), who argue that presale is a negative signal of an overly aggressive promotion strategy to sell out, hence resulting in less successful ICOs. One possible explanation can be the apparent bias in our dataset, which consists of only successful ICOs.

On the other hand, our study does not produce new insights on the impact of ownership retention rate and underpricing on long-term post-ICO performance. These two factors are considered important signals on ventures' quality in both the IPO and ICO contexts (Davydiuk et al., 2018; Jensen & Meckling, 1976; Lyandres et al., 2020), where they are proved to have a positive impact on the ventures' short-term performance after the initial offerings. We expected them to maintain their impact in the long-term post-ICO period, similarly to how they perform in the IPO context. Despite our model finding a positive relationship between retention rate and post-ICO performance and no relationship in the case of underpricing, the result is not statistically significant to draw any conclusions.

This master thesis contributes to ICO research with findings on the relationship between popular quality signal factors and long-term post-ICO performance. This is among a few research efforts looking into the factors that impact the post-ICO performance over the period of three years, which used to be an obstacle for most researchers due to the novelty of the ICO mechanism. Our research opens up new questions for further research, which will be discussed in the next section.

Furthermore, our findings carry practical implications for ICO investors who want to adopt a long-term buy-and-hold strategy. The signaling factors that we look into may be similar for both IPOs and ICOs in the short run as proved by existing research, but in the long run, they might work in either unclear or contradicting ways. As for ICO issuers, this research provides them with further insights into which quality signals to send to the market that may maximize investment and performance in the long run.

2. Limitations

A limitation of our paper is the reduction in the data sample, which might affect its external validity. Moreover, the study focuses on a subgroup of ICO issuing firms whose ICO information is retrieved from ICObench (starting point for ICO information) and token performance information is retrieved CoinmarketCap (source for post-ICO performance). This poses a risk of bias in our research sample due to the unavailability of data as some ventures actively decide to not list or to de-list their tokens from CoinmarketCap for strategic reasons (Fisch & Momtaz, 2019). Additionally, because of the absence of a standardized data source, we were forced to collect data from these two different sources and combine them to generate a final dataset. This reduced the dataset significantly as ICObench and CoinmarketCap share only a limited number of overlapping ICOs/tokens. Lastly, although we tried to collect missing data manually from other ICO aggregating websites, we could only mitigate this issue to some extent, leading to the removal of a fair number of ICOs in the dataset. These issues arise in most ICO research and pose a risk of bias (Boreiko & Sahdev, 2018; Dean et al., 2020; Fisch & Momtaz, 2019, 2020; Lyandres et al., 2020; Momtaz, 2021). We expect that in the future, there will be a standardized reliable data source to rule out these limitations.

Lastly, ventures' post-ICO performance can be impacted by other external factors such as institutional investors' investment, macroeconomic factors, regulation changes, or internal factors such as team size, human resources, industry, etc. However, due to limitations regarding time and resources as well as the unavailability of the information for all ICOs in the sample, we can not include these variables in our research for a better explanation of long-term ICO aftermarket performance.

3. Potential extensions

A potential research extension can be to investigate post-ICO performance from different perspectives. Buy-and-hold return used in this paper is a popular way to measure firms' aftermarket performance after initial offerings in both the IPO and ICO context. However, there are other ways to measure the development and success of the issuing firms such as cumulative average adjusted returns or wealth relatives and product development (Davydiuk et al., 2018), which may yield new insights for research on long-term post-ICO performance.

Moreover, future research can also study the same quality signals for post-ICO performance in different timeframes, such as 1 day, 6 months, 1 year, 2 years, 3 years, and more. This can potentially show the changes in the impacts of ICO quality signal factors over time, contributing further to both the research field on post-ICO performance as well as providing practical implications for investors and ventures.

Finally, our analysis can only explain a relatively small percentage of ventures' post-ICO performance over the period of three years. Despite this being a typical result in many other ICO research, more exhaustive data collection regarding both the number of observations and characteristics of each observation is expected to bring out a higher level of representation in the result.

VII. Conclusion

With this master thesis, we aimed to examine the impact of quality signals that BTBFs send out to the market in their ICOs on their long-term post-ICO performance. The four factors investigated are ownership retention rate, underpricing, ICO rating, and ICO presale. In the ICO context, these factors are proved to significantly influence ICO success (popularly measured by the funding amount raised) and short-term post-ICO performance (normally first-day return or up to 6-months return). In the IPO context, these factors have been proved to influence post-IPO performance, including long-term performance. Based on the similarities between IPO and ICO, we formulated four hypotheses to study these factors' impact in the new context of long-term post-ICO performance.

According to our models, rating and the availability of presale have significant positive impacts on ICO ventures' long-term aftermarket performance. These findings contradict our initial hypotheses proposing that they would not have a clear relationship with long-term post-ICO performance. Furthermore, our model does not significantly support the positive influence of underpricing and owner retention rate on long-term ICO aftermarket performance. Even though existing empirical work has found a strong impact of these factors on ventures' short-term performance after initial offerings, their implications in the long run are inconclusive in this study.

Regardless of the limitations commonly encountered by ICO researchers when generating the dataset, our findings contribute differently to the ICO research field, particularly on long-term post-ICO performance, as being one of the first papers to examine this novel mechanism in a three-year timespan. The study also has practical implications for the ventures for selecting and sending signals to the market to reduce information asymmetry and attract long-term investment as well as for investors in accessing and interpreting these signaling factors. With the increasing popularity and a wider adoption of blockchain technology, an increase in the number of BTBFs is predicted, resulting in a potential growth for ICOs and similar venture financing mechanisms such as NFTs. We can conclude that BTBFs that have good signals related to third parties publicly and positively rating their quality as well as organizing a presale of their tokens for early supporters may perform better in the long run.

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Appendix

Appendix 1: Description of variables and data sources

Variables	Description	Main data source
Dependent variable		
Three-year post-ICO performance (BHR)	Buy-and-hold returns over the first three years of trading after the first date the token's listing on the secondary market	CoinmarketCap.com
Independent variables		
RetentionRate	The portion of tokens held by the original issuers after the ICO	ICObench.com,
Underpricing	The difference between the issuing price and the closing price on the first day after the token's listing on the secondary market	ICObench.com, CoinmarketCap.com
Rating	Rating given to each ICO on ICObench, ranging from 1 to 5, with higher rating for higher quality	ICObench.com
Presale	Dummy variable equal to 1 if a presale was conducted before the ICO's official launch, and 0 otherwise	ICObench.com,
Control variables		
YearListed	The year when the tokens get listed on CoinmarketCap.com	ICObench.com,
Location	Dummy variable equal to 1 for the ICOs located in the top five most popular countries for cryptocurrencies, and 0 otherwise	ICObench.com,
ListingTime	The number of days from the end of an ICO to the time when it is listed on CoinmaketCap	ICObench.com, CoinmarketCap.com
ERC20	Dummy variable equal to 1 if the token based on Ethereum standard ERC20, and 0 otherwise	ICObench.com,
InvestorRestriction	Dummy variable equal to 1 if the ICOs have KYC and/or whitelist, and 0 otherwise	ICObench.com,
BTCPerformance	The difference in Bitcoin price over the period of three years which are similar to the tokens's three-year holding period	Nasdaq
Size	The amount of funding raised via the ICO	ICObench.com,

Appendix 2: Descriptive statistics: Winsorised Three-year Performance

Winsorized Three-year Performance	Full sample				Subsample			
	1%	2.5%	5%	10%	1%	2.5%	5%	10%
count	318	318	318	318	282	282	282	282
mean	1.455	0.703	0.407	0.052	1.142	0.563	0.283	0.072
std	11.265	5.181	3.584	2.144	10.064	5.069	3.533	2.022
min	-1	-1	-1	-0.99	-1	-1	-1	-0.99
25%	-0.96	-0.96	-0.96	-0.96	-0.97	-0.97	-0.97	-0.97
50%	-0.86	-0.86	-0.86	-0.86	-0.88	-0.88	-0.88	-0.88
75%	-0.29	-0.29	-0.29	-0.29	-0.44	-0.44	-0.44	-0.44
max	108.512	32.593	17.278	7.179	108.512	32.593	17.278	7.179

Appendix 3: Correlation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) YearListed	1											
(2) Location	0.016	1										
(3) Size	-0.081	0.086	1									
(4) ListingTime	0.328	0.088	-0.017	1								
(5) ERC20	0.189	0.020	0.029	0.074	1							
(6) InvestorRestriction	0.444	-0.043	-0.048	0.092	0.231	1						
(7) BTCPerformance	0.550	-0.021	-0.054	0.272	-0.012	0.356	1					
(8) Presale	0.195	-0.077	-0.035	0.100	0.126	0.334	0.140	1				
(9) Rating	0.162	-0.082	0.085	-0.033	0.152	0.422	0.169	0.259	1			
(10) RetentionRate	0.079	0.072	-0.120	-0.070	-0.050	0.082	-0.007	-0.059	-0.120	1.000		
(11) Underpricing	0.100	0.067	0.005	0.016	0.036	-0.038	0.103	-0.024	-0.131	-0.002	1	
(12) Three-year_Performance	0.101	-0.019	0.008	-0.041	0.023	0.071	0.147	0.130	0.098	-0.019	-0.011	1